# Salmon Creek Nonpoint Source Pollution Total Maximum Daily Load

## Water Quality Effectiveness Monitoring Report

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**Cover photo:** Salmon Creek looking east from 36th Avenue NW, Vancouver, WA.

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# Water Quality Effectiveness Monitoring Report

*by*

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# Abstract

The Washington State Department of Ecology (Ecology) is required, under section 303(d) of the federal Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations, to develop and implement Total Maximum Daily Loads (TMDLs) for impaired waters. Following TMDL implementation, data are collected to determine if the TMDL targets and water quality standards have been met.

In 1995, Ecology completed a TMDL study of Salmon Creek and four of its tributaries. The study found violations of Washington State water quality standards for fecal coliform bacteria, turbidity, dissolved oxygen, and temperature. Water quality monitoring by Clark Public Utilities from 1995 to 1999 showed that many of those violations were continuing. In 2001, Ecology submitted a TMDL report to EPA to address fecal coliform and turbidity in the Salmon Creek watershed.

The 1995 TMDL study identified percent reductions needed in fecal coliform and turbidity concentrations at four compliance sites on Salmon Creek and four of its tributaries: Cougar, Mill, Curtin, and Weaver Creeks.

Since the TMDL study, several pollution reduction actions have been implemented. These include decommissioning of high-risk, onsite sewage treatment systems; installation of riparian fencing and plantings; and completion of stormwater improvement projects.

The primary goal of this effectiveness monitoring study is to evaluate attainment of the percent reductions (load allocations) at several compliance stations identified for bacteria and turbidity concentrations and load reductions in the 2001 TMDL report.

This evaluation shows that fecal coliform concentrations in Salmon Creek and its tributaries have improved significantly since the 1995 TMDL study. However, water quality criteria have not been met at some sampling stations. All of the sites met TMDL target limits for turbidity.

# Acknowledgements

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- Clark County Clean Water Program, Clark Conservation District, Clark Public Utilities, and Clark County Public Health provided technical assistance and improved water quality in Salmon Creek.
- Washington State Department of Ecology staff:
  - Tonnie Cummings provided logistical support and organized the entire effort.
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  - Markus Von Prause helped with data analysis and Geographic Information Systems support.
  - Joan LeTourneau and Cindy Cook formatted and edited the final report.

# What is a Total Maximum Daily Load (TMDL)?

## Federal Clean Water Act requirements

The Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, every state has its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses for protection, such as cold water biota and drinking water supply, and criteria, usually numeric criteria, to achieve those uses.

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list or Water Quality Assessment. To develop the list, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data submitted by local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the 303(d) list.

## TMDL process overview

The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for each of the waterbodies on the 303(d) list. A TMDL identifies how much pollution needs to be reduced or eliminated to achieve clean water. Then the local community works with Ecology to develop a strategy to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities.

## Elements required in a TMDL

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources.

If the pollutant comes from a discrete (point) source such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If it comes from a set of diffuse (nonpoint) sources such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation.*

The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures is sometimes included as well.  The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

## Water quality assessment / Categories 1-5

The 303(d) list identifies polluted waters in Washington.

The Water Quality Assessment list tells a more complete story about the condition of Washington's water.  This list divides waterbodies into five categories:

- Category 1 – Meets tested standards for clean water.
- Category 2 – Waters of concern.
- Category 3 – No data available.
- Category 4 – Polluted waters that do not require a TMDL since the problems are being solved in one of three ways:
  - 4a – Has an approved TMDL and it is being implemented.
  - 4b – Has a pollution control plan in place that should solve the problem.
  - 4c – Is impaired by a non-pollutant such as low water flow, dams, culverts.
- Category 5 – Polluted waters that require a TMDL – the 303(d) list.

# Background

## What is effectiveness monitoring?

An effectiveness monitoring evaluation determines if the interim TMDL targets and water quality standards have been met. This is an essential component of any restoration or implementation activity since it measures to what extent the work performed or recommended has attained the watershed restoration objectives or goals.

The benefits of effectiveness evaluation include:

- More efficient allocation of funding.
- Optimization in planning/decision-making (i.e., program benefits).
- Determination of watershed recovery status (i.e., how much restoration has been achieved, how much more effort is required).
- Adaptive management or technical feedback to refine restoration treatment design and implementation.

The effectiveness evaluation addresses four fundamental questions with respect to restoration or implementation activity:

1. Is the restoration or implementation work achieving the desired objectives or goals (significant improvement)?
2. How can restoration or implementation techniques be improved?
3. Is the improvement sustainable?
4. How can the cost-effectiveness of the work be improved?

## Study area

Salmon Creek, located entirely within Clark County, flows from the foothills of the Cascade Mountains west to Lake River which in turn flows into the Columbia River. The Cascade foothills are generally forested while the lower drainage is primarily urban.

The city of Vancouver lies just south of lower Salmon Creek, and several small towns lie along the tributaries and central plains of the basin. These middle reaches contain a mixture of small towns, large and small-scale farms, pasture, and homes.

Six major tributaries flow into Salmon Creek: Rock Creek and Morgan Creek to the east, Weaver Creek (also called Woodin) and Curtin Creek (also called Glenwood) in the middle, and Mill Creek and Cougar Creek to the west (Figure 1).

The Salmon Creek basin is primarily rural-residential and is characterized by gently rolling hills and alluvial flood plains. Forestry, agriculture, commercial, and industrial activities have been significant uses within the basin (Wille, 1990). However, recent trends suggest forestry and agriculture activities have been significantly declining over the last decade (Globalwise Inc, 2007).

Urban areas also comprise a considerable proportion of the Salmon Creek basin land area, mostly along its southwest reaches. The basin is highly urbanized near Vancouver, with many small subbasins already heavily developed.

The Suds Creek, Tenny Creek, 114th Street tributary, and 119th Street tributary subbasins typify the urbanization within this portion of the Salmon Creek drainage. The areas around Cougar Creek and Curtin Creek, the larger tributaries of lower Salmon Creek, are also developing rapidly. These basins often experience problems with stormwater runoff, inadequate buffer vegetation, erosion, and sedimentation.

Rapid and diverse development within the Salmon Creek basin has also led to water quality degradation of Salmon Creek and its tributaries, resulting in non-attainment of Washington State water quality standards.

## Previous studies

Fecal coliform contamination is a major concern because it indicates that biological waste is entering the water. A 1981 study by the Southwest Washington Health District (SWHD) investigated the basin's septic systems, which were believed to contribute to nonpoint fecal coliform contamination. The study found that 3% of surveyed septic systems along the Salmon Creek drainage were leaking, and 10% had failed previously but had been fixed. One finding was that 47% of failures were preventable: the result of a lack of maintenance, undersized systems, poor siting, or physical damage (SWHD, 1981).

A 1989 follow-up survey of septic systems within Salmon Creek studied all parcels adjacent to the creek, and randomly sampled all systems within 1,000 feet of the creek and its tributaries. In this study, 5.6% of the systems were failing, sub-standard, or absent. The vast majority (92%) of systems were at least 15 years old; 58.7% of the systems had either never been pumped or were not known to have been pumped. Calculations from this study attributed from 1% to 5% of Salmon Creek's fecal coliform loading to failing septic systems (Newman, 1989). The 1989 survey results were similar to the 1981 results, implying that septic systems contributed to, but were not the major source of, fecal coliform contamination.

In 2007, Clark County Public Health (CCPH) reported: of the more than 30,000 homes within the Salmon Creek watershed, at least 9,000 use an individual on-site septic system. Since 2007, CCPH has inspected approximately 9,000 septic systems county-wide. Inspectors identified a 33% deficiency rate, with about 3% of those deemed critical deficiencies. Of those critical deficiencies, 75% were repaired within 6 months. At the time of this 2009 report, CCPH continues to inspect and locate undocumented septic systems within Clark County.

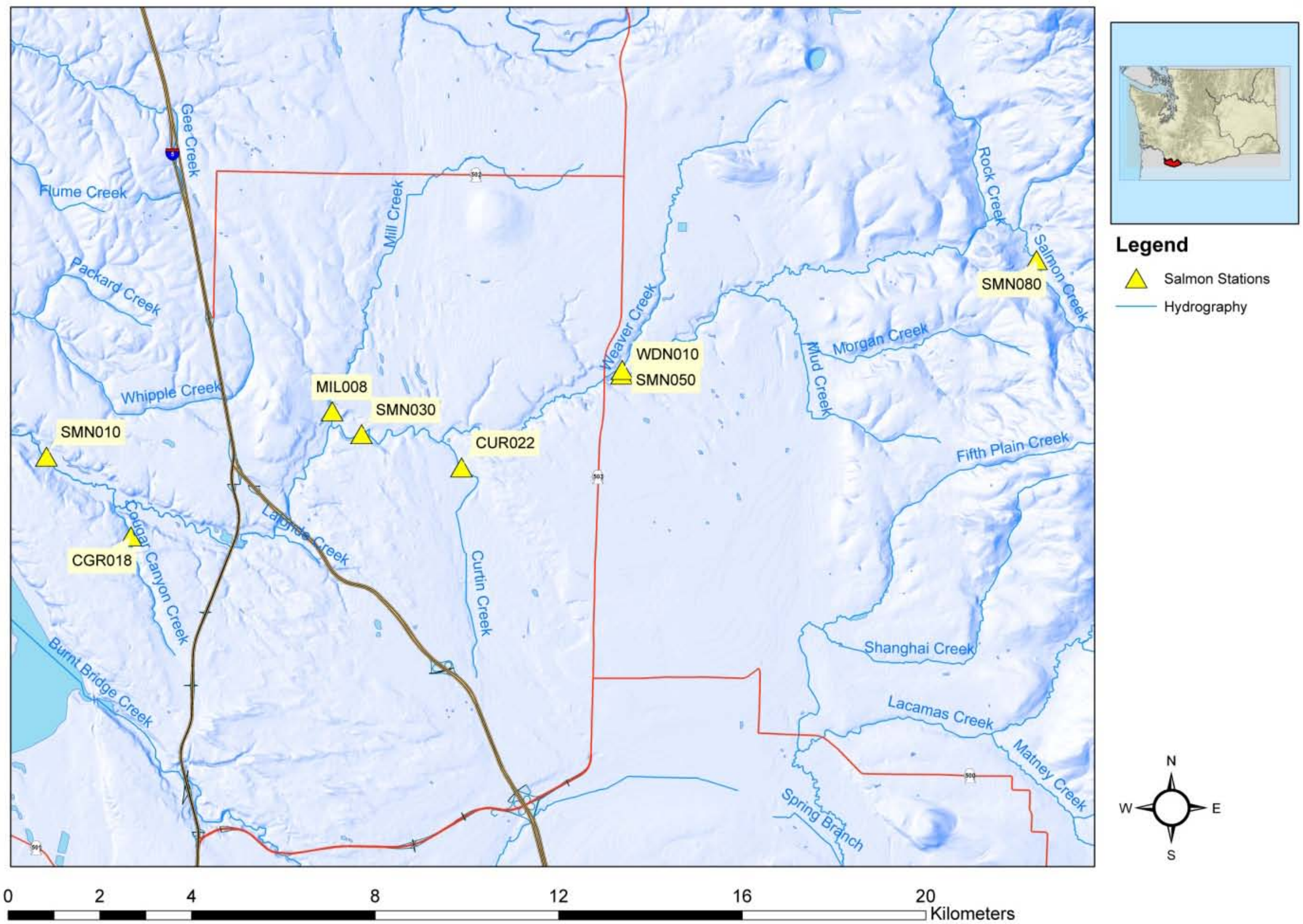


Figure 1. Salmon Creek watershed monitoring stations.
*SMN – Salmon, CGR – Cougar, MIL – Mill, CUR – Curtin, WDN – Woodin.*

A 1990 SWHD study of the Salmon Creek basin found fecal coliform to be the most consistent and most severe violator of state water quality standards. This study isolated dairies as the primary source of contamination, with the regions around lower Morgan Creek, central Salmon Creek, and Mill Creek having the highest concentrations of both dairies and coliform contamination (SWHD, 1990).

