Chapter 8 – Water Quality

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Introduction

The following chapter provides an initial evaluation of water quality information using simplified methods. The purpose of this level of assessment is to flag obvious areas of water quality impairment in the watersheds.

The term "water quality" includes the water column and the physical channel required to sustain aquatic life (Watersheds Professional Network 1999). Water quality is defined by a multitude of different parameters. Physical and chemical measures of water quality include temperature, dissolved oxygen, turbidity, total suspended solids, nutrients, and toxins such as heavy metals, pesticides and other chemicals. Biological parameters include the type and abundance of bacteria, algae, macroinvertebrates (i.e., aquatic insects), and fish.

Parameters commonly measured in a stream monitoring program are described in **Table 8-1**. A brief description on how some of these parameters affect salmonids is given in the following text.

Data Sources

Data for this chapter was compiled from the following sources: City of Salem, Oregon Department of Environmental Quality (DEQ), Oregon Water Resources Department (OWRD), U.S. Geological Survey (USGS), Oregon Department of Geology and Mineral Industries (DOGAMI), Glenn-Gibson Watershed Council, and McKay High School.

Water Quality Parameters

Temperature

High water temperatures can impair feeding, growth, and reproduction of aquatic organisms and even cause death. High stream temperatures can decrease the capability of water to hold dissolved oxygen that is crucial to the survival of aquatic organisms. Fish species vary in their tolerance to water temperatures. Even a small change in temperature can drastically affect fish life cycles. Salmonids, including salmon and trout, are especially vulnerable to temperature changes or extremes before they hatch and during their early stages of life. Spawning activities, metamorphosis, and migration can be triggered at the wrong time of year by a slight change in temperature. This, in turn, can decrease or destroy a species' chance for survival. Temperature increases may also enable warm-water fish species (e.g. bass and bluegill) to gain a competitive advantage or may facilitate predation of juvenile salmon and trout.

Removal of streamside vegetation, heated industrial discharges, return flow from irrigated fields, summer stormwater runoff from highly urbanized areas, water impoundments and low stream flows may elevate stream temperature.

Oregon Department of Environmental Quality's (DEQ) temperature standard for cold-water fish is 64 degrees Fahrenheit (17.8 Celsius) over a 7-day moving average unless there is cold-water fish spawning or bull trout habitat. These special habitat areas have standards of 55 (15.3 Celsius) and 50 (13.9 Celsius) degrees Fahrenheit respectively. In the lower Columbia and Willamette rivers, the temperature standard is 68 degrees (18.9 Celsius).

Dissolved Oxygen

Fish absorb oxygen from the water through their gills. They are sensitive to the amount (partial pressure) of oxygen in the water, just like humans are sensitive to the amount of oxygen in the air they breathe (Long Tom Watershed Council 2000). Low amounts of oxygen in the water may cause stress or even death to some aquatic organisms.

The quantity of dissolved oxygen in a stream is a function of atmospheric pressure, water turbulence (i.e., a babbling brook vs. still water), water temperature, and amount of biological activity (Portland Multnomah Progress Board 2000). Dissolved oxygen is negatively correlated with high temperatures: as water temperature rises, the carrying capacity of the water decreases and it is unable to hold as much oxygen. The same relationship occurs between dissolved oxygen and the amount of biological activity. Waterbodies with large amounts of algae produce lots of oxygen.

Table 8-1. Limiting Water Quality Parameters and Their Effect on Salmonids

Water Quality Constituent	Definition	Importance to Salmon	General Threshold	Criteria for Protecting Fish[1]
Temperature	See text	Affects metabolism, growth, embryo development, fry emergence, smoltification	Depends on species and life stage; e.g., tolerances for Coho range from 40^{0}F for spawning to 60^{0}F for adult migration; also see preferred and lethal temperature table.	64^{0}F (17.8^{0}C) 7 day moving average of daily maximum (DEQ standard)
Dissolved Oxygen	See text	Oxygen supports high energy demands associated with upstream swimming.	DO levels of 8-9 mg/L or more are needed to ensure that normal physiological functions of salmon are not impaired; low dissolved oxygen is correlated with high water temperature.	DEQ standard is 8.0 mg/l 30-day mean minimum for cold-water fish; 6.5 mg/l 30-day mean minimum for cool-water fish; 5.5 mg/l 30-day mean minimum for warm-water fish
Total Suspended Solids (TSS)	Fine particles that are suspended in water; includes silts, clays, & microscopic algae. See "Sedimentation" section in text.	Smothering of spawning gravels; pool filling; respiratory abrasion; reduced growth, reduced feeding rates, impair homing instincts.	No thresholds, although salmon typically prefer water with low turbidity and suspended sediment content. Some suspended sediment may actually be beneficial because it attaches to harmful chemicals (thus reducing the toxin's bioavailability to salmon).	None.
Turbidity	Measures the clarity of water by assessing the amount of light that scatters when a beam of light is passed through a water sample. See "Sedimentation" section in text.	Smothering of spawning gravels; pool filling; respiratory abrasion.	No thresholds, although salmon typically prefer water with low turbidity and suspended sediment content.	<50 NTU maximum above background levels (OWAM guideline); Ground disturbing activities should not increase the natural, background stream turbidity by more than 10% (DEQ standard).
Total Dissolved Solids (TDS)	Non-particulate material dissolved in water.			Total instream dissolved solids should not exceed 100 mg/L (DEQ standard).

Water Quality Constituent	Definition	Importance to Salmon	General Threshold	Criteria for Protecting Fish[1]
pH	A logarithmic scale that measures the acid or base concentration of the water. See text for further explanation.	Can be lethal to fish and other aquatic organisms if pH is too high (high base concentration) or too low (high acid concentration). pH and high temperatures together can increase the toxicity of certain chemicals such as ammonia and metals.	Fish prefer water that is close to pH neutral.	pH 6.5-8.5 (DEQ standard)
Nitrogen (N, NO3, NO2, NH3)	Important plant nutrient; in water usually occurs as nitrate (NO3) or ammonia (NH3). See "Nutrients" section in text.	Nitrogen is needed for plant growth. Algae and other aquatic plants are a source of food for aquatic insects. Salmonids, in turn, rely on an abundance and diversity of aquatic insects for growth and survival.	High nutrient levels in surface water promotes rapid growth of algae (a.k.a. algal blooms). As these algal blooms die and decompose, bacteria consume the algae and respire, using a significant portion of the dissolved oxygen in the water. The amount of oxygen remaining in the water may not be sufficient for the continual survival of salmonids.	< or = 0.30 mg/l (OWAM guideline)
Phosphorus (P, PO4)	Important plant nutrient; in water usually occurs as PO4. See "Nutrients" section in text.	Same as above.	Same as above.	< or = 0.05 mg/l (OWAM guideline)
Biological Oxygen Demand (BOD)	Reflects the amount of carbon in the water; high carbon concentration=high BOD. See "Nutrients" section in text.			None
Chemical Oxygen Demand (COD)	Reflects the amount of chemicals in the water that can be oxidized (a process that removes available oxygen from the water).			None
Toxic Substances				
Heavy Metals	Includes elements such as arsenic, cadmium, chromium, copper, lead, mercury and zinc. See "Toxic Substances" section in text.	Depending on the metal, even small amounts in surface water can be toxic to fish.		Each metal has a different standard; often depends on water hardness.

Water Quality Constituent	Definition	Importance to Salmon	General Threshold	Criteria for Protecting Fish[1]
Organic Compounds	Compounds containing carbon; some can be highly toxic. See "Toxic Substances" section in text.	Taking oil as an example of a carbon-based compound, oil can affect the gills of fish and interfere with respiration, coat and destroy fish food sources, coat the bottom of streams and interfere with spawning areas.		Each compound has a different standard.
Pesticides	See "Toxic Substances" section in text.	Depending on the pesticide and its concentration in the water, pesticides can cause behavioral changes in aquatic organisms, developmental deformities, and/or death. Some pesticides can bio-accumulate, becoming more concentrated as contaminated prey is consumed by organisms higher in the food chain.		Each pesticide has a different standard; many do not have established standards.
Biological Parameters				
Bacteria	Bacteria group used as an indicator of human or animal feces. See text for further explanation.	High counts of fecal coliform bacteria sometimes correlates with high levels of nutrients. (See Nitrogen and Phosphorus)		Standard for water-contact recreation for *E.coli* (DEQ standard states not to exceed): • 406 cells/100ml: single sample • 126 cells/100ml: log mean of at least 5 samples over 30 days Old standard for fecal coliform: • 200 cells/100ml: log mean of at least 5 samples over 30 days with no more than 10% of the samples in the 30 day period exceeding 400 cells/100ml
Macro-invertebrates	Aquatic insects and larvae commonly used to assess stream health. See text for further explanation.	Serve as a food base for salmonids and other aquatic organisms.		None

[1] DEQ water quality standards for Willamette Basin in ORS 349-041-0442; OWAM guidelines taken from Watershed Professionals Network (1999)

Table Adapted from:

1. Portland Multnomah Progress Board (2000)
2. Thieman (2000)

Factors such as high Biological Oxygen Demand (BOD), nutrient loads from point and non-point sources, urban stormwater runoff, dredging, combined sewer over flows, and sanitary sewer over flows can lower the amount of dissolved oxygen in a stream by encouraging excessive algal growth.

In waters supporting salmonids, the necessary DO levels range from 11 mg/l in spawning and rearing waters to 6 mg/l in non-spawning waters (the absolute minimum DO level needed to avoid acute mortality) (Oregon Plan Monitoring Team 1999). Dissolved oxygen levels of 8-9mg/l or more are needed to ensure that normal physiological functions of salmonids are not impaired. DEQ has set a standard of 8.0mg/l 30-day mean minimum for cold-water fish.

Sediments

Excess soil erosion can cause serious problems for a stream or waterway. Sediment suspended in a stream can smother spawning gravels (i.e., bury salmon eggs), fill pools, clog the gills of fish, bury food sources such as insect eggs and larvae, impair the vision of sight-feeding fish for locating their prey, as well as block needed light to underwater plants. Sediments also carry with them heavy metals, nutrients and pesticides that can negatively impact the quality of the aquatic environment.

A healthy stream will have naturally suspended sediment because the stream acts as a large conveyor belt carrying sediment, silt, and organic matter while carving out valleys and shaping the landscape. Although erosion is a natural process, an unnatural acceleration of erosion levels can be caused by land-disturbing activities of people. In urban areas, flushes of sediment into a stream are episodic and exacerbated by high flow and storm events. One major source of excess sediment is construction sites where erosion barriers are improperly maintained or not in place. Agriculture is another major source of excess sedimentation. This results from poor farming practices such as farming on highly erodible land or hillsides or over-planting. Surface mines, logging operations, filling floodplains for development, stream channelization, and excess water runoff from paved urban areas all contribute to erosion. When these sources of excess erosion are not abated or prevented, a stream can be seriously degraded (Izaak Walton League 1999).

In the Willamette River Basin, urban sites contribute the greatest amount of suspended sediment to the Willamette River on a *per-acre* basis. Agriculture, however, contributes more sediment to the Willamette River than any other activity in the basin (Institute for the Northwest 1999).

Particles in water may stay suspended indefinitely, or eventually settle out. Turbidity and total suspended solids (TSS) are two ways to measure these particles. DEQ does not have a standard for suspended solids. As for turbidity, DEQ states that no ground-disturbing activities should increase the natural, “background” levels of turbidity in a stream by more than 10%.

pH Levels

This indicator measures the hydrogen ion activity in water and its relative acidity on a scale of 1 to 14. A pH of 1 is most acidic, pH of 7 is neutral, and pH of 14 is least acidic or most basic. Normal rainfall is actually slightly acidic, with a pH ranging from 5 to 6 in the Pacific Northwest. In Salem, rainfall is slightly more acidic than the normal range for the Pacific Northwest; median value of local rainfall is 4.6 (City of Salem 1982). The pH of rainwater increases as it hits the ground and penetrates the soil surface or other substances. In fact, the average pH measured in Salem's streams is around 7.0 (Miller pers. comm.). The pH of water can be affected by human activities (e.g. industry, automobile exhaust, etc.), the soil and rock types in the watershed and even the amount of photosynthetic activity by algae in the water.

One reason for low pH values and high acidity is acid rain. In addition, acids can be released suddenly during the spring thaw when snowmelts occur, freeing acids concentrated in the ice during the winter months. Acids formed are from oxides of sulfur and nitrogen released into the atmosphere from combustion of fossil fuels—such as coal and oil—and from power plants, factories, and automobiles. Effluents from steel mills, plating mills, paper mills, tanneries, textile mills, and chemical plants also contribute to low pH in streams. Low pH and high water temperatures together can increase the toxicity of certain chemicals such as ammonia and metals (Izaak Walton League 1999) as well as directly affect fish.

DEQ specifies the expected pH range as 6.5 to 8.5 for basins west of the Cascades.

Nutrients

The most common nutrients contributed by human activities include nitrogen and phosphorus. These elements are important plant nutrients and can be limiting factors for plant growth. Excess levels of either of these nutrients can lead to large algal blooms, which in turn lead to lower dissolved oxygen levels.

Excess organic matter, such as algal blooms, causes many problems in streams including blocked surface light to submersed aquatic plants, odor and surface scum, competition for natural fish food sources, interference with spawning areas, disappearance of native fish populations, clogged irrigation systems and limited opportunities for recreational water use. In addition, an increase in the level of organic matter in a stream can cause a rise in the Biological Oxygen Demand (BOD). BOD is a measurement of the oxygen required to carry out the stream's natural processes, such as decomposition. A limited supply of oxygen exists in the water. Therefore, oxygen supplies will decrease as increased amounts of organic matter decompose. Native fish populations are thus deprived of necessary oxygen levels (Izaak Walton League 1999).

Natural sources of nutrients include decaying plants and animals and fecal matter from wildlife. Humans and their activities can increase the level of nutrients in a stream. Human sources of nutrients include: discharge from wastewater treatment plants; leaking septic systems; fecal matter from livestock; effluent from fruit and vegetable canneries and other industries (in Salem, effluent from canneries discharges to the sanitary sewer system, not the stormwater system); grass clippings or leaves dumped into gutters or streams; fertilizers from farms, lawns and gardens; pet waste; and detergents, especially from washing vehicles in driveways and parking lots.

The level of phosphorus and nitrogen in water is typically measured as "Total Phosphorus" and "Total Kjeldahl Nitrogen." DEQ offers no set standard for either of these nutrients in regards to fish or aquatic life. Recommendations from the Oregon Watershed Assessment Manual (OWAM) suggest that phosphorus levels remain equal to or lower than 0.05mg/l and nitrates at or below 0.30mg/l (Watershed Professionals Network 1999).

Toxic Substances

An element is said to be toxic if it injures the growth or metabolism of an organism above a certain concentration. Toxic substances can poison aquatic life, destroy aquatic food supply, and deform fish larvae. If the discharge is acute (of high intensity but lasting for a short duration), it may not last long enough to produce long-term effects on aquatic life. If the discharge is chronic (of long intensity over an extended period of time), its effects may take longer to become apparent but will be easier to measure. Some toxic substances can "bioaccumulate," which means they can increase in concentration and become more dangerous as they move up the food chain beginning with microorganisms and continuing up to humans (Izaak Walton League 1999).

Toxic pollutants commonly found in urban runoff include trace metals such as lead, copper, zinc, and organic compounds including oils, grease, phthalates, and chlorinated hydrocarbons (Richter 2000). Storm water picks up toxic substances such as oil, heavy metals and pesticides as it flows across parking lots, roads, and lawns. Illegal disposal of these substances along with paint, household chemicals, chlorine, and industrial material can also enter streams as they are illegally dumped into to storm drains. Sources of toxics include the breakdown of metal products, vehicle fuels and fluids, vehicular wear, industrial processes, and industrial and household chemicals.

Car washing can add a considerable amount of oil and phosphates into a local storm drain system. As soap is hosed off vehicles, it typically drains down driveways or across parking lots into the nearest catch basin where it is piped directly into the stream. Allowing soap to enter the storm drain system is a violation of city code. In Salem, commercial car washes must discharge to the sanitary sewer. Soaps and other pollutants are prohibited by City Code of be discharged into stormdrains. However, charity car washes and private individuals are exempt from this requirement by State Law. City Staff are encouraging those involved with charity car washes and the public at large to change their practices when practical to minimize discharge. The City of Salem in partnership with the Watershed Enhancement Team (WET), is providing public education encouraging people to wash their cars on lawns or other permeable areas.

Other factors affecting toxic levels in water and sediments include dredging (which can disturb buried sediments that contain toxic material), sanitary sewer overflows, irrigation return flows, pesticide applications, leaky underground storage tanks, contaminated groundwater, and point source discharges such as industrial effluent.

The amount of certain toxics released in industrial effluent is regulated by DEQ under the authority of the Environmental Protection Agency (EPA) through the National Pollutant Discharge Elimination System (NPDES) program. Although there are hundreds of toxic chemicals released into the environment through industrial effluents, legal limits exist on only a few. The EPA has classified a small fraction of these toxic substances, and many chemical compounds are only now being recognized as harmful. In addition, many chemicals become toxic only in combination with other compounds or under certain environmental conditions (e.g. high water temperatures and low pH) making measurements of their effects and the setting of acceptable concentration limits difficult (Izaak Walton League 1999).

Oil—A Common Toxic Substance in Urban Streams

Petroleum products severely affect all types of aquatic life in streams. Free-floating oil and emulsions act on the membrane surface of a fish's gills and interfere with respiration. Petroleum products destroy the fish's food sources by coating and destroying algae and other plankton. Additionally, the flesh of the fish can be tainted when contaminated algae and plankton are ingested. If the oily substance settles, it coats the waterway bottom, destroying bottom-dwelling organisms and interfering with spawning areas. Films of oil on the water's surface interfere with plant photosynthesis and respiration. Surface films also destroy algae and reduce the oxygen level in the water (Izaak Walton League 1999).

Sources of oil pollution include vehicle usage, leaky vehicles, vehicular accidents, industrial plant wastes, grease and fats from lubrication of machinery, the manufacturing process of hydrogenated glycerides, rolling mills, leaky underground storage tanks, storm water overflows, gas stations, and car oil dumped into street drains by homeowners. Rainwater will pick up a significant amount of oil as it flows across street surfaces and parking areas and into storm drain systems, ultimately discharging into our streams.

Pesticides—Urban and Rural Contaminants

A pesticide is any chemical that is used to prevent the growth or survival of unwanted plants, animals, insects, fungi or bacteria. Herbicides, fungicides and insecticides are types of pesticides. Acute spills of pesticides into surface waters can be lethal to aquatic organisms, depending on the chemical(s) that constitute the pesticide. Even small amounts of pesticides can be harmful to aquatic organisms, affecting their behavior, development, and overall strength. Many pesticides are water-soluble and will percolate down into the ground water. Other pesticides will attach themselves to sediment particles and remain in the soil until erosion washes them into streams.

Pesticides are used extensively in both rural and urban environments. The four most common pesticides found in Willamette Valley streams are atrazine, metolachlor, simazine and diuron (Anderson et al. 1997) (**Table 8-2**). Five other compounds—carbaryl, diazinon, dichlobenil, prometon, and tebuthiuron—had significantly higher concentrations at urban sample points than at agricultural sites (Anderson et al. 1997).

Table 8-2. Most Frequently Detected Herbicides in the Willamette Basin

Most frequently detected compounds found in Willamette Basin	Percent of samples compound detected	Detection limit (micrograms per liter)	Maximum found (micrograms per liter)	EPA pesticide risk assessment (rainbow trout)	Lethal Concentration (LC)(micrograms per liter)	Exposure time (hours)	General use and sample trade name
atrazine and its by products	99%	0.001	90	slightly toxic	9,900	96	Herbicide (AAtrex)
metolachlor	85%	0.002	4.5	moderately toxic	2,000	96	Herbicide (Dual)
simazine	85%	0.005	1	low toxicity	56,000	48	Herbicide (Princep)
diuron	73%	0.020	29	moderately toxic to fish; highly toxic to aquatic invertebrates	3,500	96	Herbicide

Fecal Coliform Bacteria

Escherichia coli (E. coli) is a member of a group of bacteria called fecal coliform bacteria. As the name implies, this group of bacteria is associated with fecal matter from both humans and animals. *E. coli* is a specific species of bacteria found in the fecal coliform "family" of bacteria.

While the presence of fecal coliform in surface waters in not unnatural, high concentrations of fecal coliform bacteria pose a threat to water-contact recreation, water foal and wildlife. High levels of fecal coliform in a water body may be an indicator of large inputs of nutrients. Wastewater treatment facilities, faulty septic systems, runoff from livestock operations, and runoff carrying pet waste may all contribute to high levels of fecal coliform bacteria in our streams and lakes.

Prior to 1996, a water body did not comply with state water quality standards for water-contact recreation if the log mean of at least 5 surface water samples taken in a 30-day period exceeded 200 fecal coliform per 100 ml, with no more than 10% of the samples in the 30-day period exceeding 400 colony forming units (cfu) per 100 mls. To improve the standard, the fecal indicator was changed in 1996 from the bacterial group of fecal coliforms, which includes a suite of different species of bacteria, to a specfic species within the fecal coliform family called *E. coli*. DEQ changed this standard as of January 11, 1996, to read "no single sample should exceed 406 *E. coli* organisms per 100 ml" (Oregon Administrative Rules 340.41). This standard was set for water-contact recreation and not for the survival of salmonids. The standard was set to protect human health. While high levels of *E. coli* bacteria in a stream may be a human health hazard, it does not indicate whether or not it is a hazard to aquatic species.

Macroinvertebrates

Macroinvertebrates are small organisms lacking backbones; they can be seen without the aid of a microscope. The types and number of macroinvertebrates present in a stream can be used as an indicator of stream health. Most streams, no matter how polluted, contain invertebrates. Some species cannot tolerate poor stream conditions, while others may thrive in polluted streams.

Degraded stream conditions can be determined by presence or absence of tolerant and intolerant species. Stoneflies, mayflies, and most species of caddisflies are abundant in healthy streams: those characterized by low water temperatures, high dissolved oxygen and low suspended solids. Black fly larvae, amphipods, and "left-handed" snails are abundant in streams in poor condition: those characterized by low dissolved oxygen, high temperatures, and stream bottoms with fine sediment deposits (i.e., stream bottoms with high amounts of silt particles and low amounts of sand and gravel particles).

The 303(d) List and Stream Health

Section 303(d) of the Clean Water Act requires each state to develop a list of water bodies that do not meet water quality standards, and to submit an updated list to the Environmental Protection Agency (EPA) every two years. The list of water bodies helps state residents to identify problems and develop and implement watershed recovery plans to protect beneficial uses while achieving federal and state water quality standards (DEQ 2001e).

DEQ establishes water quality standards to protect beneficial uses of the state's waters. Beneficial uses are defined by law and include such things as recreation, aquatic life, irrigation, fisheries and drinking water (**Table 8-3**). While there may be competing beneficial uses in a river or stream, federal law requires DEQ to protect the **most sensitive** of these beneficial uses. For Willamette River tributaries, aquatic life, particularly salmonid spawning and rearing, is considered one of the most sensitive beneficial uses. For this reason, the standards for water quality and in-stream conditions are geared towards assuring adequate quality for salmonids, which will assure adequate quality for other beneficial uses.

Table 8-3. Beneficial Water Uses in the Willamette Basin

Beneficial Uses	Willamette River Tributaries						Main Stem Willamette River				
	Clackamas River	Molalla River	Santiam River	McKenzie River	Tualatin River	All Other Streams & Tributaries	Mouth to Willamette Falls, Including Multnomah Channel	Willamette Falls To Newberg	Newberg to Salem	Salem to Coast Fork	Main Stem Columbia River (RM 86 to 120)
Public Domestic Water Supply[1]	X	X	X	X	X	X	X	X	X	X	X
Private Domestic Water Supply[1]	X	X	X	X	X	X	X	X	X	X	X
Industrial Water Supply	X	X	X	X	X	X	X	X	X	X	X
Irrigation	X	X	X	X	X	X	X	X	X	X	X
Livestock Watering	X	X	X	X	X	X	X	X	X	X	X
Anadromous Fish Passage	X	X	X	X	X	X	X	X	X	X	X
Salmonid Fish Rearing	X	X	X	X	X	X	X	X	X	X	X
Salmonid Fish Spawning	X	X	X	X	X	X			X	X	X
Resident Fish & Aquatic Life	X	X	X	X	X	X	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X	X	X	X	X	X	X
Fishing	X	X	X	X	X	X	X	X	X	X	X
Boating	X	X	X	X	X	X	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X	X	X	X[2]	X	X	X
Aesthetic Quality	X	X	X	X	X	X	X	X	X	X	X
Hydro Power	X	X	X	X	X	X	X	X			X
Commercial Navigation & Transportation							X	X	X		X

[1] With adequate pretreatment and natural quality that meets drinking water standards.
[2] Not to conflict with commercial activities in Portland Harbor.

Source: DEQ (2001)

Pringle, Clark and Mill Creeks are listed as water quality limited streams and are included on the 1998 303(d) list (**Table 8-4**). Pringle Creek is listed for bacteria, temperature and toxics (i.e., dieldrin). Clark Creek and Mill Creek are listed for bacteria only.

Table 8-4. Water Quality--Limited Streams from 303(d) List

Stream Location	Parameter Examined	Criteria	Season of Concern	Basis for Listing	Supporting Data
Pringle Creek mouth to headwaters	Temperature	Rearing 64° F (17.8° C)	Summer	City of Salem data	Two City of Salem sites in 1997; 7-day ave. max. temperatures were 63.3/74.3° F. Did not/did exceed temperature standard of (64° F)(17.8 Celsius).
Pringle Creek mouth to headwaters	Toxics	Water - Pesticides (Dieldrin)		USGS data	USGS Data: (Site 14191970, at Bush Park): 2 of 3 values with an average of 0.0025 ug/l exceeded dieldrin standard (0.0019 ug/l - fresh water chronic criteria, 0.71 ug/l water and fish ingestion criteria) on 11/30/94 (USGS, 1995). 1996 USGS data additional 6 exceedances of 6 samples at 0.1 ug/l.
Pringle Creek mouth to headwaters	Bacteria	Water-contact recreation (*E. coli*) Fresh Water		NPS Assessment-segment 95: moderate data (DEQ,1988); City of Salem data.	Two City of Salem sites 50% (23 of 46) of samples exceed *E.coli* bacteria standard of (406). High value was 1330.
Clark Creek mouth to headwaters	Bacteria	Water-contact Recreation (*E. coli*) Fresh Water		City of Salem data	Two City of Salem sites 44% (7 of 16) samples exceed *E. coli* bacteria standard of (406). High value was 11,700.
Mill Creek mouth to headwaters	Bacteria	Water-contact Recreation (fecal coliform-96-Std).	Year round	City of Salem data; NPS Assessment - segment 64 and 65: moderate data (DEQ, 1988).	City of Salem data (10 sites):32% (249 of 781).Annual values exceeded fecal coliform standard (400) between 1990-1994.

Source: DEQ (2001i)

DEQ seeks all available information on a water body to determine if it is violating water quality standards. Data collected by individuals, organizations, government agencies and DEQ staff can be used to determine if a water body is water-quality limited, as long as the data meets specified minimum quality assurance requirements.

DEQ does not have information on all Oregon water bodies. Those with no information, or information not compatible with EPA guidelines, are not included on the 303(d) list. To date, Claggett is not listed on the 303(d) list for any water quality parameter. Data collection using EPA/DEQ guidelines will be necessary to determine if these creeks should be listed for one or more water quality parameters. Data collected by DEQ in 2002 may cause Glenn and Gibson creeks to be added to the list for the first time and Pringle to be listed for three more parameters **(Table 8-5).**

Table 8-5: Proposed DEQ 2002 303(d) Listings for the Salem Area Streams[1]

Waterbody Name	Parameter	Season	River Mile	List Date
Clark Creek	E Coli		0 to 1.9	1998
Gibson Gulch	**Dissolved Oxygen**	**October 1- May 31**	**0 to 2.8**	**2002**
Glenn Creek	**Dissolved Oxygen**	**October 1- May 31**	**0 to 7**	**2002**
Mill Creek	Fecal Coliform	Year Around	0 to 25.7	1998
Pringle Creek	E Coli		0 to 6.2	1998
Pringle Creek	Dieldrin	Year Around	0 to 6.2	1998
Pringle Creek	Temperature	Summer	0 to 6.2	1998
Pringle Creek	**Copper**	**Year Around**	**0 to 6.2**	**2002**
Pringle Creek	**Lead**	**Year Around**	**0 to 6.2**	**2002**
Pringle Creek	**Zinc**	**Year Around**	**0 to 6.2**	**2002**

[1] Additions in **bold**
Source: Oregon Department of Environmental Quality 2003.

Sources of Pollution: Point Source and Non-point Source

Pollution entering Oregon's streams can be classified into one of two categories: point source pollution and non-point source pollution. Point source pollution refers to end-of-pipe discharges or pollution that originates from a clear source. Types of facilities/activities that can generate point source pollution include sewage treatment plants, factories, food processing facilities, mines, construction sites, paper and pulp mills, leaky underground storage tanks, solid waste sites and hazardous waste sites.

Regulation of Point Source Pollution

Discharges to Ground and Surface Waters

DEQ regulates some types of point source pollution by issuing water quality permits. The agency requires a water quality permit whenever there is a discharge of pollutants to waters of the state or to the ground (DEQ 2001d). Permits are required for discharges of wastewater (sewage, processing water, etc.), wash water, and even relatively clean wastewaters, such as non-contact cooling water. These discharges may occur through a variety of disposal systems including land irrigation, seepage ponds, on-site sewage systems and dry wells, or may discharge to surface waters directly via a pipe or ditch or indirectly through a stormwater system.

There are two types of water quality permits:

1. National Pollutant Discharge Elimination System (NPDES) is a requirement of the Clean Water Act and Oregon law. DEQ has been given authority by the Environmental Protection Agency (EPA) to administer this program and issue permits. NPDES permits are required for point source discharges of pollutants to surface waters. Certain industries, municipalities and activities are also required to obtain NPDES permits for stormwater runoff.

2. Water Pollution Control Facilities (WPCF) is a state requirement for the discharge of wastewater to the ground only. WPCF permits are issued for land irrigation of wastewater, non-discharging wastewater lagoons, on-site disposal systems, and underground injection control systems (i.e., dry wells, sumps, etc.). The primary purpose of a WPCF permit is to prevent discharges to surface waters and to protect groundwater from contamination. This permit is also used to prevent nuisance conditions such as odors and mosquitoes. The intent is to prevent overloading surface soils and vegetation with contaminants such as organics, nutrients, and heavy metals.

As of February 2001, a total of 59 NPDES and WPCF permits are active in the Claggett, Pringle, and Mill Creek (including Beaver Creek) watersheds (**Table 8-6**). No water quality permits were issued in the Glenn-Gibson basin. Of the 59 permits issued, 40 of the permits are in the Mill Creek watershed, which includes the Beaver Creek basin. This is not surprising considering the Mill Creek watershed is 5 to 10 times larger than the Claggett and Pringle Creek watersheds.

Table 8-6. National Pollution Discharge Elimination System Permits by Watershed Active as of February 2001 for the Greater Salem Area Watersheds

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
Claggett Creek	0.0	106167/A	Tosco Corporation	IND	GEN15A	Petroleum Hydrocarbon Cleanups - NPDES	N
	1.5	111000/A	Salem-Keizer School District	IND	GEN12C	Construction disturbing >= 5 acres	I
	2.1	104663/A	SumcoUSA	IND	GEN12Z	Industrial Activities	D
	3.0	103549/B	Rainsweet Inc.	IND	GEN12Z	Industrial Activities	D
	3.2	111122/A	Salem-Keizer School District 24J	IND	GEN12C	Construction disturbing >= 5 acres	I
	4.0	87663/A	Americold Corporation	IND	GEN01	Cooling Water/Heat Pumps - NPDES	D
	4.0	104619/A	IFF Concentrates Inc.	IND	GEN12Z	Industrial Activities	D

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
	4.5	110906/A	Tran Co.	IND	GEN12C	Construction disturbing >= 5 acres	I
	5.0	108174/A	Graham, John	IND	GEN12Z	Industrial Activities	I
	5.0	102576/A	May Trucking Company	IND	GEN12Z	Industrial Activities	I
	7.0	107759/B	STAATS Corp.	IND	GEN10	Gravel Mining - WPCF	N
Pringle Creek	2.0	106415/A	Boise Cascade Corporation	IND	GEN12Z	Industrial Activities	I
	2.0	108033/A	NORPAC Foods, Inc.	IND	GEN12Z	Industrial Activities	D
	2.0	107948/A	Yamasa Corporation U.S.A.	IND	GEN12Z	Industrial Activities	D
	2.5	106923/A	Salem, City of	IND	GEN12Z	Industrial Activities	I
	3.0	110121/A	SAIF Corporation	IND	GEN15A	Petroleum Hydrocarbon Cleanups - NPDES	I
	4.0	109676/A	Russell's Landscape Service, Inc.	DOM	GEN54	Holding Tank - WPCF On-Site - Expired	N
	5.0	110959/A	Mountain West Investment Corporation	IND	GEN12C	Construction disturbing >= 5 acres	I
	6.0	108824/A	SumcoUSA	IND	GEN12Z	Industrial Activities	I
Mill Creek	1.5	110017/A	G & R Auto Wreckers, Inc.	IND	GEN12Z	Industrial Activities	I
Mill Creek	1.5	110017/A	G & R Auto Wreckers, Inc.	IND	GEN54	Holding Tank - WPCF On-Site - Expired	I
	1.5	103758/A	Microflect Company, Inc.	IND	GEN12Z	Industrial Activities	D
	1.5	110456/A	Oregon Department of Forestry	IND	GEN12C	Construction disturbing >= 5 acres	I
	2.0	110133/A	Carter, Laurence, & S. Diana	DOM	GEN54	Holding Tank - WPCF On-Site - Expired	N
	2.5	110704/A	Federal Express Corporation	IND	GEN12Z	Industrial Activities	D
	2.5	110566/A	Kettle Foods Inc.	IND	GEN12Z	Industrial Activities	D
	2.5	109727/A	Oregon State Penitentiary	IND	NPDES		D
	3.0	110101/A	Harris, Harlow	DOM	GEN52A	Gravel Filter <5,000 gpd - WPCF On-Site - Expired	N
	3.0	106809/A	State of Oregon Department of Administrative Services	IND	GEN01	Cooling Water/Heat Pumps - NPDES	D
	4.0	106826/A	Kyotaru Oregon, Inc.	IND	GEN12Z	Industrial Activities	I
	4.0	107320/A	United States Postal Service	IND	GEN12Z	Industrial Activities	I
	4.5	111113/A	Rogers, Eric	IND	GEN12C	Construction disturbing >= 5 acres	I

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
	5.0	102895/C	Calyx Fruit, LLC	IND	GEN14A	Seasonal Food Processing<25,000gpd - WPCF	I
	5.0	109040/A	Pottheff, John H.	IND	GEN54	Holding Tank - WPCF On-Site - Expired	N
	5.0	110922/B	Trapani, Anthony	IND	GEN12C	Construction disturbing >= 5 acres	I
	5.5	107426/B	J. C. Compton Company DBA River Bend Sand & Gravel Co.	IND	GEN12A	Sand, gravel, and non-metallic mining	D
	6.0	109144/A	Trussell, Carl V.	DOM	GEN54	Holding Tank - WPCF On-Site - Expired	N
	7.5	110960/A	RMA Development, L.L.C.	IND	GEN12C	Construction disturbing >= 5 acres	I
	7.8	110426/A	William Kostenborder	IND	GEN12C	Construction disturbing >= 5 acres	D
	8.5	106804/A	Salem Black Top and Asphalt Paving, Inc.	IND	GEN12A	Sand, gravel, and non-metallic mining	A
	9.0	110410/A	Meduri Farms, Inc.	IND	GEN14A	Seasonal Food Processing<25,000gpd - WPCF	N
	9.0	102749/A	Meduri Farms, Inc.	IND	WPCF	Terminated	N
Mill Creek	9.0	108574/A	Sass, Gerald M. Jr.	IND	GEN14A	Seasonal Food	I
	10.0	108854/A	Turner Gravel Inc	IND	GEN12A	Sand, gravel, and non-metallic mining	D
	10.0	104544/A	Willamette Valley Vineyards, Inc.	IND	GEN14A	Seasonal Food Processing<25,000gpd - WPCF	I
	10.2	12355/B	Caliber Forest Products, Inc.	IND	GEN12Z	Industrial Activities	N
	10.2	12355/B	Caliber Forest Products, Inc.	IND	GEN05	Boiler Blowdown - NPDES	N
	10.5	108181/A	Bruce Packing Company, Inc.	IND	GEN14B	Other Food Processing <25,000gpd - WPCF	I
	10.5	77770/A	Salem, City of	IND	NPDES	Franzen Reservoir	D
	18.5	84820/A	NORPAC Foods, Inc.	IND	NPDES	Food Processor	I
	18.5	84820/A	NORPAC Foods, Inc.	IND	GEN12Z	Industrial Activities	I
Beaver Creek	2.5	4475/A	Aumsville, City of	DOM	NPDES	Sanitary Sewer—Domestic wastewater treatment	D
	4.1	110141/A	Great American Development Company	IND	GEN12C	Construction disturbing >= 5 acres	I
	4.1	110281/A	Wood Waste Reclamation, Inc.	IND	GEN12Z	Industrial Activities	D
	5.0	109885/A	M & H Oregon City	IND	GEN12C	Construction	I

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
			(South End), L.L.C.			disturbing >= 5 acres	
	12.0	107298/A	United Disposal Service, Inc. DBA	IND	GEN12Z	Industrial Activities	I
	13.0	109762/A	Brundidge Construction, Inc.	IND	GEN12C	Construction disturbing >= 5 acres	I
	17.0	109630/A	Forell, Jack	IND	GEN12C	Construction disturbing >= 5 acres	I

[1] Information on active permits taken from DEQ (2001h). Permits listed were active as of 02-16-01. The list of active permits changes frequently. Please refer to the website for the most up-to-date information.
[2] No NPDES permits for Glenn and Gibson Creeks or for Battle Creek were found during this search.
[3] River Mile: Refers to the distance upstream from the mouth of the creek.
[4] Category: IND=Industrial; DOM=Domestic. Domestic permits are issued to sewage and wastewater treatment plants, as well as other systems designed to treat water that is primarily composed of human sewage.
[5] Discharge Type: D=Directly into stream; I=Indirectly into stream; A=Adjacent to stream; N-Discharge to nearest stream.