In response to this agriculturally-based water quality degradation, the Clark County Conservation District (CCCD) undertook a review of basin farming practices, recommending implementation of appropriate best management practices (BMPs) for agriculture (CCCD, 1990). The document outlines BMPs for erosion and animal waste control, pastureland and cropland management, and stream corridor protection. It concludes with strong recommendations for stream fencing, streambank re-vegetation, and animal waste and sediment education programs to counter the negative impacts of dairy production.

A recent analysis of agricultural trends in Clark County indicates a 83% loss of dairy operations since 1984 (Globalwise Inc, 2007). Currently only seven dairies exist in Clark County, none of which are located in the Salmon Creek watershed. The report goes on to suggest that, as the economy of Clark County increases, the county's traditional agricultural enterprises have steadily declined.

The earliest impediments to salmonid reproduction occurred in the late 19th century, when logging dams were first constructed along Salmon Creek. Today, however, it is sedimentation from widespread development that impairs stream habitat quality.

While no historical data exist, current coho, steelhead, and cutthroat trout populations are between 3% and 5% of what an intact habitat might support (Wille, 1989). The highest quality of existing salmonid habitat presently lies within the basin's less developed headwaters: upper Salmon Creek, upper Morgan Creek, and Rock Creek.

Direct cattle access along lower Salmon Creek and many tributaries increases turbidity and ammonia levels, and impairs habitat quality. As a low-gradient creek (averaging slope of 0.24% over the first 35 km), Salmon Creek has a limited ability to flush sediment deposits (Wille, 1989). In addition to covering pool habitat for salmon, sediment buildup over time decreases the channel capacity. This increases the potential for flooding and can lead to increases in water temperature due to greater solar heating of the shallower waters.

Wetlands, which provide flood control and contribute to summer streamflow levels, have been estimated to constitute 3.4% of the basin (Wille, 1990). Roughly half of Salmon Creek basin wetlands are emergent (usually seasonal and adjacent to the stream), while forested and scrub-shrub wetlands are also fairly common. The greatest numbers of wetlands are within Mill Creek and Curtin Creek subbasins, but the greatest acreage lies along lower and central Salmon Creek. However, one fifth of recent county developments involve wetlands. Threats to wetlands include channelization and draining, as well as indiscriminate filling of privately owned wetlands (Wille, 1990). Loss of remaining wetlands could contribute to further water quality degradation by removing ecologically important water detention and filtering systems.

## Pollutants addressed by this report

Although the 2001 TMDL report included only fecal coliform and turbidity, this effectiveness monitoring study addresses all five 303(d) listed parameters and the two nutrients, nitrate-nitrite and phosphorus. Clark County provided enough data for this report to determine if current listings are still necessary or if additional action is required. The current 303(d) listing includes four sites on Salmon Creek as well as four tributaries: Cougar, Mill, Curtin, and Weaver Creeks (Figure 1).

The 1995 TMDL study indicated fecal coliform and turbidity concentrations needed to be reduced at eight sites (Cusimano and Giglio, 1995). Table 1 provides site descriptions and IDs as well as 303(d) listings with parameters and categories.

Table 1. Study area waterbodies on the 2008 303(d) list including sampling locations, parameters, and categories.

| Sample site | Site ID | Fecal[1] Coliform | Turbidity[1] | pH | Dissolved oxygen | Tempera-ture[2] |
|---|---|---|---|---|---|---|
| Salmon Creek (mouth) at 36th Ave. | SMN010 | 4A | 4A | 5 | 5 | 5 |
| Cougar Creek at 119th St. | CGR020 | 4A | | 2 | 2 | |
| Salmon Creek (lower) at 112th Ave. | SMN030 | 4A | | 2 | | 2 |
| Mill Creek at Salmon Creek Rd. | MIL010 | 4A | | 2 | 2 | |
| Curtin Creek at 139th St. | CUR020 | 4A | | 5 | 5 | |
| Salmon Creek (upper) at 122nd Ave. | SMN050 | 4A | | 5 | 2 | 2 |
| Weaver (Woodin) Creek at 122nd Ave. | WDN | 4A | | | 4A | |
| Salmon Creek (headwaters) at 199th St. | SMN080 | 4A | | 5 | | |

[1]2001 TMDL report (Howard, 2001).
[2]Innovative TMDL currently under development.
[3]1995 TMDL (Cusimano and Giglio, 1995).

## Watershed implementation or restoration activities

In a 2001 report, Ecology discussed other agencies' activities that would contribute to clean-up efforts for meeting TMDL target limits for fecal coliform bacteria and turbidity in the Salmon Creek watershed (Howard, 2001). Additional information on responsible agencies and activities was provided in Ecology's 2005 *Detailed Implementation Plan* (DIP) for the Salmon Creek watershed (Howard, 2005).

Control measures focused on (1) reducing the amount of animal waste entering the creek, (2) locating and eliminating sources of human fecal coliform contamination, and (3) reducing the amount of sediment entering the creek from stormwater and farming, forestry, and construction activities.

Stakeholders began implementing cleanup activities within the Salmon Creek watershed even before completion of the 2005 DIP. This was reflected by Clark County monitoring data presented in the DIP showing a significant drop in both wet- and dry-season fecal coliform at TMDL target stations (Howard, 2005). Since completion of the DIP, additional cleanup work has taken place.

In November 2007, stakeholders held an adaptive management meeting to discuss accomplishments, ongoing activities, and additional needs in the watershed. A report generated from that meeting can be found at:
www.ecy.wa.gov/programs/wq/tmdl/SalmonCr/SalmonCr110707MtgRpt.pdf. Accomplishments described in the report are summarized in Table 2 below.

Table 2. Direct cleanup actions in the Salmon Creek watershed.

| Source Type | Who | Action |
|---|---|---|
| Agricultural Practices | Clark County Conservation District | Provided educational workshops and mailings. |
| Agricultural Practices | Clark County Conservation District | Acquired manure spreader and developed exchange program. |
| Agricultural Practices | Clark County Conservation District | Installed 1,851 feel of livestock exclusion fencing. |
| Agricultural Practices | Clark County Conservation District | Provided funding for planting of 9,815 riparian trees and shrubs. |
| Agricultural Practices | Clark County Conservation District | Developed various private land management plans. |
| Agricultural Practices | Clark County Conservation District | Installed one off-channel livestock watering facility. |
| Agricultural Practices | Natural Resource Conservation Service | Provided funding to 2 landowners for manure storage to reduce runoff. |
| Agricultural Practices | Washington Department of Agriculture | Inspecting dairy farms and managing diary permits and non-dairy permitted facilities. |
| Stormwater/ Other | Clark County Clean Water Program | Spent $1.8 million on stormwater related capital improvements between 2002 and 2007. |
| Stormwater/ Other | Clark County Clean Water Program | Enforced codes. |
| Stormwater/ Other | Clark County Clean Water Program | Provided public outreach and education. |
| Stormwater/ Other | Clark County Clean Water Program | Maintained and operated stormwater systems. |
| Stormwater/ Other | Washington Department of Fish and Wildlife | Reviewed approximately 50 hydraulic permit applications/year. |
| Stormwater/ Other | Washington Department of Fish and Wildlife | Reviewed approximately 300 State Environmental Policy Act applications/year. |
| Septic Systems | Clark County Public Health | Provided outreach and mailing related to on-site septic systems. |
| Septic Systems | Clark County Public Health | Conducted home surveys and corrected failing septic systems. |
| Septic Systems | Clark County Public Health | Strengthened regulations related to on-site septic systems. |
| Riparian Improvements | Clark Public Utilities | Installed 10,000 linear feet of livestock exclusion fencing. |
| Riparian Improvements | Clark Public Utilities | Reconnected 2,500 feet of diked and channelized stream to floodplain. |
| Riparian Improvements | Clark Public Utilities | Planted 121,820 trees in riparian areas. |
| Forest Practices | Washington Department of Natural Resources | Abandoned 349 miles of forest road in DNR Pacific Cascades Region. |

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# Water Quality Standards and Beneficial Uses

The Washington State water quality standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC), include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state. This section provides Washington State water quality information and those standards applicable to the Salmon Creek watershed.

The 2001 TMDL report was designed to address impairments of characteristic uses caused by fecal coliform and turbidity (Howard, 2001). While resources in the Salmon Creek watershed are shared by many groups, protecting contact recreation and fisheries within the watershed have been top priority.

The Salmon Creek watershed was listed on the 2008 303(d) list for fecal coliform bacteria, turbidity, pH, and dissolved oxygen. The applicable water quality criteria for these parameters are summarized in Table 3. Although temperature and ammonia are parameters included on the 303(d) list, they will not be discussed in this report as they are part of an additional study. The TMDL report developed target limits only for fecal coliform and turbidity. However, this report provides an analysis and comparison of all listed 303(d) listed parameters, with the exception of temperature and ammonia, as well as nutrients with available data.

Table 3. Washington State water quality standards for parameters monitored in the Salmon Creek watershed.

| Parameter | 2006 Classification | 2006 Criteria |
|---|---|---|
| Fecal Coliform | Primary Contact Recreation | Shall not exceed a geometric mean value of 100 cfu/100 ml, and not more than 10% of all samples exceed 200 cfu/100 ml. |
| Turbidity | Salmonid Spawning, Rearing, and Migration | Shall not exceed 5 NTU over background levels. |
| pH | | 6.5 to 8.5 units. |
| Dissolved Oxygen | | 9.5 mg/L 1-DMin[1], 8.0 mg/L 1D-Min[2]. |

[1] 1-DMin means the lowest annual daily minimum oxygen concentration occurring in the waterbody.
[2] Dissolved oxygen for Salmon Creek from latitude 45.7176, longitude -122.6958 (below junction with Cougar Creek) and tributaries (Core Summer Habitat).