Stormwater

Although stormwater is typically considered a non-point source of pollution, DEQ regulates stormwater discharge as a point source pollutant. In 1990, the EPA adopted regulations requiring NPDES permits for stormwater discharges from certain industrial sites (DEQ 2001g). Stormwater permits are also needed for construction or land disturbing activities (i.e., clearing, grading and excavation) that disturb one or more acres of land. Large cities are also required to get a NPDES stormwater discharge permit.

The City of Salem's NPDES permit for stormwater is a negotiated permit. The City of Salem proposes Best Management Practices (BMPs) that could help reduce pollutants entering the storm drain system and creeks in its permit application. DEQ may approve the BMPs or suggest revisions to the proposed BMPs. BMPs may include education to landowners and businesses on waste management, maintenance of existing public works structures, the construction of new structures (e.g. bioswales, stormwater detention ponds) and/or stream and wetland restoration projects.

Sixty percent of all water quality permits issued in the four watersheds were for stormwater. One-third of all the stormwater permits issued were for construction activities (**Table 8-7**).

Table 8-7. Number and Types of Active NPDES Permits in Watersheds of the Salem-Keizer Area

Watershed	Stormwater	Other	Total
Claggett	8	3	11
Pringle	6	2	8
Mill	16	17	33
Beaver	6	1	7
Glenn-Gibson	0	0	0
Grand Total	**36**	**23**	**59**

Source: DEQ (2001h)

Hazardous Waste Facilities

Hazardous wastes can be liquids, solids, or sludges. They can be by-products of manufacturing processes or discarded commercial products. If hazardous wastes are not handled properly, they pose a potential hazard to people and the environment.

To ensure that companies handle waste safely and responsibly, EPA has written regulations that track hazardous wastes from the moment they are produced until their ultimate disposal. DEQ is authorized by the federal Environmental Protection Agency (EPA) to regulate hazardous waste in Oregon. The regulations set standards for the hazardous waste management facilities that treat, store, and dispose of hazardous waste (EPA 2001).

Hazardous waste management facilities receive hazardous wastes for treatment, storage, or disposal. There are no permitted hazardous waste management facilities within the four watersheds. But there are many hazardous waste generators. These businesses generate or store hazardous for short periods of time. They include businesses such as dentist offices (store and use silver for fillings), warehouses or retail stores (use and sell light bulbs which contain mercury), and stores that process film (silver). Hazardous waste generators do not need a permit to operate. But they are required to follow regulations on the storage and disposal of hazardous waste.

Solid Waste

According to Oregon Revised Statute (ORS) 459, solid waste is all "useless or discarded putrescible and non-putrescible materials, including but not limited to garbage, rubbish, refuse, ashes, paper and cardboard, sewage sludge, septic tank and cesspool pumpings or other sludge, useless or discarded commercial, industrial, demolition and construction materials, discarded or abandoned vehicles or parts thereof, discarded home and industrial appliances, manure, vegetable or animal solid and semisolid materials, dead animals and infectious waste (ORS 1999).

Solid waste facilities can pollute water resources if leachate--percolating liquid that seeps through the landfill and picks up soluble material--enters the groundwater. Conventional contaminants include total dissolved solids, chloride, sulfate and heavy metals. Leachate may also include organics, which can effect the Biological Oxygen Demand (BOD) of groundwater (Jones-Lee and Lee 1993).

Oregon Revised Statutes (ORS 459) require that a solid waste facility apply to the Department of Environmental Quality for a Solid Waste Disposal Permit prior to starting operation. There are many of kinds of facilities that need a permit, including landfills, composting facilities, incinerators, and transfer stations, among others (DEQ 2000). Only one active landfill, the Salem Airport Disposal Site, is located within the four watersheds. The site is located near the watershed boundaries of Pringle Creek and Mill Creek. The permittee is the City of Salem and the site is used for the disposal of public works construction debris, street cleaning debris and the like.

Underground Storage Tanks

Leaky underground storage tanks pose a possible threat to Oregon's air, water and land quality. Petroleum products and other hazardous wastes stored in underground tanks may enter groundwater and pollute drinking water sources. Contaminated groundwater may also filter into streams and other surface water.

In 1987, DEQ developed the Underground Storage Tank (UST) Program. The goal of the program is to maintain, restore and enhance the quality of Oregon's air, water and land by the proper installation of new tank systems; the monitoring, maintenance and upgrade of existing tank systems; and the timely cleanup of petroleum contamination from leaky underground storage tanks (DEQ 2001b).

Compliance and prevention requires the registration of USTs and specifies the technical requirements for new and existing UST systems. A regulated UST (requiring a permit) is any tank that has at least 10% of its volume underground and which is used to store petroleum or certain hazardous substances. Tanks not requiring permits include: farm and residential tanks holding 1,100 gallons or less of motor fuel used for noncommercial purposes; residential and commercial heating oil tanks; septic tanks; and tanks holding less than 110 gallons.

The UST cleanup program, otherwise known as Leaking UST or LUST, requires the reporting of petroleum releases in both regulated and nonregulated tanks, and the investigation and remediation of soil and groundwater contamination resulting from leaks and spills.

Although not requiring permits, Heating Oil Tanks (HOT) also pose a possible threat to water resources. Heating oil tanks are not regulated until a spill/release occurs. All HOT releases are required to be reported to DEQ. Clean-up and remediation of releases is done by certified HOT Service Providers. DEQ certifies the cleanup reports submitted by the HOT Service Providers.

Although DEQ provides a list of all leaky USTs and HOTs throughout the state, we could not determine the number of leaky underground storage tanks specifically within the four watersheds (DEQ 2001b). To get an estimate of the number of reported leaky USTs and HOTs in the general area, we compiled a list of all reported leaky underground storage tanks located in Salem, Keizer, Turner, Aumsville, Sublimity and

Stayton. Approximately 1,320 leaky UST's and HOT's have been reported for the general area since 1987. Many of the tanks have undergone or are currently undergoing cleanup.

Spills and Accidents

Spills resulting from carelessness or accidents can result in the release of petroleum products, hazardous material, or excessive sediments entering our storm drains and streams. The City of Salem's Environmental Services Department takes both reactive and pro-active measures to protect Salem's water quality. Reactive responses include going out to spill and accident sites to perform or oversee cleanup and remediation once something has occurred. Pro-active responses include educating people and regulating their activities in an attempt to prevent problems. The Environmental Service Department is also working on spill prevention plans and facilities under the City of Salem's wastewater pretreatment program.

From July 1, 2000, through June 26, 2001, Environmental Services responded to 618 calls that resulted in, or had the potential for, harmful discharges entering storm drains (Roley pers. comm.) (**Table 8-8**).

Table 8-8. Number of Spill Responses by Pollutant Type Conducted by the City of Salem Environmental Services from July 1, 2000, to June 26, 2001.[1]

Pollutant	# of Calls
Chemical	61
Fuel	219
Hazardous Material	28
Oil Spills	133
Other Spills	19
Storm-related Complaints[2]	158
Total	**618**

[1] Does not include spills from motor vehicle accidents or leaks from the sanitary sewer system.
[2] Category includes everything from overflowing manholes, containers filling with storm water and overflowing contents to surface, and observations of bubbles/color/foam in creek. Of the 158 calls, 57 were related to erosion episodes that created cloudy water or excessive sediments in the creek.

Contaminated Sites and Long-term Cleanup

The Environmental Cleanup Program, dedicated to cleaning up contaminated sites, is run by DEQ and is responsible for longer-term environmental cleanup projects. According to the Environmental Cleanup Program's "Active Site List", there are four cleanups occurring as June 18, 2001, within the four watersheds (DEQ 2001f). The list includes only long-term projects.

Two dry-cleaners in the Pringle Creek watershed have leaked chlorinated solvents (i.e., Perchloroethylene) into the soil and groundwater. The first dry-cleaner is located on the corner of Commercial Street and Owens Street SE, right on the watershed boundary between Pringle Creek and the Willamette River. This site is also contaminated with petroleum. The second dry-cleaner is located near the headwaters of the West Fork of Pringle Creek near the Sunnyslope Shopping Center on Hermitage Way.

The other two active cleanup sites are located in Mill Creek. The first site is the Oregon State Penitentiary. Groundwater samples collected in 1989 from two of OSP's irrigation water wells contained solvents, including trichloroethylene (TCE) and perchloroethylene (PCE). The water supply wells at OSP were removed from service in 1989 as soon as the contamination was discovered. The likely source of the contamination was leakage or improper disposal of wastewater from the laundry dry-cleaning facility. The laundry facility was upgraded in 1983 and no longer uses dry-cleaning fluids. The second site is a former mint distillery and dairy and located on Marion Road in Turner. Soil and surface water contamination from a diesel spill at that site occurred in July of 1997.

Surface Mining

Sand and gravel mining within or adjacent to river and stream channels can initiate channel degradation and erosion (Hartfield 1997). Inappropriately sited floodplain mines may capture the river during flood events, causing a relocation of the thalweg (i.e. the part of a stream channel in which the water moves the fastest). Such changes are accompanied by increased water velocity above the mined areas precipitating local channel scouring and erosion. Mining-induced erosion can threaten upstream property, reduce recreational and fish and wildlife values, and negatively impact aquatic fauna by adding sediments to the stream channel.

To mine for rock, sand or gravel in Oregon, mine operators must obtain an Aggregate Mine Permit from the Oregon Department of Geology and Mineral Industries (DOGAMI). DOGAMI regulates the extraction and reclamation of all upland and underground mining in Oregon to minimize the impacts of mining to the state's lands and waters.

Mill Creek watershed hosts seven active aggregate mine sites (**Map 8-1**). Claggett contains three active mine sites, one in the Salem Industrial area, one on Wheetland Road, the other near the mouth of Claggett Creek as it flows into the Willamette River via a slough (**Map 8-2**). The Glenn-Gibson watershed does not contain any active aggregate mine sites with the exception of two sites on the Willamette River floodplain through which Glenn Creek flows before emptying into the Willamette River. The Pringle Creek watershed contains no active mine sites. Mining at a majority of these sites is for sand and/or gravel; two sites in the Mill Creek watershed are being mined for basalt.

Non-point Source of Pollution

During the last 25 years, as pipe discharges have been regulated, it became clear that while each individual pipe discharge into a water body might meet water quality standards, the water body as a whole might still fail to meet the standards (DEQ 1998). It became evident that there are sources of pollution other than from pipes.

Non-point source pollution does not originate from a clear or discrete source. It can be described as the accumulation of pollutants resulting from common, widespread activities in both urban and rural areas. Activities that can cause non-point source pollution include overuse of fertilizers and pesticides; improper disposal of household hazardous wastes (e.g., paint, aerosol sprays, swimming pool/hot tub chemicals, oil, gasoline, radiator fluid, ammonia-based cleaners); illicit dumping of chemicals and garbage in streams or storm drains; leaky vehicles on streets, driveways and parking lots; habitat destruction and poor erosion control techniques on construction sites and agricultural fields.

Agricultural runoff carries pesticides, fertilizers and sediments as a result of erosion. In contrast, urban runoff pollutants are many and variable depending on the land uses and pollutant sources. Typically, urban pollutants are greatest from industrial and commercial areas, roads and freeways, and higher-density residential areas. Major categories of urban pollutants include sediments, nutrients, microbes (e.g., fecal coliform bacteria), and toxic metals and organics. Motor vehicles are recognized as a major source of pollutants, contributing oils, greases, hydrocarbons, and toxic metals (Richter 2000).

After years of regulating point source pollution, state and federal agencies are now taking a more comprehensive approach to water quality improvement, taking into account the accumulative impacts of both point source and non-point source pollution (DEQ 2001a). DEQ is in the process of calculating pollution load limits, known as Total Maximum Daily Loads (TMDLs), for each pollutant entering a body of water. TMDLs take into account pollution from all sources, including discharges from industry and sewage treatment facilities; runoff from farms, forests and urban areas; and natural sources, such as decaying organic matter.

DEQ plans to have federally approved TMDLs on all water bodies listed on the 1998 303(d) list by the end of the year 2007. Salem's watersheds lie within the Mid-Willamette Sub-basin. TMDLs are scheduled for completion in this basin in late 2003. A draft work plan for determining TMDLs for the Mid-Willamette Sub-basin can be viewed on the DEQ web site (DEQ 2001c).

In conjunction with TMDL approval, each water body will have a comprehensive water quality management plan that will guide water quality improvement efforts. These comprehensive plans will be developed by state government agencies with the help of local governments, industry, agriculture, soil and water conservation districts, watershed councils, nonprofit organizations and other interested parties.

Past Studies on Stormwater and Surface Water Quality

To diagnose the health of our streams, the watershed councils have compiled information from past water quality studies conducted in the Salem-Keizer area. The information that follows is presented on a study-by-study basis. Most of the data collected is the result of stormwater quality studies conducted by several agencies, and an on-going stream monitoring program conducted by the City of Salem.

Section 208 Urban Stormwater Runoff Plan: 1975-1977

The Mid Willamette Valley Council of Governments (MWVCOG) was designated as a Section 208 Areawide Waste Treatment Management Agency in November of 1974. The agency's task was to develop an area-wide waste treatment management plan for the three-county region of Marion, Polk and Yamhill counties. The project was funded by the EPA in the summer of 1975, and work was begun in the early fall of 1975. The section 208 Plan was organized into four sub-plans and a Final Summary Plan. Those sub-plans were (City of Salem and ODOT 1994):

1. Urban Stormwater Runoff Sub-plan
2. Master Sewage Plan
3. Individual Waste Disposal Sub-plan
4. Soil Erosion and Sediment Countrol Sub-plan

The Urban Stormwater Runoff Sub-plan (MWVCOG 1977), which was completed in October, 1977, had four objectives:

1. To quantify with a rational methodology the parameters, factors and relationships that contribute to urban stormwater runoff pollution.
2. Development of a simulation model for predicting urban stormwater runoff pollution in the future.
3. Development and implementation of abatement controls for urban stormwater pollution if the pollutant assessments indicate water quality degradation.
4. Prioritization of areas in the three-county region where urban stormwater pollution could be a problem.

Only the first two objectives were partially completed during the study because of the record drought in the Willamette Valley during the winter of 1976-1977. However, to address the first two objectives, six stormwater outfalls were selected within the Salem urban area for water quality and quantity sampling during four storm events. The six outfalls drained areas ranging in size from 10 acres to 390 acres. Land uses included a mixture of open space, agricultural, residential and commercial uses. Three of the outfalls were located in the more hilly south Salem area, and three in relatively flat east Salem.

The drought conditions severely crippled the monitoring component of the urban stormwater sub-plan. Since the monitoring element was the key to a site-specific assessment of Salem and the development of a simulation model, the sub-plan left many questions unanswered as to the validity and usability of the model for management decisions. Because of these limitations, results of the study are not presented in this assessment.

USGS Study on Stormwater: 1979-1981

In July of 1978, the City of Salem authorized MWVCOG to investigate and prepare an urban storm water runoff proposal for Salem. A grant application was submitted to EPA in March of 1979. The project was awarded the grant monies in July of 1979. In order to utilize early 1979 rainfall/runoff condition in advance of receiving EPA monies, Salem joined with the USGS in a cooperative agreement to assess rainfall/runoff relationships in the urban area (City of Salem 1982; City of Salem and ODOT 1994).

The goal of the EPA-funded study was to define runoff as related to urbanization. Data was collected from winter of 1979 to spring of 1981. Fourteen in-stream monitoring stations were set up in 13 sub-basins of Glenn-Gibson, Claggett, Pringle, Mill, Croisan and the Little Pudding watersheds to monitor for water quality. Parameters measured included Temperature, pH, Total Phosphorus, Dissolved Nitrates and Nitrites, Suspended Kjeldahl Nitrogen, Dissolved Ammonium, Dissolved Kjeldahl Nitrogen, Total Lead, Chemical Oxygen Demand, Suspended Organic Carbon, Dissolved Organic Carbon, Fecal Coliform, Biological Oxygen Demand, Suspended Sediment, Dissolved Solids, Specific Conductance, and Turbidity.

The USGS' findings were presented in a report (Laenen 1983). Peak flow, storm runoff, and rainfall intensity information was used to define flood-frequency relationships for specific gauged sites. Specific data and the resulting predictive model information can be found in the USGS report.

Data collected in the USGS study is presented in two chapters of this assessment. Information on stormwater hydrology (water quantity) in Salem is discussed in the hydrology chapter of this assessment. Information on the water quality of Salem's streams and stormwater, as a result of the EPA-funded project, follows.

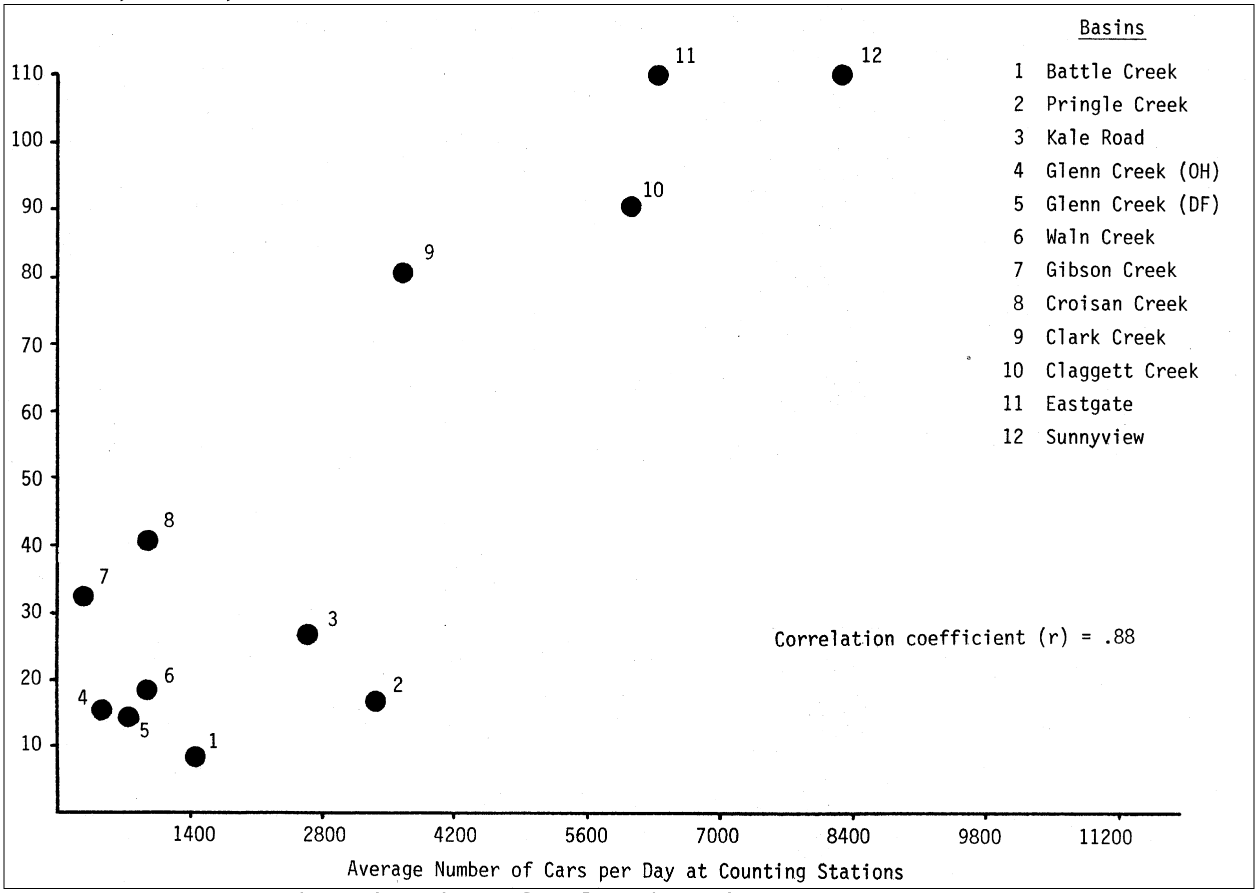
The Salem Urban Area Water Quality Plan (City of Salem 1982) presented the findings of the two-year EPA-funded Salem/MWVCOG/USGS water quality and quantity sampling program. The results of the study suggested that while isolated and intermittent trouble spots were present, Salem generally had high water quality. Based on this information, it was recommended that Salem should address surface water quality from a maintenance rather than an improvement perspective.

Ambient water quality in Salem's streams was found to be of high quality. However, three contaminants were found in high enough concentrations to merit discussion.

Lead

Instances were recorded where lead levels equaled or exceeded DEQ's standard for drinking water (50ug/l) in 12 of 13 basins, with an average concentration for all basins of 73ug/l. Of the 67 samples analyzed for lead, 35 samples (52%) exceeded 50ug/l. The highest concentration (370ug/l) was recorded at the outlet of Hawthorne Ditch at Sunnyview, along the west side of I-5. This basin drains a significant portion of I-5 and has a high proportion (42%)of commercial land use. Data analysis for this and other sites resulted in the study's conclusion that a strong relationship exists in Salem between surface runoff lead content and traffic patterns and intensity (**Figure 8-1**).

Figure 8-1. Correlation Between Traffic Counts and Median Lead Concentrations in Streams, Salem, OR.



Data source: USGS (1997); City of Salem (1982)

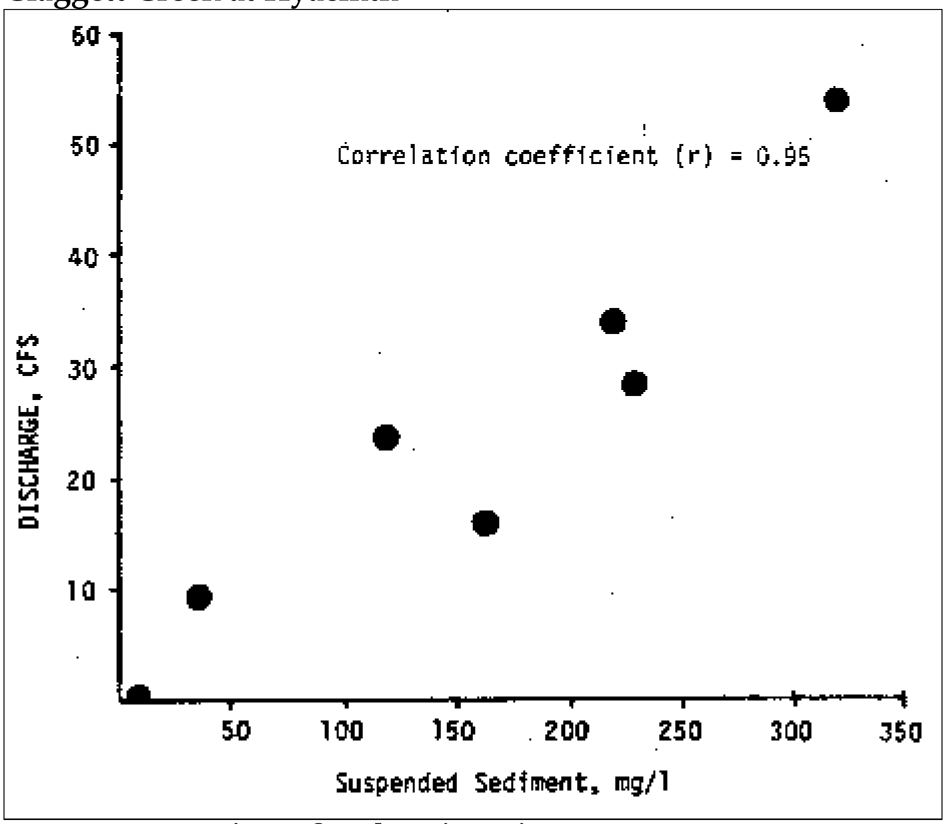
Fecal Coliform

DEQ's water quality standard for fecal coliform is based on preserving the designated beneficial use of water contact. The standard is the log mean of 200 fecal coliform per 100 ml based on a minimum of 5 samples in a 30-day period, with no more than 10% of the samples in the 30-day period exceeding 400 cfu per 100 ml. (This is the old DEQ standard. See **Table 8.1** for current standards.) Twenty-four of the 32 samples collected for fecal coliform analysis exceeded the 200 cfu/100 ml standard. The maximum concentration of 6300 was recorded at a tributary of the Little Pudding River at Kale Road; a minimum level of 38 was recorded at Claggett Creek during non-runoff base flow conditions. While Salem exhibits elevated fecal coliform levels, the levels identified in the USGS' Salem study were significantly lower than levels found in Portland (up to 27,000 cfu/100 ml) and Medford (up to 200,000cfu/100 ml).

Suspended Sediment

A major finding of the Salem Urban Area Water Quality Plan was that "elevated suspended sediment levels seem to be primarily related to increased streamflows resulting from urbanization, poor channel and bank design, and, in some cases, construction activities" (City of Salem 1982). A total of 30 samples were collected from Claggett, Glenn and Waln Creeks, and Hawthorne Ditch; maximum suspended sediment concentrations approached 800mg/l. The data revealed a strong correlation between discharge (streamflow) and sediment concentrations. A sample graph from the Claggett Creek watershed shows the correlation (**Figure 8-2**) (City of Salem 1982).

Figure 8-2. Correlation Between Rate of Discharge and Suspended Sediment in Claggett Creek at Hyacinth



Data source: City of Salem (1982)

Dry Weather Field Screening: 1992

The following information is summarized from *Salem Part I NPDES Municipal Stormwater Discharge Permit Application* (City of Salem and ODOT 1994).

The detection and elimination of illicit discharges from storm sewers to receiving waters is one of the primary goals of EPA's Phase I. stormwater regulations. As a first step in the process of achieving this goal, EPA's Phase I regulations governing municipal applications for an NPDES stormwater discharge permit require municipalities to conduct a field screening program looking for evidence of illicit discharges.

EPA requires municipalities to conduct their field screening using one of two sampling schemes: 1) field screening points, or 2) screening at major outfalls. The City of Salem chose to field screen the major outfalls.

EPA rules define a "major outfall" as "a municipal separate storm sewer outfall that discharges from a single pipe with an inside diameter of 36-inches or more, or its equivalent; or for municipal separate storm sewers that receive stormwater from lands zoned for industrial activity, an outfall that discharges from a single pipe with an inside diameter of 12 inches or more, or its equivalent." The City of Salem conducted field screening at all major outfalls, plus some additional outfalls that were later determined to be "non-major" based upon verification of their size, drainage area, and/or upland land use. Ninety major outfalls were screened.

Two grab samples were collected at each outfall that had dry-weather flow (i.e., during August and September). In most instances the two samples were collected within a 24-hour period, but with a minimum period of four hours between samples. Following EPA requirements, the water samples were tested for pH, total chlorine, total copper, total phenol and detergents. Visual observations were also made.

Forty-one of these major outfalls were flowing during the dry-weather field screening and were subsequently sampled. Results using the five parameters follows.

Detergents

Detergents were detected at concentrations greater than 0.1 mg/l at 13 of the 41 outfalls. Concentrations ranged from 0.1 to 1.15 mg/l, with the highest observed at Outfall No. 45-488-731, discharging into Shelton Ditch. Between the first and second sampling visit, five outfalls decreased in detergent concentration and eight increased.

Total Chlorine

Total chlorine was detected at concentrations greater than 0.1 mg/l at 20 of the 41 outfalls. Concentrations ranged from 0.1 to 0.6 mg/l, with the highest concentration at Outfall No. 39-474-611, discharging into the Willamette River. Between the first and second sampling visit, 11 outfalls decreased in concentration of chlorine and 8 outfalls increased. The field test kit used to measure chlorine does not register chlorine concentrations below 0.1 mg/l. Therefore, discharges without detectable chlorine concentrations as measured in the field may or may not exceed water quality criteria for effects in freshwater organisms as adopted by the State of Oregon (chronic criterion = 0.011 mg/l; acute criterion = 0.019 mg/l).

Total Copper

The field test kit does not detect concentrations of copper below 0.1 mg/l, and discharges with non-detectable copper concentrations may or may not exceed water quality criteria for receiving waters. The receiving water quality chronic criterion for copper is 0.012 mg/l for waters having a hardness of 100 mg/l.

Total Phenol

Phenol was detected at only one outfall, with the two samples recording concentrations of 1.0 and 0.3 mg/l. The samples were taken from Outfall No. 42-482-611, discharging into the Willamette River. The concentrations detected at this outfall were significantly below the receiving water quality chronic criterion for phenol of 2.6 mg/l.

pH

pH values ranged from 4.9 to 8.6, with the highest value recorded at Outfall No. 45-466-652, discharging into the East Fork of Pringle Creek. The lowest value was recorded at Outfall No. 42-482-611, discharging into the Willamette River. In-stream water quality standards for pH are 6.5 to 8.5. While outfall discharges are required to meet water quality standards, four outfalls were below the 6.5 minimum, and one outfall exceeded the 8.5 maximum.

Visual Observations

Field crews also took note of any visible signs of pollution in stormwater discharges (**Table 8-9**). They identified solid and liquid pollution, but not the sources.

Table 8-9. City of Salem Dry Weather Field Screening (1992) Significant Visual Observations and Field Sampling Results

Map No.	Outfall No.	Location	Observations
30-456	12-1 (Non-Major)		This outfall is an open channel about 30" in width. Landowners on both sides have complained that the flow in this ditch has become excessive since the new subdivision has been built on Joplin Street, which is where the ditch originates. Landowners have tried building up the sides of the ditch to control water.
39-474	611		This 18" metal outfall has pumpkin seeds and pulp being washed down through it. It also had chlorine reading of 0.6 mg/l.
42-476	619		This is a 42" concrete outfall emptying into the Willamette River. It had a "musty sewage" smell and had brownish-gray scum hanging off it. The detergent reading was 0.25 mg/l.
42-482	611		This 42" outfall into the Willamette River had a very strong smell of sewage, sulfur, and other "musty" smells. The pipe was flowing with gray slime and surface scum. The pH was 4.9 the first day, and also contained detergents and phenols. It turned the copper test black.
42-476	696 (Non-Major)		This 12" outfall into Mill Creek was barely trickling, but its concentration of detergent was off-scale. It drains a car wash.
51-486	2-1		This ditch is in the process of being dammed by beavers right near its outfall.
51-488	603 (Non-Major)		This is only a 12" outfall. It was running very slowly, but had a strong "sewer" smell. There were black oily deposits around and below the outfall. It had a 6 mg/l copper, and turned the phenol test blue.
48-464	613		This 30" outfall into Pringle Creek did not appear to be flowing (see Table 6-1), but the water surface ponding in it was covered with thick yellow "gunk" (possibly cooking grease).

Source: City of Salem and ODOT (1994)

Wet Weather Screening: 1995-2000

The following information was taken from *Salem Part I NPDES Municipal Stormwater Discharge Permit Application* (City of Salem and ODOT 1994) and from *Part 2 NPDES Municipal Storm Water Permit Application* (City of Salem and ODOT 1996).

Required as part of the City of Salem's NPDES stormwater permit part 2 application, wet weather sampling of outfalls and/or screening points (i.e., manholes) was initiated in 1995. As "wet weather sampling" suggests, the samples are taken during the rainy season, mostly during winter and early spring.

First flush grab samples and time-based composite samples are taken of stormwater discharges after three storm events occurring at least one month apart. The grab samples are taken during the first 15-30 minutes of runoff from a storm event. The grab samples are analyzed for 131 parameters as required by EPA/DEQ. The composite samples are taken using automatic sampling equipment. Samples are drawn at 15-minute intervals for a duration of three hours. The composite samples are then tested for 12 parameters: biological oxygen demand, (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc.

Results of wet weather monitoring are submitted to DEQ. The annual reports contain the raw data for the both the grab and composite samples. DEQ reviews the data. If the data suggests that pollutant loads have changed from previous years, DEQ may ask the City of Salem to modify the BMPs outlined in their NPDES stormwater permit in order to reduce the targeted pollutant (Namburi pers. comm.).

Water-quality monitoring of stormwater is conducted at four sample points in Salem (**Table 8-10**). These sample points were chosen to provide a means of quantifying the pollutant contributions and potential water quality impacts associated with stormwater runoff from particular land uses.

A brief description of the four selected sampling sites is provided in the following discussion.

Table 8-10. Monitoring Sites for Wet Weather Sampling

Location	Size	Land Use	Access
Site #1: Commercial St. SE	31 Acres	42 % Residential 58 % Commercial Includes ODOT ROW (Hwy. 99E)	Manhole (MH42458210)
Site # 2: Red Leaf, SE	72 Acres	100 % Residential	Manhole (MH3345020212)
Site #3: Edgewater, NW	35 Acres	100 % Industrial	Manhole (MH39474202)
Site #4: Cottage, SE	40 Acres	100 % Commercial	Manhole (MH42472295)

Source: City of Salem and ODOT (1996)

Commercial St. Site

The Commercial St. site is a 36-inch outfall that drains a mixture of residential and commercial development, including the main highway arterial of Commercial St. SE. The site is located between Commercial and 12th Sts. SE. The outfall discharges into the West Fork Pringle Creek within the Pringle Creek Basin. The sampling site is a manhole approximately 7 feet deep. A flow meter and automatic sampler were installed at this site.

Red Leaf Site

This sampling site is a manhole (approximately 7 feet deep) located along Red Leaf Drive SE at Serend Court. This site is a 42-inch outfall which discharges into Waln Creek within the Battle Creek Basin from a strictly residential development area in South Salem. The monitoring manhole is the downstream intersection of the piped storm drainage system serving single-family residential development. A flow meter and automatic sampler were installed in the manhole.

Edgewater Site

The sampling site is a manhole (approximately 18 feet deep) located near the intersection of Patterson Ave. NW and Edgewater St. in West Salem. The outfall discharges directly into the Willamette River from the West Bank Basin. This area represents industrial land use. A flow meter and automatic sampler were installed in the manhole.

Cottage Site

The sampling site was initially located in a manhole (approximately 8 feet deep) in the 100 block of Cottage St. SE. This area represents commercial land use. The outfall from the storm sewer eventually discharges to the Shelton Ditch, which in turn discharges to Pringle Creek. A flow meter and automatic sampler were installed in the manhole. In October 2000, this site was relocated to another manhole slightly "upstream" within the same drainage basin. Located at Peterson and 2nd, the move was prompted by manhole surging at the initial site during high river levels (Downs, 2003).

Surface Water Quality: 1982-2000

As part of Salem's water quality monitoring program, the city initiated a surface water monitoring program in 1982. Seventeen stream monitoring stations were set up in 6 watersheds including Claggett (includes Labish Ditch), Croisan, Glenn, Mill (includes Battle Creek and Waln Creek), Pringle (includes Clark Creek), and the Willamette. The number of monitoring stations was later expanded to include a total of 31 sites (**Table 8-11**), not including 11 sites on the Willamette River.

Table 8-11. Locations of Water Quality Monitoring Stations and Their Sampling Duration

Watershed	Data Source[1]	Site Number	Site Name	Site Location	Data Sampling Period
Claggett Creek	C	1	Claggett River Road	Claggett Creek at River Road	1982-1993
	C	2	Claggett Hyacinth	Claggett at Hyacinth St.	1982-1993
	C	3	Claggett Mainline	Claggett at Mainline Drive	1982-1993
	C	17	Hawthorne Ditch	Hawthorne Ditch at East Gate Basin Park between Hawthorne Ave. and Beacon St.	1982-1993
	C	24	Labish Ditch	Labish Ditch at River Road NE.	1983-1993
	S	1	Dearborne Ave.	Claggett Creek Park at Dearborne Ave.	1994-1995
Mill Creek	C	MC0010 (5)	Front	Mill Creek at Front Street	1982-1995
	C	MC0707 (12)	Turner	Mill Creek at Turner Rd	1982-1995
	C	MC0308 (14)	23rd	Mill Creek at 23rd	1982-1995
	C	16	Battle Creek	Battle Creek at Fairway Ave. SE	1982-1993
	C	21	Shelton Ditch	Shelton Ditch at Church St.	1983-1993
	C	MC0209	North Salem H.S.	Mill Creek at N.S. High School -- Between 12th and 14th Streets	1990-1995
	C	MC1006	Delaney	Delaney Road in Turner	1990-1995
	C	MC1305	70th	Mill Creek at 70th St.	1990-1995
	C	MC1604	Bishop	Mill Creek at Bishop Road	1990-1995
	C	MC1803	Shaff	Salem Ditch at Shaff Rd. Rd.	1990-1995
	C	MC1901	Cascade	Salem Ditch at Cascade Rd.	1990-1995
	C	MC1902	Pioneer	Salem Ditch at Pioneer Park, Stayton	1990-1995
Glenn-Gibson	C	6	Glenn Creek Orchard Heights	Glenn Creek at Orchard Heights Rd.	1982-1989
	C	22	Glenn Creek Salem-towne	Glenn Creek at Salemtowne	1990-1993
	W	1	Upper Glenn Creek	1168 Willow Creek Drive	1998-2000
	W	2	Winslow Creek	Gibson Creek at Grice Hill Dr.	1998-2000
	W	3	North Gibson Creek	North Gibson Creek at Private Road just west of confluence with South Gibson Creek	1999-2000
	W	4	South Gibson Creek	South Gibson Creek at Private Road just west of confluence with North Gibson Creek	1998-2000
	W	5	Lower Gibson Creek	South side of Wallace Road	1999-2000
	W	6	Lower Glenn Creek	Glenn Creek at River Bend Rd.	1999-2000
Pringle Creek	C	7	Clark Ratcliff	Clark Creek at Ratcliff	1982-1994
	C	8	Pringle 12th	West Fork Pringle Crk at 12th Street	1982-1994
	C	18	Pringle Bush	Pringle Creek at Bush Park	1997-1998
	C	19	Clark Bush Park	Clark Creek at Bush Park	1983-2000
	C	20	Cross Street	Pringle Creek at Cross Street	1983-2000
	C	26	Pringle Church	Pringle Creek at Church St.	1983-1994
	C	27	Ewald Street	Clark Creek at Ewald	1995-2000
	C	28	Cannery Park	W. Fork Pringle Crk at Cannery Park	1995-2000
	C	29	Woodmansee Park	West Fork Pringle Creek at Woodmansee Park	1995-2000
	C	30	Madrona Street	West Fork Pringle Creek at Madrona	1995-2000
	C	31	Pringle Park	Pringle Creek at Pringle Park	1995-2000

Twenty water quality parameters were measured at each of the monitoring stations: fecal coliform, dissolved oxygen (DO), total solids (TS), volatile solids (TVS), turbidity, pH, alkalinity, temperature, biological oxygen demand (B.O.D.), chemical oxygen demand (COD), hardness, conductivity, suspended solids (TSS), stream depth, visual observations, chlorides, and metals (copper, lead, zinc, cadmium and chromium).