## Fecal coliform bacteria

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In Washington State, Ecology's water quality standards use fecal coliform as an "indicator bacteria" for the state's freshwaters (e.g., lakes and streams). Fecal coliform in water "indicates" the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. While the specific level of illness rates caused by animal versus human sources has not been quantitatively determined, warm-blooded animals (particularly those that are managed by humans and thus exposed to human derived pathogens as well as those of animal origin) are a common source of serious waterborne illness for humans.

The *Primary Contact* use is intended for waters "where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing." More to the point, however, the use is designated to any waters where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. To protect this use category: "Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200/colonies mL"
[WAC 173-201A-200(2)(b), 2003 edition]
(http://apps.leg.wa.gov/WAC/default.aspx?dispo=true&cite=173-201A-200).

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than ten total samples) limit. These two measures used in combination ensure that bacterial pollution in a waterbody will be maintained at levels that will not cause a greater risk to human health than intended. The criteria used in the state standards are designed to allow seven or fewer illnesses out of every 1,000 people engaged in primary contact activities.

While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal (summer versus winter) data sets. Once the concentration of fecal coliform in the water reaches the numeric criterion, human activities that would increase the concentration above the criteria are not allowed. If the criterion is exceeded, the state will require that human activities be conducted in a manner that will bring fecal coliform concentrations back into compliance with the standard. If natural levels of fecal coliform (from wildlife) cause criteria to be exceeded, no allowance exists for human sources to measurably increase bacterial pollution.

## Turbidity

Turbidity is a measure of light refraction in the water, and one uses it to control the amount of sediment and suspended solids. Suspended solids in the water column and sediment that has settled out on the bottom of the waterbody affect fish and other aquatic life. Effects are similar for both freshwaters and marine waters.

The effects of suspended solids on fish and other aquatic life can be divided into four categories:

1. Acting directly on the fish swimming in the water and either killing them or reducing their growth rate, resistance to disease, etc.
2. Preventing the successful development of fish eggs and larvae.
3. Modifying natural movements and migrations.
4. Reducing the abundance of available food.

Suspended solids may also serve to transmit attached chemical and biological contaminants to waterbodies where they can be taken up in the tissue of fish. This can affect the health of humans or wildlife that eat the fish.

Turbid waters also interfere with the treatment and use of water as potable water supplies. This can interfere with the recreational use and aesthetic enjoyment of the water.

Washington State established turbidity criteria in the water quality standards primarily to protect aquatic life. Two turbidity criteria are established to protect six categories of aquatic communities [WAC 173-201A-200; 2003 edition].

The turbidity water quality standards for the Salmon Creek watershed protect the designated aquatic life uses of "Core Summer Salmonid Habitat." Turbidity must not exceed: (A) 5 NTU over background when the background is 50 NTU or less, or (B) a 10% increased in turbidity when the background turbidity is more than 50 NTU.

## Nutrients

Nutrients including nitrogen and phosphorus are compounds that are necessary components for the growth of plants and animals. However, in excessive concentrations, nutrients are a water quality concern in drinking water and are a major contributor to eutrophication in rivers, lakes, and reservoirs. Large nutrient concentrations can contribute to excessive growth of algae and other aquatic plants that can cause destruction of habitat and depletion of dissolved oxygen. Major sources of nutrients are fertilizers, sewage effluent, precipitation, and dissolution of naturally occurring minerals.

Washington State water quality standards do not have numeric nutrient (nitrogen and phosphorus) criteria for streams. However, Chapter 173-201A contains a narrative criterion that applies to nitrogen and phosphorus:

*"Toxic, radioactive, or deleterious material concentrations shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department."*

## pH

The pH of natural waters is a measure of acid-base equilibrium achieved by the various dissolved compounds, salts, and gases. pH is an important factor in the chemical and biological systems of natural waters. pH both directly and indirectly affects the ability of waters to have healthy populations of fish and other aquatic species. Changes in pH affect the degree of dissociation of weak acids or bases. This effect is important because the toxicity of many compounds is affected by the degree of dissociation.

While some compounds (e.g., cyanide) increase in toxicity at lower pH, others (e.g., ammonia) increase in toxicity at higher pH. While there is no definite pH range within which aquatic life is unharmed and outside which it is damaged, there is a gradual deterioration as the pH values are further removed from the normal range. However, at the extremes of pH, lethal conditions can develop. For example, extremely low pH values (<5.0) may liberate sufficient carbon dioxide from bicarbonate in the water to be directly lethal to fish.

Washington State established pH criteria in the water quality standards primarily to protect aquatic life. The criteria also serve to protect waters as a source for domestic water supply. Water supplies with either extreme pH or that experience significant changes of pH even within otherwise acceptable ranges are more difficult and costly to treat for domestic water purposes. pH also directly affects the longevity of water collection and treatment systems, and low pH waters may cause compounds of human health concern to be released from the metal pipes of the distribution system.

In the state's water quality standards, two pH criteria are established to protect six different categories of aquatic communities [WAC 173-201A-200; 2003 edition].

The pH water quality standards for the Salmon Creek watershed protect the designated aquatic life uses of "Core Summer Salmonid Habitat." pH must be kept within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units.

## Dissolved oxygen

Aquatic organisms are very sensitive to reductions in the level of dissolved oxygen in the water. The health of fish and other aquatic species depends on maintaining an adequate supply of oxygen dissolved in the water. Oxygen levels affect growth rates, swimming ability, susceptibility to disease, and the relative ability to endure other environmental stressors and pollutants. While direct mortality due to inadequate oxygen can occur, Washington State designed the criteria to maintain conditions that support healthy populations of fish and other aquatic life.

Oxygen levels can fluctuate over the day and night in response to changes in climatic conditions as well as the respiratory requirements of aquatic plants and algae. Since the health of aquatic species is tied predominantly to the pattern of daily minimum oxygen concentrations, the criteria are the lowest 1-day minimum oxygen concentrations that occur in a waterbody.

In the state water quality standards, freshwater aquatic life use categories are described using key species (salmonid versus warm-water species) and life-stage conditions (spawning versus rearing). Minimum concentrations of dissolved oxygen are used as criteria to protect different categories of aquatic communities [WAC 173-201A-200; 2003 edition].

From the Salmon Creek watershed headwaters to the confluence of Cougar Creek, the following designated aquatic life use(s) and criteria are to be protected: "Core Summer Salmonid Habitat and Migration." The lowest 1-day minimum oxygen level must not fall below 9.5 mg/L more than once every ten years on average. From the Salmon Creek confluence of Cougar Creek to the mouth, the following designated aquatic life use(s) and criteria and to be protected:

“Salmonid Spawning, Rearing, and Migration.” The lowest 1-day minimum oxygen level must not fall below 8.0 mg/L more than once every ten years on average.

The above described criterion is used to ensure that where a waterbody is naturally capable of providing full support for its designated aquatic life uses, that condition will be maintained. The standards recognize, however, that not all waters are naturally capable of staying above the fully protective dissolved oxygen criteria. When a waterbody is naturally lower in oxygen than the criteria, the state provides an additional allowance for further depression of oxygen conditions due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.2 mg/L decrease below that naturally lower (inferior) oxygen condition.

While the numeric criteria generally apply throughout a waterbody, the criteria are not intended to apply to discretely anomalous areas such as in shallow stagnant eddy pools where natural features unrelated to human influences are the cause of not meeting the criteria. For this reason, the standards direct that one take measurements from well-mixed portions of rivers and streams. For similar reasons, samples should not be taken from anomalously oxygen rich areas. For example, in a slow moving stream, sampling on surface areas within a uniquely turbulent area would provide data that are erroneous for comparing to the criteria.

# Goals and Objectives

## Project goals

The primary goal of this effectiveness monitoring study was to evaluate attainment of the percent reductions (load allocations) at several compliance stations identified for bacteria and turbidity concentrations and load reductions in the 2001 TMDL report (Howard, 2001).

The secondary goal of this study is to evaluate data on additional water quality parameters collected by Clark County and compare results to current 303(d) listings for the Salmon Creek watershed.

## Study objectives

To meet project goals, the following steps were taken.

1. Review historic documentation related to the TMDL.
2. Compile information and data generated by Clark County
3. Review data for representativeness, comparability, and usability.
4. Analyze and interpret data to determine if the TMDL water quality targets were met.
5. Determine if changes in water quality were significant.

# Methods

## Field and laboratory

Water quality data have been collected as part of monitoring programs as well as special studies. The Clark County Conservation District (CCCD) and Clark County Department of Community Development (CCDCD) conducted monthly water quality sampling for the Southwest Washington Health District (SWHD). Four sites on the mainstem Salmon Creek were sampled from October 1988 through September 1989 as part of a Centennial Clean Water Fund grant. From May 1991 through February 1994, the SWHD sampled water quality monthly at up to ten sites on the mainstem and major tributaries of Salmon Creek.

Ecology approved a Quality Assurance (QA) Project Plan for the 1991-1994 data (Gaddis, 1991). All field measurements followed manufacturer's recommendations. All laboratory tests were performed at Clark County Water Quality Laboratory, accredited by Ecology.

Although a QA Project Plan was not prepared for the 1988-1989 data, the same methods and procedures used in the 1991-1994 were followed. Because these studies have all been under the direction of SWHD, using acceptable quality assurance, this effectiveness monitoring report used the information to develop water quality trends.

In 2002, Clark County Water Resources (now the Clark County Clean Water Program) and Clark Public Utilities agreed to consolidate ambient monitoring in Salmon Creek, standardize monitoring methods, and eliminate overlapping activities. As a result, Clark County Water Resources assumed responsibility for collecting water quality data at eight sites within the Salmon Creek watershed.

In 2003, a QA Project Plan was developed by Clark County Water Resources to provide ongoing water quality data and information on the health of the Salmon Creek watershed to state and local officials (Schnabel, 2003). The 2003 QA Project Plan can be found in Appendix B.

All raw data used for this report is located in Appendix C.

## Data analysis

Field and laboratory data were compiled and organized using Excel® spreadsheet software (Microsoft Corporation, 2001). Statistical analyses, plots, and data calculations were made using Excel®. Percentiles calculated within Excel® were based on the mean, standard deviation, and Z-score.

The range of data used for analysis for each parameter was based on Water Quality category listings. A description of these listings can be found in Chapter 1 of the Water Quality Program Policy 1-11 (WQPP, 2006).

Analysis of the fecal coliform and turbidity data was conducted in the same way as described in the 2001 TMDL submittal report (Howard, 2001). Fecal coliform and turbidity data were partitioned into wet and dry seasons and data were log transformed. Geometric means for fecal coliform and means for turbidity were calculated using Excel® formulas. The 90$^{th}$ percentiles were calculated based on the mean, standard deviation, and Z-score. Data collected from 2005-2007 were used to compare to TMDL target limits and current water quality standards.

The pH data were analyzed with methods described in Murphy (1981). Data was transformed to hydrogen ion concentrations (-log (mean [$H^+$]) for statistical analysis. Data collected from 1997-2007 were used to compare to TMDL target limits and current water quality standards

Untransformed dissolved oxygen data was used for statistical analysis. Data collected from 1997-2007 were used to compare to current water quality standards and category listings.

Nutrient data were log transformed for statistical analysis. Data collected from 2005-2007 were used to compare with TMDL study data. Data collected from 1988-2007 were used for a trends analysis.

## Trend analysis

Trend analysis was conducted using MAKESENS (Salmi et al., 2003). MAKESENS is a Microsoft Excel 97 template with macros coded in Microsoft Visual Basic used for the calculation of annual trend statistics. The procedure is based on both:

- The Mann-Kendall test
  - Identifies whether or not a statistically significant trend exists.
  - Is a non-parametric test used when a monotonic trend in the time-series data is present with no additional seasonal cycle.
- The Sen's method
  - Estimates the magnitude of the trend.
  - Is a non-parametric method which uses a linear model to estimate the slope of the trend. The variance of the residuals is assumed to be constant in time.

The absolute value of Z statistics is compared to the standard normal cumulative distribution to determine if there is a trend at the selected level of significance ($\alpha$). A positive (negative) value of Z indicates an upward (downward) trend. For example, Z scores greater than ±1.64 show a strong negative (positive) decreasing trend while Z scores less than ±1.64 indicate a weak decreasing (increasing) trend with less than 95% confidence.

# TMDL Summary

In 1995, Ecology completed a TMDL study (Cusimano and Giglio, 1995). This study recommended using water quality data collected by the CCCD and CCDCP from 1988-1994 to develop the TMDL. In 2001, Ecology completed a TMDL submittal report for fecal coliform and turbidity in the Salmon Creek watershed (Howard, 2001).

To better show temporal and spatial differences, and to define seasonal allocation targets, target limits for both fecal coliform and turbidity were developed at site-specific control points during both wet (November-April) and dry (May-October) seasons. The seasons were established by grouping the highest and lowest average flows for six contiguous months (Cusimano and Giglio, 1995).

## Fecal coliform

The fecal coliform TMDL targets are simply the freshwater fecal coliform standard. To meet the TMDL targets, concentration-based target limits were established for all eight monitoring stations annotated in Table 1. Table 4 lists the dry- and wet-season levels for both the geometric means and 90$^{th}$ percentiles for each site based on the 1988-1994 data. Table 4 also lists the percent reduction required to meet the target limit at each site for both parts of the criteria (geometric mean and 90$^{th}$ percentile).

Table 4. Salmon Creek watershed wet- and dry-season fecal coliform (colonies/100 mL) geometric means, 90$^{th}$ percentiles, and recommended reductions, 1988-1994.

| Station | GM<100 | | | | 90% of samples <200 | | | | Recommended Target Levels | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TMDL GM | | % Reduction Needed | | TMDL 90$^{th}$ %tile | | % Reduction Needed | | Target GM | | Target % Reduction | |
| | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry |
| SMN010 | 313 | 129 | 68 | 23 | 1917 | 301 | 89 | 34 | 33 | 86 | 89 | 34 |
| CGR020 | 722 | 899 | 86 | 89 | 9243 | 1803 | 98 | 89 | 16 | 100 | 98 | 89 |
| SMN030 | 182 | 281 | 45 | 64 | 1261 | 806 | 84 | 75 | 29 | 70 | 84 | 75 |
| MIL010 | 839 | 282 | 88 | 65 | 8763 | 1121 | 98 | 82 | 19 | 50 | 98 | 82 |
| CUR020 | 1155 | 743 | 91 | 87 | 4409 | 2608 | 86 | 92 | 52 | 57 | 96 | 92 |
| SMN050 | 234 | 751 | 57 | 87 | 1125 | 1404 | 82 | 86 | 42 | 100 | 82 | 87 |
| WDN | 534 | 857 | 81 | 88 | 9204 | 6509 | 98 | 97 | 12 | 26 | 98 | 97 |
| SMN080 | 28 | 54 | 0 | 0 | 200 | 318 | 0 | 37 | 28 | 34 | 0 | 37 |

GM – geometric mean.

## Turbidity

The turbidity nonpoint TMDL target is the numeric freshwater turbidity standard. To meet the TMDL target, numeric target limits were established for all eight monitoring stations.

Target limits were established such that turbidity levels would not exceed 5 NTU over background 90% of the time. Background turbidity was assumed to be equal to turbidity at the uppermost sampling site on Salmon Creek (SMN080). The turbidity target limits for each site is the background level plus 5 NTU. The target percent reduction is the percent reduction required for the 90$^{th}$ percentile of the data to meet the target limits. Table 5 lists the 90$^{th}$ percentile of background-adjusted data and target percent reductions needed to meet the target limits.

Table 5. Salmon Creek watershed wet- and dry-season average turbidity (NTU), 90$^{th}$ percentiles, and recommended reductions, 1988-1994.

| Station | 90$^{th}$ Percentile of Adjusted TMDL Data[1] | | 90$^{th}$ Percentile of Adjusted TMDL Data minus LA of 5 NTU[1] | | Recommended Target Percent Reduction[2] | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| SMN010 | 13.4 | 3.7 | 8.4 | -1.3 | 63 | 0 |
| CGR020 | 20.1 | 1.9 | 15.1 | -3.1 | 75 | 0 |
| SMN030 | 12.8 | 1.8 | 7.8 | -3.2 | 61 | 0 |
| MIL010 | 21.1 | 3.5 | 16.1 | -1.5 | 76 | 0 |
| CUR020 | 5.9 | 2.8 | 0.9 | -2.2 | 16 | 0 |
| SMN050 | 8.2 | 3.2 | 3.2 | -1.8 | 39 | 0 |
| WDN | 10.1 | 2.0 | 5.1 | -3.0 | 51 | 0 |
| SMN080 | NA | NA | NA | NA | NA | NA |

[1]Adjusted data equals site value minus background (site SMN080) value for each sampling event.
[2]Target reduction is the percent reduction required to reduce the 90$^{th}$ percentile of the adjusted data to 5 above background.
LA – Load allocation.

# Results and Discussion

## Fecal coliform bacteria

Geometric mean and 90th percentile reduction TMDL target limits for fecal coliform were based on wet and dry seasons for each site. Data used for the TMDL target limit comparison were collected monthly from 2005 through 2007 under guidelines in the Clark County Water Resources QA Project Plan (see Appendix B).

Wet-season (May to October) geometric mean target limits were met at all sites except for CGR020. When compared to geometric mean values in Table 4, fecal coliform decreased at all stations, ranging from 77% to 98% during the wet season (Table 6).

Dry-season (November to April) geometric mean target limits were only met at SMN010 and SMN080. When compared to geometric mean values in Table 4, fecal coliform decreased at all stations, ranging from 23% to 86% (Table 6).

Table 6. 1995 TMDL study fecal coliform (colonies/100 mL) criterion compared to 2005-07 data.
*Geometric mean values for wet and dry seasons.*

| Station | Wet season | | | | | Dry season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TMDL | 05-07 | % change[1] | Meets criterion? | % Required change[2] | TMDL | 05-07 | % change[1] | Meets criterion? | % Required change[2] |
| SMN010 | 313 | 59 | -82 | **Yes** | none | 129 | 90 | -30 | **Yes** | none |
| CGR020 | 722 | 143 | -80 | No | 30 | 899 | 696 | -23 | No | 86 |
| SMN030 | 182 | 42 | -77 | **Yes** | none | 281 | 151 | -46 | No | 34 |
| MIL010 | 839 | 50 | -94 | **Yes** | none | 282 | 106 | -62 | No | 6 |
| CUR020 | 1155 | 23 | -98 | **Yes** | none | 743 | 116 | -84 | No | 14 |
| SMN050 | 234 | 21 | -91 | **Yes** | none | 751 | 106 | -86 | No | 6 |
| WDN | 534 | 71 | -87 | **Yes** | none | 857 | 184 | -79 | No | 46 |
| SMN080 | 28 | 6 | -79 | **Yes** | none | 54 | 34 | -35 | **Yes** | none |

[1] Percent change required to meet TMDL target limits.
[2] Additional change required to meet TMDL target limits.

Wet-season 90th percentile TMDL target limits were only met at four stations (Table 7). When compared to TMDL values in Table 4, the 90th percentiles decreased at all stations, with the percent change ranging from 83% to 98% during the wet season (Table 7).

Dry-season 90th percentile TMDL target limits were only met at SMN080 (Table 7). When compared to TMDL values in Table 4, the 90th percentile decreased at all stations with the percent change ranging from 36 to 87 percent.

Table 7. 2001 TMDL report fecal coliform (colonies/100 mL) criterion compared to 2005-07 data.
*90th percentile values for wet and dry seasons.*

| Station | Wet season | | | | | Dry season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TMDL | 05-07 | % change[1] | Meets criterion? | % Required change[2] | TMDL | 05-07 | % change[1] | Meets criterion? | % Required change[2] |
| SMN010 | 1917 | 321 | -83 | No | -38 | 301 | 347 | -15 | No | -42 |
| CGR020 | 9243 | 601 | -93 | No | -67 | 1803 | 1577 | -13 | No | -87 |
| SMN030 | 1261 | 194 | -85 | **Yes** | none | 806 | 342 | -58 | No | -36 |
| MIL010 | 8763 | 381 | -96 | No | -48 | 1121 | 483 | -57 | No | -59 |
| CUR020 | 4409 | 93 | -98 | **Yes** | none | 2608 | 472 | -82 | No | -58 |
| SMN050 | 1125 | 138 | -88 | **Yes** | none | 1404 | 346 | -75 | No | -42 |
| WDN | 9204 | 468 | -95 | No | -57 | 6509 | 628 | -90 | No | -68 |
| SMN080 | 200 | 22 | -89 | **Yes** | none | 318 | 98 | -69 | **Yes** | none |

[1] Percent change required to meet TMDL target limits.
[2] Additional change required to meet TMDL target limits.

Table 8 shows the target geometric mean value calculated in the 1995 TMDL study would be required to meet both the geometric mean and the 90th percentile criteria for both the wet and dry seasons. Three sampling stations, CUR020, SMN050 and SMN080, met the wet-season target while only SMN080 met the dry-season target geometric mean. The uppermost station on Salmon Creek, SMN080, met both the wet- and dry-season recommended target geometric mean value.