The City of Salem has done some analysis on the water quality data they have collected in the last 20 years (Schweickert pers. comm.). Data collected in Pringle and Mill Creeks were made into presentations given at public forums in the 1990s. Findings from the data were also used to formulate a list of recommendations for the City of Salem's Stormwater Master Plan early in its development. As of March of 2001, publication of the surface water quality data in its entirety has not been attempted by the City of Salem. The watershed councils were able to obtain the databases and conduct their own analysis. The remainder of this chapter will concentrate on the analysis and results of the city-collected data, in addition to some supplemental data provided by schools and watershed councils.

Information Sources

Much of the data was collected by the City of Salem as part of a stream monitoring program initiated in 1980 (City of Salem 1982). Permanent stream monitoring locations were established throughout the city (**Maps 8-3, 8-4, 8-5, 8-6**). Mill Creek was sampled upstream from Stayton. Sampling frequency was monthly in most instances. The duration of sampling varies per stream (**Table 8-11**). Some stream segments, such as Glenn Creek at Salemtowne, only have three years of data from 1990 to 1993. In contrast, some monitoring stations along Mill Creek were sampled for longer durations (i.e., 1982 to 1995). Some monitoring stations were abandoned early on due to limited access (e.g., flooding); others were not established until the 1990s. Water quality monitoring was re-instituted in 2001.

Other information sources on water quality include the Oregon Water Resources Department (OWRD), watershed councils and schools involved in the City of Salem's Adopt-A-Stream program. The OWRD has a permanent monitoring station on Mill Creek near North Salem High School. The station currently monitors temperature and flow on a continuous basis. Glenn-Gibson Watershed Council initiated its own water quality-monitoring program in 1999 and has contributed the data to the watershed assessment. Schools involved in Salem's Adopt-A-Stream program collect basic water quality data and macroinvertebrates (City of Salem 2001).

Data Analysis

Information collected from different sources is graphed separately to avoid confounding data results due to the varying expertise of the data collectors. In order to compare the similarities and differences between the four watersheds, information for each watershed will be presented separately. Waters are considered temperature-limited if the stream exceeds 64 degrees F (17.8 C) for a moving seven-day average

(DEQ standard). In the absence of moving seven-day averages, we consider simple temperature values as indicative of temperature conditions. The same applies for dissolved oxygen. The standard of 8.0 mg/l for DO is based on a 30-day mean minimum (DEQ standard). Because water quality monitoring stations were not sampled daily, single sample DO values were compared to the 30-day mean minimum standard. Additional data, using DEQ protocols, will need to be collected to determine if listing is appropriate.

Data can be used to determine trends and seasonal changes in water quality parameters. It also can be used to determine where more monitoring may be necessary. The water samples were collected in the morning. Because stream temperatures typically don't reach their daily maximums until the afternoon, stream temperatures may get significantly warmer than what is reported. DO levels also undergo diurnal fluctuations. To measure the daily minimum DO level, water samples should be taken very early in the morning, immediately before sunrise, when photosynthesis and the production of oxygen is at its lowest.

In the absence of state standards for Total Phosphorus and Total Nitrates as they relate to cold-water fish health, standards suggested by the Oregon Watershed Assessment Manual (OWAM) were used to determine if these nutrients were at high or low concentrations in water samples.

Because bacteria samples were not consistently collected by the City of Salem prior to 1995 using DEQ protocol, fecal coliform counts were graphed, but could not be directly compared to any standard. However, we considered a fecal coliform count to be high above 400 cfu/100 ml. This self-imposed standard was set based on the old DEQ standard for fecal coliform, which stated that no more than 10% of the surface water samples taken in a 30-day period should exceed 400cfu/100 ml if the water is to be considered safe for water-contact recreation.

As of January 11, 1996, DEQ changed its bacteria standard for water contact recreation to read, "no single sample should exceed 406 *E. coli* organisms per 100 ml." When the standard for bacteria was changed to *E. coli*, the City of Salem began collecting data on *E. coli* levels. To determine if Claggett Creek, Glenn Creek and Gibson Creek are water quality limited for bacteria, water samples will need to be collected and counts of *E. coli* will need to be compared to the new DEQ standard for single samples. By 1996, Mill Creek was already determined to be water-quality limited for fecal coliform bacteria using the old DEQ standards for bacteria.

Gaps in data collection are indicated on graphs by the interruption of data curves. The lack of data may be due to several factors, including access difficulty, no flows during summer or fall months, or human error in transcribing field data.

Not all 20 parameters collected by the City of Salem were analyzed. Some of the databases lacked information on particular parameters. Parameters, such as conductivity, are weakly linked to pollution and were not considered for analysis. Because the sampling frequency was monthly in most instances, total suspended solids (TSS) and turbidity were also not analyzed. The best time to measure suspended sediments is during high flow and after storm events when soil erosion is at its peak. However, the monthly measurements of TSS and turbidity could be used to determine background levels of sediments in the streams. See results of the USGS study on stormwater (Laenen 1983) and the Salem Urban Area Water Quality Plan (City of Salem 1982) for the results of monitoring sediments in stormwater.

Results by Watershed

1. Pringle Creek

A total of 11 monitoring stations were established by the City of Salem in the Pringle Creek watershed (**Map 8-3**). Four monitoring stations are located along the main stem of Pringle Creek (C20, C18, C26, C31) from Cross Street to Pringle Park, which is located about a quarter mile upstream from the mouth of Pringle Creek at the Willamette River. Three monitoring stations are located on Clark Creek from its headwaters near the intersection of Ewald Street and Liberty Road (C27) to Ratcliff Drive (C7) to Bush Pasture Park (C19) where Clark Creek flows into Pringle Creek. Four monitoring stations were established along the West Fork of Pringle Creek. The first station is located near the headwaters at Cannery Park (C28). Less than a mile downstream a second monitoring station is located at Woodmansee Park (C29). A third station is at Madrona Street (C30). The fourth and final monitoring station at 12th Street (C8) is located just upstream from the confluence of the West Fork of Pringle Creek and the main stem of Pringle Creek.

Duration of water quality sampling varied between monitoring stations (**Table 8-11**). Monitoring stations along Clark Creek were typically sampled from 1982 or 1983 to 1994 or until May of 2000. Two of four of the monitoring stations along the main stem of Pringle Creek were initiated in 1983; one station was abandoned in 1994, while the other was sampled until May of 2000. Another station at Bush's Pasture Park was only sampled in 1997 and 1998. The fourth station at Pringle Park collected samples from 1995 to 2000. With one exception, all the stations along the West Fork of Pringle Creek were sampled from 1995 to May of 2000.

An exception to the monitoring protocol occurred in the mid 1990s when the City of Salem followed DEQ protocols for monitoring stream temperature and installed Hobo temperature monitors in Pringle and Clark Creeks. Data collected was sent to DEQ and used to designate Pringle and Clark Creeks as water quality-limited for temperature.

a. Water Temperature

Pringle Creek is water quality-limited for temperature, according to DEQ (**Table 8-4 and Table 8-5**). Water temperatures varied seasonally in Pringle Creek and in two of its tributaries, Clark Creek and West Fork of Pringle Creek. With one exception, temperatures in the West Fork of Pringle Creek remained below the DEQ standard of 17.8 degrees Celsius every year from 1982-2000, even during summer months (**Figures 8-3** and **8-4**).

Water temperatures in Clark Creek ranged widely, from 2 to 19 degrees Celsius (**Figure 8-5**). Of the three monitoring stations on Clark Creek, the two stations lowest in the system, Ratcliff (C7) and Bush's Pasture Park (C19), reported temperatures at or slightly above the DEQ standard of 17.8 Celsius during July, August and/or September at least a few times during the sampling period. Clark Creek flows through a 500-foot long steam sewer before daylighting briefly in Bush's Pasture Park where it flows into the main stem of Pringle Creek. According to a recent study (Andrus 2000), cutthroat trout have been documented in this small reach of Clark Creek (see Fish Chapter). Water temperatures taken in May indicate that afternoon temperatures in Clark Creek are almost six degrees cooler than in Pringle Creek (Andrus 2000). The trout may be using Clark Creek as a refuge to avoid the high afternoon temperatures in Pringle Creek.

Unlike the West Fork of Pringle Creek and Clark Creek, water-quality monitoring stations along the main stem of Pringle Creek (C20, C26, C31) exceeded 17.8 degrees Celsius during summer months almost annually (**Figure 8-6**). Recorded water temperature ranged from 2 to 22 degrees Celsius at these three monitoring stations. Additional data on Pringle Creek collected at Bush's Pasture Park (C18) from 1997-1998 also shows that July and August water temperatures did exceed 17.8 degrees Celsius (**Figure 8-7**).

b. Dissolved Oxygen

The West Fork of Pringle Creek kept above 8.0 mg/l of dissolved oxygen at the 12th Street monitoring station (C8) from 1982-1994 (**Figure 8-8**). This trend continued in the late 1990's for at least two of the monitoring stations along the West Fork (**Figure 8-9**). The Cannery Park monitoring station (C28), which is the station located highest in the West Fork watershed, reported dissolved oxygen levels lower the DEQ's standard seven times between 1995-2000. The low records occurred from July through October.

Clark Creek contains suitable levels of dissolved oxygen throughout the year according to information collected from three monitoring stations (C7, C19, C27) from 1982-2000 (**Figure 8-10**). Only two recordings of dissolved oxygen fell below the recommended minimum of 8.0 mg/l (DEQ standard). A record low of 0.8 mg/l was recorded in January of 1996 at Bush's Pasture Park. This oddity may be a recording error rather than an actual reading.

With only a few exceptions, the main stem of Pringle Creek also maintained suitable levels of dissolved oxygen for cold-water fish during most of the year (**Figures 8-11** and **8-12**). Dissolved oxygen levels fell slightly below 8.0 mg/l during some summer months. The lowest dissolved oxygen recorded was 6.6 mg/l at the Cross Street monitoring station (C20) in August of 1997.

Figure 8-3.

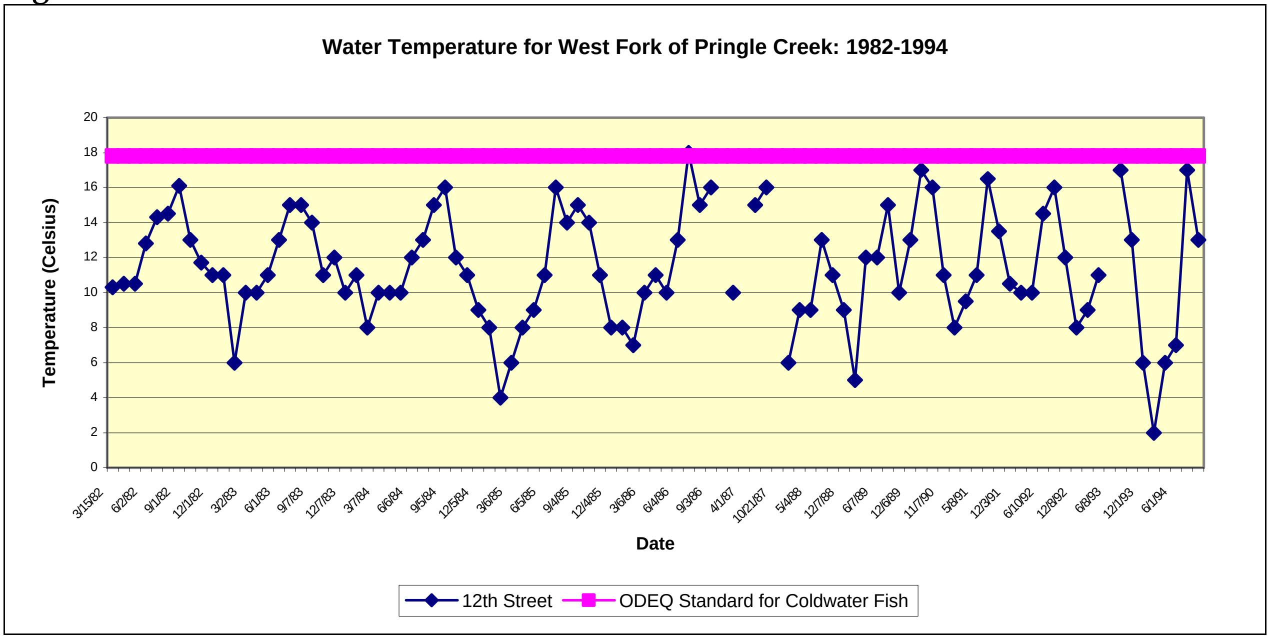


Figure 8-4.

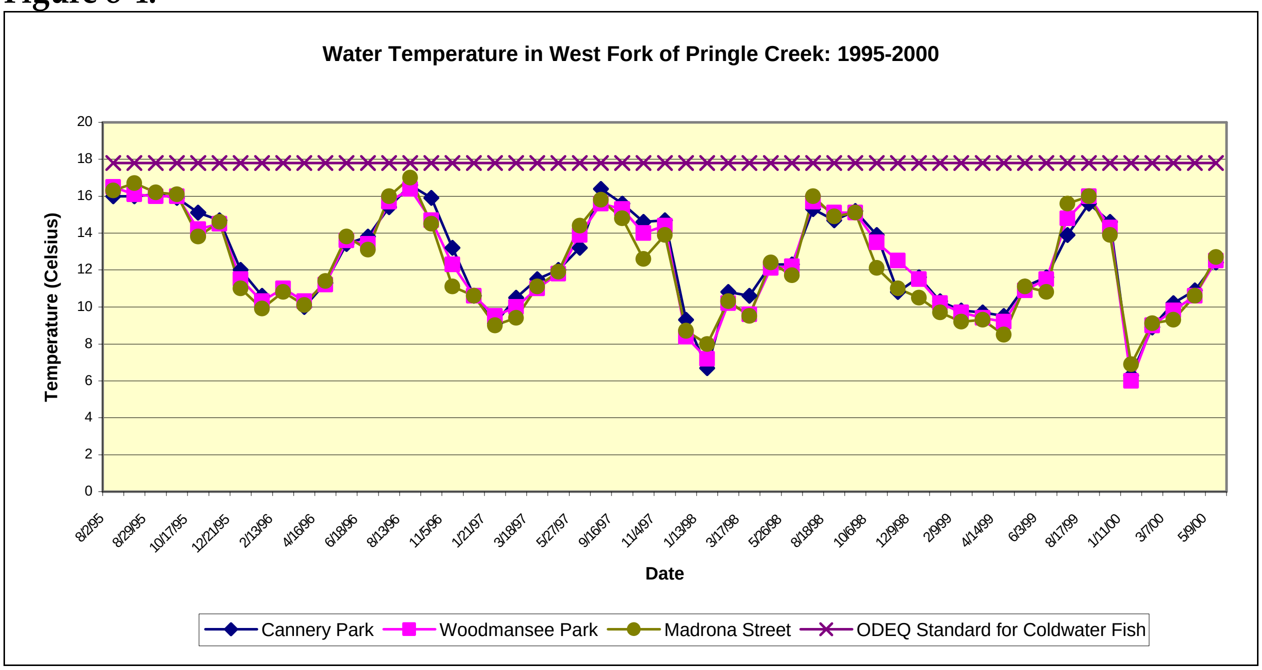


Figure 8-5.

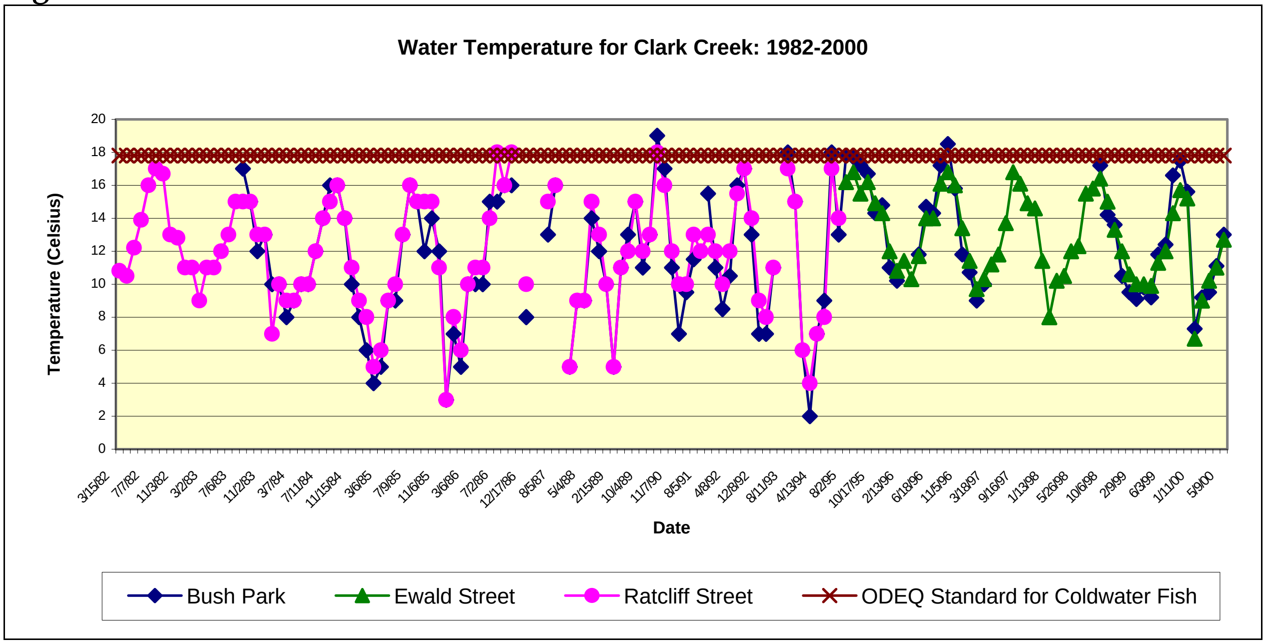


Figure 8-6.

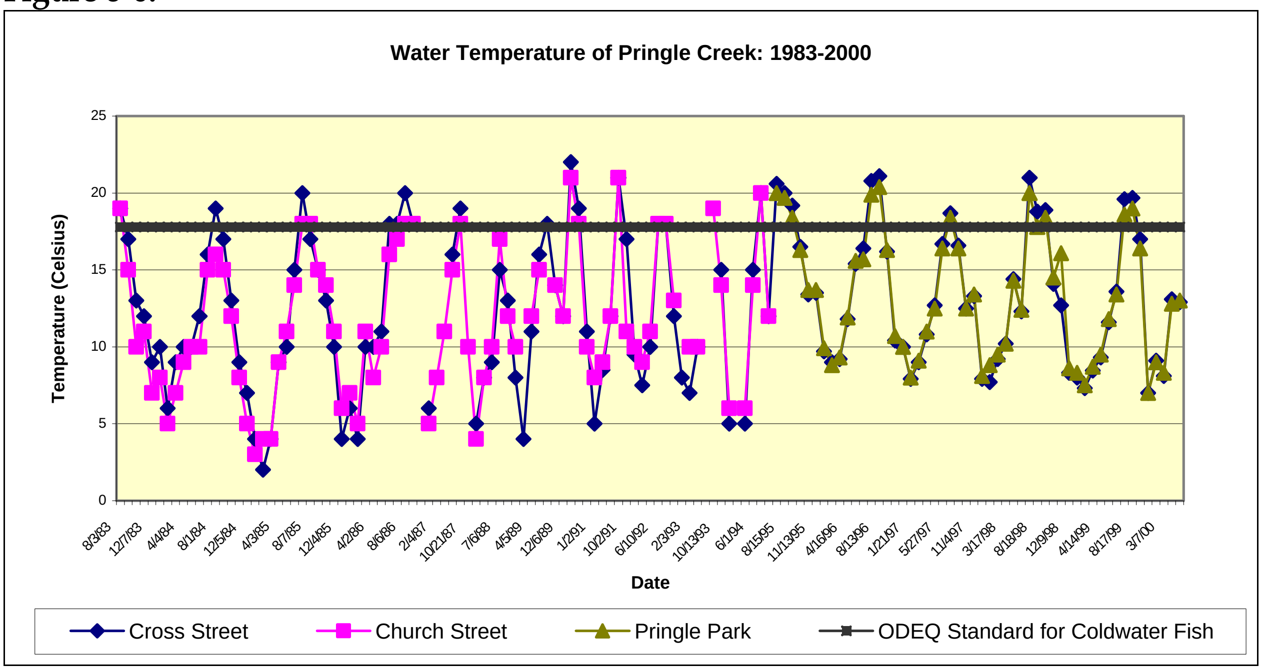


Figure 8-7.

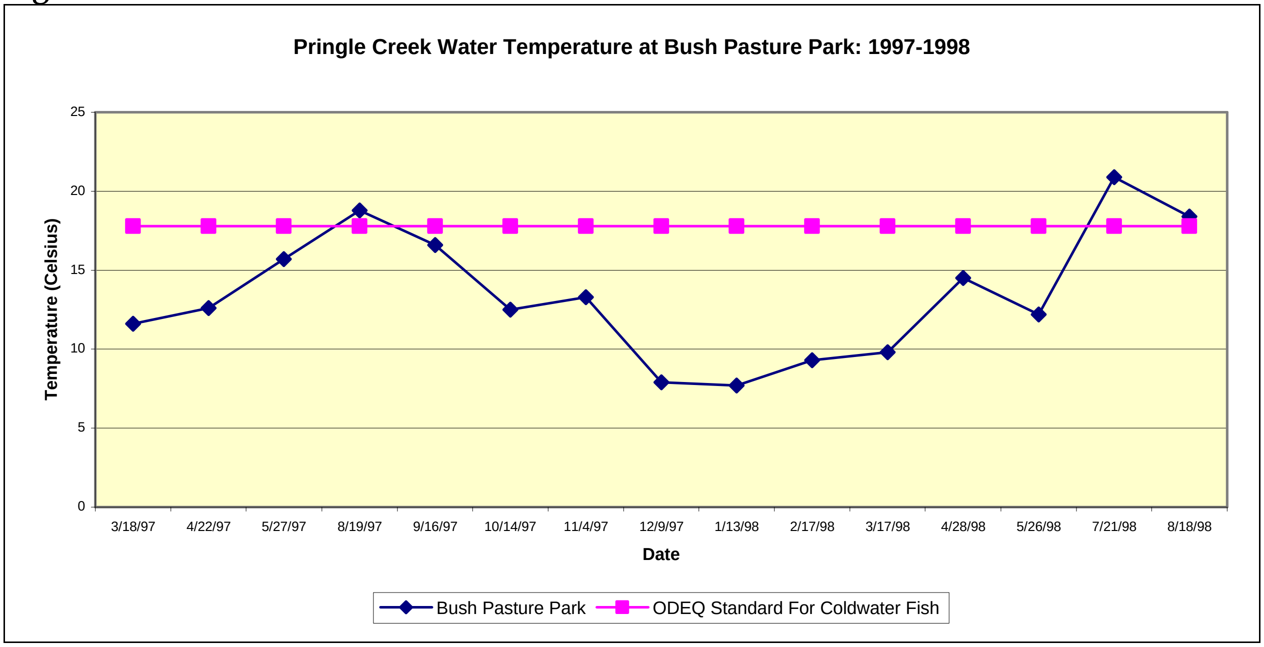


Figure 8-8.

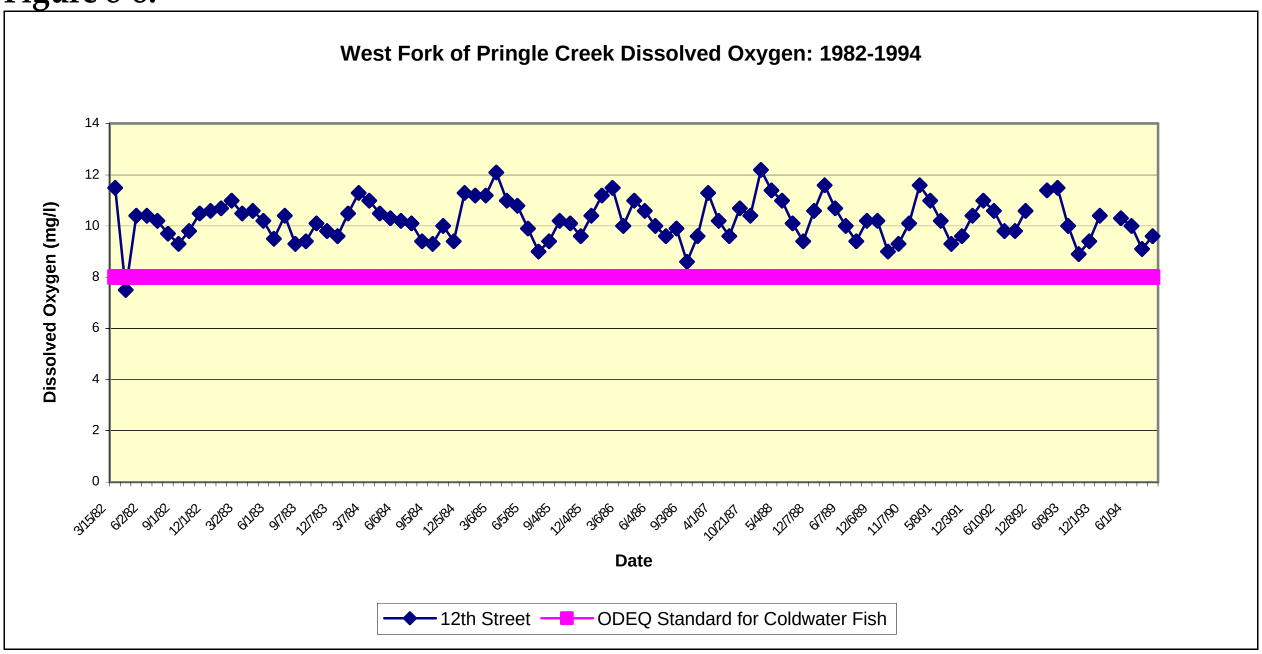


Figure 8-9.

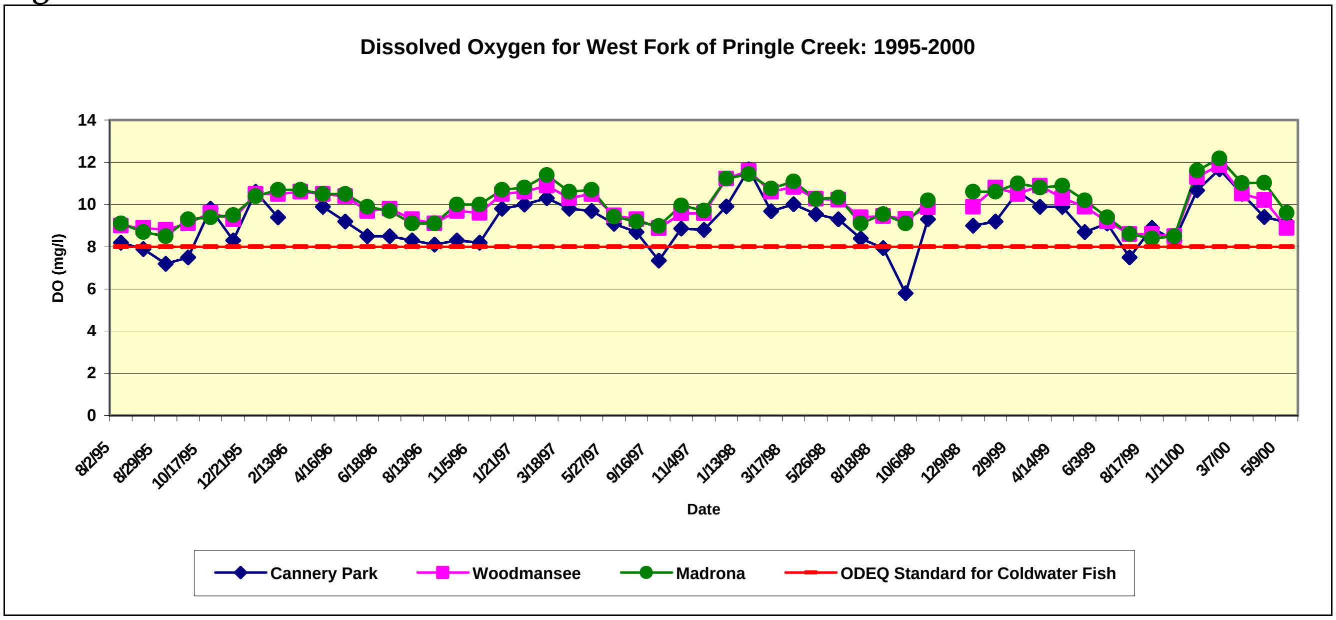


Figure 8-10.

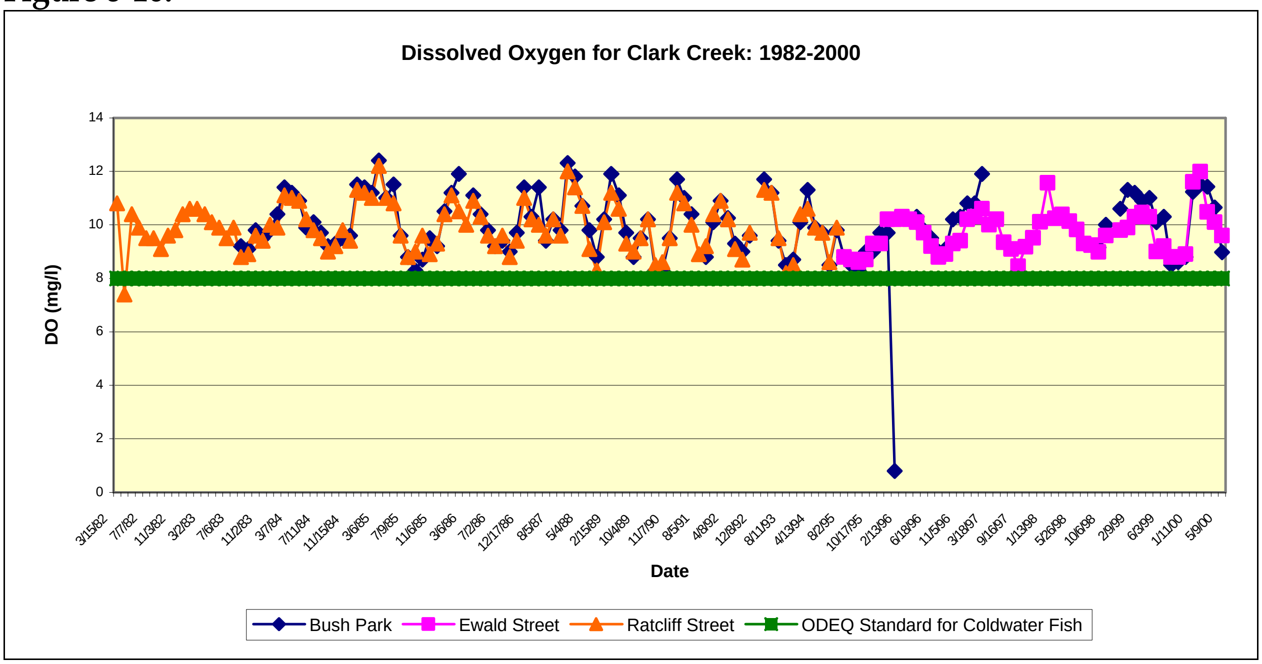
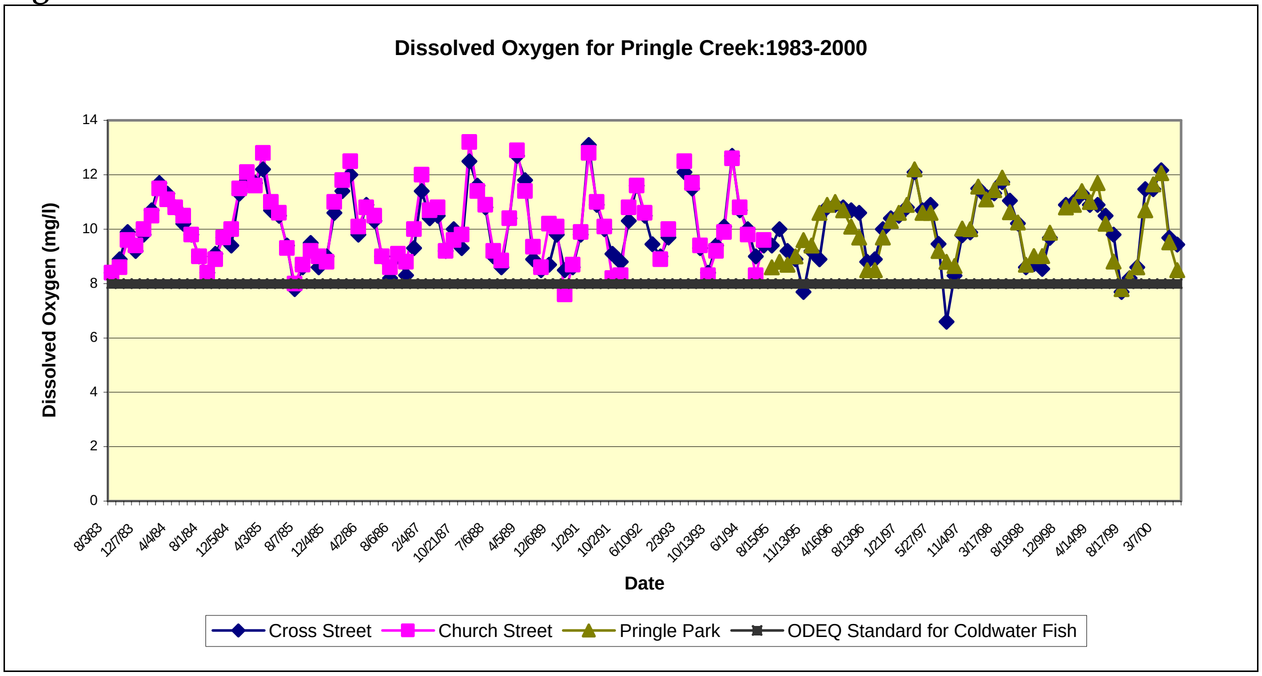
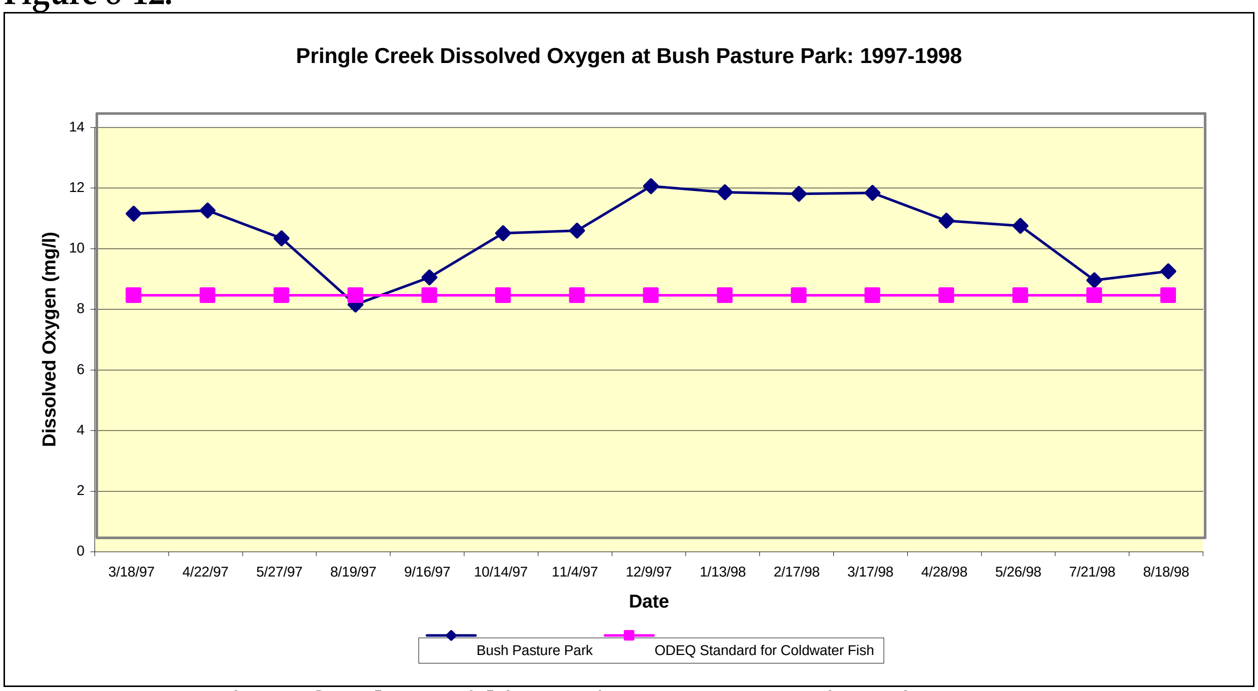


Figure 8-11.



Data source: City of Salem Public Works Department (2000)

Figure 8-12.



Data source: City of Salem Public Works Department (2000)

c. pH

Levels of pH ranged from a low of 5.6 to a high of 7.3 in the West Fork of Pringle Creek. Two monitoring stations located in the South Salem Hills along the West Fork of Pringle Creek, C29 and C28, consistently recorded pH levels below 6.5 (**Table 8-12**). However, most of the pH readings were only slightly below the recommended minimum.

Table 8-12. Counts of High and Low pH Samples from Pringle Creek Watershed: 1982-2000

Monitoring Station	Location	Low pH(<6.5)	High pH (>8.5)	Total	# of samples	% exceedence
Clark Creek						
C19	Clark Bush Park	6	0	6	117	5%
C7	Clark Ratcliff	0	0	0	99	0%
C27	Ewald Street	31	0	31	53	58%
West Fork of Pringle Creek						
C30	Madrona Street	6	0	6	53	11%
C29	Woodmansee Park	20	0	20	53	38%
C28	Cannery Park	34	0	34	52	65%
Pringle Creek						
C8	Pringle 12th	2	0	2	98	2%
C20	Cross Street	5	7	12	134	9%
C18	Pringle Bush	1	0	1	15	7%
C26	Pringle Church	0	0	0	82	0%
C31	Pringle Park	7	1	8	52	15%

Note: Normal pH levels of streams in Oregon range from 6.5 to 8.5 units.

Levels of pH in Clark Creek exhibited a similar pattern as the West Fork of Pringle Creek. pH levels ranged from a low of 5.6 to a high of 7.8. The Ewald Street monitoring station, C27, consistently recorded low pH levels throughout the year, most recordings only slightly below 6.5. The two monitoring stations lower in the Clark Creek basin, C7 and C19, almost always recorded pH levels within the recommended range.

The slightly lower pH of stream water may be the result of the low pH of the soils found in the headwaters of both the West Fork of Pringle Creek and Clark Creek. Jory Silty Clay Loam and Nekia Silty Clay Loam are prominent soil types in the south Salem hills. Both soils are on low, red foothills that are dissected by drainageways and streams. The Jory soil series has a surface pH of 5.9 and increases in acidity to 4.9 at a depth of 50 inches. The Nekia soil series has a surface pH of 5.6 and increases slightly in acidity to 5.3 at a depth of 36 inches (U.S. Soil Conservation Service 1972). Water in contact with these highly acidic soils, be it either surface runoff or groundwater, may also become acidic in nature.

The pH levels recorded in the main stem of Pringle Creek ranged from 5.4 to 9.4. Only 6% of all water quality samples taken from the five monitoring stations along Pringle Creek ever fell outside the recommended range of 6.5 to 8.5 units.

d. Nutrients

Total Nitrates in water samples taken throughout the Pringle Creek watershed basin were high, ranging from zero to 3.8 mg/l (**Table 8-13**). Approximately 98% of all water quality samples taken at the three monitoring stations along the West Fork of Pringle Creek exceeded OWAM's recommended standard of 0.30 mg/l. Clark Creek also exceeded the standard 98% of the time. Water samples from Pringle Creek exceeded the standard 91% of the time.

Table 8-13. Total Nitrates of Pringle Creek Watershed: 1983-2000

	Pringle Park	Church Street	Bush Park	Cross Street
Number	C52	C80	C15	C132
Minimum	0.24	0.3	0.369	0
Maximum	2.4	3.8	1.45	3.2
Median	0.967	1	1.102	0.9
Number (>0.30mg/l)	51	73	15	115
% exceedance	98%	91%	100%	87%

Total Phosphorus was only measured from 1995-2000. Water quality samples taken from the West Fork of Pringle Creek exceeded OWAM's suggested standard of 0.05 mg/l in 17% of the samples (**Table 8-14**). This percentage of exceedance was low compared to samples taken in the main stem of Pringle Creek where 65% of the samples exceeded the standard. In Clark Creek, frequency of samples with high Total Phosphorus differed greatly between a headwater monitoring station (C27) and a station lower in the watershed (C19), with the latter exceeding the standard 3 times as much as samples taken at C27.

Table 8-14. Total Phosphorus of Pringle Creek Watershed: 1995-2000

	Pringle Park	Church Street	Bush Park	Cross Street
Number	C51	no data collected	C15	C52
Minimum	0.007		0.031	0.031
Maximum	0.248		2.16	2.96
Median	0.056		0.051	0.056
Number (>0.05mg/l)	34		8	34
% exceedance	67%		53%	65%

e. Fecal Coliform and *E. Coli*

Pringle Creek and Clark Creek are water quality-limited for *E. coli* according to DEQ (**Table 8-4, 8-5**). Data collected from 1995-2000 show that approximately 41% of all water-quality samples taken within the Pringle Creek watershed exceeded DEQ's single sample standard of 406 *E. coli* colonies/100 ml. High levels were recorded in all seasons, but summer and early fall sample periods usually defined the highest fecal coliform counts for each year (**Figures 8-13, 8-14** and **8-15**). The highest *E. coli* count in the watershed occurred at Cannery Park (C28) in May of 2000, with a record count of 6080 cfu/100 ml.

Water quality samples taken in the Pringle Creek watershed prior to 1995 were tested only for fecal coliform. From 1982-1997, approximately 46% of water quality samples tested for fecal coliform in the Pringle Creek watershed exceeded 400cfu/100 ml.

f. Toxic Substances

Pringle Creek is on the 303(d) list for dieldrin. In order to protect aquatic life in fresh water, chronic levels of dieldrin are not to exceed 0.0019ug/l (microgram per liter)(DEQ standard). The dieldrin standard was exceeded at Bush Pasture Park in 1994 and 1996. According to USGS collected data, the average dieldrin level was 0.0025ug/l for two of three water samples taken in 1994 (Harrison et al. 1995). The dieldrin standard was exceededed in six out of six samples taken in 1996 at a level of 0.1ug/l.

Dieldrin is an insecticide that was widely used from the 1950s to the early 1970s. It has been used in agriculture for soil and seed treatment and in public health to control disease vectors such as mosquitoes. Because of concerns about damage to the environment and potential harm to human health, EPA banned all uses of dieldrin in 1974 except to control termites. In 1987, EPA banned all uses.

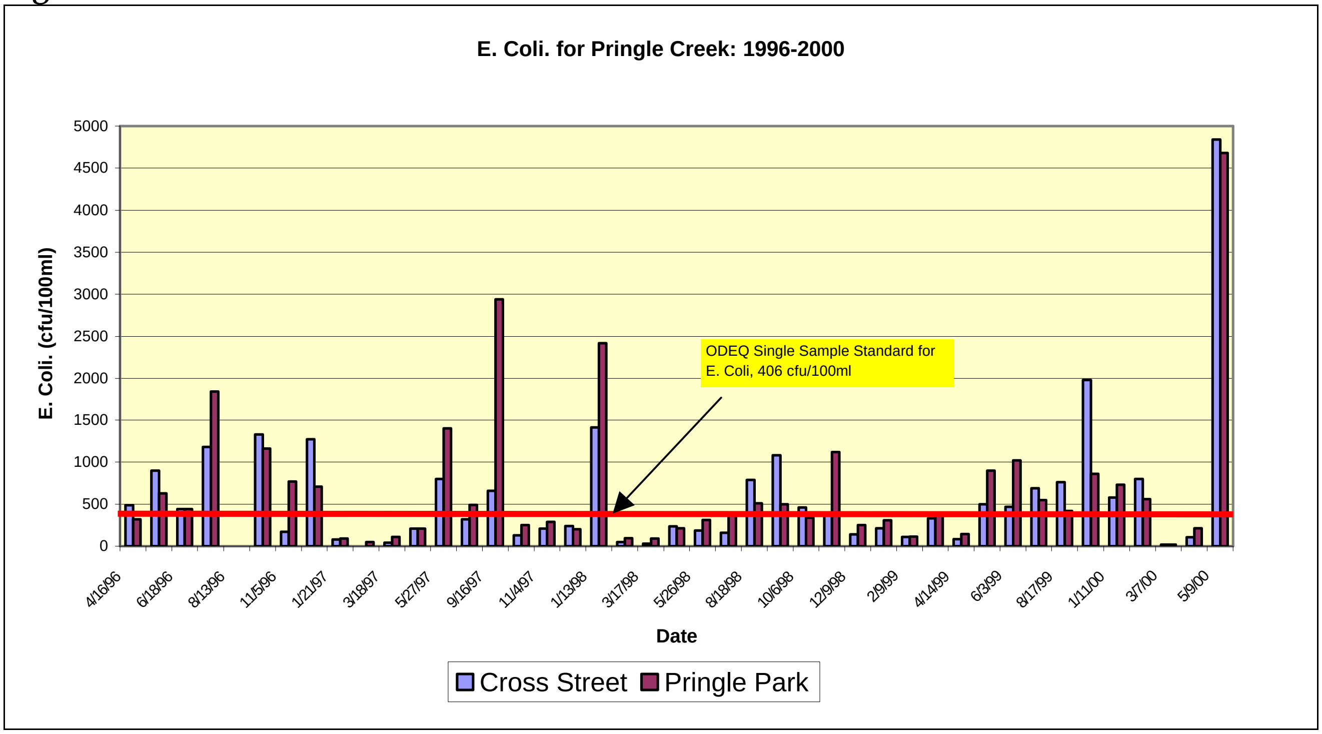
Once dieldrin reaches surface waters it will adhere strongly to sediments, bioconcentrate in fish and slowly photodegrade. Because dieldrin accumulates in sediment it may be detected for years after the chemical is no longer in use. Human exposure to dieldrin may occur by consuming fish that have accumulated this compound in their fatty tissues. Exposure to high levels of dieldrin result in convulsions and death. The effects of exposure to low levels of dieldrin over a long time are unknown.

High levels of lead and DDT have also been documented in Pringle Creek by the USGS (Harrison et al. 1995). However, Pringle Creek is not currently listed for these toxics because the minimum data requirements were not met. In both instances, only one water-quality sample was taken. DEQ requires that the toxic exceed the standard more than 10% of the time and for a minimum of two values. The proposed 2002 303(d) list lists Pringle for lead.

Lead is a naturally occurring metal found in the earth's crust. Lead is used in the production of batteries and can be found in ammunition, pipes, roofing and other products. Because of health concerns, lead from gasoline, paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years. According to the USGS, lead concentrations in bed sediment are significantly higher for streams draining urban areas than for streams draining rural lands (Wentz et al. 1998). Past studies in Salem suggest that there is a strong relationship between lead content and traffic patterns and intensity (City of Salem and ODOT 1994). Health effects from lead poisoning include damage to the central nervous system, kidneys and the immune system. Exposure to lead is more dangerous for young children and the unborn.

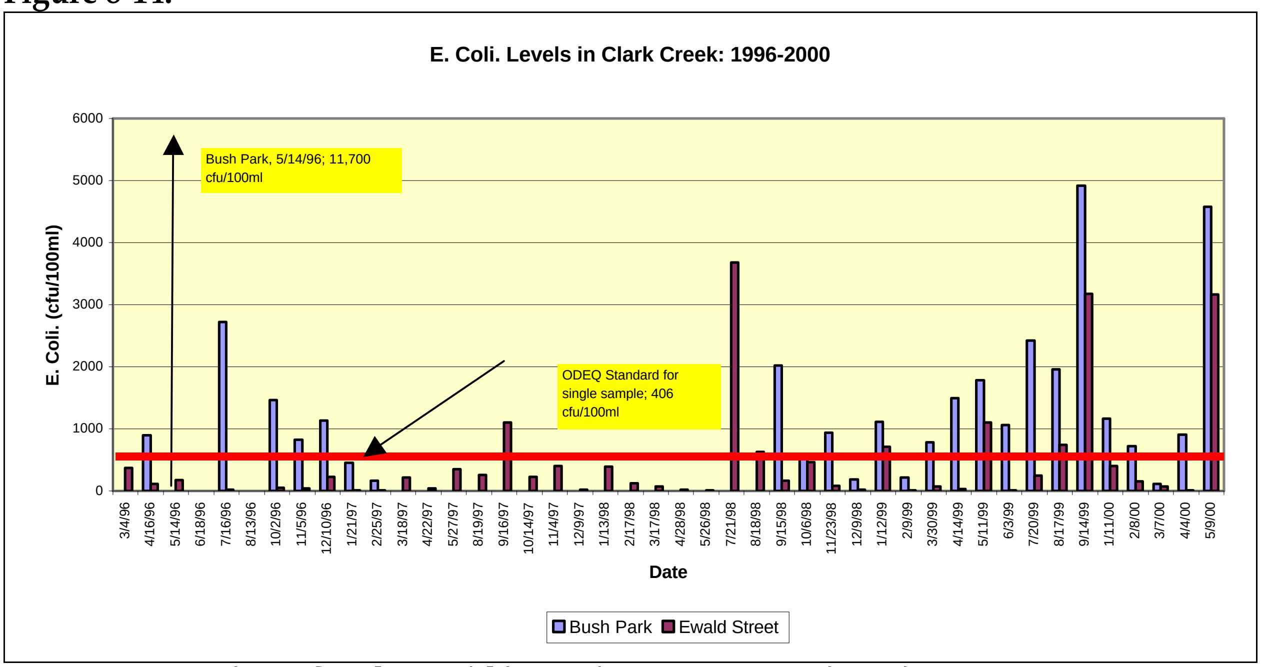
DDT is an organochlorine pesticide that has been linked to reproductive problems in aquatic invertebrates, fish, birds, and mammals. DDT is not metabolized very rapidly by animals; instead, it is deposited and stored in the fatty tissues. The use and manufacture of DDT has been banned since 1973, but it is still present in aquatic systems because of its environmental persistence.

Figure 8-13.



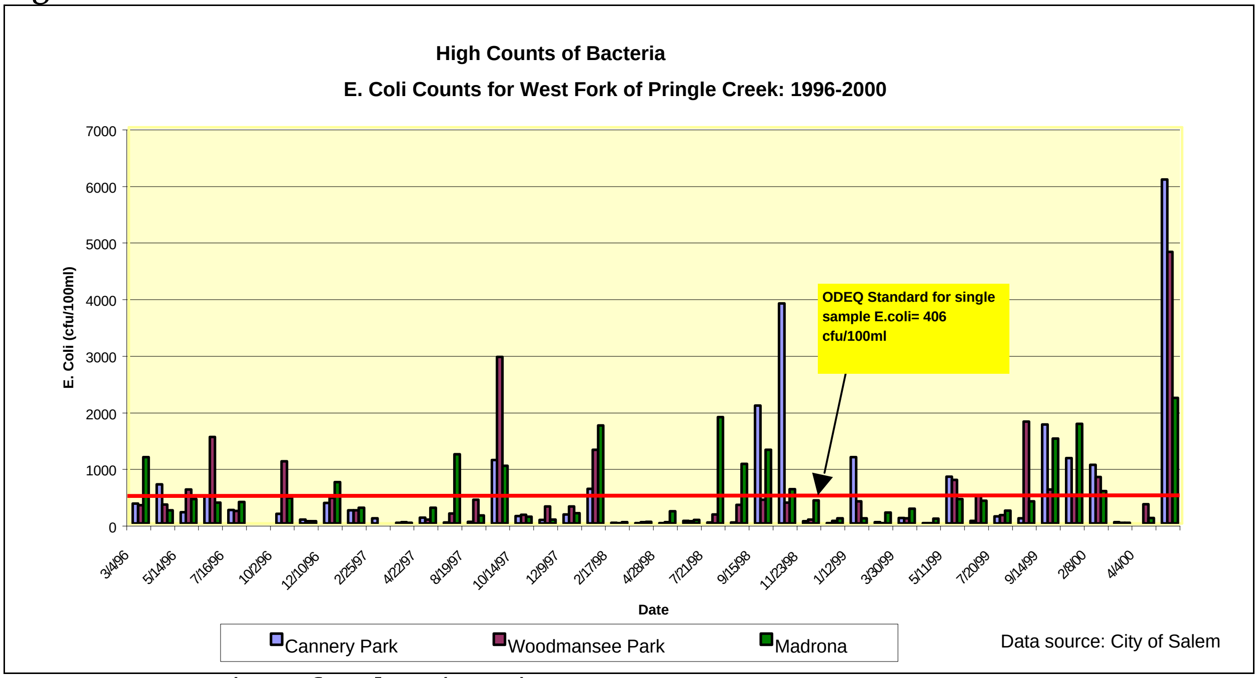
Data source: City of Salem Public Works Department (2000)

Figure 8-14.



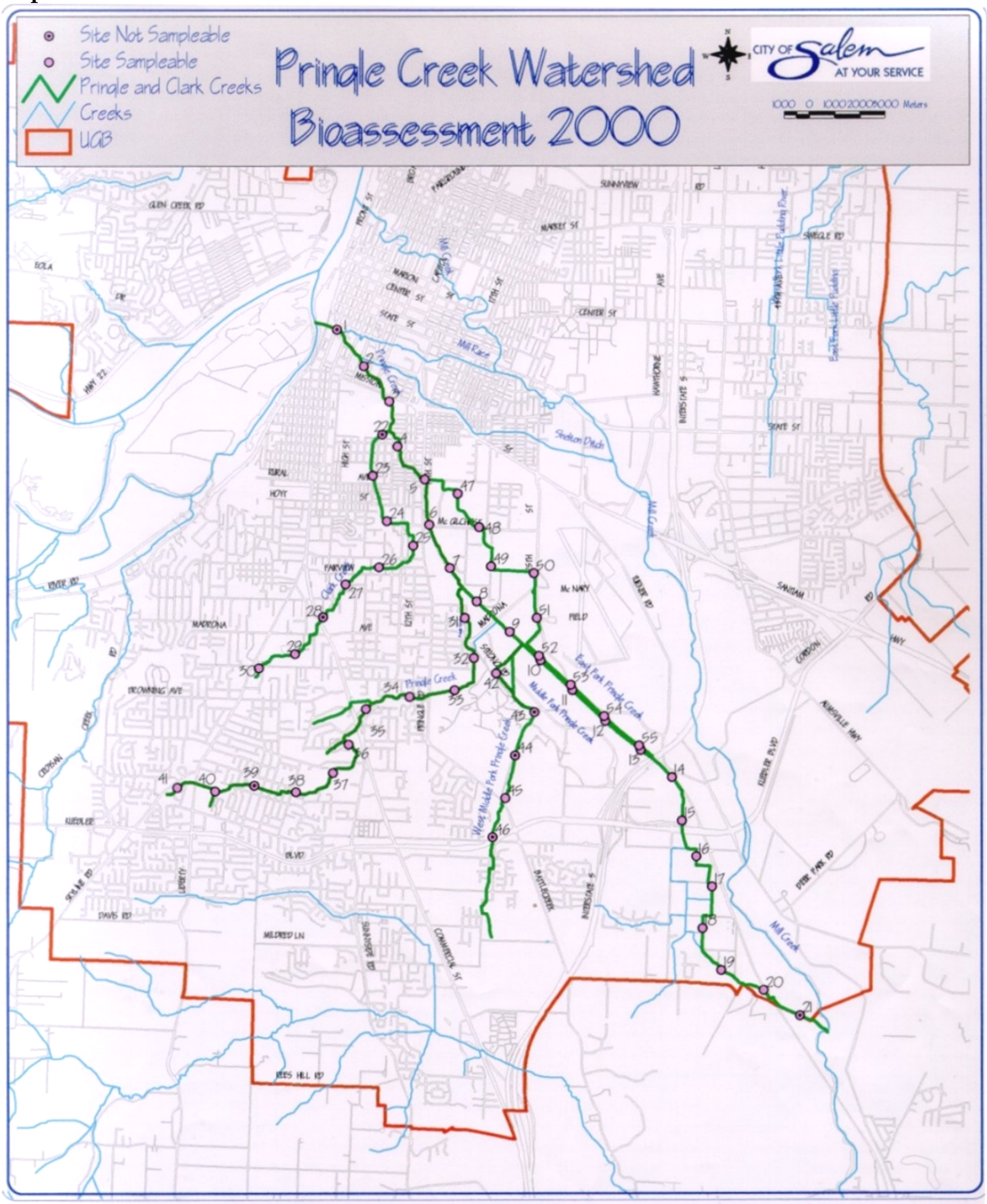
Data source: City of Salem Public Works Department (2000)

Figure 8-15.



Data source: City of Salem (1982)

Map 8-7.


Site Not Sampleable
Site Sampleable
Pringle and Clark Creeks
Creeks
UGB
Pringle Creek Watershed
Bioassessment 2000
CITY OF Salem
AT YOUR SERVICE
Meters

g. Pringle Creek Watershed Stream Bioassessment Project

The following background information was taken from the Pringle Creek Watershed Stream Bioassessment Project: Field and Laboratory Methods Manual (City of Salem 2000).

In 2000 the City of Salem embarked on an ambitious project to determine the current status, extent, changes, and trends in the condition of the Pringle Creek Watershed. The Pringle Creek Watershed Stream Bioassessment Project uses procedures outlined in the Environmental Monitoring and Assessment Program (EMAP), a program developed by the EPA to assess stream conditions.

The following two objectives guided the City of Salem's bioassessment research:

1. Estimate the current status, extent, changes and trends in indicators of the condition of the Pringle Creek watershed with known confidence.
2. Monitor indicators of pollutant exposure and habitat condition and seek associations between human-induced stresses and ecological condition.

The goal of the bioassessment was to answer three general assessment questions:

1. What proportion of stream within the watershed is in acceptable (or poor) biological condition?
2. What is the relative importance of potential stressors (habitat modification, sedimentation, nutrients, temperature, grazing, etc.) to the Pringle Creek watershed?
3. With what stressors are streams in poor biological condition associated?

A plethora of parameters were measured at 55 sample points throughout the Pringle Creek watershed (**Map 8-7**). The parameters included chemical, physical and biological attributes of the stream. Some of the chemical variables measured included dissolved oxygen, temperature, pH, total suspended solids and conductivity. Physical attributes included bank width, bank height, incised height of channel, canopy cover and fish cover. Macroinvertebrates were collected as part of the biological portion of the assessment.

- *Biological*

Macroinvertebrates were collected at 46 sample points. With few exceptions, macroinvertebrates were counted and categorized down to genus/species level for all specimens. Fifty-eight macroinvertebrate indices have been calculated from the data (**Table 8-15**). Although the macroinvertebrate data is currently undergoing analysis, we were able to make a few simple observations regarding the data using the indices.

Taxa Richness is the total number of invertebrate taxa identified from a sample. Theoretically, taxa richness will increase as habitat diversity increases.

Table 8-15. Benthic Macroinvertebrate Indices Used for the Pringle Creek Watershed Stream Bioassessment

Richness Measures	Composition Measures	Tolerance Measures	Trophic/Habit Measures
Taxa Richness	% EPT	# Intolerant Taxa	# Clinger Taxa
# Total Taxa	% Ephemeroptera	% Tolerant Organisms	% Clingers
# EPT Taxa	% Chironomidae	Hilsenhoff Biotic Index (HBI)	# Filterer Taxa
# Ephemeroptera Taxa	% Odonata	% Dominant Taxon	% Filterers
# Plecoptera Taxa	% Plecoptera	Hydropsychidae / Total Trichoptera	# Scraper Taxa
# Trichoptera Taxa	% Megaloptera	Baetidae / Total Ephemeroptera	% Scrapers
# Odonata Taxa	% Coleoptera	% Intolerant Ephemeroptera	# Predator Taxa
# Coleoptera Taxa	% Diptera	% Intolerant Trichoptera	% Predators
# Chironomidae Taxa	% Contribution of 1 dominant taxon	% Intolerant Plecoptera	# Collector-Gatherer Taxa
Ephemerellidae Richness	% Contribution of 5 dominant taxa	Community Loss Index	% Collector-Gatherer Taxa
Heptageniidae Richness	% Multivoltine		# Collector-Filterer Taxa
Caddisfly, Stonefly, and Shredder Richness	% Univoltine		% Collector-Filterer Taxa
Rhyacophilidae Richness	% Semivoltine		# Shredder Taxa
EPT index	Ration EPT & Chironomidae abundance		% Shredder
Benthic Index of Biological Integrity	Relative Abundance		Scraper / (Scraper + Collector-Filterer)
Total Individuals			Biotic Condition Index
			Ratio scrapers / filtering Collectors

Source*:* City of Salem (2000).

The number of taxa found at each sample point ranged from 19 to 48. **Map 8-8** shows the distribution of the sample points according to the number of taxa found. Several monitoring sites located in the East Fork of Pringle Creek had high taxa richness. Monitoring sites in the West Fork of Pringle Creek typically ranked Medium Low or Medium

High in taxa richness. No other discernible patterns are evident on the map.

Modified Hilsenhoff Biotic Index (HBI) is an index of a taxon's sensitivity to organic enrichment that typically occurs as a result of excessive nutrients (Oregon Plan Monitoring Team 1999). Index values range from 1 to 10. The higher the index number the more tolerant a taxon is to nutrient loading. For example, stonefly species have low index values, typically on the scale of zero to two, while species of gastropods, including snails, have HBI values of five to eight (Oregon Plan Monitoring Team 1999).

An HBI score for an individual sample point is calculated by using a weighted average of all the taxa found at that site. Thirty-six of the 46 sample points had HBI values greater than 5.0 (**Map 8-9**). Using scoring criteria presented in the Water Quality Monitoring Technical Guide Book (Oregon Plan Monitoring Team 1999), HBI scores over 5.0 indicate an invertebrate community very tolerant of high nutrient levels. Of the remaining 10 sample points, seven sites had HBI values of 4.0-5.0, indicating moderate tolerance of nutrients. Only three sites had low HBI values. With the exception of the lower reach of the West Fork of Pringle Creek, the distribution of sample points with medium or low HBI scores is scattered throughout the watershed. The reach of the West Fork of Pringle Creek with medium HBI scores is located on or near the Fairview Training Center and Leslie Middle School.

Sensitive Taxa are the identified taxa known to be very sensitive to stream disturbance. Stream disturbances include such activities as vegetation removal, channelization, dredging, stormwater and excessive bank erosion. These kinds of disturbance typically lead to degraded water quality, with high stream temperatures, low dissolved oxygen, high nutrient loads, increased sedimentation and simplification of in-stream habitat.

There were no sensitive taxa found in any of the 46 sample points. This would imply that Pringle Creek and its tributaries contain degraded habitat and/or degraded water quality.

- *Physical, Chemical and Biological*

The watershed councils have a copy of the raw data collected from the study. Data from this project is currently being analyzed by the City of Salem. Results of the analysis will be incorporated into the watershed assessment as a separate chapter at a later date. This includes a more thorough analysis of the macroinvertebrate data.

2. Glenn and Gibson Creeks

The City of Salem collected data on Glenn Creek at two monitoring locations: Orchard Heights (C6) and Salemtowne (C22) (**Map 8-4**). Frequency and duration of water quality monitoring varied at both sites (**Table 8-11**). Water samples were taken at the Orchard Heights monitoring station between 1982-1989 on a monthly basis. Data were collected sporadically at the Salemtowne site from 1990-1993.

More recent information was collected by members of the Glenn-Gibson Watershed Council from August 1998 to December 2000 (**Table 8-11**). Water quality information was collected at six monitoring stations; four in Gibson Creek (W2, W3, W4, W5) and two in Glenn Creek (W1, W6) (**Map 8-4**).

For the first two months, morning and afternoon samples were collected semi-weekly. The purpose of this early, intensive monitoring was to see if the morning and afternoon sample results at any of the five sampling sites were markedly different. In water with too much nitrogen and/or phosphorus, algae growth becomes excessive. When excessive nutrients are available in a stream, the pH, temperature, and dissolved oxygen will vary significantly from morning to afternoon. Starting in October of 1998, sampling was cut back to once per day, once a month. Using the data collected from the three sample sites that were monitored consistently between August 1998 and December 2000 (e.g., W1, W2, W6), information on diurnal fluctuations of temperature, dissolved oxygen and pH are included in this assessment.

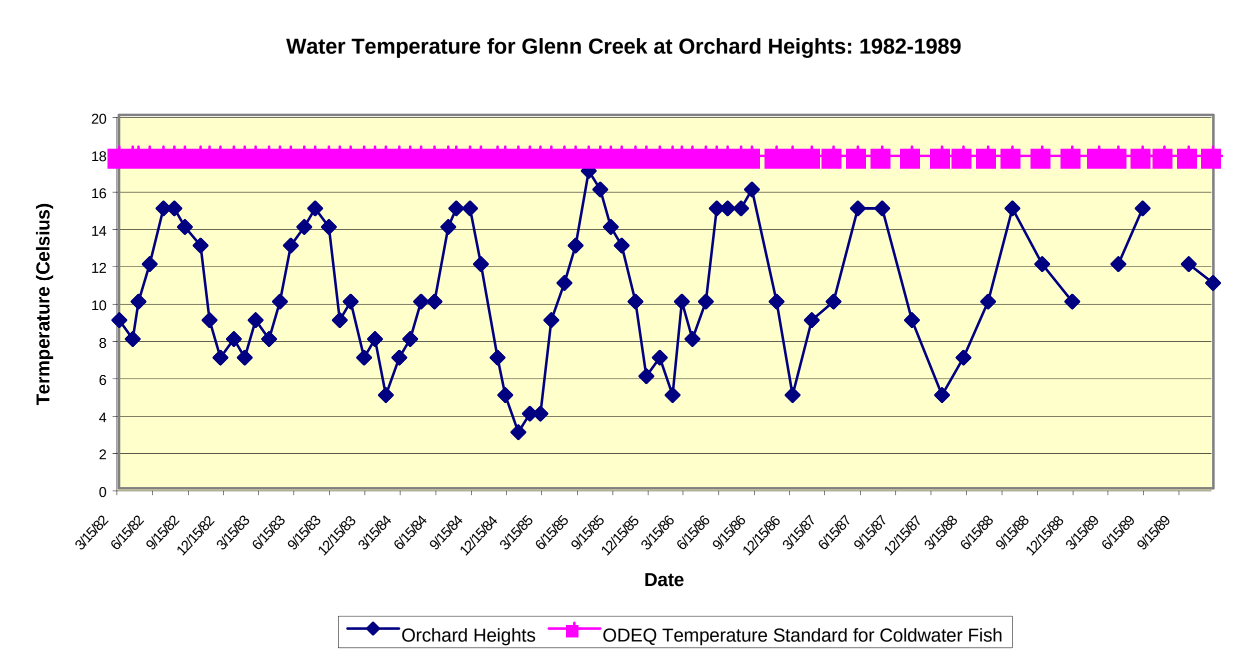
Data was also collected for a short period (August to December 1998) at the Salemtowne Pond in lower Gibson Creek. The site did not provide free flowing water, and showed the effects of ponding (algae, wide swings in pH and dissolved oxygen, and high temperatures). The site was dropped from the monitoring schedule and replaced with a more representative sample of stream conditions. The water quality data collected at the Salemtowne pond indicate poor water quality conditions for salmonids and trout. Poor water quality conditions may act as a barrier for upstream movement of fish. More data would be needed to substantiate this.

a. Water Temperature

According to city-collected data, water temperatures did not exceed the standard for cold-water fish in Glenn Creek during the duration of the sampling periods in the 1980's and early 1990's (**Figures 8-16** and **8-17**). Recent data show that water temperatures did exceed the DEQ standard of 17.8 Celsius in lower Glenn Creek (W6) in August of 1998 (**Figure 8-18**). Water temperatures exceeded the standard at two sites in Gibson Creek, North Gibson Creek (W3) and Lower Gibson Creek (W5) in August of 2000 (**Figure 8-19**).

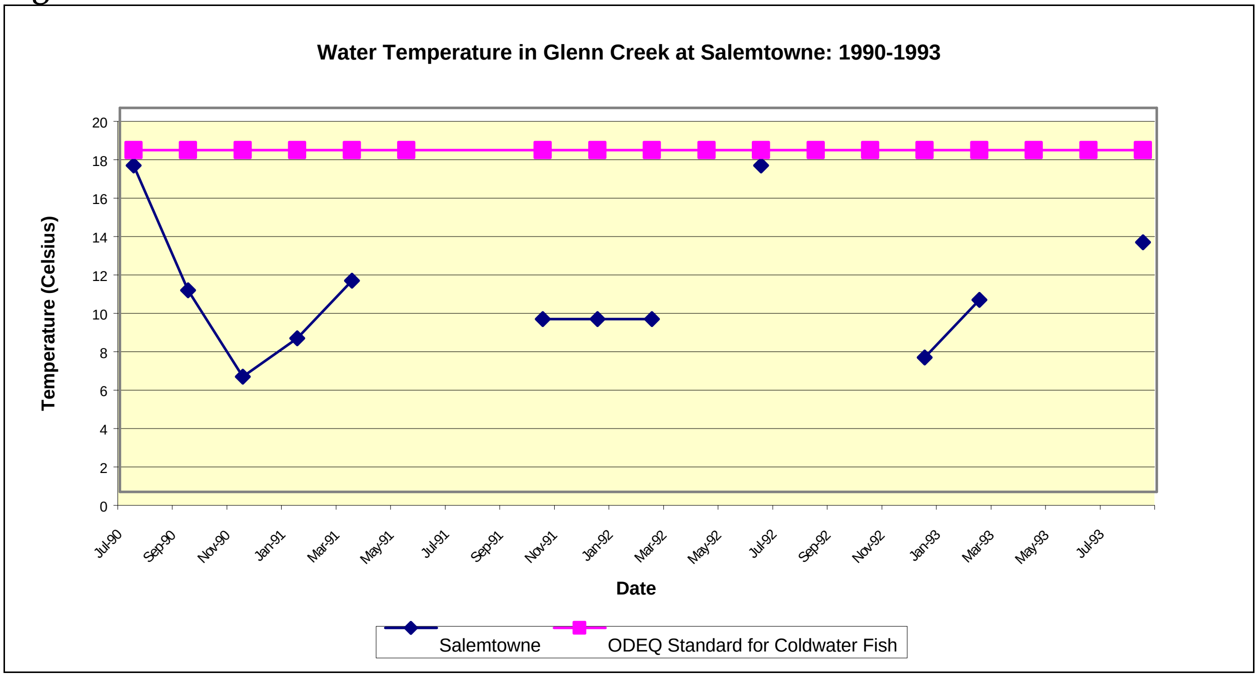
For the two months, August and September 1998, in which morning and afternoon samples were taken, stream temperatures increased by an average of 2.3 degrees Celsius in the afternoon.

Figure 8-16.



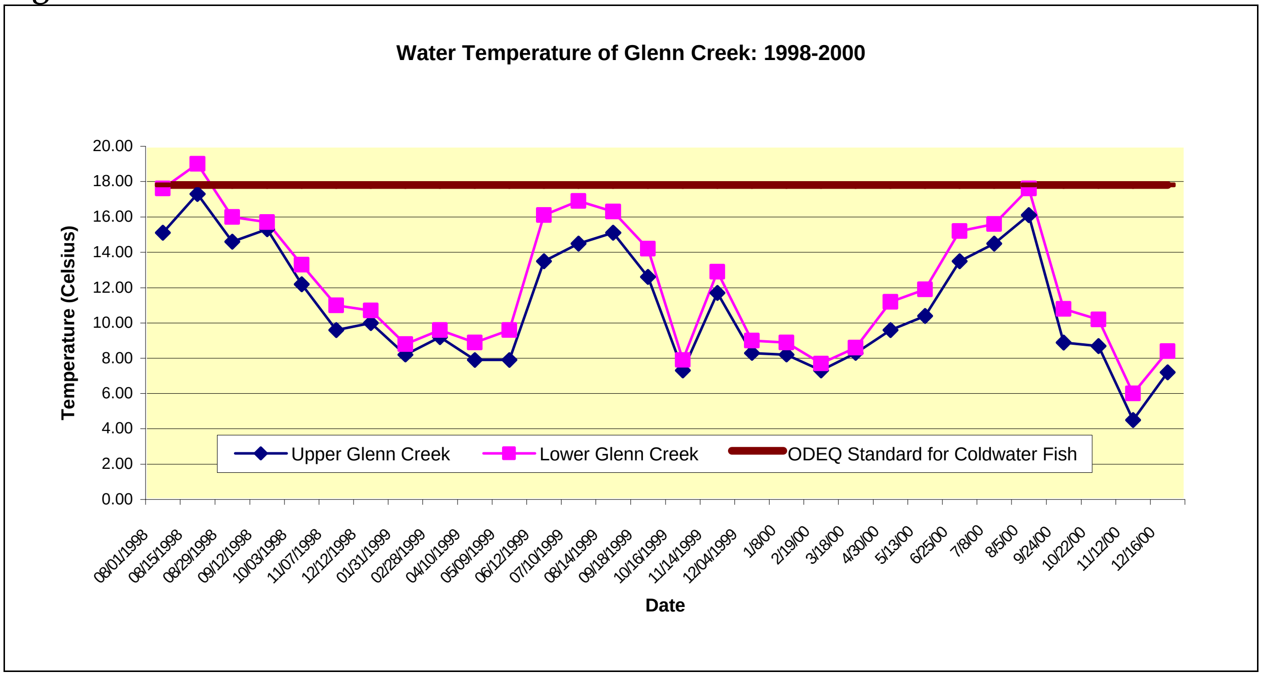
Data source: City of Salem Public Works Department (undated)

Figure 8-17.