One might expect that higher fecal coliform concentrations would be observed during the wet season as runoff flows deliver fecal coliform from upland areas into waterbodies. This was not the case for Salmon Creek. Wet-season geometric mean concentrations were on average 70% lower than dry-season geometric means. This could suggest that fecal coliform sources within the watershed may be chronic, and inputs are hydrologically connected to surface water. Higher wet-season flows may be diluting fecal coliform concentrations from chronic sources.

Table 8. 1995 TMDL study fecal coliform (colonies/100 mL) geometric mean recommended target levels compared to 2005-07 data to meet both the geometric mean and 90th percentile criteria.

| Station | Wet season | | | | Dry season | | | |
|---|---|---|---|---|---|---|---|---|
| | Target | 05-07 | Meets Target? | % Required change[1] | Target | 05-07 | Meets Target? | % Required change[1] |
| SMN010 | 33 | 59 | No | -44 | 86 | 90 | No | -4 |
| CGR020 | 16 | 143 | No | -89 | 100 | 696 | No | -86 |
| SMN030 | 29 | 42 | No | -31 | 70 | 151 | No | -54 |
| MIL010 | 19 | 50 | No | -62 | 50 | 106 | No | -53 |
| CUR020 | 52 | 23 | **Yes** | none | 57 | 116 | No | -51 |
| SMN050 | 42 | 21 | **Yes** | none | 100 | 106 | No | -6 |
| WDN | 12 | 71 | No | -83 | 26 | 184 | No | -86 |
| SMN080 | 28 | 6 | **Yes** | none | 34 | 34 | **Yes** | -3 |

[1]Additional change required to meet TMDL target limits.

To determine if there were any statistically significant trends in fecal coliform concentrations over time, a step trend statistical test was used. The data used for this analysis were collected between 1988 through 2007.

All eight stations demonstrated a significant decreasing yearly trend (Z score < -1.65) in fecal coliform concentrations (Table 9). Yearly is defined from January to December. For the wet season, all stations, except the upper-most station (SMN080), had significant decreasing fecal coliform trends. A significant decrease in dry-season fecal coliform was observed at all but three stations. SMN010, CGR020, and SMN080 had decreasing trends as indicated by the negative Z score; however the trends were not determined to be significant (Z score not < -1.65).

The fact that no significant wet- or dry-season trends in fecal coliform were observed at station SMN080 was not unexpected given that this is the upper-most station in the Salmon Creek watershed. Development and other land disturbances upstream of this station are limited when compared to other stations. Because of the relative lack of human disturbance, it would be expected that water quality parameters would be less variable over time. This observation also validates the trend analysis by demonstrating the expected result. (See also SMN080 in Table 11).

The overall decreasing trend in fecal coliform concentrations during the wet season indicates that implementation projects have been effective in reducing stormwater-related or runoff-related fecal coliform pollution. Elevated dry-season fecal coliform may be due to a lack of dilution. As discussed above, this may indicate that pollution sources are consistent over time and are diluted by higher flows during the wet season.

Table 9. Fecal coliform geometric mean trend test results, 1988-2007.

| Station | Z score | | Trend increasing or decreasing | | Have fecal coliform levels changed significantly? | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| SMN010 | -2.40 | -1.58 | ↓ | ↓ | **Yes** | No |
| CGR020 | -2.86 | -0.92 | ↓ | ↓ | **Yes** | No |
| SMN030 | -2.67 | -2.47 | ↓ | ↓ | **Yes** | **Yes** |
| MIL010 | -3.04 | -1.77 | ↓ | ↓ | **Yes** | **Yes** |
| CUR020 | -2.89 | -2.99 | ↓ | ↓ | **Yes** | **Yes** |
| SMN050 | -3.60 | -3.22 | ↓ | ↓ | **Yes** | **Yes** |
| WDN | -1.97 | -2.75 | ↓ | ↓ | **Yes** | **Yes** |
| SMN080 | -1.58 | -0.92 | ↓ | ↓ | No | No |

↑ increasing trend.
↓ decreasing trend.

## Fecal coliform compliance with water quality standards

Seasonal geometric means met the Washington State fecal coliform standard at all stations, except for CGR020 and WDN. SMN080 was the only station that met both the geometric mean standard and the 90th percentile standard (Figure 2). The fecal coliform standard is not based on seasonal separation but rather on a number of samples collected over a period of time (WQPP, 2006.)

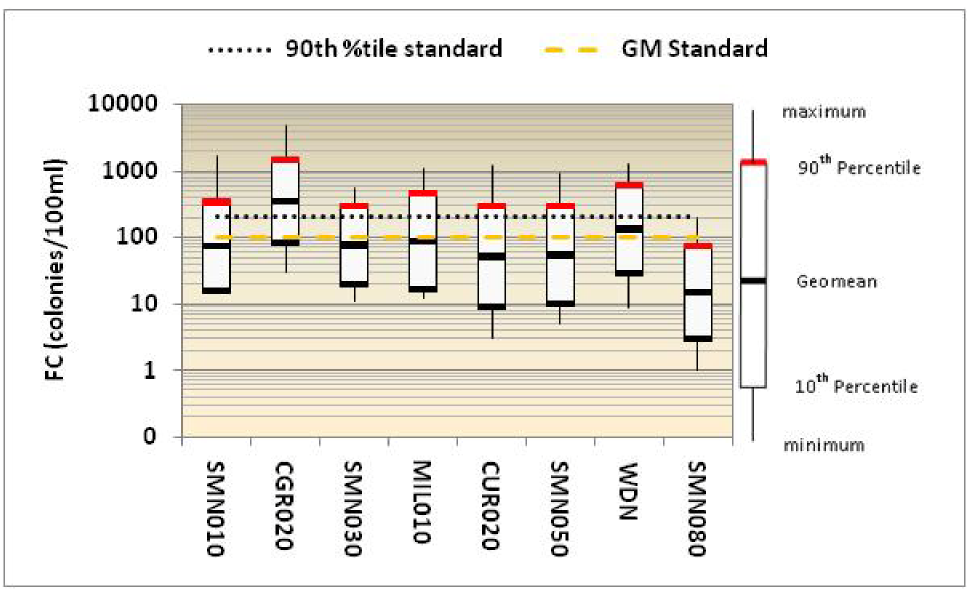


Figure 2. Seasonal fecal coliform (FC) monitoring data, 2005-2007.

## Turbidity

The 2001 TMDL wet-season 90th percentile target levels for turbidity and the 2005-07 turbidity levels are presented in Table 10. No target limits were established for the dry season because no violations in turbidity standards were observed in the TMDL. Data used for the TMDL target limit comparison were collected monthly from 2005 through 2007 under guidelines in the Clark County Water Resources QA Project Plan (see Appendix B).

All stations met the TMDL target limits for turbidity. When compared to TMDL values, 90th percentiles decreased at all stations, ranging from 63% to 151% during the wet season (Table 10).

Table 10. 2001 TMDL report wet-season 90th percentile target levels for turbidity (NTU) compared to 2005-07 data.

| Station | 90th Percentile of Adjusted Data minus Load Allocation of 5 NTU | | | |
|---|---|---|---|---|
| | TMDL Target[1] | 05-07[1] | % change | Meets target? |
| SMN010 | 8.4 | 5 | -63 | **Yes** |
| CGR020 | 15.1 | 2 | -90 | **Yes** |
| SMN030 | 7.8 | 4 | -69 | **Yes** |
| MIL010 | 16.1 | 7 | -67 | **Yes** |
| CUR020 | 0.9 | -3 | -151 | **Yes** |
| SMN050 | 3.2 | 3 | -63 | **Yes** |
| WDN | 5.1 | 1 | -90 | **Yes** |

[1]Adjusted data equals each site value minus background (SMN080) value for each sampling event.

## Nutrients

The nutrients of interest are phosphorus and nitrogen. Nutrient levels, while not specifically regulated by numeric water quality criteria, were identified in the 1995 TMDL study as high relative to other streams and rivers in southwestern Washington.

Nitrate-nitrite concentrations decreased along the mainstem of Salmon Creek from upstream to downstream (Figure 3). The highest concentrations were found in tributary stations CGR020 and CUR020. Typically, the presence of nitrates in concentrations greater than 4-5 mg/L may reflect unnatural conditions. Nuisance plant growth has been noted in streams because of elevated concentration of nitrogen. All of the mean nitrate-nitrite concentrations were below 4 mg/L.

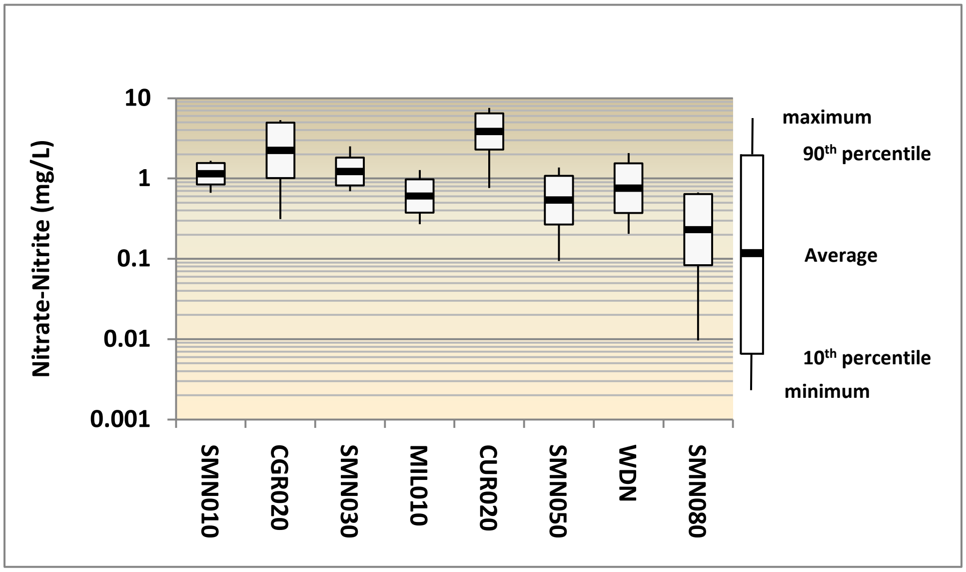


Figure 3. Nitrate-nitrite data, 2005-2007.