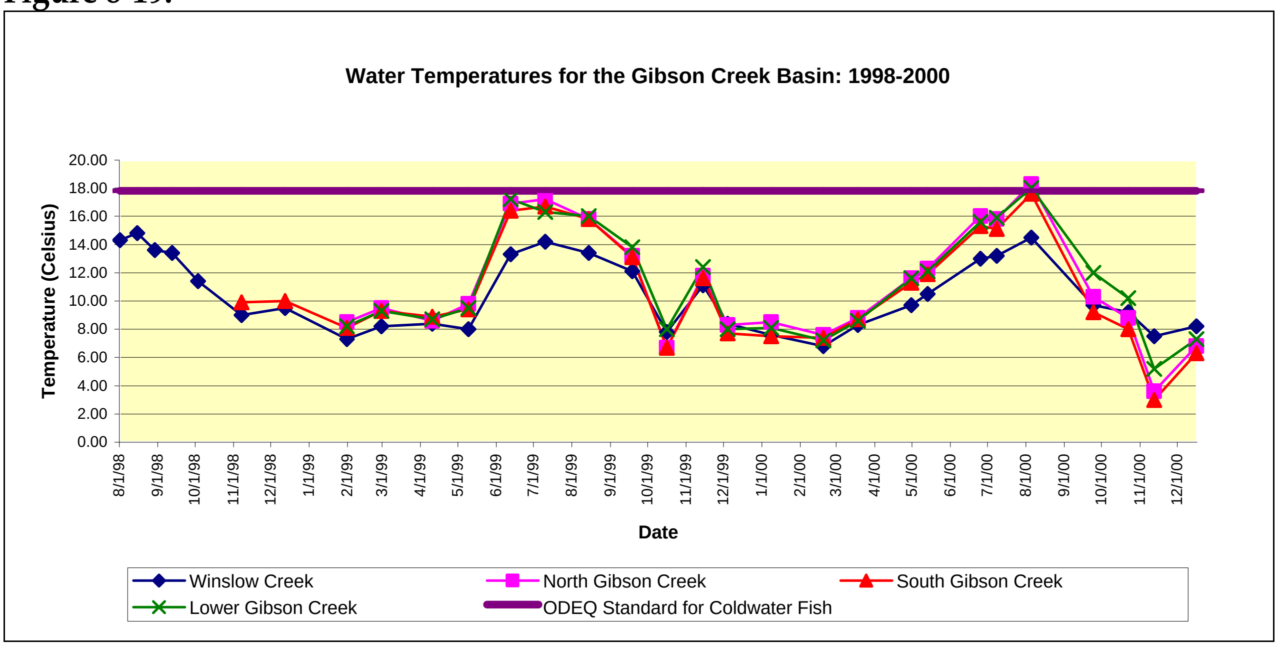
Data source: City of Salem Public Works Department (undated)

Figure 8-18.



Data source: Glenn-Gibson Watershed Council (2001)

Figure 8-19.



Data source: Glenn-Gibson Watershed Council (2001)

b. Dissolved Oxygen

City data indicate that dissolved oxygen dipped below 8.0 mg/l eight times between 1982-1989 at the Orchard Heights monitoring station (C6) (**Figure 8-20**). The low dissolved oxygen levels were recorded between July and October. A record low of 3.9 mg/l was recorded at this site in July of 1988. Low dissolved oxygen was recorded once in July of 1990 at the Salemtowne monitoring station (C22) along lower Glenn Creek (**Figure 8-21**). Data collected from 1998 to 2000 show that dissolved oxygen levels were slightly below the minimum of 8.0 mg/l in both upper (W1) and lower Glenn Creek (W6) during summer and early fall months (**Figure 8-22**).

Dissolved oxygen levels remained above the DEQ standard in all four seasons at the Winslow Creek (W2) and South Gibson Creek (W4) monitoring stations (**Figure 8-23**). North Gibson Creek (W3) recorded 7.9 mg/l for two consecutive months in the summer of 1999; otherwise dissolved oxygen levels were recorded above 8.0 mg/l. Lower Gibson Creek (W5) experienced low dissolved oxygen levels seven times during the sampling period during summer and fall months. A low of 6.4 mg/l was recorded in August of 2000.

During August and September of 1998, dissolved oxygen levels decreased an average of 1.32 mg/l between morning and afternoon sampling times.

c. pH

With only a few exceptions, pH levels remained within the recommended limits of 6.5 and 8.5. In March of 1991, the Salemtowne monitoring station (C22) recorded a pH of 5.8. On three occasions from 1998 to 2000, the pH of lower Glenn Creek at station W6 dropped to 6.4. Diurnal fluctuations in pH readings were negligible.

d. Nutrients

Data on Total Nitrates were collected at the two water quality monitoring stations sampled by the City of Salem (C6 and C22). Nitrate concentrations exceeded the standard of 0.30mg/l (OWAM standard) in over 90% of the samples (**Table 8-16**). Nitrate levels ranged from a high of 4.06mg/l to a low of 0.10mg/l. Total Phosphorus was not sampled in Glenn or Gibson Creeks.

Table 8-16. Total Nitrates in Glenn Creek: 1982-1989

Statistic	Orchard Heights	Salemtowne
Number	62	14
Minimum	0.30	0.10
Maximum	4.60	3.80
Median	1.00	2.05
Number (>0.30mg/l)	58	13
% exceedance	94%	93%

Data source: City of Salem

e. Fecal Coliform

Fecal coliform counts were taken only in Glenn Creek at the two city monitoring stations (C6 and C22). Fecal coliform counts exceeded 400 colonies/100 ml (DEQ standard) at Orchard Heights (C6) 19 times from 1982 to 1989 (**Figure 8-24**). Counts of fecal coliform colonies ranged from 0 to 1,910. High counts of bacteria happened in all four seasons. The highest count occurred in July of 1986. The Salemtowne monitoring station (C22) recorded a high fecal coliform level of 1020 cfu/100 ml in July of 1992 (**Figure 8-25**). No bacterial counts were taken in Gibson Creek.

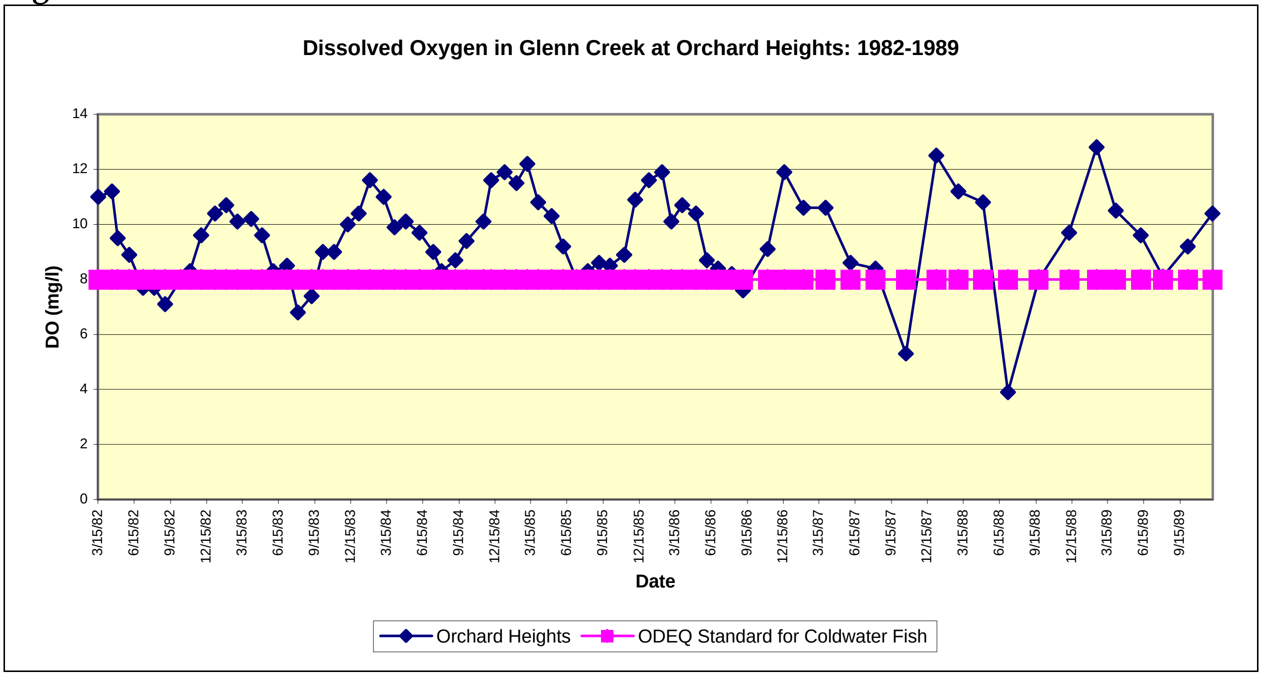
3. Claggett Creek

Five monitoring stations were established by the City of Salem in the Claggett Creek watershed (**Map 8-5**). Three of the stations are on the "main stem" of Claggett Creek: River Road (C1), Hyacinth Road (C2) and Mainline Drive (C3). Another station is in Hawthorne Ditch at East Basin Park (C17). Hawthorne Ditch is a remnant of Claggett Creek's headwaters and runs parallel to Hawthorne Drive, just west of Interstate 5. The fifth monitoring station is at the juncture of Labish Ditch and River Road (C24).

Monthly or semi-monthly samples were collected between March 1982 and December 1989 at all five monitoring stations. Data collection was interrupted in January of 1990 and resumed again in July of 1990. Data were collected every two months between July 1990 and October 1993.

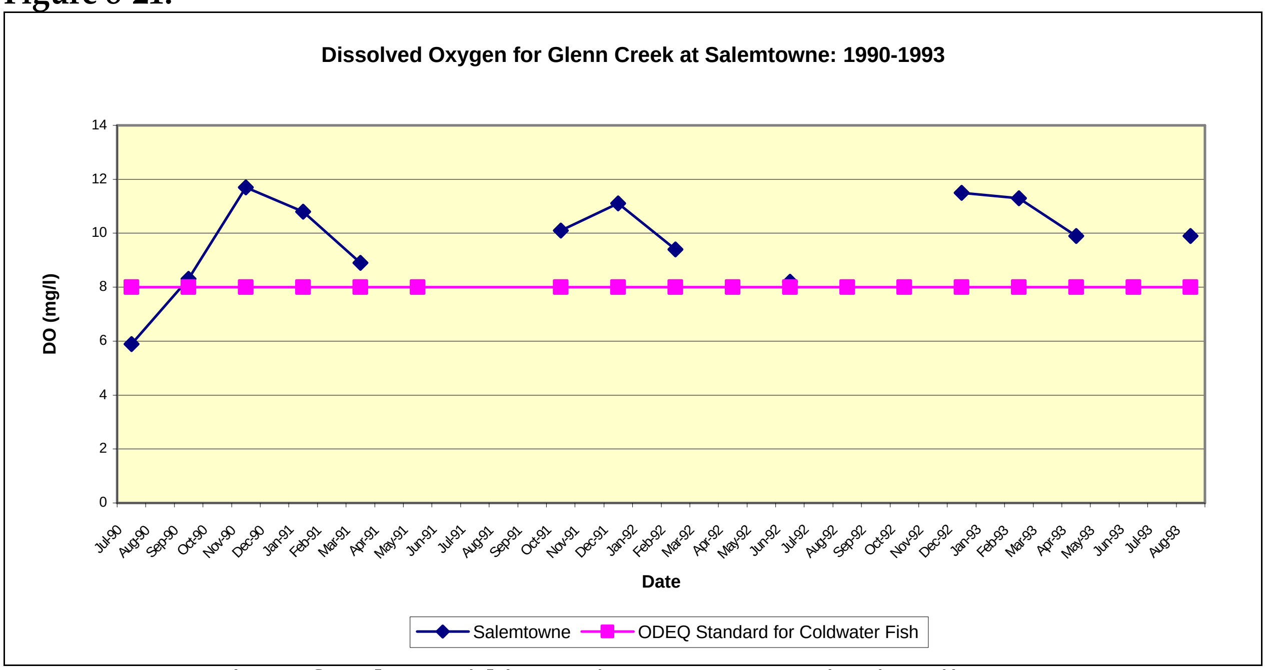
A science class at McNary High School established a monitoring station at Claggett Creek Park near Dearborne Avenue (S1) as part of the City of Salem's Adopt-A-Stream Program. They have been collecting data from this location since 1994.

Figure 8-20.



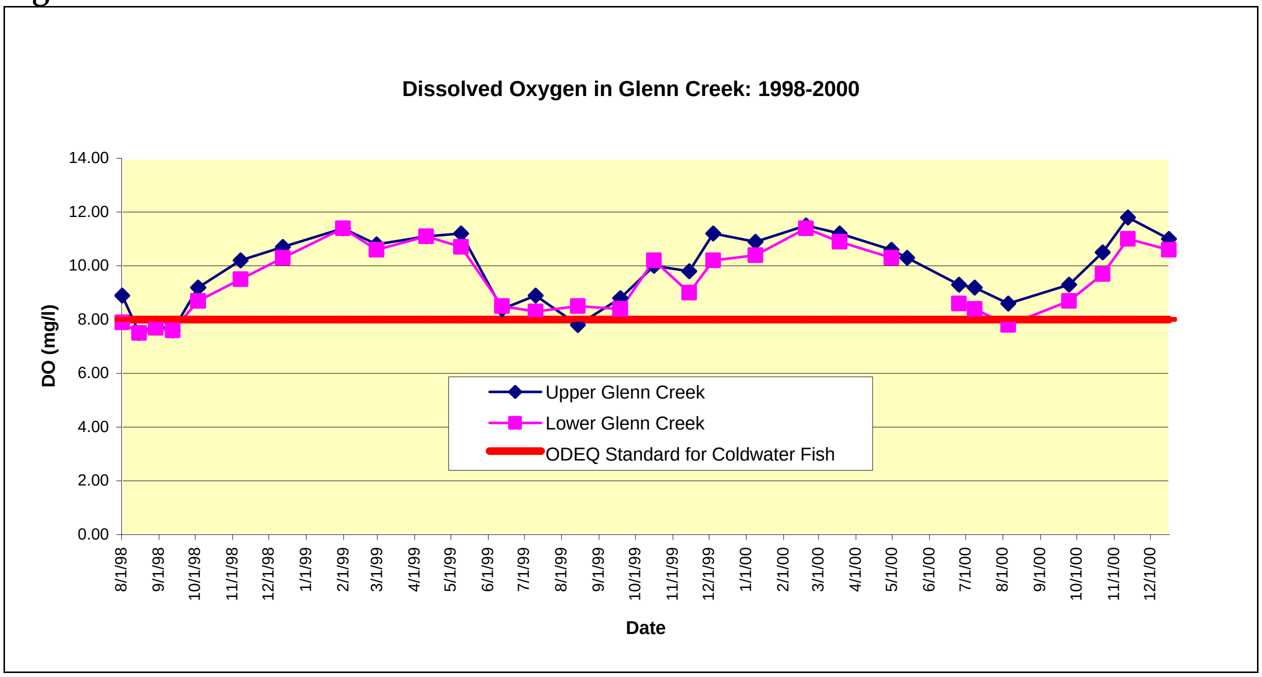
Data source: City of Salem Public Works Department (undated)

Figure 8-21.



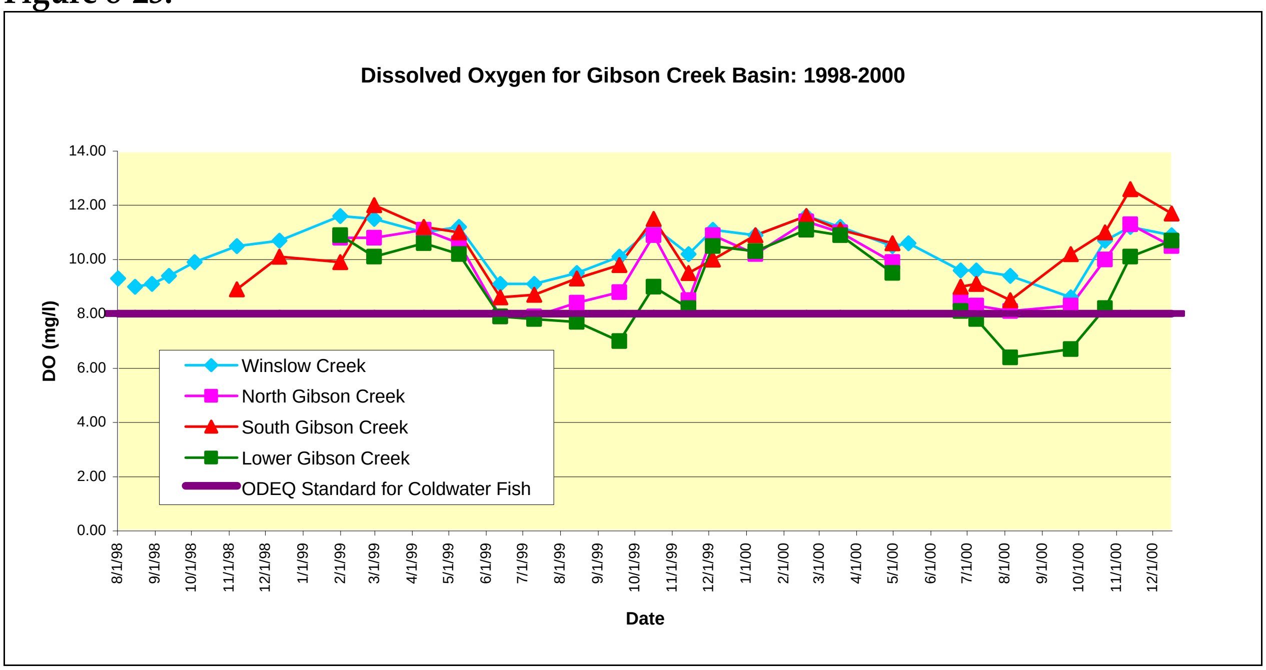
Data source: City of Salem Public Works Department (undated)

Figure 8-22.



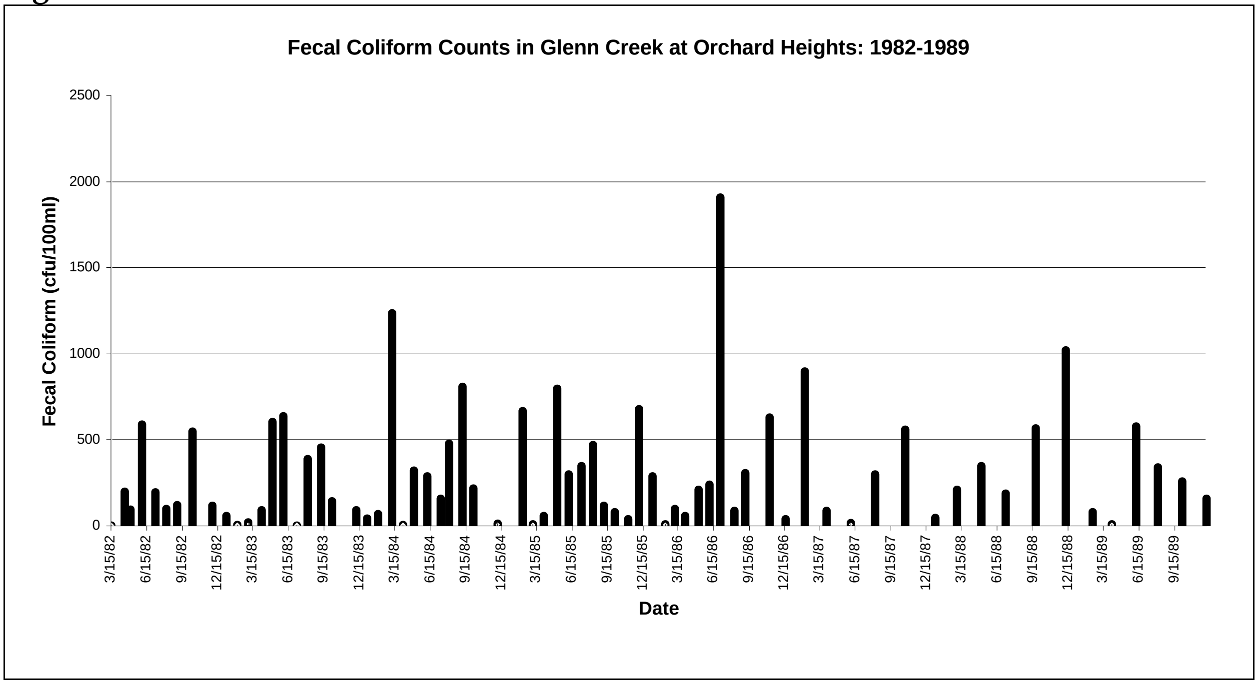
Data source: Glenn-Gibson Watershed Council (2001)

Figure 8-23.



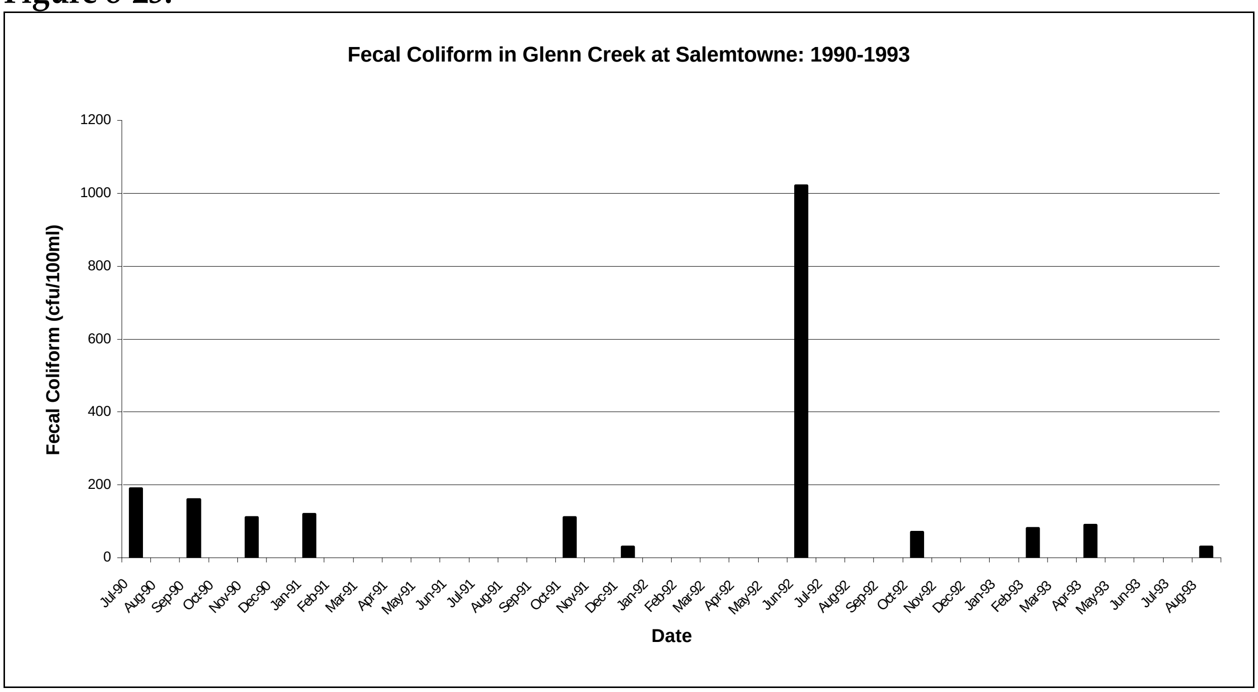
Data source: Glenn-Gibson Watershed Council (2001)

Figure 8-24.



Data source: City of Salem Public Works Department (undated)

Figure 8-25.



Data source: City of Salem Public Works Department (undated)

a. Water Temperature

Monthly sampling indicates that water temperatures along the main stem of Claggett Creek typically exceed the standard for cold-water fish during summer and early fall (**Figure 8-26**). Water temperatures exceeded standards at all three monitoring stations at least once during the 12-year sampling period.

Data collected by the Adopt-A-Stream class indicate high water temperatures during summer months and early fall (**Figure 8-27**).

Water temperatures for Hawthorne Ditch (C17) remained below 17.8 degrees Celsius (DEQ standard) during winter and spring months (**Figure 8-28**). However, the ditch experiences water levels of less than 1 inch during summer and early fall months, providing little to no habitat for aquatic species. Dry creek bed conditions were recorded several times during summer months.

Labish Ditch (C24) experienced high water temperatures during the summer months of 1990 and 1992.   No data were collected during the summer in 1991 or 1993 (**Figure 8-29**). Data collected prior to July 1990 indicate that Labish water temperatures typically remained below the DEQ water temperature standard.

b. Dissolved Oxygen

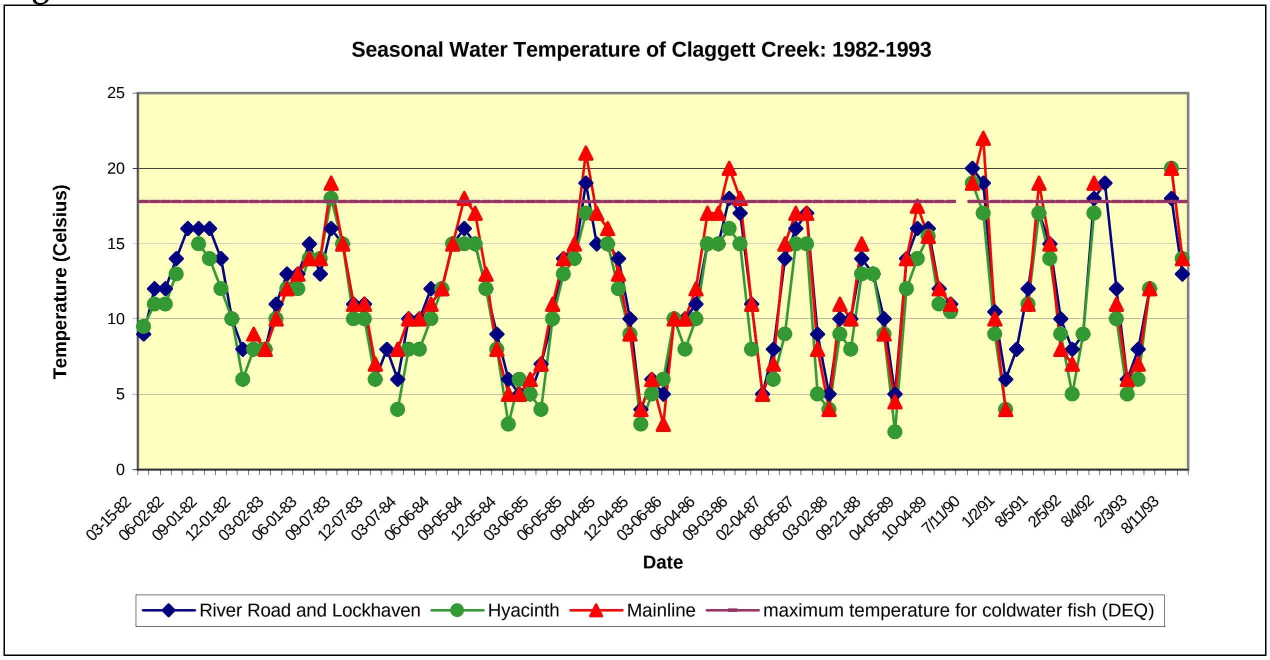
Claggett Creek is low in dissolved oxygen (DO) for five months a year between July and November (**Figure 8-30**). Claggett Creek has the longest duration of low oxygen levels of all the other creeks assessed in this report.

Data from the Adopt-A-Stream class indicate low DO levels during summer and early fall. DO levels were measured at or near the DEQ standard of 8.0mg/l during the spring and summer of 1995 (**Figure 8-27**).

Data collected at Hawthorne Ditch (C17) reveal low dissolved oxygen during summer and early fall for durations of three or four months (**Figure 8-31**). Water samples were only taken bi-monthly after 1986 for this monitoring station, so duration of oxygen depletion is probably longer than depicted on the graph for these years.

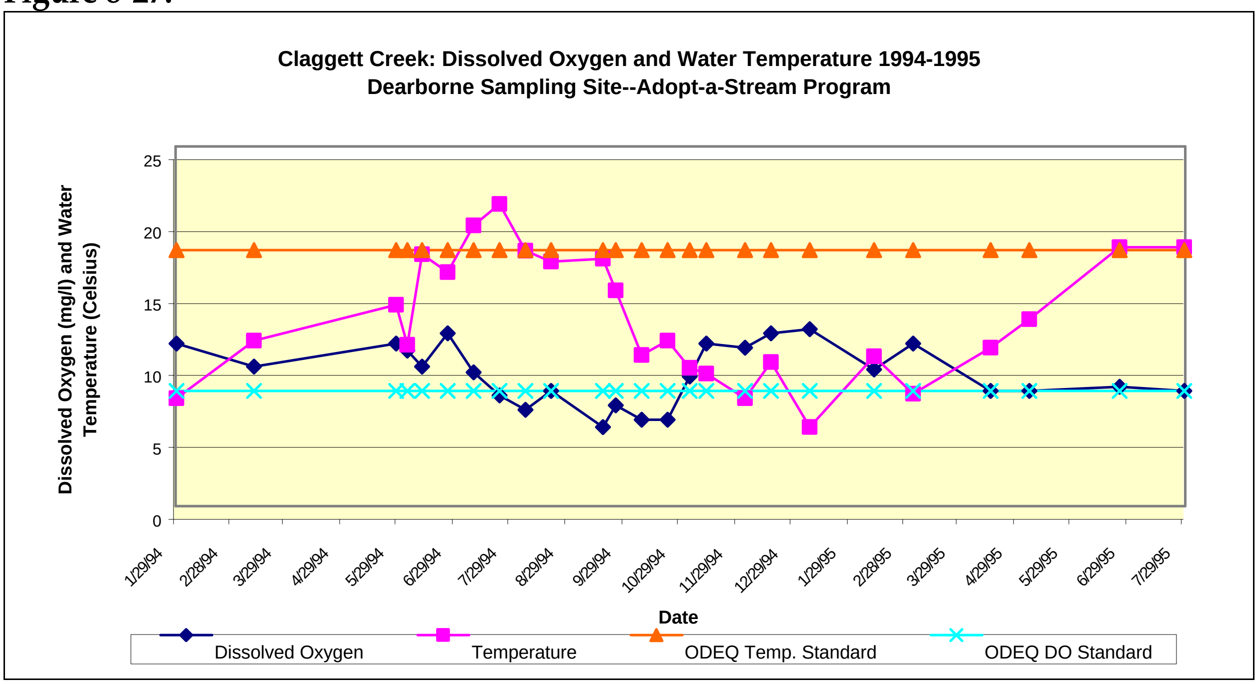
Labish Ditch (C24) experienced DO levels at or slightly lower than 8.0 mg/l from 1983 to 1987 (**Figure 8-32**). DO levels begin to fluctuate more dramatically after 1987. Water samples were only taken bi-monthly after 1986 for this monitoring station, so duration of oxygen depletion is probably longer than depicted on the graph for these years.

Figure 8-26.



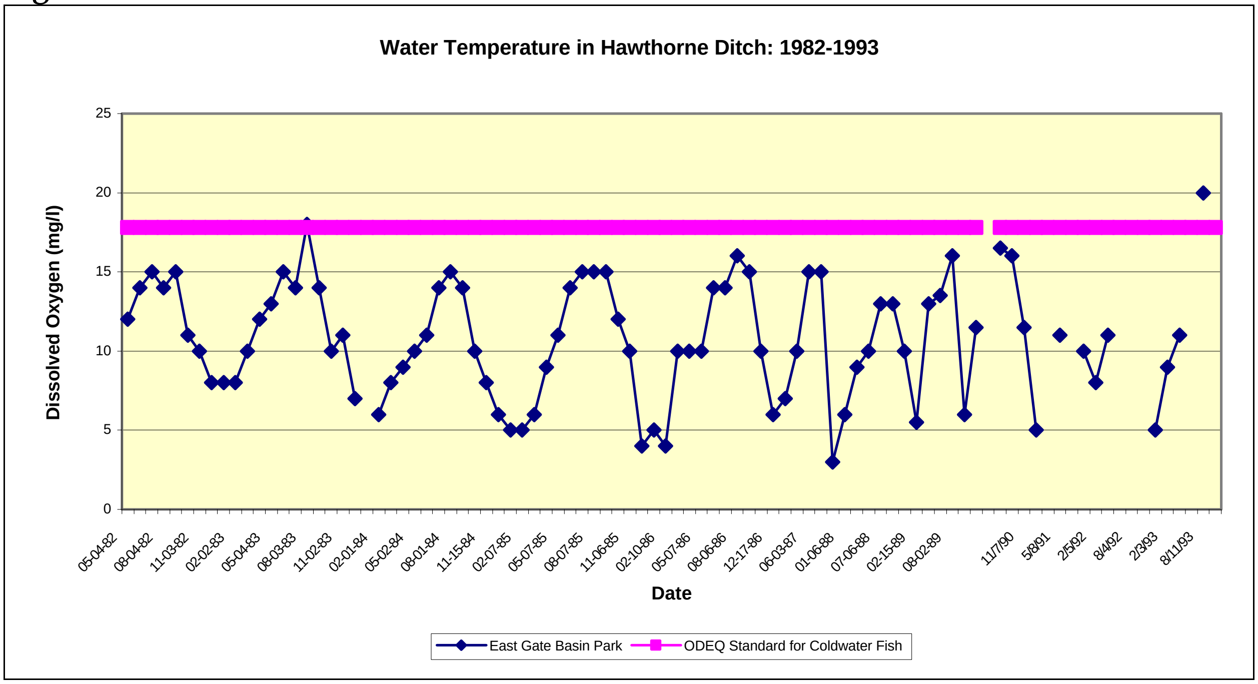
Data source: City of Salem Public Works Department (undated)

Figure 8-27.



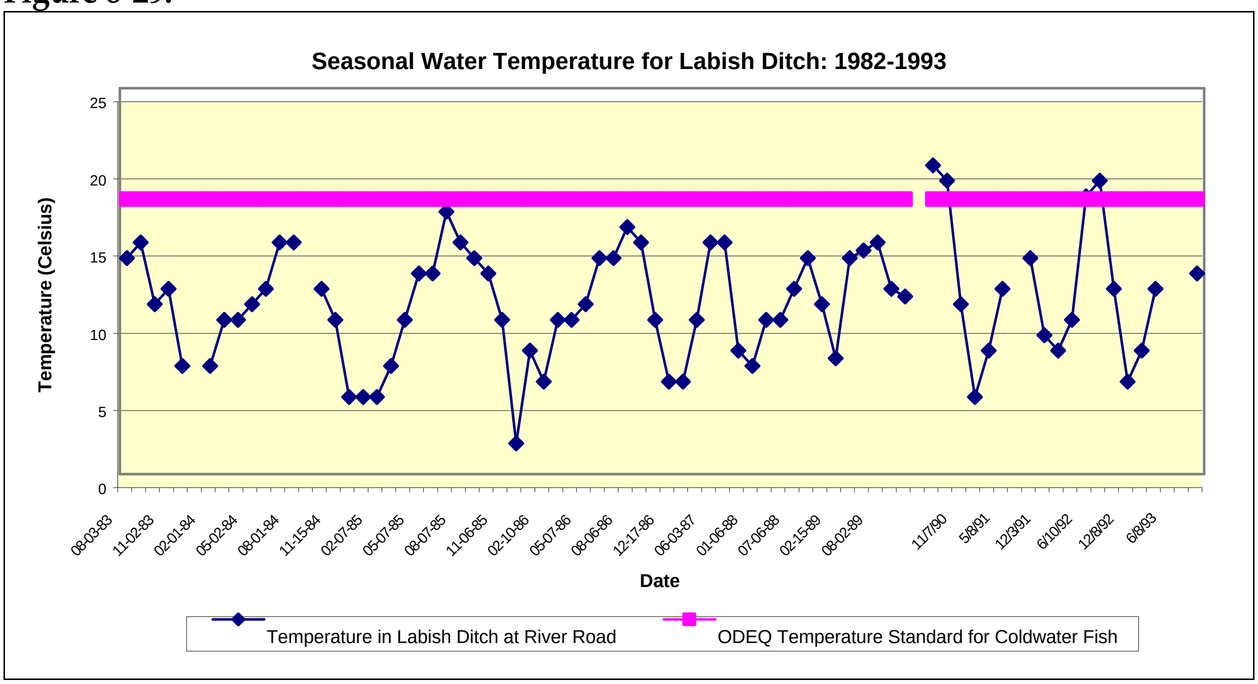
Data source: City of Salem Public Works Department (undated)

Figure 8-28.



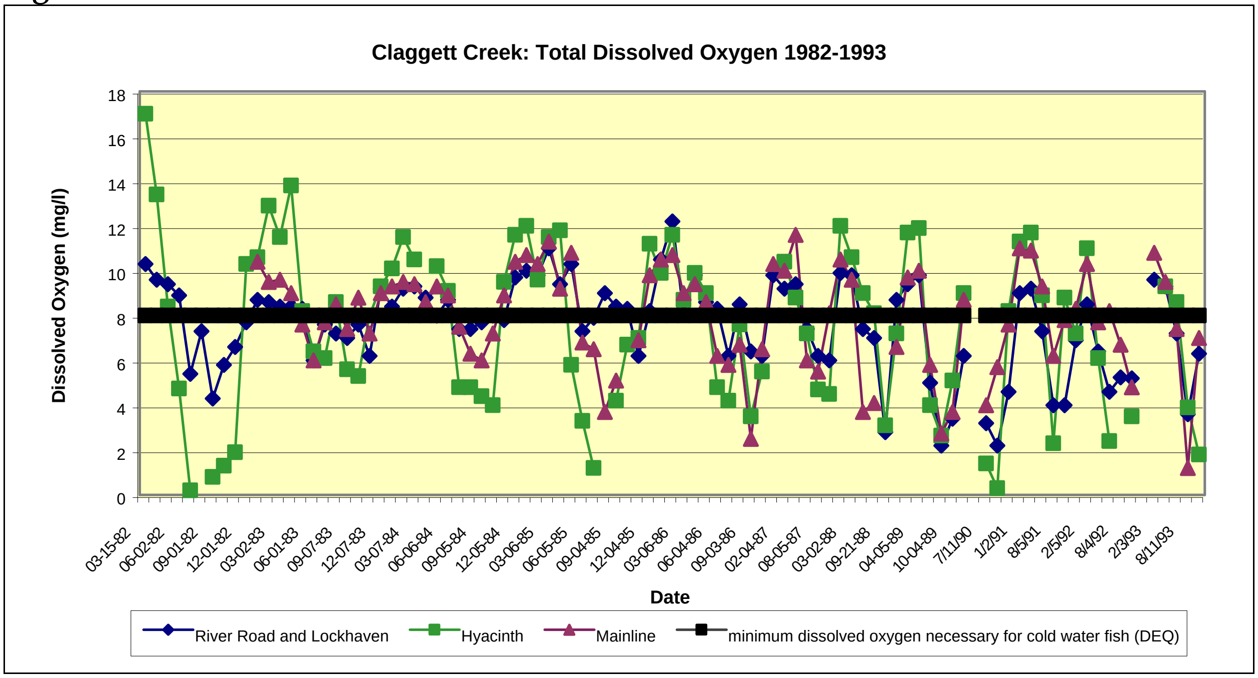
Data source: City of Salem Public Works Department (undated)

Figure 8-29.