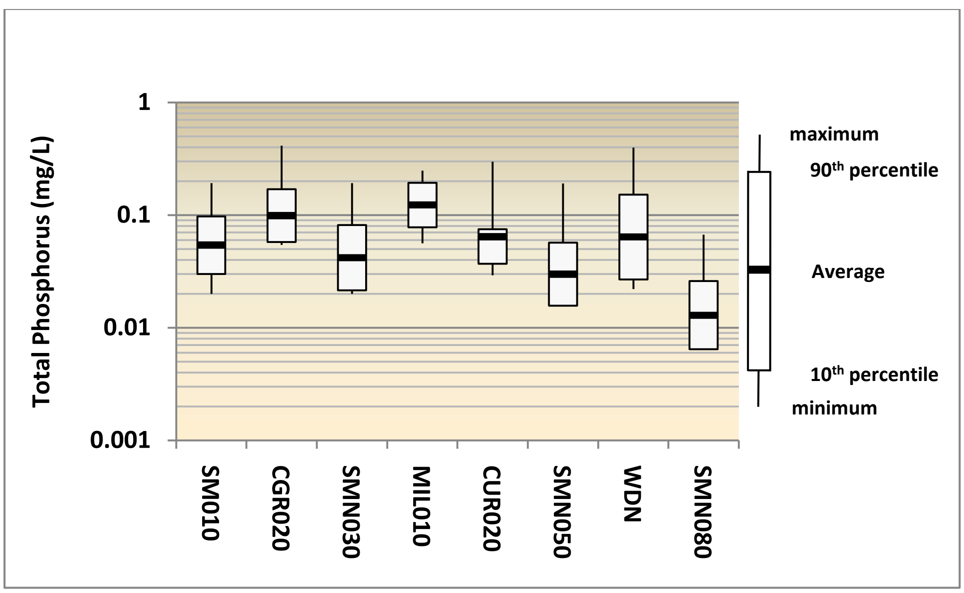


Figure 4. Total phosphorus data, 2005-2007.

Like nitrate-nitrite, phosphorus concentrations decreased along the mainstem of Salmon Creek from upstream to downstream (Figure 4). As with nitrate-nitrite, highest phosphorus concentrations were observed at CGR020 and CUR020. Total phosphorus concentrations were typical lower when compared to nutrient data presented in the 1995 TMDL study (Table 11). High (unnatural) total phosphorus concentrations in surface water tend to fuel nuisance algal production.

Table 11. Trend test results for the nutrients, nitrate-nitrite and phosphorus, 1988-2007.

| Station | Z score | | Trend increasing or decreasing | | Have nutrient levels changed significantly? | |
|---|---|---|---|---|---|---|
| | Nitrate-Nitrite | Total Phosphorus | Nitrate-Nitrite | Total Phosphorus | Nitrate-Nitrite | Total Phosphorus |
| SMN010 | -2.30 | -2.49 | ↓ | ↓ | **Yes** | **Yes** |
| CGR020 | 0.99 | -1.87 | ↑ | ↓ | No | **Yes** |
| SMN030 | -2.39 | -3.18 | ↓ | ↓ | **Yes** | **Yes** |
| MIL010 | -3.28 | -1.87 | ↓ | ↓ | **Yes** | **Yes** |
| CUR020 | -1.42 | -1.56 | ↓ | ↓ | No | No |
| SMN050 | -2.50 | -1.85 | ↓ | ↓ | **Yes** | **Yes** |
| WDN | -2.87 | -2.14 | ↓ | ↓ | **Yes** | **Yes** |
| SMN080 | -1.19 | 1.45 | ↓ | ↑ | No | No |

↑ increasing trend.
↓ decreasing trend.

To determine if there were any statistically significant trends in nitrate-nitrite and total phosphorus, a step trend statistical test was conducted. The data used for this analysis was collected between 1988 and 2007.

Significant decreasing trends in nitrate-nitrite were observed at all stations, except for CGR020, CUR020, and SMN080 (Table 11). CGR020 had an increasing trend in nitrate-nitrite as indicated by a positive Z score; however, the score was too low to indicate any significant change over time. The largest decreasing trend in nitrate was observed at MIL010, as indicated by the lowest negative Z score of -3.28.

Significant decreasing trends in total phosphorus were observed at all stations, except for CUR020 and SMN080.

Nitrogen and phosphorus are found in human and animal wastes, fertilizers, and organic matter (such as leaves and grass) that can wash into streams. Phosphorus can also be found in some soaps and detergents. Nutrients related to human and animal wastes should decrease as fecal coliform sources to the creek are removed. At those stations that demonstrated significant decreases in fecal coliform but not in nutrients (i.e., CUR020 and CGR020), nutrient inputs are likely from sources other than human and animal waste or may be a natural condition.

## pH

As indicated in Table 1, all stations except SMN080 were identified on the 2008 303(d) list for violations of the low range of the pH criteria. (Sites are listed as Category 2 or 5; see *Water Quality Assessment*/Categories 1-5). For a Category 1 listing, 5% or fewer pH samples in the latest 10 years must not exceed the applicable criterion (pH <6.5 or >8.5). For a Category 5 determination, at least 10% of single grab samples in a given year from the last five years of data do not meet the criterion. Single sample monthly pH measurements collected by Clark County from 1997 through 2007 were used to compare with water quality criteria.

pH ranged from 5.6 – 8.5 at all stations with the mean pH ranging from 6.9 – 7.4. No exceedances of the upper pH criterion (>8.5) were observed at any of the eight sampling stations (Figure 5). All stations had single sample exceedances of the lower pH criterion of <6.5 from 1997 through 2007. Of these stations, only CUR020 met the criteria for a Category 5 listing. The 10th percentile of the single sample pHs collected between 2003 and 2007 was 6.5 at the uppermost station (SMN080), suggesting low pH values observed within the watershed may be a natural condition.

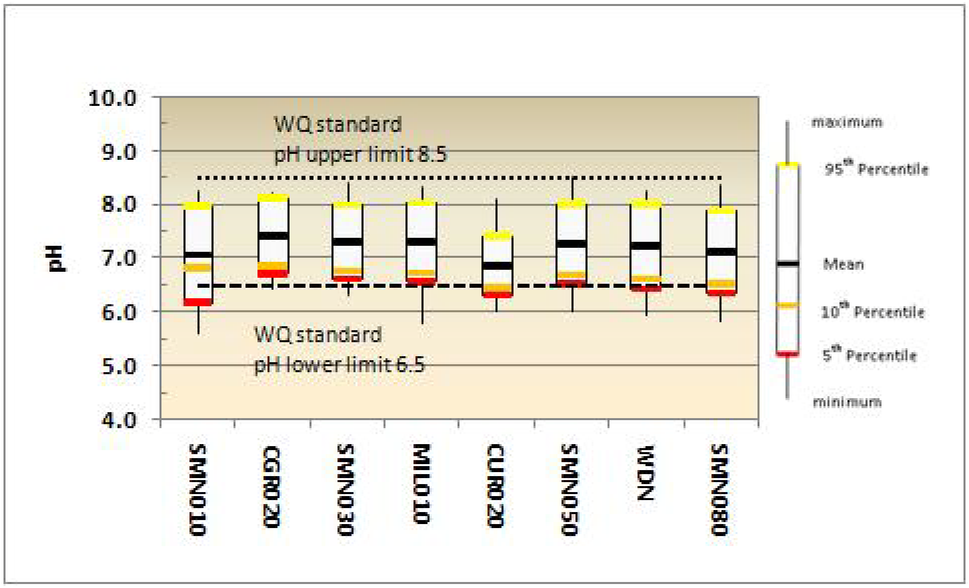


Figure 5. pH data, 1997-2007.

Only four stations met the Category 1 listing, meaning that less than 5% of the samples fell below a pH of 6.5. CUR020, WDN, and SMN080 (the uppermost station) had >5% of pH samples fall below 6.5.

Because photosynthesis increases pH during daylight hours, single samples collected during daylight hours may not be indicative of the lower threshold of the pH range. In all likelihood, continuous pH monitoring would indicate lower end exceedances of the pH criterion at all stations.

A combination of the geology of the watershed and the original source of the water determine the initial pH of the water. Stream conditions typically associated with naturally low pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids.

Wetlands make up 17.1% of the subwatershed that contains station SMN010 while 6.1% of the subwatershed containing CUR020 is comprised of wetlands (Wierenga, 2005). Percent wetlands within the study area range from 1.7 - 17.1%. Lack of buffering capacity due to soil composition and vegetative decay in swampy watersheds can also lead to low instream pH.

In western Washington, pH violations are typically found on the upper end of the criterion (>8.5). This is because increased nonpoint source nutrient inputs can increase photosynthesis, thus increasing the pH. Additional study of pH within the Salmon Creek watershed is needed to determine if low pH conditions are natural.

## Dissolved oxygen

As indicated in Table 1, all stations, with the exception of SMN030 and SMN080, are identified on the 2008 303(d) list for violation of the dissolved oxygen (DO) standard. Single sample monthly DO measurements collected by Clark County from 1997 through 2007 were used to compare with water quality criteria.

All eight stations did not meet the DO water quality criteria (but not comparable to that of SMN030 and SMN080) (Figure 6). Greater than 10% of the single sample measurements fell below the water quality criteria of 9.5 mg/L (8.0 mg/L for SMN010, see *Water Quality Standards and Beneficial Uses*, Dissolved Oxygen section). The lowest DO levels were observed on CUR020.

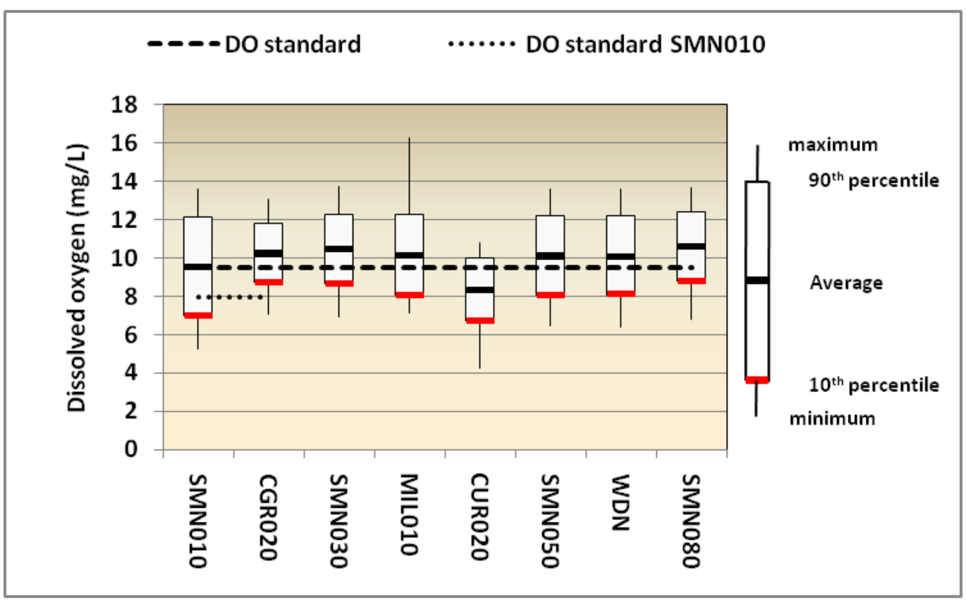


Figure 6. Dissolved oxygen data, 1997-2007.

As with pH, DO concentrations vary throughout the day and are driven by photosynthesis, respiration, and decomposition. Generally under natural conditions, DO concentrations are lowest just before dawn and then steadily increase as photosynthesis increases throughout the day. Because of this, single samples collected during daylight hours may not be indicative of the lowest DO values. Continuous monitoring of DO would likely demonstrate even lower minimum values than what was observed during daylight sampling.

Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions in a free-flowing stream that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished.

Indicators of these conditions include low slope, the presence of wetlands, and often low pH due to organic acids produced in the decay process. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

As with pH, DO is driven by many confounding factors, and the relationship between slope, percent wetlands, and DO is only antidotal. Additional study is needed to determine what factors are contributing to low DO levels within the watershed.

## Land-use disturbance

A road density analysis was performed for the Salmon Creek watershed based on the catchment areas (or subwatersheds) delineated from Hydrologic Unit Code 6$^{th}$. This was done to relate fecal coliform concentrations with population densities or land-use disturbance (LUD).

Stormwater and watershed management literature document a strong relationship between increased impervious area and decreasing stream and wetland quality. In Washington State, May (1996) reviewed a large body of data and found a strong correlation between watershed percent impervious area and the overall quality of Puget Sound Lowlands stream habitat.

In general, the higher the LUD value, the higher the density of roads. In this analysis, road densities are presumed to be indicative of overall anthropogenic disturbance within each subwatershed.

LUD areas appear to relate to fecal coliform concentrations (Figure 7). The highest LUD score, Cougar Creek (CGR020), had the highest observed concentrations of fecal coliform while the lowest LUD score, for upper Salmon Creek (SMN080), had some of the lowest observed values. This analysis could be broadly used to delineate future pollution prevention projects within the watershed. This analysis may indicate fecal coliform sources associated with high population densities increase potential for fecal coliform impacts from stormwater. Much of the Cougar Creek subwatershed is connected to the City of Vancouver sanitation system; however, septic systems do exist.

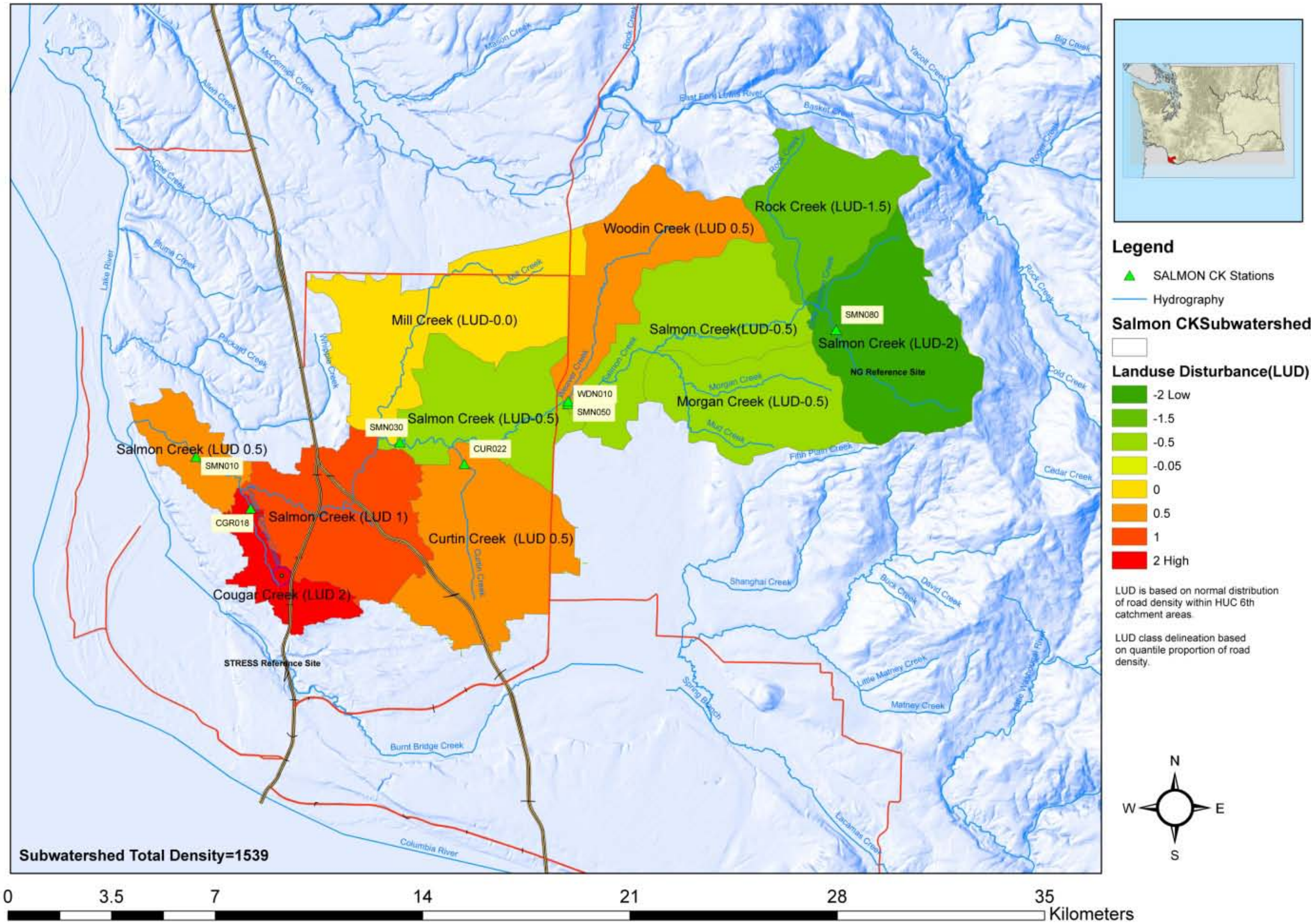


Figure 7. Road density analysis delineated from Hydrologic Unit Code 6th.

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# Summary

Following is a summary of the 2005-07 TMDL effectiveness monitoring study of the Salmon Creek watershed.

## Fecal coliform

Wet-season and dry-season fecal coliform geometric means and 90$^{th}$ percentiles decreased at all stations with the percent decrease ranging from 13% to 98% from concentrations reported in the 1995 TMDL study.

Despite statistically significant decreases in fecal coliform concentrations, only the uppermost Salmon Creek sampling station (SMN080) met both the geometric mean and 90$^{th}$ percentile water quality standard.

The decrease in dry-season fecal coliform concentrations was on average 30% less than the decrease in wet-season fecal coliform concentrations. Elevated dry-season fecal coliform concentrations are not unique to the Salmon Creek watershed. A report published by Ecology in 2008 demonstrated this pattern has been observed throughout Washington (Bell-McKinnon, 2008). The 2008 report suggests the most likely reason for the difference is that wet-season flows can dilute fecal coliform concentrations from sources that are chronic in nature.

Cougar Creek (CGR020) had some of the highest observed fecal coliform concentrations within the watershed. A road density analysis performed for the Salmon Creek watershed demonstrated the Cougar Creek subwatershed had some of the highest road densities.

The 2005-07 Clark County data indicate the 2001 TMDL report target limits for turbidity were met at all stations.

## Nutrients

Significant decreasing trends in nitrate-nitrogen were observed at all stations, except for CGR020 and SMN080. Mean concentrations were not higher than levels indicative of significant anthropogenic influence. The highest concentrations of nitrate-nitrogen were observed in Cougar Creek and Curtin Creek.

Significant decreasing trends in total phosphorus were observed at all stations, except for CUR020 and SMN080. These levels are not considered to be indicative of significant anthropogenic contributions.

## Dissolved oxygen and pH

Both dissolved oxygen levels and pH violated their respective water quality criterion at all sampling stations.  Because parameters are generally their lowest during non-daylight hours, the level of exceedances would increase if continuous monitoring were conducted.

Low dissolved oxygen and pH conditions within the Salmon Creek watershed are likely integrally connected and may be naturally occurring.  Both of these conditions have been documented as occurring within the study area and should be taken into consideration for any future studies.

# Conclusions and Recommendations

## Conclusions

Overall, the water quality improvements within the Salmon Creek watershed are related to a combination of (1) pollution-prevention (implementation) activities and (2) the loss of large- and small-scale agricultural or confined animal feeding operations (specifically dairies).

It is likely that as the loss of agricultural operations plateaus, the decreasing trends in fecal coliform within the watershed will level off. As the population of the Salmon Creek watershed continues to expand and become denser, sources of nonpoint pollution will change from agricultural and rural related sources to sources related to high density population. This is evident by results obtained from Cougar Creek.

To improve water quality further, future best management practices (BMPs) and watershed planning actions will need to be altered to accommodate the above changes.

## Recommendations

The following recommendations are suggested based on the results of this 2005-07 TMDL effectiveness monitoring study of the Salmon Creek watershed:

- All data collected in the Salmon Creek watershed by Clark County should be entered into Ecology's Environmental Information Management (EIM) system.
- A detailed continuous monitoring study should be conducted to determine if Salmon Creek pH and dissolved oxygen levels are naturally low.
- Water quality monitoring should continue at the eight existing sampling stations.
- Salmon Creek Advisory Committee members should continue their excellent implementation work which has resulted in a significant improvement in water quality within the Salmon Creek watershed.
- Further implementation should address:
  - Dry-season fecal coliform sources throughout the watershed downstream of station SMN080. These sources may include hydrologically connected failing septic systems, illicit discharges, and areas of high erosion and streambank erosion.
  - Wet-season sources causing $90^{th}$ percentile not meeting water quality standards (e.g., stormwater, runoff) near the mouth of Salmon Creek and in the Cougar, Mill, and Weaver Creek subbasins. These sources include animal waste and stormwater runoff.

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# Appendices

Appendix A.  Glossary, Acronyms, and Abbreviations.

Appendix B.  Clark County Water Resources Quality Assurance Project Plan.

Appendix C.  Raw Data from 1988-2007.

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# Appendix A.  Glossary, Acronyms, and Abbreviations

**Anthropogenic:**  Human-caused.

**Background:**  Natural (levels) or free of human influence

**Clean Water Act:**  Federal Act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

**Designated uses**:  Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each waterbody or segment, regardless of whether or not the uses are currently attained.

**Dry season:**  November to April (in this study).

**Effectiveness monitoring:**  Monitoring to determine whether the recommended *Detailed Implementation Plan*, after a significant portion of the recommendations or prescriptions have been implemented, is adequate in meeting (1) the goals and objectives for the TMDL project or (2) other desired outcomes over long temporal scales.

**Eutrophication:**  An increase in productivity resulting from nutrient loads from human activities such as fertilizer runoff and leaky septic systems.