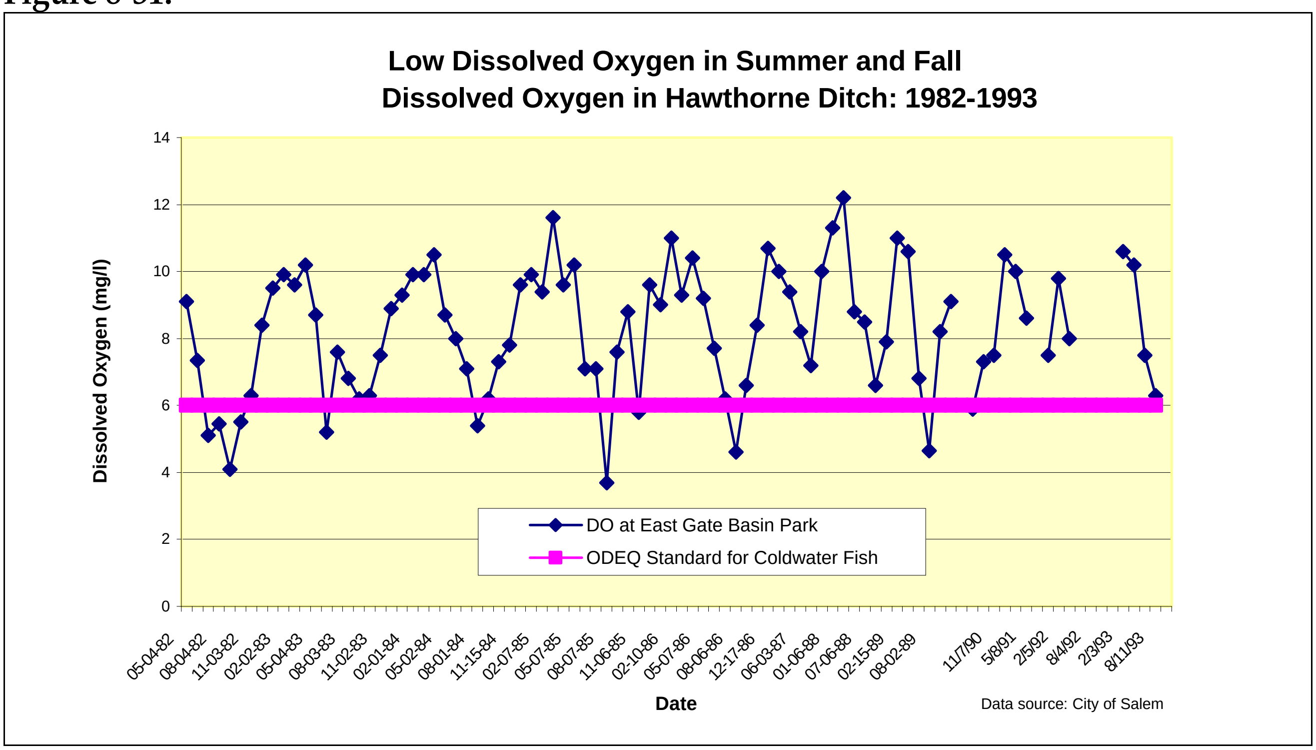
Data source: City of Salem Public Works Department (undated)

Figure 8-30.



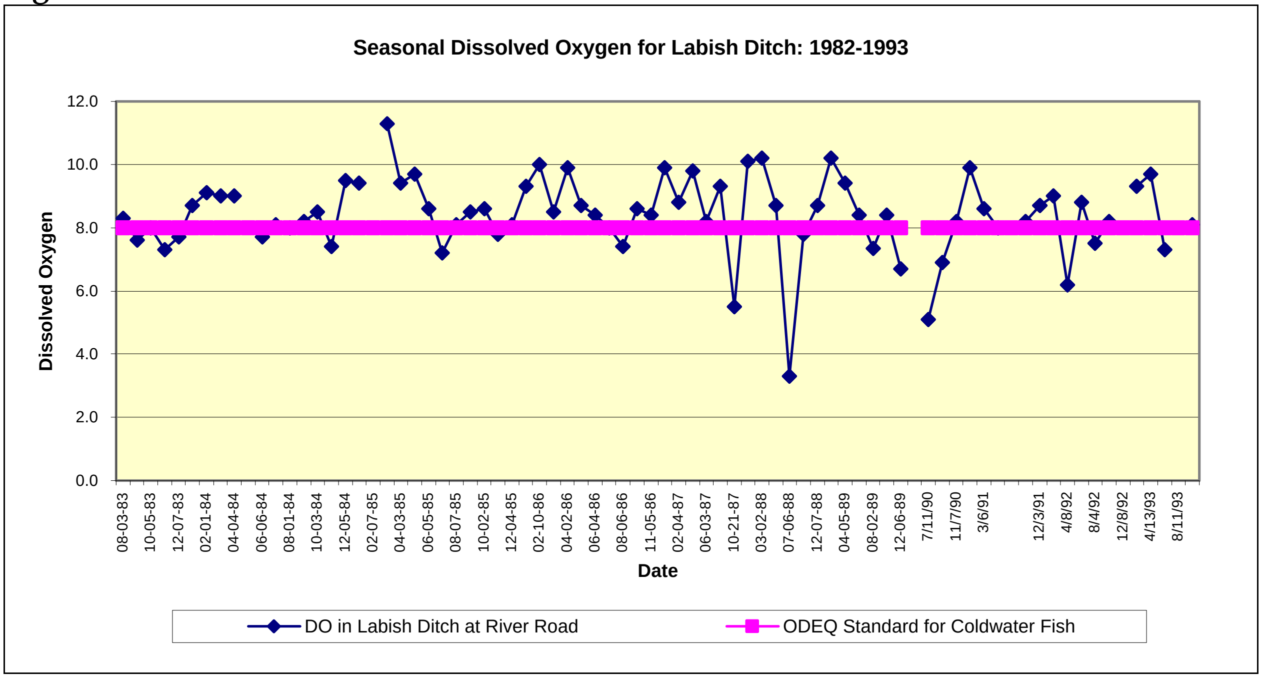
Data source: City of Salem Public Works Department (undated)

Figure 8-31.



Data source: City of Salem Public Works Department (undated)

Figure 8-32.



Data source: City of Salem Public Works Department (undated)

c. pH

From 1982-1993, city data indicate that Claggett Creek maintained normal pH levels (i.e., between 6.5 and 8.5) in all but five water quality samples taken. Three of the samples were only slightly more acidic than the recommended standard (e.g., 6.2, 6.4, 6.4). Two high pH recordings were documented at the Hyacinth water quality monitoring station (C2). A pH of 9.0 was recorded on March 15, 1982. On February 3, 1993, a pH of 10.8 was also recorded at this station.

d. Nutrients

Data on Total Nitrates were collected at all five monitoring stations sampled by the City of Salem. Nitrate concentrations exceeded the standard of 0.30mg/l (OWAM standard) at all five sites at least 47% of the time (**Table 8-17** and **Figure 8-33**). Water samples taken in Labish Ditch (C24) showed incredibly high nitrate concentrations, ranging from 1.3mg/l to 33 mg/l.

Total Phosphorus was not sampled in the Claggett Creek watershed.

Table 8-17. Total Nitrates for Claggett Creek Watershed: 1982-1993

	Sample Sites				
Statistic	**River Road**	**Hyacinth**	**Mainline**	**Hawthorne**	**Labish**
Number	82	79	81	76	73
Minimum	0.20	0.08	0.05	0.00	1.3
Maximum	3.70	3.90	5.00	9.20	33
Median	1.53	0.30	0.70	0.60	4.3
Number (>0.30mg/l)	80	37	59	47	73
% exceedance	97%	47%	73%	62%	100%

e. Fecal Coliform Bacteria

High fecal coliform levels (>400cfu/100ml) were detected frequently at all five sample sites between 1982-1993 (**Figures 8-34** and **8-35**). Counts of fecal coliform ranged from 0 to 16,760. High counts occurred in all four seasons, but were more frequent during summer and fall.

Fecal coliform levels in Labish Ditch (C24) (**Figure 8-35**) exceeded 400cfu/100 ml in 46% of the water samples taken, the highest of all five monitoring stations. The Hyacinth monitoring station (C2) (**Figure 8-36**) recorded high fecal coliform counts in 41% of the samples. The remaining three monitoring stations had high counts less frequently: Hawthorne, 15%; River Road, 28%; Mainline, 25%.

f. Macroinvertebrates

The McNary High School class collected macroinvertebrates as part of their Adopt-A-Stream program at the Dearborne monitoring station (S1) (**Map 8-5**). The students used hand-seining to collect the invertebrates. This method involves placing a net downstream and dislodging invertebrates from their hiding places by disturbing the streambed and shaking streamside vegetation upstream. The dislodged invertebrates then flow downstream into the net.

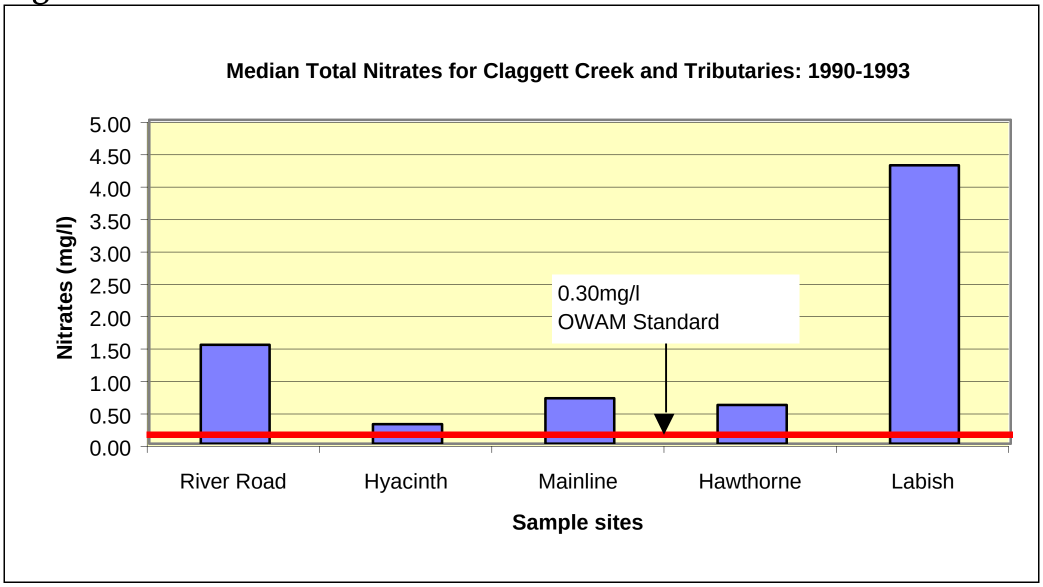
The macroinvertebrates collected ranged from species that were intolerant of poor water conditions (e.g., right-handed snails, caddisflies and stoneflies) to species that are commonly found in degraded streams (e.g., left-handed snails, aquatic worms and midge larvae). According to the analysis of data collected from spring of 1994 to spring of 1995, the most commonly collected invertebrate were scuds. Scuds are from the family Amphipoda. They look a lot like miniature freshwater shrimp, but they are only distantly related to marine shrimp. They live in the substrate of the streams. Scuds are "somewhat tolerant" of poor water quality.

Using the presence and abundance of different macroinvertebrate species as an indicator of stream health, Claggett Creek consistently ranks as having fair to good water quality.

4. Mill Creek

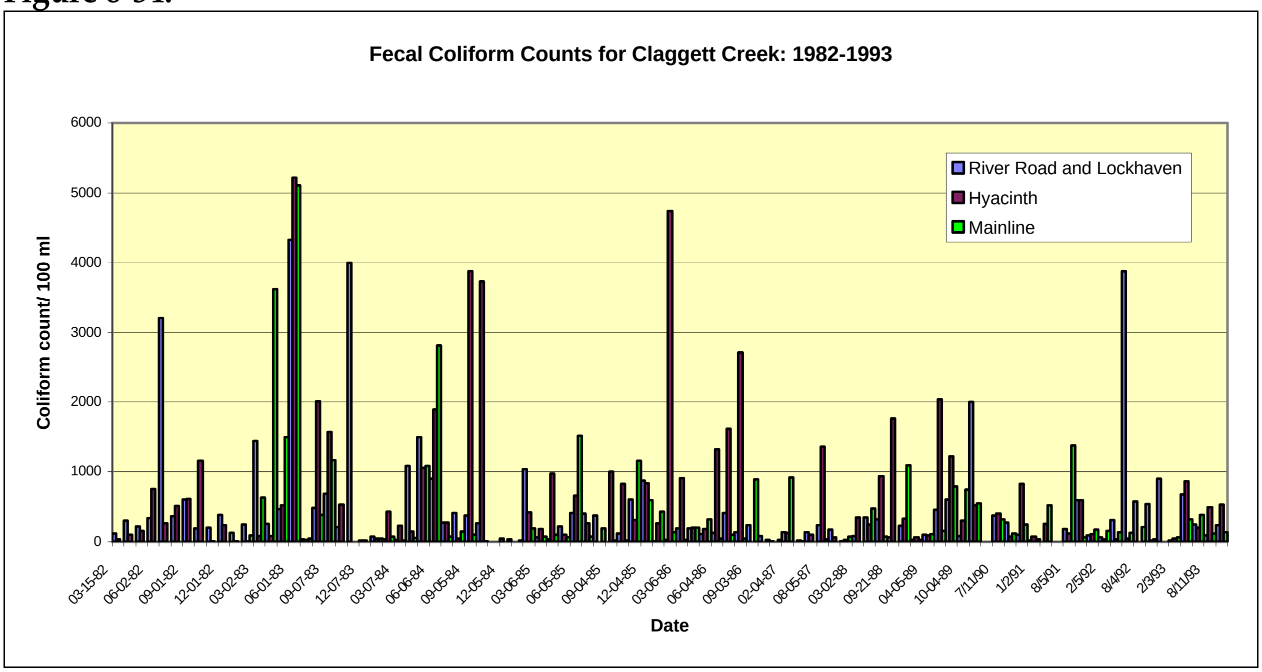
A total of 12 monitoring stations were established by the City of Salem in the Mill Creek watershed (**Map 8-6**). Seven monitoring stations are located along the mainstem of Mill Creek from Front Street (CMC 0707), near the mouth of Mill Creek at the Willamette River, to Bishop Road (CMC1604), located near Stayton just downstream from the creek's confluence with the Salem Ditch. No monitoring stations were established in Mill Creek upstream from Salem Ditch. Three additional monitoring stations were established along the Salem Ditch (CMC 1803, CMC 1901, CMC 1902), a hand-dug channel that diverts water from the North Santiam River into Mill Creek. Water quality was also sampled in Shelton Ditch (C21), a ditch that diverts flow from Mill Creek into Pringle Creek. Finally, one monitoring station was established in Battle Creek (C16), a tributary to Mill Creek that is located in south Salem and flows west to east and empties into Mill Creek near Turner. No monitoring stations were established in any other tributary to Mill Creek, including Beaver Creek, which drains the northern portion of the Mill Creek watershed.

Figure 8-33.



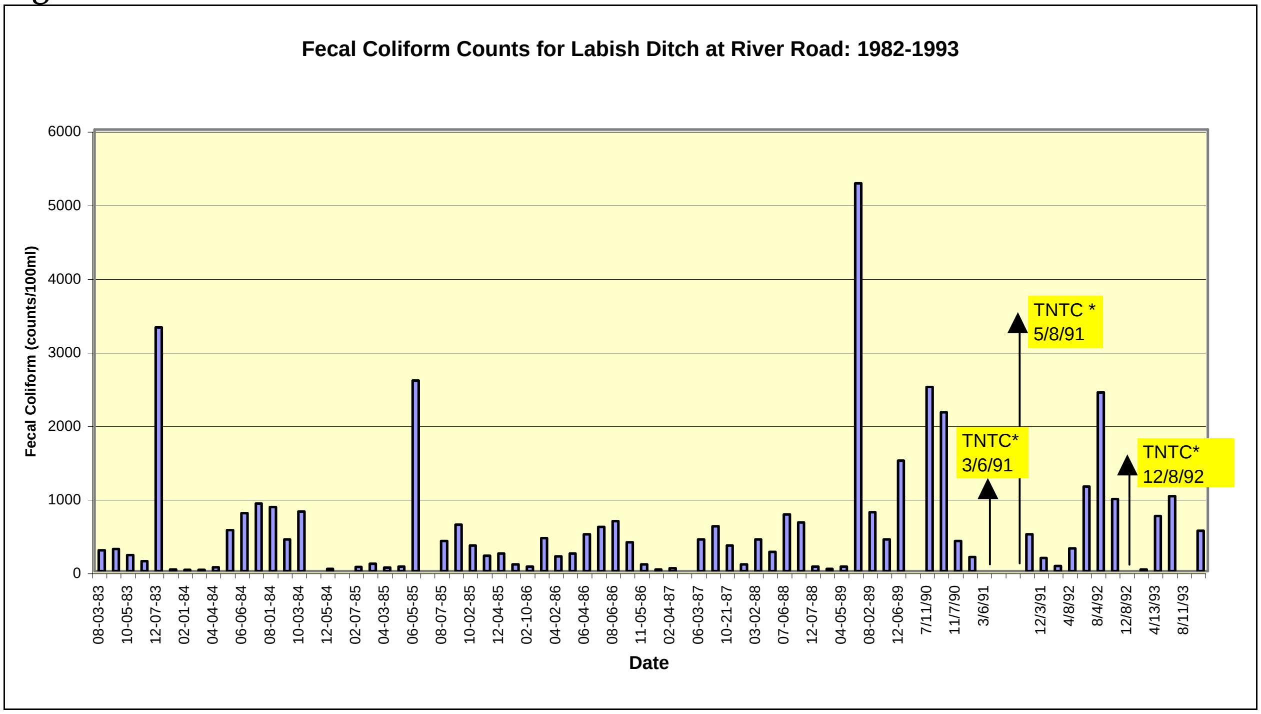
Data source: City of Salem Public Works Department (undated)

Figure 8-34.



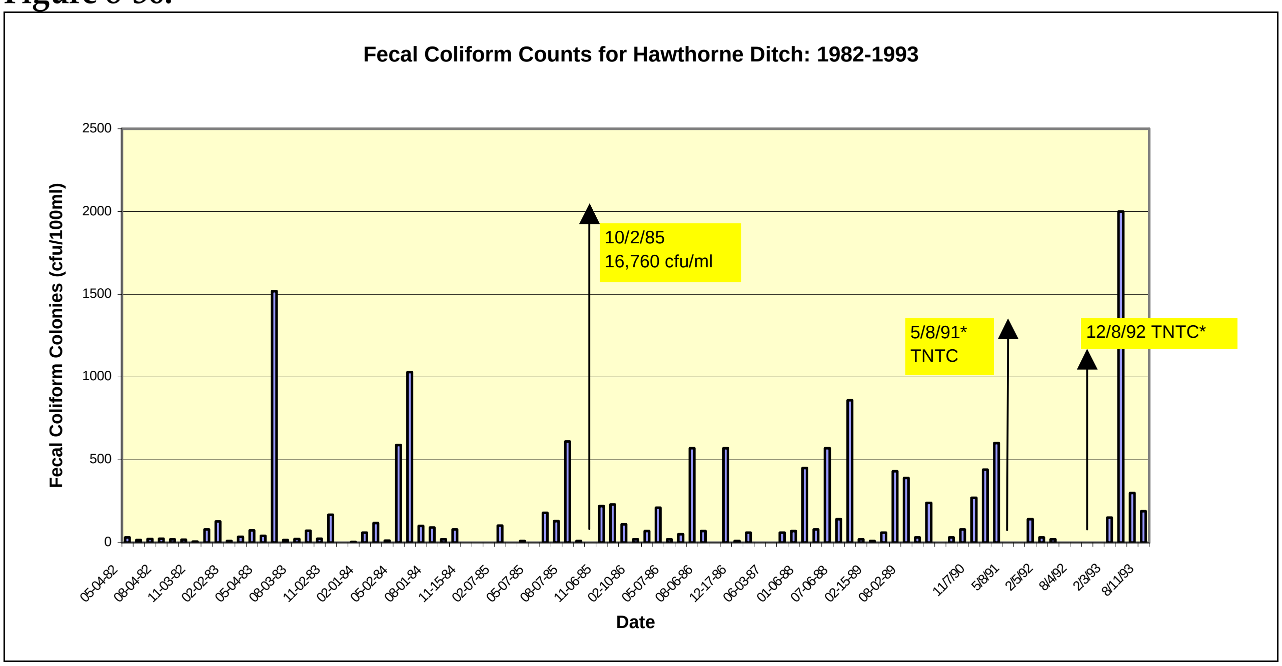
Data source: City of Salem Public Works Department (undated)

Figure 8-35.



*too numerous to count

Figure 8-36.



*too numerous to count

Data source: City of Salem Public Works Department (undated)

Duration of sampling at the 12 sites varied (**Table 8-11**). Monitoring stations at Front Street, 23rd Street (CMC 0308) and Turner Road (CMC0707) were sampled from 1982 to 1995. Battle Creek was monitored from 1982 to 1993. Shelton Ditch was monitored from 1983 to 1993. Monthly sampling occurred at the rural monitoring stations {i.e. Delaney Road (CMC1006), 70th Street (CMC1305), and Bishop Road (CMC1604)} and the Salem Ditch (i.e. Shaff Road, Cascade Road, and Pioneer Park) from 1990 to 1995.

Because of the number of sample points and the variation in collection times, Mill Creek water quality data is graphed based on location of monitoring stations. Data collected from the urban monitoring stations are graphed together, as are the data from stations near the urban growth boundary, and from the rural stations. For comparison of urban and rural monitoring stations, Front Street and Bishop Road were graphed together.

a. Water Temperature

The lowest and highest water temperatures recorded for Mill Creek vary by over 21 degrees Celsius. The lowest water temperature recorded was 1 degree Celsius in February of 1989 at the Turner (CMC 0707) monitoring station. In contrast, a water temperature of 22.4 degrees Celsius was recorded at both the Turner and Front Street (CMC 0010) sample sites in July of 1995.

Recorded water temperatures sometimes exceeded the DEQ standard of 17.8 degrees Celsius during July, August and/or September in Mill Creek (**Figures 8-37, 8-38** and **8-39**). Urban sites exceeded the standard every year between 1990-1995 with the exception of 1992 when no water samples were taken in July or August (**Figure 8-37**). Of the 170 samples taken between 1990 and 1995, the urban sites exceeded the standard 10% of the time. Samples taken near the urban growth boundary exceeded the standard 6% (21 out 352 samples) of the time (**Figure 8-38**). Only 1% (3 out of 267 samples) of the readings exceeded the standard at the rural monitoring stations. A comparison of urban and rural sample sites indicates that water temperatures are consistently lower in the rural area (**Figure 8-40**). However, temperatures taken at the Bishop Road (CMC 1604) monitoring station are probably influenced by North Santiam water flowing out of the Salem Ditch. Water temperatures in the ditch are cold (**Figure 8-41**). No data are available in Mill Creek above Salem Ditch. As for Shelton Ditch, water temperatures exceeded 17.8 degrees Celsius nine times from 1983-1993 (**Figure 8-42**).

Not all tributaries to Mill Creek had high summer temperatures. Only one sample taken from Salem Ditch in 1995 exceeded the DEQ temperature standard (**Figure 8-41**). Data collected from Battle Creek indicate that stream temperatures were below or at DEQ standard the duration of the monitoring period (**Figure 8-43**).

In addition to the surface water quality monitoring conducted by the City of Salem, OWRD has a permanent water quality monitoring station that continuously records temperature, flow and water levels in Mill Creek. The water quality-monitoring probes were installed at the OWRD gauging site on Mill Creek behind North Salem High School. While the probes are calibrated and working, the satellite link that was supposed to transmit the data to various websites is not functioning properly. Friends of Mill Creek received an OWEB grant in 2001 to purchase more equipment, including *E. coli* monitoring equipment, which is portable. The high school will be working with DEQ to use this equipment in its field biology classes and will make it available to other area schools and organizations.

b. Dissolved Oxygen

Dissolved oxygen does not seem to be a limiting factor for salmonids in the main stem of Mill Creek (**Figures 8-44, 8-45** and **8-46**) or in Shelton Ditch (**Figure 8-47**). With one exception on September 14, 1994, dissolved oxygen levels were above the DEQ standard of 8.0mg/l. The low DO level measured on this date may be a sampling error.

Unlike Mill Creek, Battle Creek seems to suffer from low DO levels from July to September. From 1982 to 1993 dissolved oxygen in Battle Creek dipped below the DEQ standard 10 times (**Figure 8-48**).

Low dissolved oxygen levels were routinely recorded in the Salem Ditch at the Cascade Road monitoring station (CMC1901) during summer and early fall months (**Figure 8-49**). Low dissolved oxygen was not recorded at the other two monitoring stations located above and below Cascade Road.

c. pH

Most water quality samples taken along the main stem of Mill Creek recorded normal pH levels (**Table 8-18**). A large percentage of low pH recordings were taken from Salem Ditch, especially at the Cascade water quality monitoring station (CMC1901). Most of the samples taken at Cascade were only slightly lower than 6.5. Only 4 of the 31 samples with low pH were below 6.0.

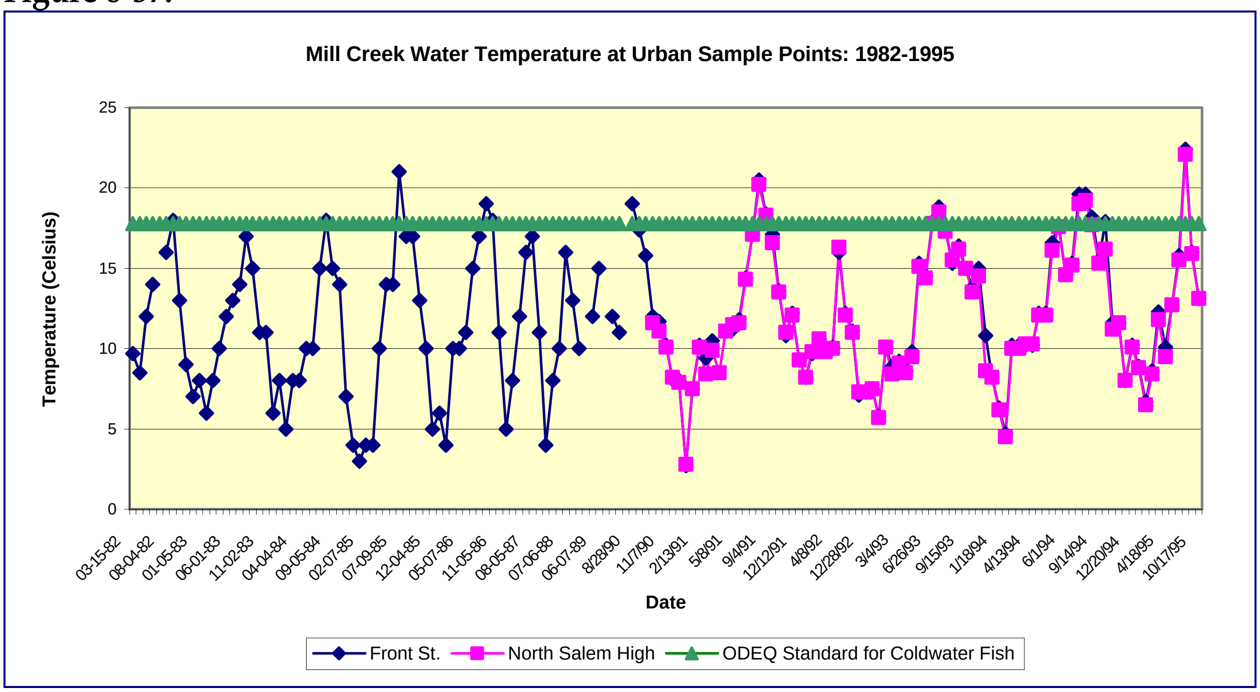
A high percent of low pH samples was also recorded in Battle Creek, however, none of the low pH recordings fell below 6.2.

Table 8-18. pH Levels for Mill Creek

		Low (<6.5)	High (>8.5)	Total	# of samples	%exceedence
Mainstem of Mill Creek						
MC0010	Front	2	0	2	86	2%
MC0209	North Salem H.S.	3	0	3	83	4%
MC0308	23rd	3	0	3	178	2%
MC0707	Turner	7	0	7	178	4%
MC1006	Delaney	4	0	4	90	4%
MC1305	70th	11	0	11	92	12%
MC1604	Bishop	8	0	8	85	9%
Salem Ditch						
MC1803	Shaff	14	0	14	86	16%
MC1901	Cascade	31	0	31	80	38%
MC1902	Pioneer	14	0	14	83	17%
Tributaries of Mill Creek						
16	Battle Creek	17	0	17	90	19%
21	Shelton Ditch	0	0	0	76	0%

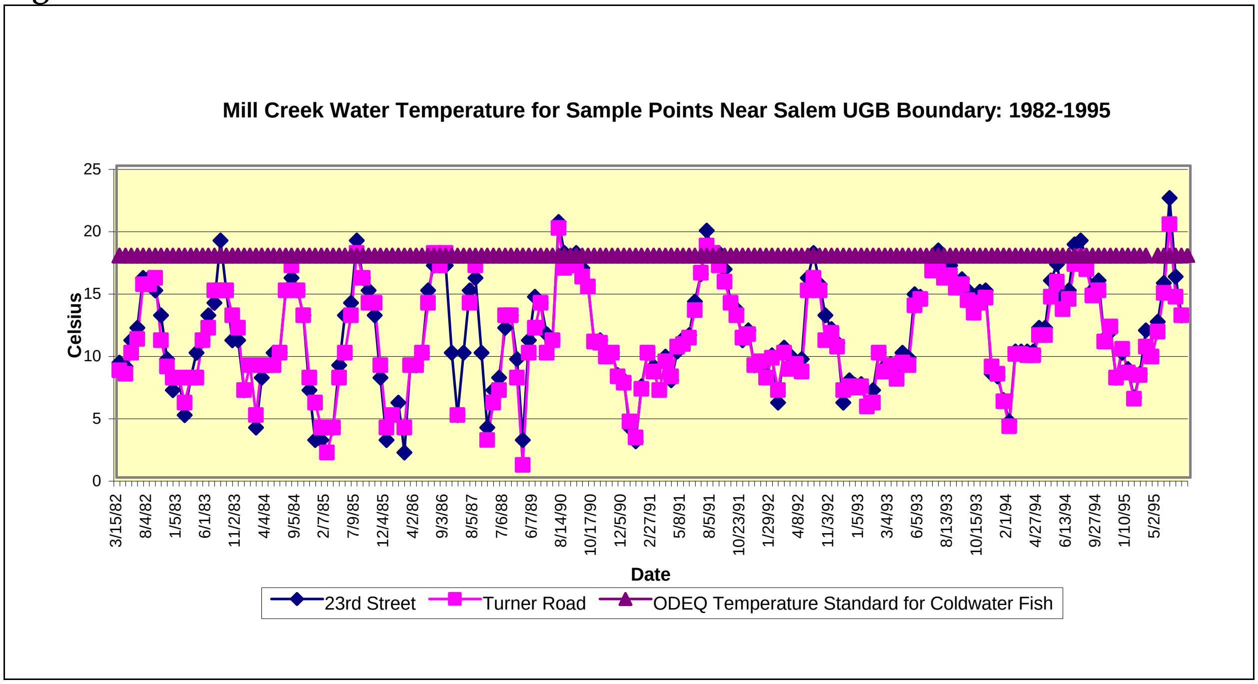
Data Source: ODWR (2001)

Figure 8-37.



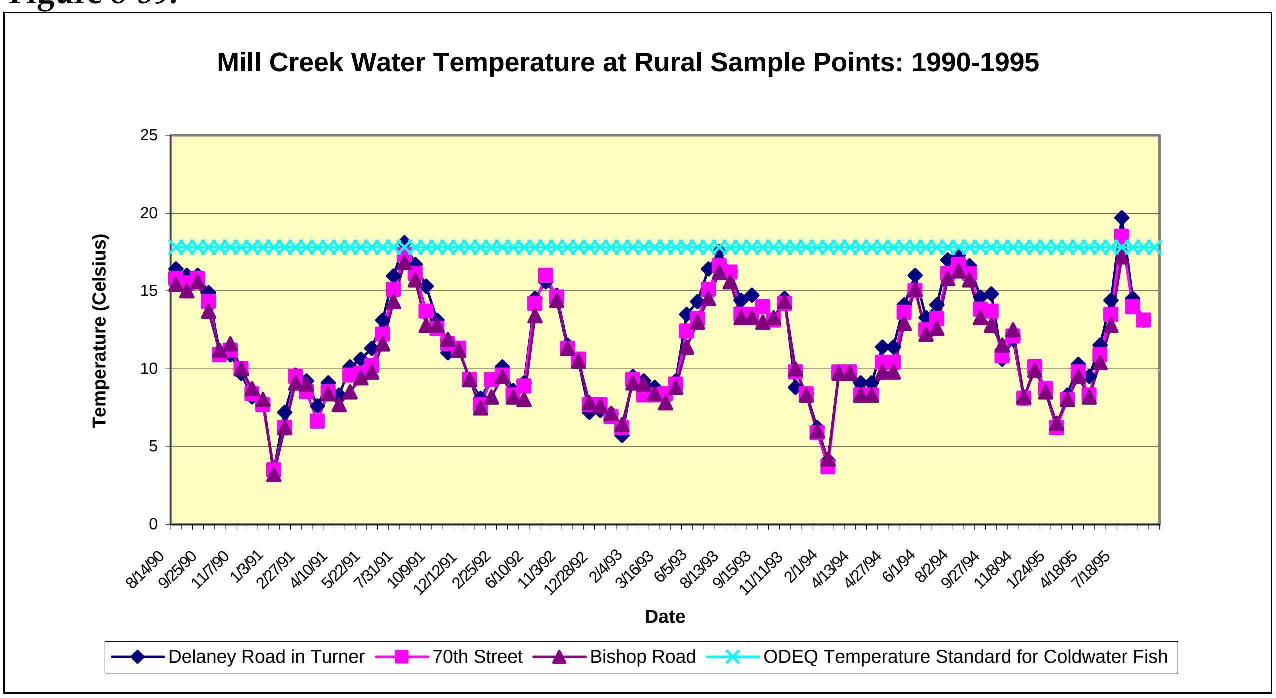
Data source: City of Salem Public Works Department (undated)

Figure 8-38.



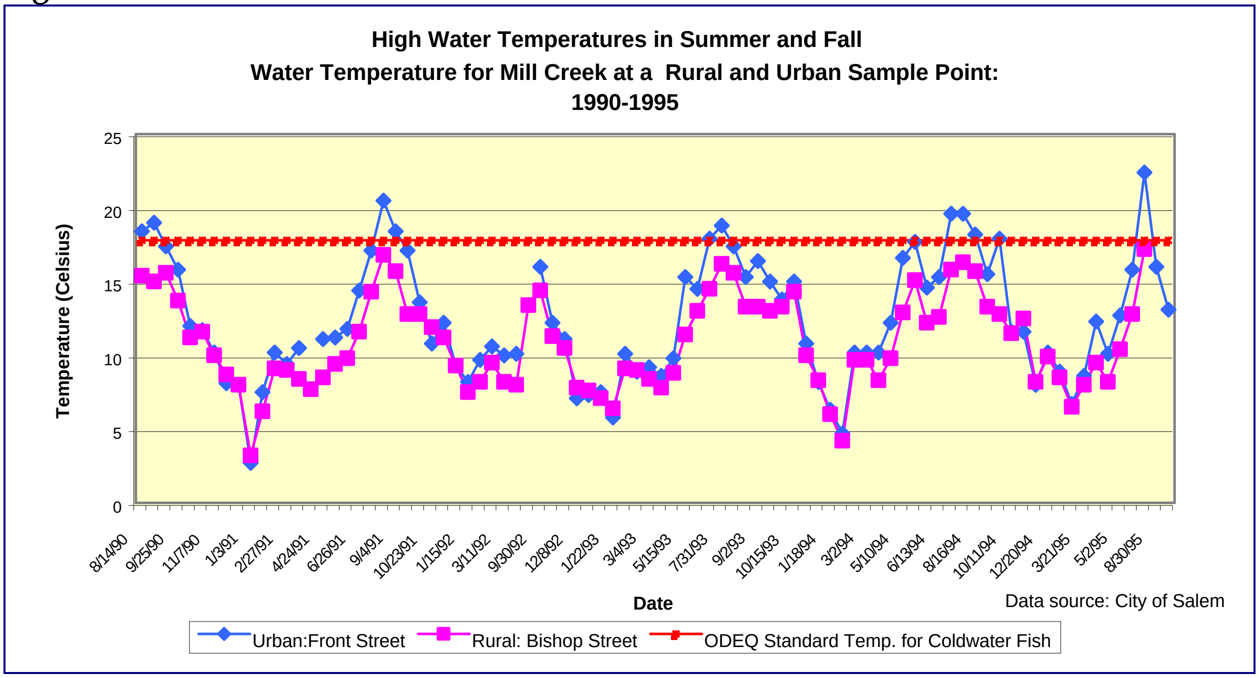
Data source: City of Salem Public Works Department (undated)

Figure 8-39.



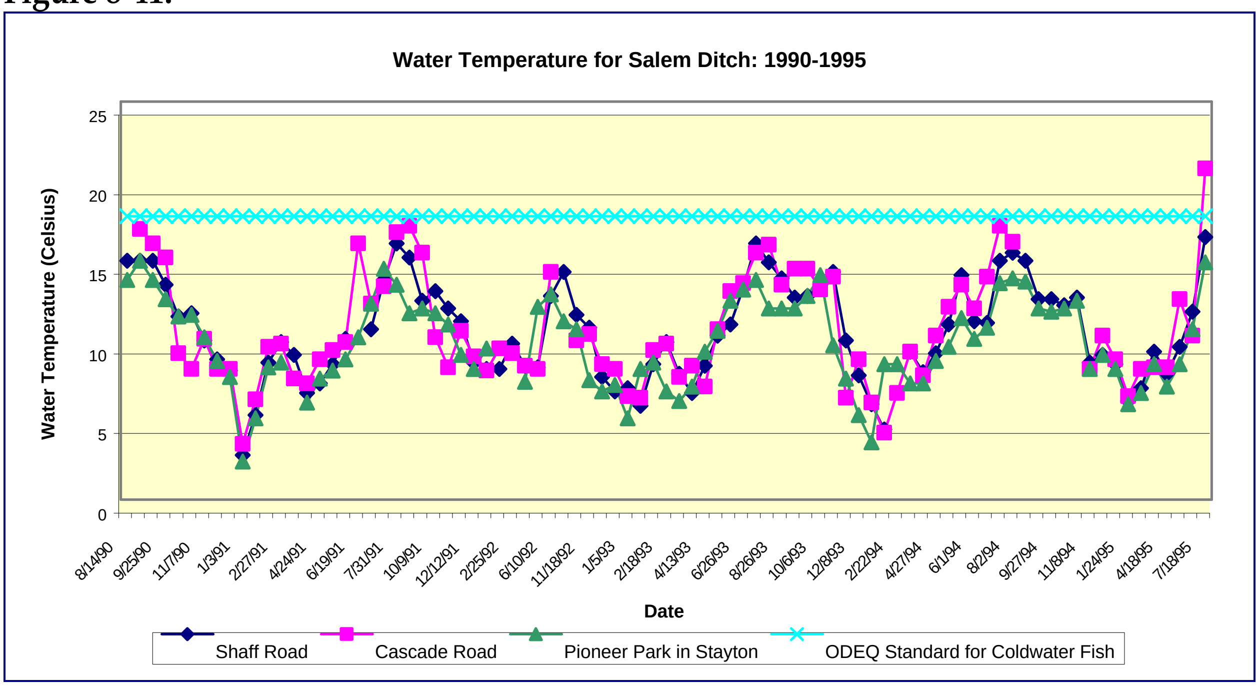
Data source: City of Salem Public Works Department (undated)

Figure 8-40.



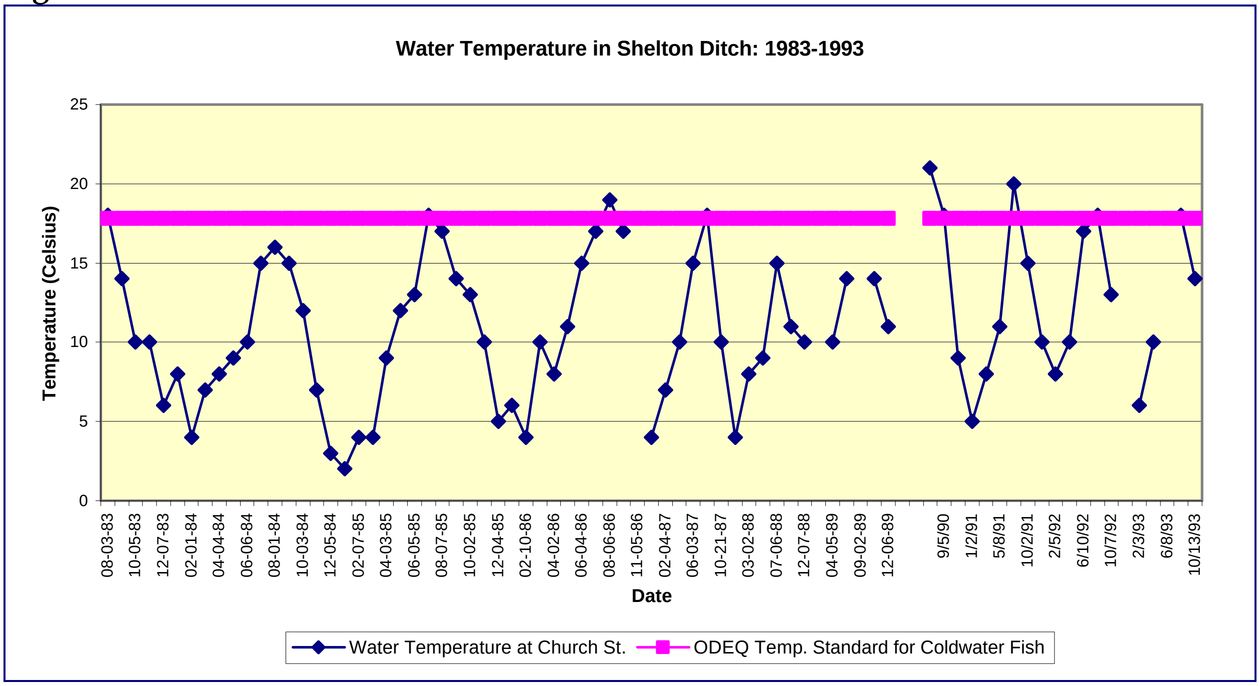
Data source: City of Salem Public Works Department (undated)

Figure 8-41.



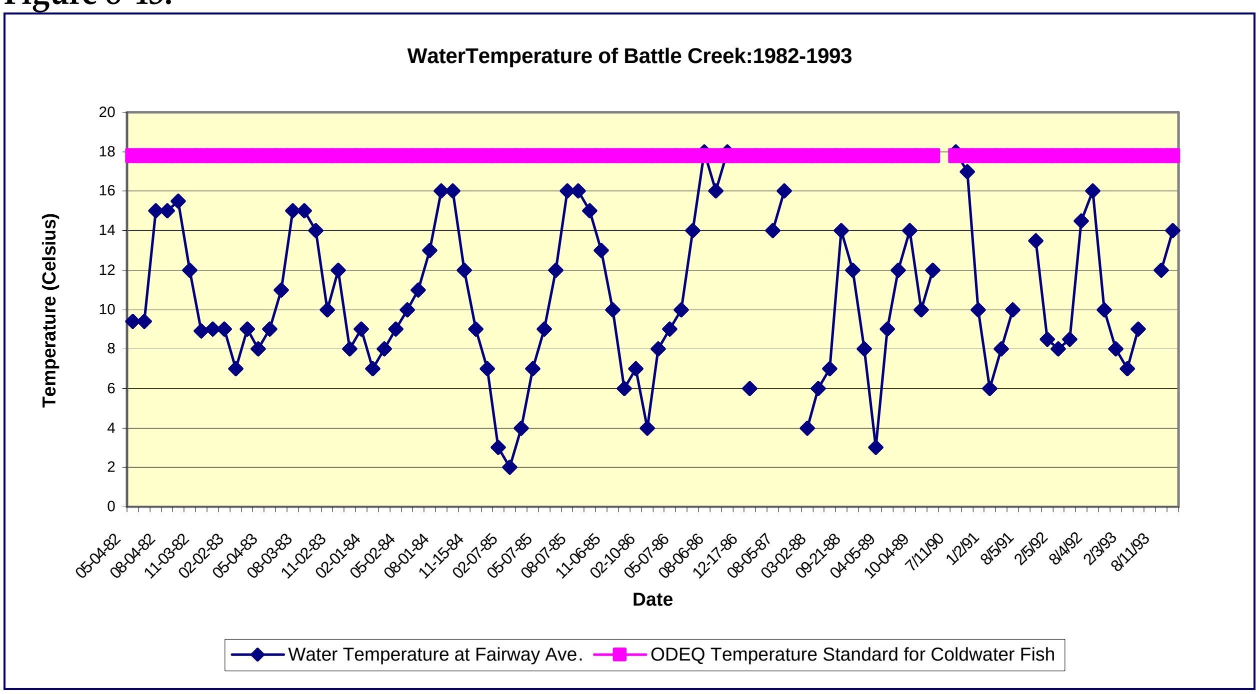
Data source: City of Salem Public Works Department (undated)

Figure 8-42.



Data source: City of Salem Public Works Department (undated)

Figure 8-43.



Data source: City of Salem Public Works Department (undated)

Figure 8-44.

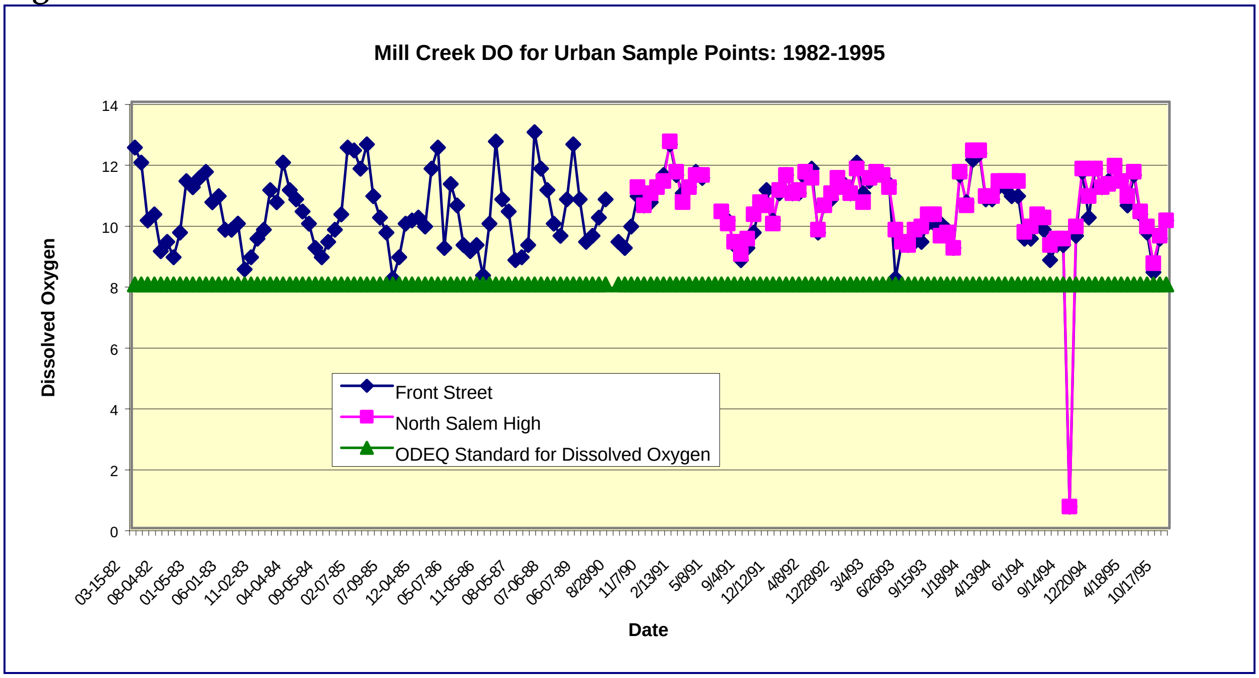


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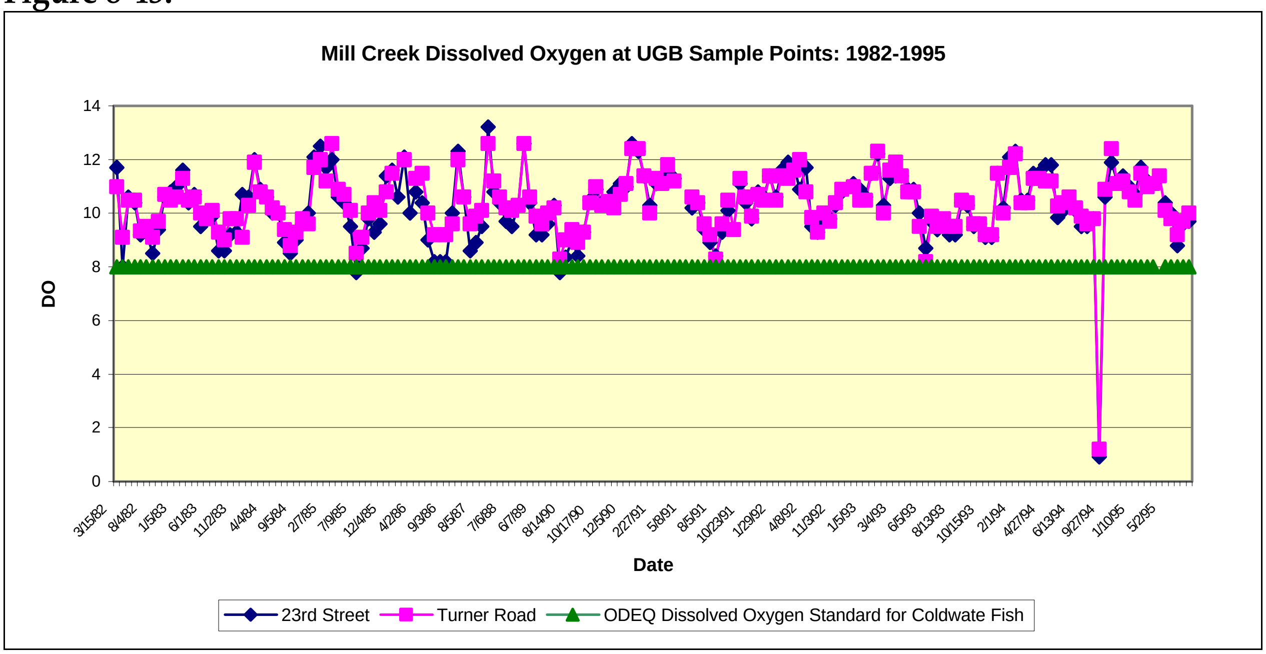
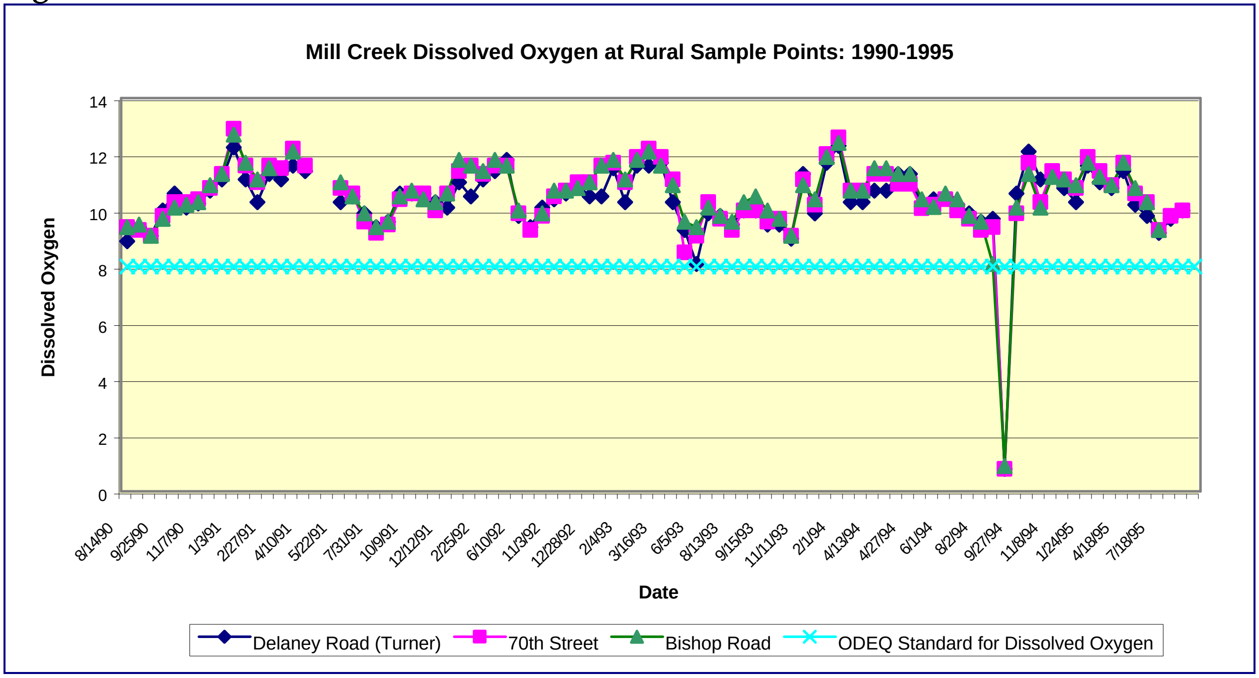
Figure 8-45.



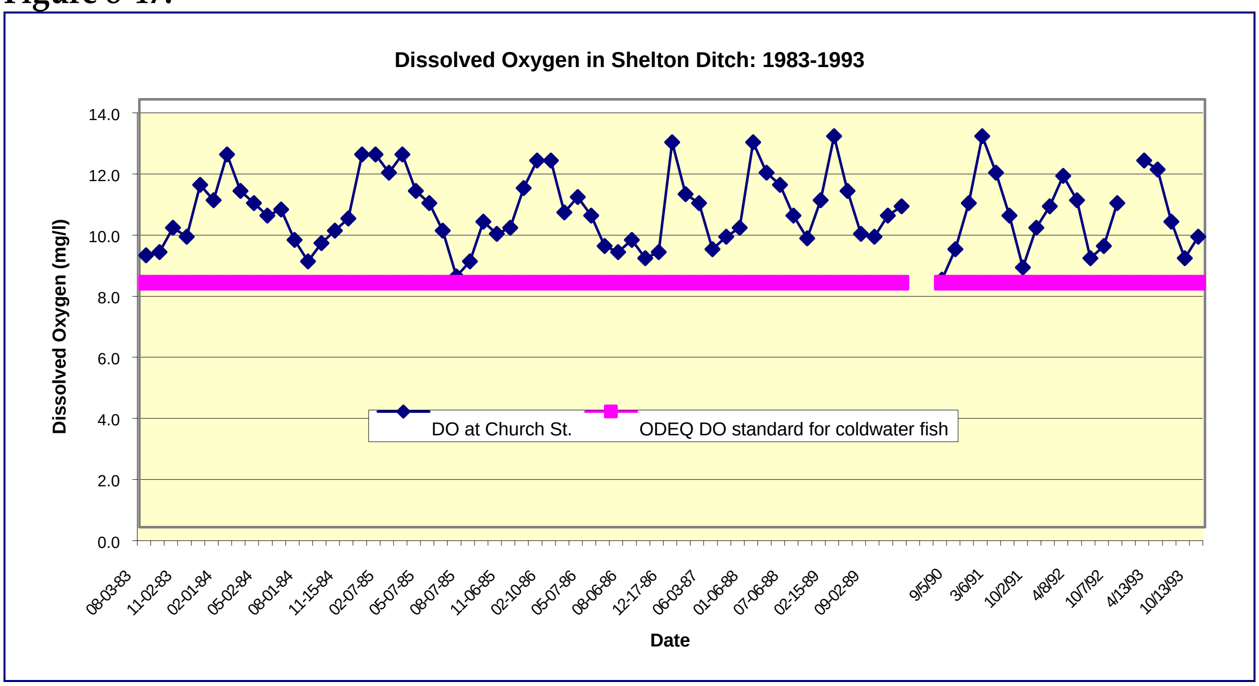
Data source: City of Salem Public Works Department (undated)

Figure 8-46.



Data source: City of Salem Public Works Department (undated)

Figure 8-47.



Data source: City of Salem Public Works Department (undated)

Figure 8-48.

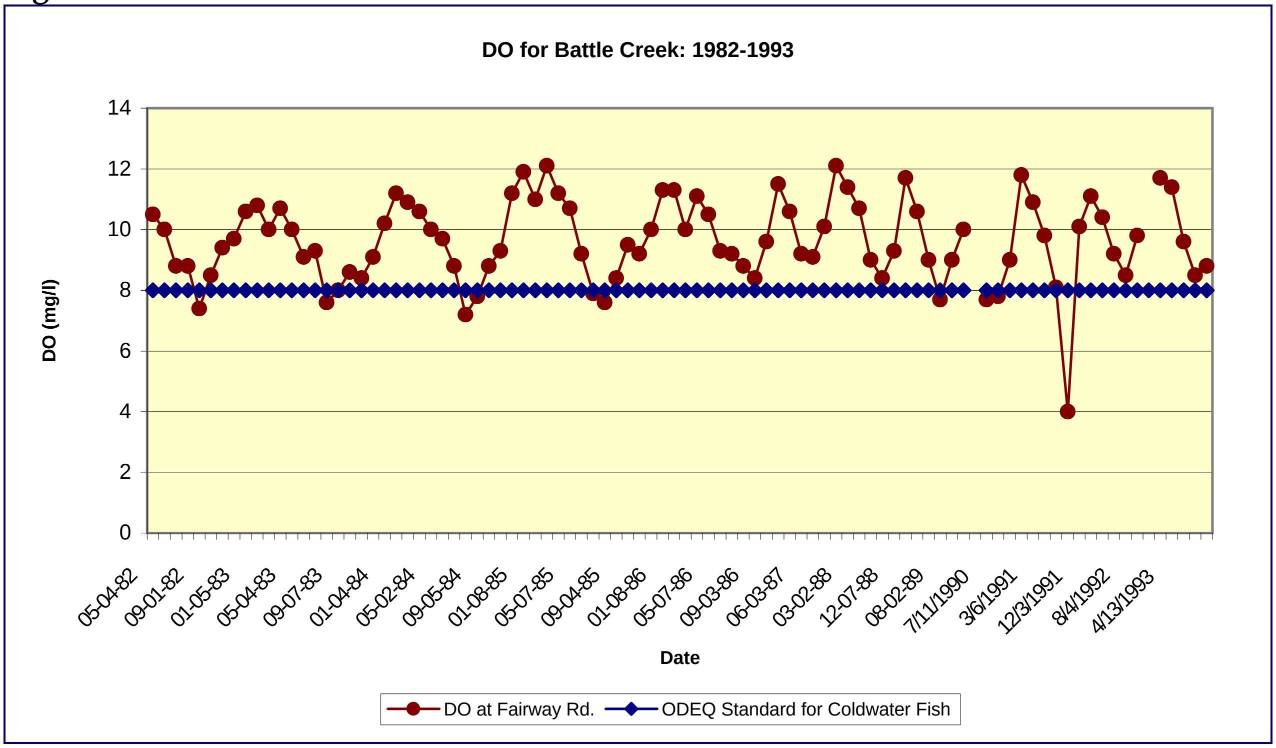


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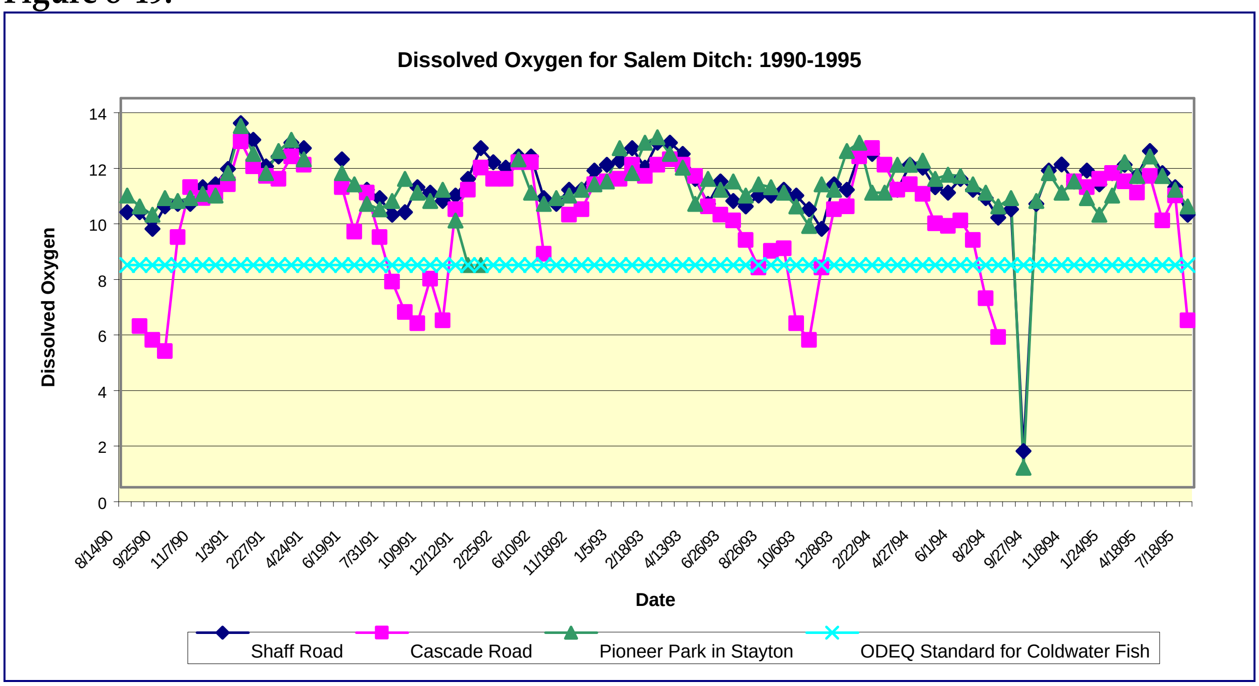
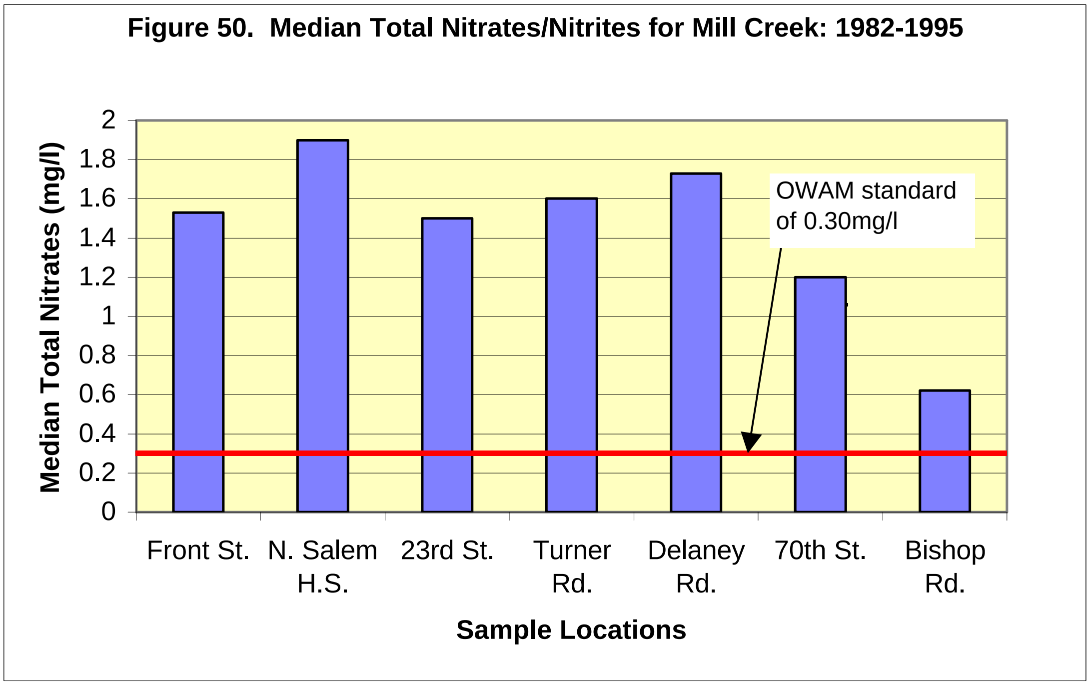
Figure 8-49.



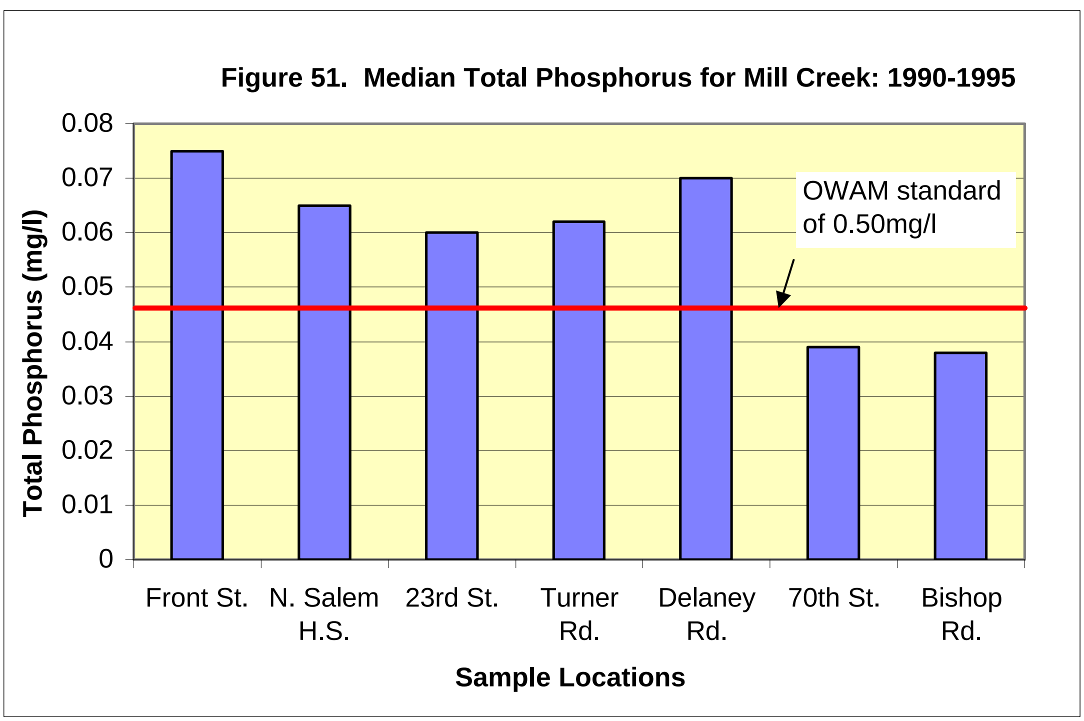
Data source: City of Salem Public Works Department (undated)

Figure 8-50.



Data source: City of Salem Public Works Department (undated)

Figure 8-51.



Data source: City of Salem Public Works Department (undated)

d. Nutrients

Total Kjeldahl Nitrogen exceeded OWAM's recommended standard of 0.30 mg/l in 88% of the samples taken along the main stem of Mill Creek. Over 90% of the samples taken from five of the seven monitoring stations exceeded the standard (**Table 8-19**). Graphing median Total Nitrates reveals two large jumps in Total Nitrates at the 70th Street monitoring station (CMC1305) and at Delaney Road (CMC1006) (**Figure 8-50**). Nitrate levels remained high for the lower portion of the creek.

Table 8-19. Total Nitrate/Nitrite Statistics for Mill Creek: 1982-1995

Total Nitrates	Front St.	N. Salem H.S.	23rd St.	Turner Rd.	Delaney Rd.	70th St.	Bishop Rd.
Number	145	80	164	164	87	87	83
Minimum	0.034	0.24	0	0	0.084	0.001	0
Maximum	7.25	7.68	7.65	7.95	66	5.1	2.691
Median	1.53	1.9	1.5	1.6	1.73	1.2	0.62
Number (>0.30mg/l)	132	76	150	152	81	69	53
% exceedance	91%	95%	91%	93%	93%	79%	64%

Measurements of Total Phosphorus in Mill Creek indicate a similar pattern as the nitrates/nitrites (**Table 8-20**). Approximately 58% of the water quality samples taken exceeded OWAM's recommended standard of 0.05mg/l. Median Total Phosphorus levels jumped at Delaney Road (CMC1006), exceeding the standard, and remained high during the remaining length of the stream (**Figure 8-51**).

Table 8-20. Total Phosphorus Statistics for Mill Creek: 1990-1995

Total Phosphorus	Front St.	N. Salem H.S.	23rd St.	Turner Rd.	Delaney Rd.	70th St.	Bishop Rd.
Number	85	81	84	85	87	87	83
Minimum	0.008	0.007	0.006	0.006	0.006	0	0.003
Maximum	0.82	0.8	0.83	0.901	2.35	1.082	1.101
Median	0.075	0.065	0.06	0.062	0.07	0.039	0.038
Number (>0.05 mg/l)	60	55	54	54	57	34	27
% exceedance	71%	68%	64%	63%	65%	39%	32%

The Delaney Road (CMC1006) monitoring station is below Mill Creek's confluence with McKinney Creek, Battle Creek and Beaver Creek. A jump of nitrate and phosphorus levels at this station may therefore indicate high levels of nutrients flowing from these tributaries.

North Santiam water flowing through Salem Ditch has lower levels of nitrates/nitrites and phosphorus (**Table 8-21 and 8-22**) compared to Mill Creek. The only exception is found at the Cascade Road (CMC1901) monitoring station where 93% of the samples taken exceeded the nitrate standard (**Figure 8-52**). Although 29% of the samples taken in Salem Ditch exceeded the phosphate standard, median total phosphate levels remained below 0.05 mg/l at all three stations (**Figure 8-53**).

Table 8- 21. Total Nitrate/Nitrite Statistics for Salem Ditch: 1990-1995

Total Nitrates	Shaff Road	Cascade Road	Pioneer Park
Number	80	81	80
Minimum	0.00	0.36	0
Maximum	1.54	3.4	1.19
Median	0.1	1.2	0.1
Number (>0.30mg/l)	25	75	20
% exceedance	31%	93%	25%

Table 8-22. Total Phosphorus Statistics for Salem Ditch: 1990-1995

Total Phosphorus	Shaff Road	Cascade Road	Pioneer Park
Number	80	75	80
Minimum	0	0.002	0
Maximua	0.72	0.7	0.531
Median	0.03	0.04	0.022
Number (>0.05 mg/l)	24	28	17
% exceedance	30%	37%	21%

Shelton Ditch exceeded the total nitrate standard in 93% of the samples taken (**Table 8-23**). Battle Creek exceeded in 90% of the samples (**Table 8-24**). The influx of nutrients from Battle Creek may have been contributing to the high nitrate levels recorded in Mill Creek at the Delaney Road monitoring station. Beaver Creek's contribution of nutrients to Mill Creek is unknown. Total Phosphorus was not measured in Shelton Ditch or Beaver Creek.

Table 8-23. Total Nitrates For Shelton Ditch: 1983-1993

Statistic	Shelton
Number	75
Minimum	0.10
Maximum	5.40
Median	1.40
Number (>0.30mg/l)	70
% exceedance	9

Table 8-24. Total Nitrates For Battle Creek :1982-1993

Statistic	Battle
Number	81
Minimum	0.20
Maximum	2.50
Median	0.90
Number (>0.30mg/l)	74
% exceedance	91%

e. Fecal Coliform Bacteria

According to DEQ's 303(d) list, Mill Creek is listed as water quality-limited for fecal coliform bacteria (**Table 8-4 and Table 8-5**) according to the pre-1996 standard. Data collected from all 12 monitoring stations in the Mill Creek watershed, including monitoring stations in the Salem Ditch, support this listing (**Figures 8-54, 8-55, 8-56, 8-57, 8-58** and **8-59**). High levels were recorded in all seasons, but summer and early fall sample periods usually recorded the highest fecal coliform counts for each year. Battle Creek data show the seasonality of fecal coliform counts (**Figure 8-58**). Five years of data show that water quality samples taken from an urban monitoring station tend to have higher fecal coliform counts than water samples taken from a rural setting (**Figure 8-60**).

Pesticides in an Urban Environment

Historical information on the presence and concentrations of pesticides (i.e., herbicides, insecticides and fungicides) in Salem's streams is scarce. However, two recent studies may shed some light on the type and concentrations of pesticides that are currently found in Salem's urban streams.

Water-Soluble Pesticides

Some pesticides are soluble in water, whereas others attach to soil particles and remain in stream sediments. In 1996, the USGS initiated a study to determine the distribution of dissolved pesticide concentrations in selected small streams throughout the Willamette Valley (Anderson et al. 1997). Of the twenty sample sites, 16 were in primarily agricultural areas and four were in urban areas. Two of the urban sample sites were Claggett Creek at North River Road and Pringle Creek at Bush's Pasture Park.

According to the study, the four most frequently detected pesticides in small streams in the Willamette Valley are atrazine, desethylatrazine (a degredation product of atrazine), simazine, metolachlor, and diuron (**Table 8-2**) (Anderson et al. 1997). These compounds were found in three-quarters of all samples regardless of land use.

While there were similarities in the chemical compounds found at urban and rural sample points, some pesticides had a definite "urban signature," being more closely associated with urban than rural sample points. **Table 8-25** lists six pesticides that were associated with urban land use according the USGS study. Most of these chemical compounds are used frequently on gardens and lawns in both residential and commercial areas (Anderson et al. 1997). Carbaryl, diazinon and dichlobenil are available through retail stores and are used by both homeowners and commercial landscapers. Prometon and triclopyr are widely used by homeowners who desire "complete vegetation control." Some formulations of prometon and triclopyr compounds are marketed as an all-purpose herbicide. While these two compounds can be used to control weeds along rights-of-ways, the Oregon Department of Transportation no longer uses prometon for roadside applications; triclopyr is only used to spot-spray along roadsides in some parts of the state. The presence of these pesticides in our creeks implies that homeowners and other users of pesticides may be overspraying.

Table 8-25. Pesticides Associated with Urban Land Uses in the Willamette Valley

Pesticide	Common Name	Use	Location of Use
Carbaryl	Sevin	Insecticide	home and garden care
Diazinon		Insecticide	home and garden care
Dichlobenil	Casoron	Herbicide	home and garden care
Tebuthiuron		Herbicide	rangeland, pasture, right-of-ways, under asphalt, industrial settings
Prometon		Herbicide	landscaping, rights-of-ways, industrial settings
Triclopyr	Garlon	Herbicide	landscaping, rights-of-ways, industrial settings

Source: USGS (1997)

As for the impact of pesticides on aquatic life, toxicity criteria have been established by the U.S. Environmental Protection Agency for only 5 of the 86 pesticides analyzed in this study. The complete impact of pesticides on aquatic life, including salmonids, has been determined. When pesticide exposure is combined with high stream temperatures, low dissolved oxygen, and high nutrient loads, impacts are more complex. Pesticides also bio-accumulate in humans; presenting health concerns, especially for infants and children.

Although toxicity to aquatic organisms for a specific chemical may be unknown, misapplication of pesticides can indirectly affect the habitat of aquatic organisms. Pringle Creek, which parallels the Union Pacific (UP) railroad tracks for approximately 3.5 miles, is vulnerable to pesticide applications used to keep the railroad right-of-way free of plants. An overspray of three herbicides, including diuron (**Table 8-2**), along the (UP) Railroad in March of 2000 may be the cause of death and chemical burn to some plant, tree and shrub species on the banks of Pringle Creek. Any loss of vegetation along Pringle Creek means less shade for the stream and a possible rise in water temperatures as the waterway becomes more exposed to the sun. Because Pringle Creek is already water quality-limited for temperature (**Table 8-4 and Table 8-5**), the shade provided by streamside vegetation is of the utmost importance. UP railroad tracks are also found paralleling or intersecting Claggett and Mill Creeks.

Pesticides and Sediments

In 1999, the USGS initiated a study in cooperation with the City of Salem. The objective was to identify the occurrence and potential sources of trace elements and hydrophobic organic compounds (including pesticides) in streambed sediments in the Salem area (USGS 2001). There were two main reasons for analyzing the streambed sediment: 1) fine grained particles and organic matter are accumulators of trace elements and hydrophobic organic constituents; and 2) streambed sediments provide a time-integrated sample of intermittent or storm-related contaminants.

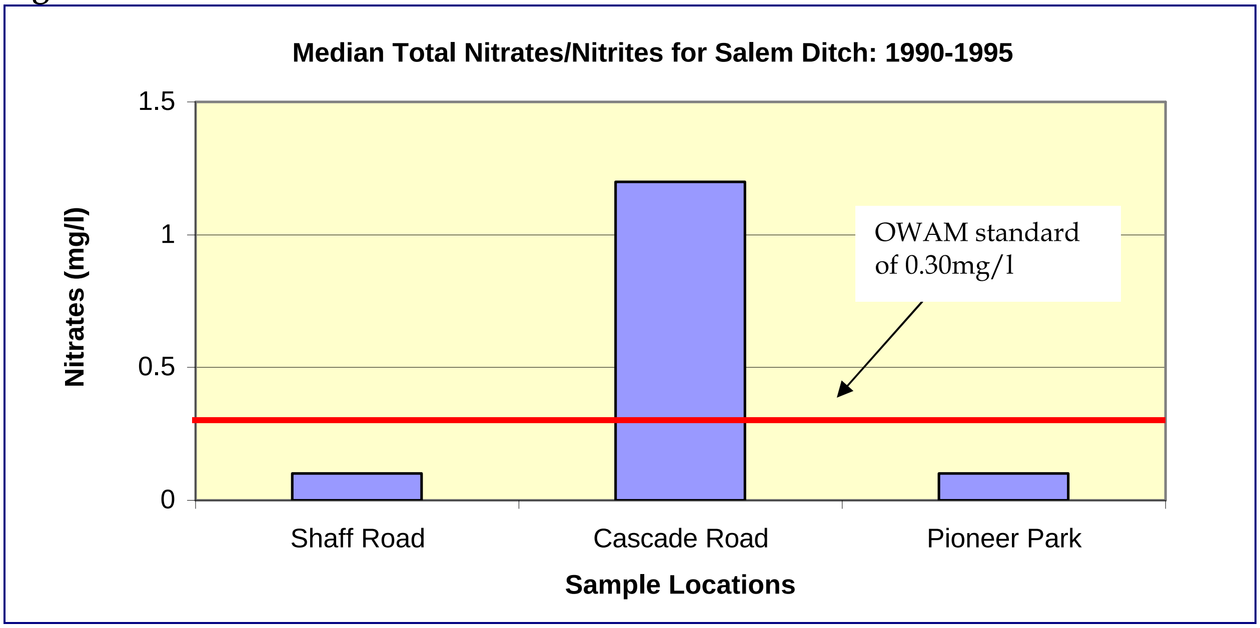
Sampling was done in October of 1999 at 14 sites in Salem and Keizer's streams. The sites were selected upstream and downstream from anticipated point and non-point sources of contaminants. Claggett Creek contained one sample point at the Salem Parkway. Glenn and Gibson Creeks contained one sample point each. The Mill Creek watershed contained six sample sites, including one in Shelton Ditch and one in Battle Creek. The Pringle Creek watershed had three sample sites. The remaining sample points were located in Pettyjohn and Croisan Creeks.

Samples were analyzed for 45 trace elements, 79 semivolatile organic compounds and 31 organochlorine pesticides. Results of the sampling can be viewed online (USGS 2001). Analysis of the data, including a comparison of contaminant levels in Salem's streams compared to streams nationally, will be included in an USGS technical paper scheduled for completion in 2003 (Tanner pers. comm.).

Other Studies

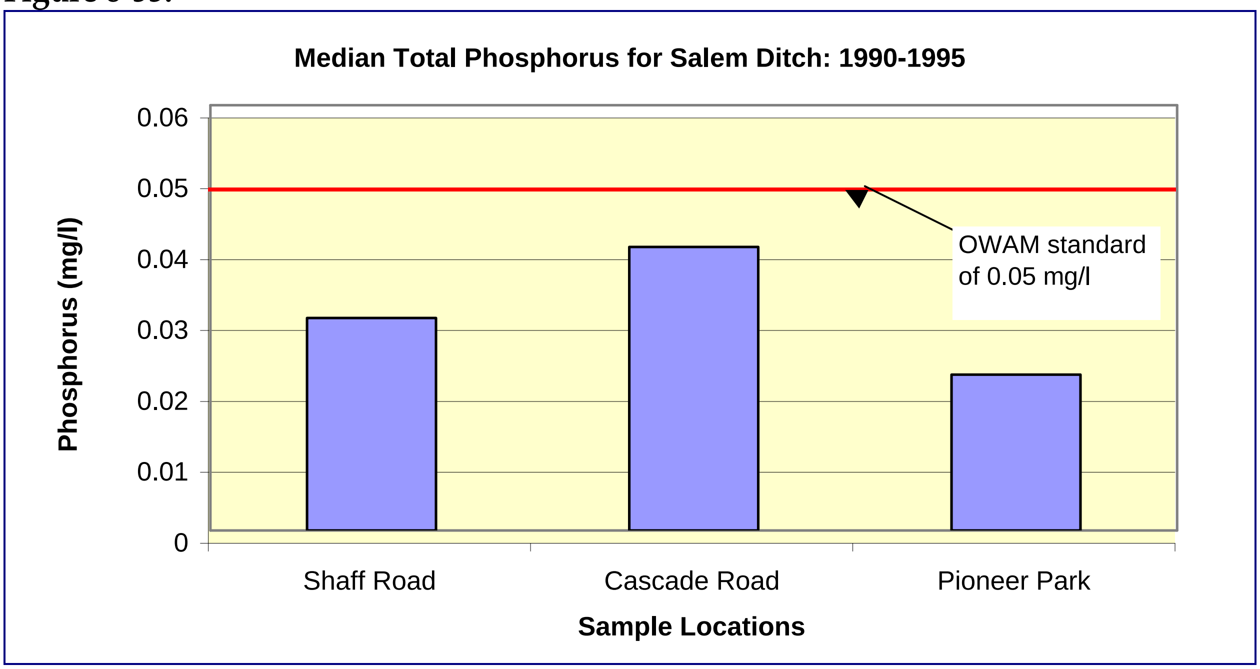
In the summer of 2001 the City of Salem expanded its stream bioassessment work beyond the Pringle Creek watershed. Approximately 50 sites were sampled throughout all of Salem's watersheds, including Mill, Glenn-Gibson and Claggett Creek watersheds. These sites, as well as the Willamette River, are now sampled approximately once a month. Physical parameters, water chemistry data and macroinvertebrate samples were taken at each site. The data will be analyzed and made available to the public at an undetermined date.

Figure 8-52.



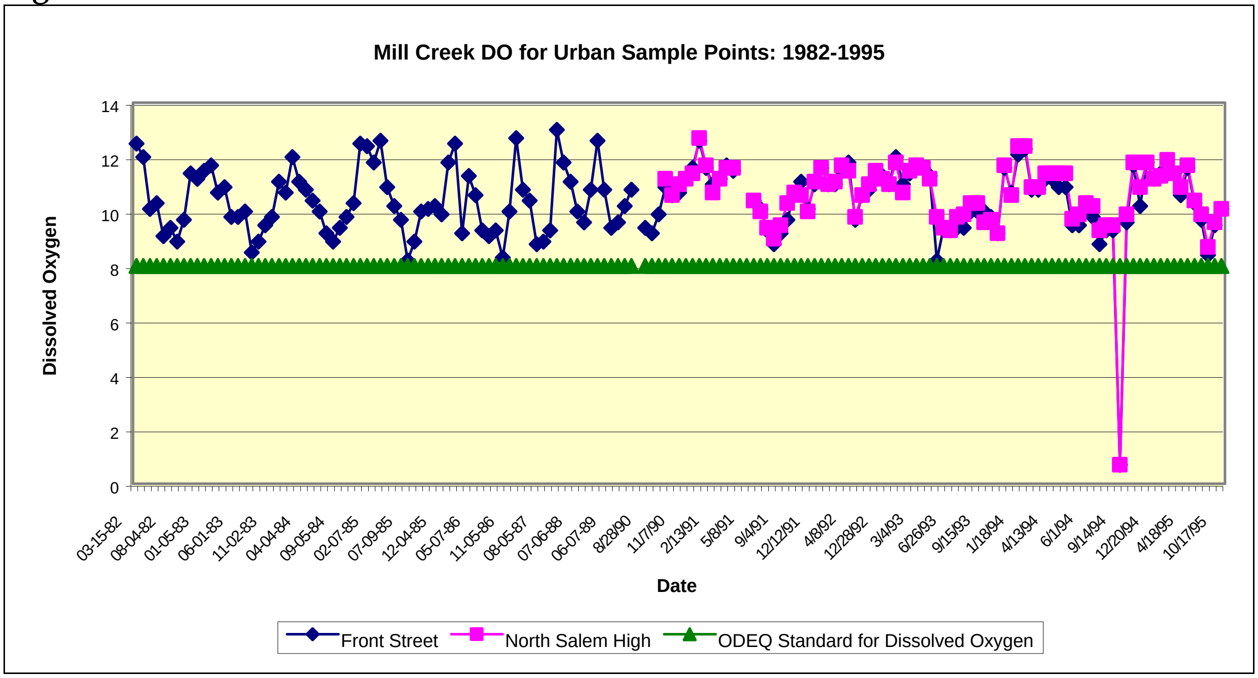
Data source: City of Salem Public Works Department (undated)

Figure 8-53.



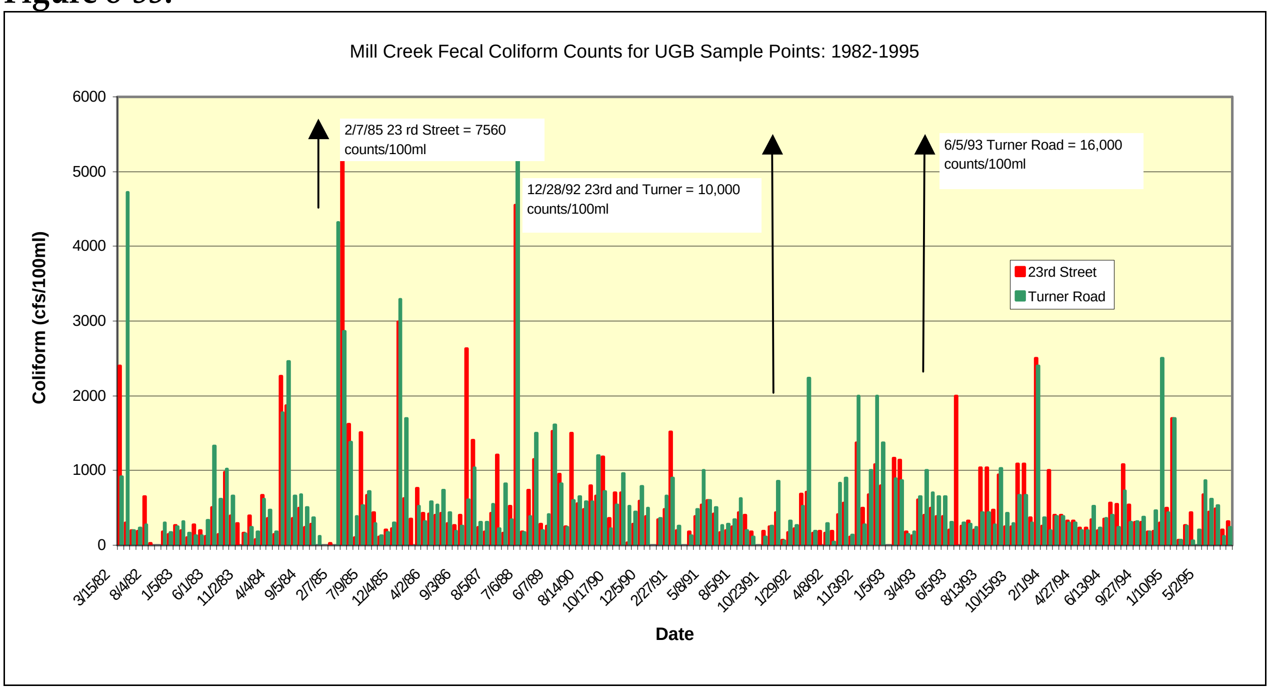
Data source: City of Salem Public Works Department (undated)

Figure 8-54.



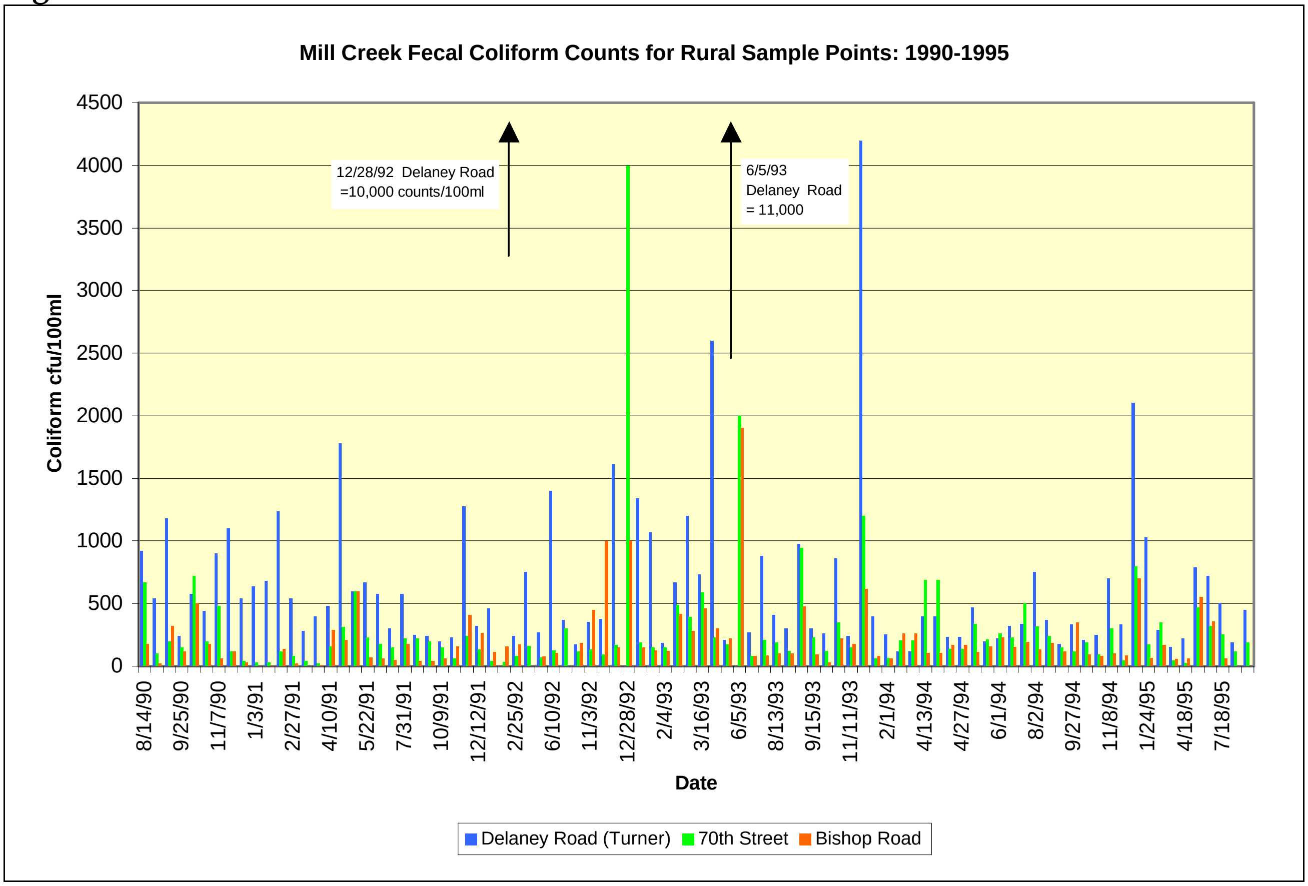
Data source: City of Salem Public Works Department (undated)

Figure 8-55.



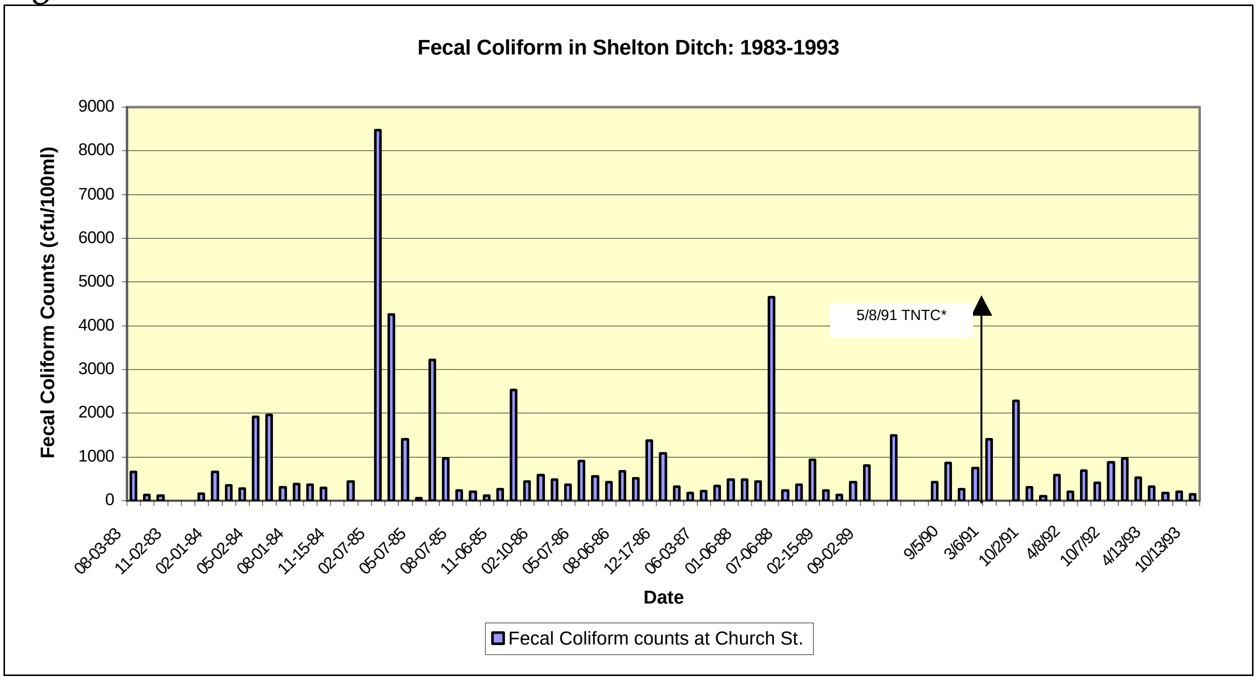
Data source: City of Salem Public Works Department (undated)

Figure 8-56.



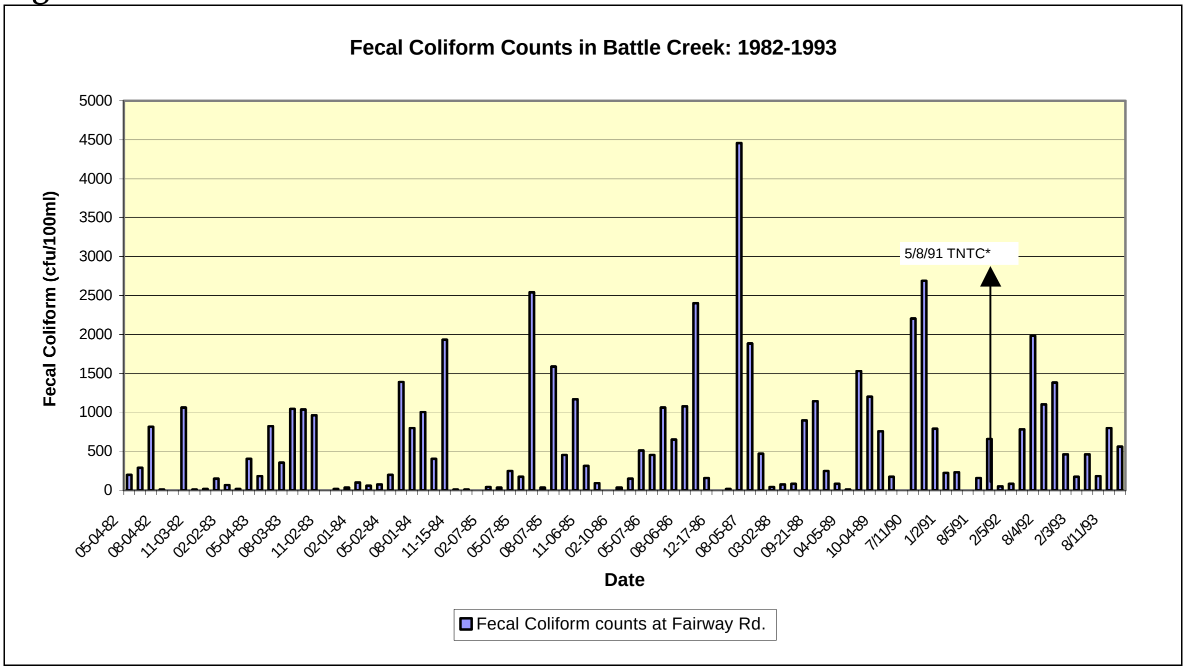
Data source: City of Salem Public Works Department (undated)

Figure 8-57.



* too numerous to count
Data source: City of Salem Public Works Department (undated)

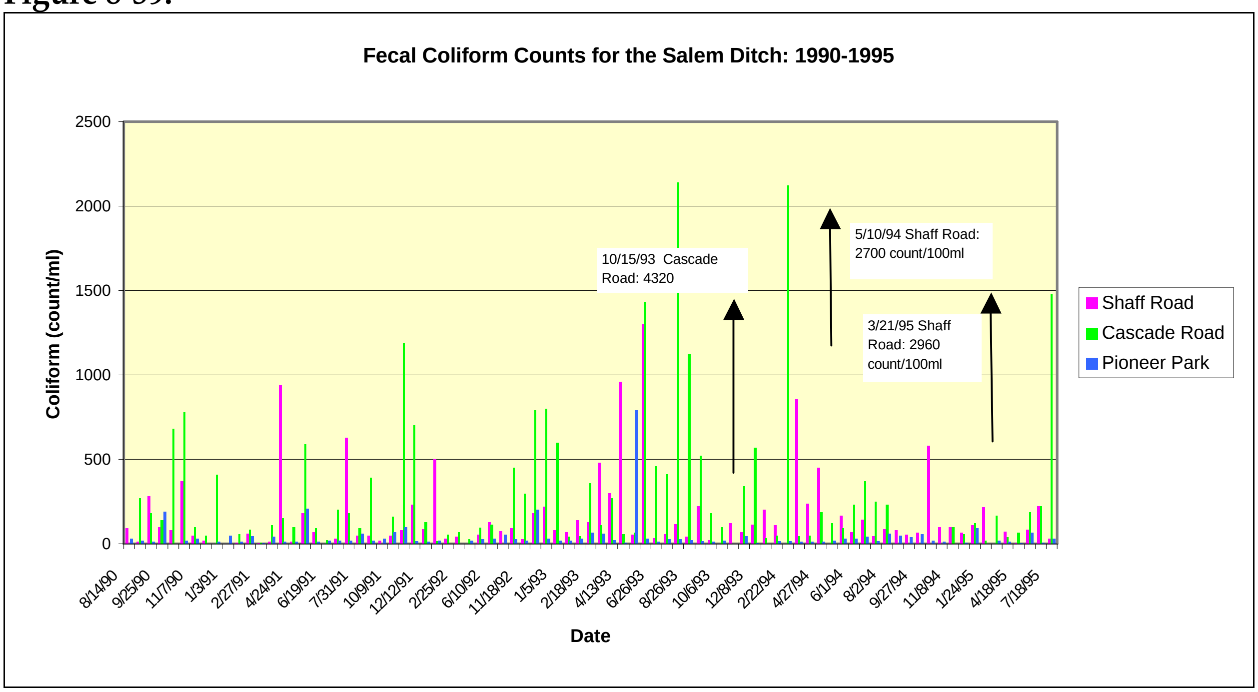
Figure 8-58.



*too numerous to count

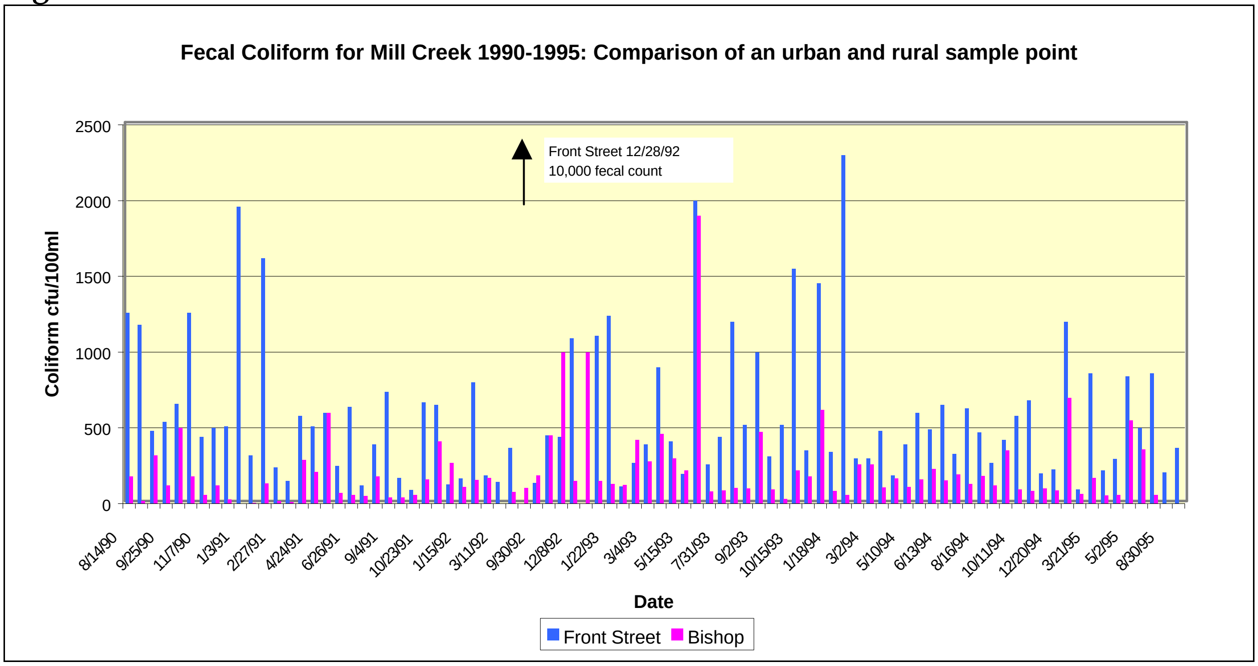
Data source: City of Salem Public Works Department (undated)

Figure 8-59.



Data source: City of Salem Public Works Department (undated)

Figure 8-60.



Data source: City of Salem Public Works Department (undated)

Summary

The information presented in this chapter of the assessment is summarized below. **The data collected by the City of Salem in the surface water-monitoring met DEQ Level 1 standards.** Data can be used to determine trends and seasonal changes in water quality parameters. It can also be used to determine where more monitoring may be necessary. The data cannot be used to determine if a stream should be listed on the 303(d) list.

Water Temperature—Claggett, Mill and Pringle Creeks routinely exceed 17.8 degrees Celsius during summer months. Since 1998, water temperatures in Glenn and Gibson Creeks have exceeded the DEQ standard a few times in the month of August only. According to DEQ's 303(d) list, Pringle Creek is water quality-limited for temperature.

Dissolved Oxygen—Records show that Claggett Creek has low dissolved oxygen in the summer. Lower Gibson Creek and Glenn Creek experience DO levels slightly below the DEQ standard of 8.0 mg/l during summer months. Mill Creek maintains high dissolved oxygen levels year-round with the exception of its tributary, Battle Creek, and at the Cascade monitoring station in Salem Ditch. Pringle Creek maintains high DO level year round with the exception of the upper reaches of the West Fork Pringle Creek at Cannery Park.

pH— Recorded pH levels outside of the recommended range of 6.5 to 8.5 were intermittent and rare. The only stream reaches that routinely recorded low pH levels were in the upper reaches of Clark Creek and the West Fork Pringle Creek, where pH values were only slightly below 6.5. Consistently low pH readings may be due to acidic soils near the headwaters. In the Mill Creek basin, the Cascade monitoring station in the Salem Ditch and Battle Creek also recorded pH values slightly lower than 6.5 throughout the years.

Nutrients—Using the standard for nitrogen supplied by the Oregon Watershed Assessment Manual (OWAM) (Watershed Professionals Network 1999), nitrogen exceeded 0.30 mg/l in over 90% of the samples taken at 15 of the 23 monitoring stations analyzed in this assessment. Total Phosphorus was sampled at 13 sites in the Pringle and Mill Creek watersheds. Total Phosphorus exceeded OWAM's standard of 0.05mg/l in over 50% of the samples taken from 8 of the 13 monitoring stations.

Fecal coliform and *E. coli*—High counts of fecal coliform or *E. coli*. were found in all four watersheds. An analysis of Mill Creek's fecal coliform counts indicates that water quality samples taken from an urban monitoring station have higher bacteria counts than water samples taken from a rural monitoring station. Mill, Pringle, and Clark creeks are water quality-limited for bacteria.

Stormwater--The studies by or with the City of Salem suggest that the surface water quality of Salem's streams is affected by stormwater quality. High concentrations of lead have been found in stream reaches near high traffic areas. High levels of fecal coliform are ubiquitous in Salem's streams and elevated levels of suspended sediment are associated with urbanization, poor channel and bank design, and construction activities (City of Salem 1982; Laenen 1983). Illicit dumping and illicit discharges of contaminants into Salem's stormwater have resulted in high levels of detergents and chlorine, in addition to solid waste, surface scum, oily deposits and strong odors at stormwater outfalls (City of Salem and ODOT 1994). Monitoring of storm water quality continues, as part of the requirements for Salem's NPDES stormwater permit, with wet weather sampling at four locations in Salem.

Pesticides—Six pesticides are commonly found in streams in urban areas: carbaryl, diazinon, dichlobenil, prometon, triclopyr, and tebuthiron. Most of these chemical compounds are used frequently on gardens and lawns in both residential and commercial areas (Anderson et al. 1997).

Recommendations

Nationally, urban runoff is considered a major source of the pollution flowing into our rivers and streams (O'Mara 1978). The water quality of our urban streams is highly dependent on the actions of thousands of private landowners and businesses that collectively contribute significant amounts of pollution to our surface and ground water. Improving water quality in the future will require a combination of monitoring, education and regulation. The key to improving water quality will be identifying sources of pollution and educating the public on its roles and responsibilities in protecting local streams. The following recommendations are **initial steps** that can be taken to improve water quality in Claggett, Mill, Glenn-Gibson and Pringle Creeks.

All Basins

1. Future surface water monitoring should follow DEQ protocol in order to determine the legitimacy of including Salem streams on the 303(d) list.

2. Include quality assurance/quality control procedures in all future water quality-monitoring programs in order to assess environmental variability, sampling procedures validity, and repeatability of the sample methods.

3. Work with the City of Salem, Marion County and Polk County on developing a surface water quality-monitoring program that determines the **sources** of water quality problems in the four watersheds. A determination of pollution sources will require extensive monitoring efforts. (The objective of surface water monitoring in the 1980's and 1990's was to determine if a problem existed. This recommendation takes the monitoring program one step further.) This recommendation includes determining the sources of pollution at stormwater outfalls, as well as the quality of surface water as it enters the urban area from upstream tributaries and rural areas.

4. Continue to support water quality-monitoring programs such as the City of Salem's Adopt-A-Stream program. This program works with teachers and students ranging from elementary to high school. Students learn about water quality in local streams while collecting valuable information on stream health. Data is posted on the City of Salem's web site (City of Salem 2001).

5. Incorporate the results of the City of Salem's stream bioassessment work into the watershed assessment. Use the results to help determine which stream reaches are most in need of restoration or enhancement.

6. Continue to promote non-structural Best Management Practices (BMPs) such as public education and the enforcement of government regulations and

ordinances protecting water quality. This includes supporting the Watershed Enhancement Team (WET). WET is a partnership effort involving state and local governments and community volunteers working together to enhance and protect the Pringle Creek watershed. WET is a volunteer effort to get homeowners and businesses to go beyond regulatory requirements. Its goal is to educate the public and private businesses on how they can improve water quality in our streams by making small changes in their lives (e.g., plant drought-resistant plants to save water, reduce pesticide and fertilizer use on lawns and gardens and dispose of hazardous wastes properly). Promote the initiation of this program in other watersheds.

7. Promote the use of structural BMPs such as parking lot bioswales, diverter valves in parking lots to divert car wash water into the sanitary sewer system, stormwater detention ponds that incorporate native plants, the use of porous pavement, and the restoration of wetlands and riparian areas along streams. All of these "structures" help filter or divert urban runoff that would otherwise flow directly into our streams and degrade water quality.

8. Identify and map leaky underground storage tanks by watershed. Analyze their proximity to sensitive areas such as wetlands, springs, seeps and streams.

9. Contact the Salem Fire Department for information regarding the number and location of spills from motor vehicle accidents to determine where there is a pattern of pollution.

10. Participate with local jurisdictions, DEQ , and other stake-holders to identify local pollution reduction scenarios for Salem-Keizer watersheds.

11. Take samples from the same sites and stormwater outfalls noted in earlier work using current DEQ protocols to determine if problems such as detergents, pH levels, chlorine, copper, DDT, lead and water quality have declined or increased at Salem's stormwater outfalls.

12. Collect and analyze current data to determine what, if any, correlation exists between traffic counts and median lead concentrations in Salem's streams. Compare with data analyzed earlier from the 35 sites where lead levels equaled or exceeded DEQ's standard for drinking water.

13. Support establishing a state standard for nitrate/nitrites and phosphorus levels which meets or exceeds that proposed in the Oregon Watershed Assessment Manual.

14. Analyze available data for water temperature, dissolved oxygen and pH for each watershed, and graph all exceedances to determine where patterns or commonalities exist. Compare with known fish locations to determine if they act as a barrier to fish health, spawning and migration.

15. Analyze available data for nutrients (nitrates/nitrites and phosphorus) and toxics (pesticides) and graph all exceedances to determine where patterns or commonalities exist. Identify upstream and nearby riparian land uses.

16. Compare locations where E. coli samples exceeded the E. coli standard with City of Salem Parks Operations' "Mutt Mitt" program areas and places where ducks and geese congregate. Analyze data to determine if there are seasonal patterns or commonalities.

17. Support fast-track federal and state action to establish toxicity criteria for the impact of pesticides on aquatic life, both singly and in combination with the high stream temperatures, low dissolved oxygen and high nutrient loads of urban streams.

Pringle Creek

1. Follow up with DEQ's Environmental Cleanup Program to determine current status on the two dry cleaning sites contaminated by chlorinated solvents (perchloroethylene) in the Pringle Creek watershed.

2. As an "early action" item, continue working with Union Pacific Railroad representatives to implement adequate procedures for weed control along tracks paralleling fish-bearing streams and other sensitive areas.

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