**Fecal coliform (FC):**  That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 + or - 0.2 ° Celsius. FC are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

**Geometric mean:**  A mathematical expression of the central tendency (an average) of multiple sample values.  A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated.  This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from ten to 10,000 fold over a given period.  The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

**Load allocation:**  The portion of a receiving waters' loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

**Loading capacity:**  The greatest amount of a substance that a waterbody can receive and still meet water quality standards.

**Margin of safety:**   Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving waterbody.

**National Pollutant Discharge Elimination System (NPDES):** National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

**Nonpoint source:** Pollution that enters any waters of the state from any dispersed land-based or water-based activities. This includes, but is not limited to, atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

**Parameter:** A physical chemical or biological property whose values determine environmental characteristics or behavior.

**Pathogen:** Disease-causing microorganisms such as bacteria, protozoa, viruses.

**Point source:** Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

**Pollution:** Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or is likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

**Riparian:** Transitional zone between aquatic and upland areas. The riparian area has vegetation or other physical features reflecting permanent influence on surface water or subsurface water.

**Salmonid**: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

**Stormwater:** The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

**Surface waters of the state**: Lakes, rivers, ponds, streams, inland waters, saltwaters, wetlands and all other surface waters and water courses within the jurisdiction of the state of Washington.

**Total Maximum Daily Load (TMDL):** A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

**Wasteload allocation:** The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocation constitutes one type of water quality-based effluent limitation.

**Watershed:** A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

**Wet season:** May to October (for this study).

**303(d) List:** Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited waterbodies (ocean waters, estuaries, lakes, and streams) that fall short of state surface water quality standards, and are not expected to improve within the next two years.

**90th percentile:** A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

## Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

| | |
|---|---|
| °C | Degrees centigrade |
| CCCD | Clark County Conservation District |
| CCDCD | Clark County Department of Community Development |
| e.g. | For example |
| Ecology | Washington State Department of Ecology |
| EPA | U.S. Environmental Protection Agency |
| LUD | Land-use disturbance |
| mg/L | Milligrams per liter (parts per million) |
| NTU | Nephelometric turbidity units |
| QA | Quality assurance |
| SWHD | Southwest Washington Health District |
| TMDL | Total Maximum Daily Load (water cleanup plan) |
| WAC | Washington Administrative Code |

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## Appendix B. Clark County Water Resources: Quality Assurance Project Plan, 2003.

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# Clark County NPDES
# Salmon Creek Monitoring Project

## Quality Assurance Project Plan

Version 1.0 February 2003

| | |
|---|---|
| Project Name: | Salmon Creek Monitoring Project |
| Project Code: | SCMP |
| Agency Name: | Clark County Washington |
| Agency Contact Name: | Jeff Schnabel |
| Department: | Public Works Water Resources |
| Funding Source: | Clark County Clean Water Fee |

**Approvals:**

Project Manager: ________________________________________ Date: ______________
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Supervisor: ________________________________________ Date: ______________
Rod Swanson, Monitoring Coordinator
Clark County Public Works Water Resources

Client Approval: ________________________________________ Date: ______________
Earl Rowell, Water Resources Manager
Clark County Public Works Water Resources

CPU Approval: ________________________________________ Date:______________
Steve Prather, Water Quality Manager

Laboratory Contact: ________________________________________ Date: ______________
Howard Holmes, Project Manager
North Creek Analytical Laboratories

QC Coordinator: ________________________________________ Date: ______________
Ron Wierenga, Water Resource Scientist

Prepared by: Clark County Public Works Water Resources

# Salmon Creek Monitoring Project
# Quality Assurance Project Plan

## Purpose of the Quality Assurance Project Plan

Clark County Public Works Water Resources (Water Resources) follows the general Quality Assurance Project Plan (QAPP) format defined by the State of Washington Department of Ecology (Ecology) (Lombard and Kirchmer, 2001). Water Resources requires a QAPP for each monitoring project. The plan addresses project design, schedule, methods of data collection and management, quality assurance and quality control requirements, data analysis, and reporting.

## Background and Problem Statement

Clark Public Utilities (CPU) began water quality monitoring in the Salmon Creek watershed in 1995 to characterize conditions in the Salmon Creek main-stem and several major tributaries. Field monitoring activities were carried out by CPU staff. Data management and analysis were performed by Pacific Groundwater Group (PGG) as part of larger ongoing environmental studies funded by CPU.

In 2000, Clark County instituted the Clean Water Fee, which provides funding for expanded implementation of the county's NPDES Stormwater Management Program. As part of this implementation effort under the 1999 NPDES Permit, the county expanded its water quality monitoring activities. Among these new activities was a project begun in 2001 to evaluate the long-term health of several stormwater-influenced Clark County streams. The site list for the Long-term Index Site Project (LISP) included three sites on Salmon Creek tributaries which overlapped with the ongoing CPU water quality monitoring project (Cougar Creek, Mill Creek, and Curtin Creek). Though the county LISP studies a more comprehensive list of stream health characteristics, including habitat assessment and benthic macroinvertebrate sampling, the overlap in water quality monitoring resulted in duplicated effort.

During 2002, Water Resources and CPU signed an intergovernmental agreement (IGA) to consolidate ambient monitoring activities in Salmon Creek, standardize monitoring methods, and eliminate overlapping activities. As a result of this IGA, Water Resources assumed responsibility for collecting data for the CPU Salmon Creek monitoring project. CPU in turn agreed to provide maintenance and operation for two Clark County stream flow gages and three continuous rainfall gages (Clark County, 2002).

A general QAPP was prepared for the 1995 CPU Salmon Creek project. However, due to changes in the monitoring project and the absence of a rigorous QC protocol in the 1995 QAPP, a new QAPP was required to assure both parties that quality data are being generated.

In summary, CPU and Water Resources have an ongoing need to provide water quality data and information about the health of the Salmon Creek watershed to state and local officials. The Salmon Creek Monitoring Project (SCMP) meets the need for defensible water quality data, alleviates historical overlap in monitoring sites, and facilitates the goal of coordinating monitoring activities and protocols among local agencies.

## Organization and Timeline

*Project Staff*

Water Resources activities are administered through Clark County Public Works as part of the county's NPDES Stormwater Management Program.

| | |
|---|---|
| Client: | Earl Rowell, Water Resources Manager |
| Supervisor: | Rod Swanson, Senior Planner |
| Project Manager: | Jeff Schnabel, Water Resource Scientist |
| QC Coordinator: | Ron Wierenga, Water Resource Scientist |
| Project Team: | Bob Hutton, Planner III |
| | Jeff Schnabel |
| | Ron Wierenga |

*Laboratory Contracts*

Laboratory water quality analyses for the project are performed by North Creek Analytical Laboratories (NCA), an Ecology-accredited laboratory located in Beaverton, Oregon.

| | |
|---|---|
| Laboratory: | North Creek Analytical Laboratory |
| Address: | 9405 SW Nimbus Avenue, Beaverton, OR 97008-7132 |
| Phone: | 503-906-9200 |
| Contact: | Howard Holmes |

*Budget*

Budget estimates for the SCMP are found in Table 1:

| Budget Category | Estimated Cost (annual) |
|---|---|
| Staff | $8,500.00 |
| Vehicle | $250.00 |
| Laboratory | $13,750.00 |
| **Total** | **$22,500.00** |

**Table 1. Annual budget estimates for the Water Resources SCMP.**

*Project Timeline*

The SCMP is an ongoing ambient monitoring project. Under the IGA with CPU, Water Resources began monitoring in May 2002. Data collection activities by Water Resources will continue until the SCMP project is revised or discontinued by agreement between CPU and Water Resources. Water Resources data are submitted to CPU on a monthly basis for analysis. Brief annual project reports including methods, data, and QC results will be submitted by Water Resources to CPU beginning with the year 2003 report due in March 2004.

## Project Description

The intent of the SCMP is to provide high-quality data and water quality information about the Salmon Creek watershed to Clark Public Utilities and Clark County decision-makers. Within this context, data are used for a variety of purposes, including:

- Annual report of Salmon Creek water quality by Clark Public Utilities

- Watershed management by CPU, Clark County, and other local entities
- 303(d) data submittals to Ecology
- Clark County Stream Health Report

*Objectives*

Specific project objectives are to:

- Provide CPU and Clark County with timely, high-quality data that are comparable to those collected by other local and regional agencies.
- Determine whether water quality at sampling stations exceeds state standards.
- Provide Clark County decision-makers and the general public with analytical information that describes water quality status in the Salmon Creek watershed.

## Sampling Design

*Station Selection*

Sampling stations for the original CPU monitoring project in 1995 were selected to match the stations used in earlier Salmon Creek studies conducted by Clark County (1989-1990 and 1991-1994). Four stations are located along the main stem of Salmon Creek and four additional stations are located near the mouths of major tributaries: Cougar Creek, Mill Creek, Curtin Creek, and Woodin Creek. Stations are located at road crossings to facilitate convenient sampling.

All SCMP stations remain in the same locations as the original CPU stations, except that CPU Site 4 (Salmon Creek abv Mill Cr) has been relocated approximately 500 yards upstream to NW 50$^{th}$ Ave for easier access. Figure 1 shows the locations of the eight SCMP monitoring stations. Table 2 contains station names and descriptions from the original CPU project and the SCMP. SCMP sites have been assigned station names consistent with Water Resources' county-wide naming conventions.

| Original CPU Project Station Name | Description | SCMP Station Name | Description |
|---|---|---|---|
| CPU Site 1 | Salmon Cr. @ NW 36$^{th}$ Ave | SMN010 | Salmon Cr. @ NW 36$^{th}$ Ave |
| CPU Site 2 | Cougar Cr. @ NE 119$^{th}$ St | CGR020 | Cougar Cr. @ NE 119$^{th}$ St |
| CPU Site 3 | Salmon Cr. abv Mill Cr. | SMN030 | Salmon Cr. @ NW 50$^{th}$ Ave |
| CPU Site 4 | Mill Cr. @ Salmon Cr. Rd | MIL010 | Mill Cr. @ Salmon Cr. Rd |
| CPU Site 5 | Curtin Cr. @ NE 139$^{th}$ St | CUR020 | Curtin Cr. @ NE 139$^{th}$ St |
| CPU Site 6 | Salmon Cr. @ NE 122$^{nd}$ Ave | SMN050 | Salmon Cr. @ Caples Rd. |
| CPU Site 7 | Woodin Cr. @ NE 122$^{nd}$ Ave | WDN010 | Woodin Cr. @ Caples Rd. |
| CPU Site 8 | Salmon Cr. @ NE 199$^{th}$ St | SMN080 | Salmon Cr. @ NE 199$^{th}$ St |

**Table 2. Station names and location from the original CPU Salmon Creek project and the Water Resources SCMP.**

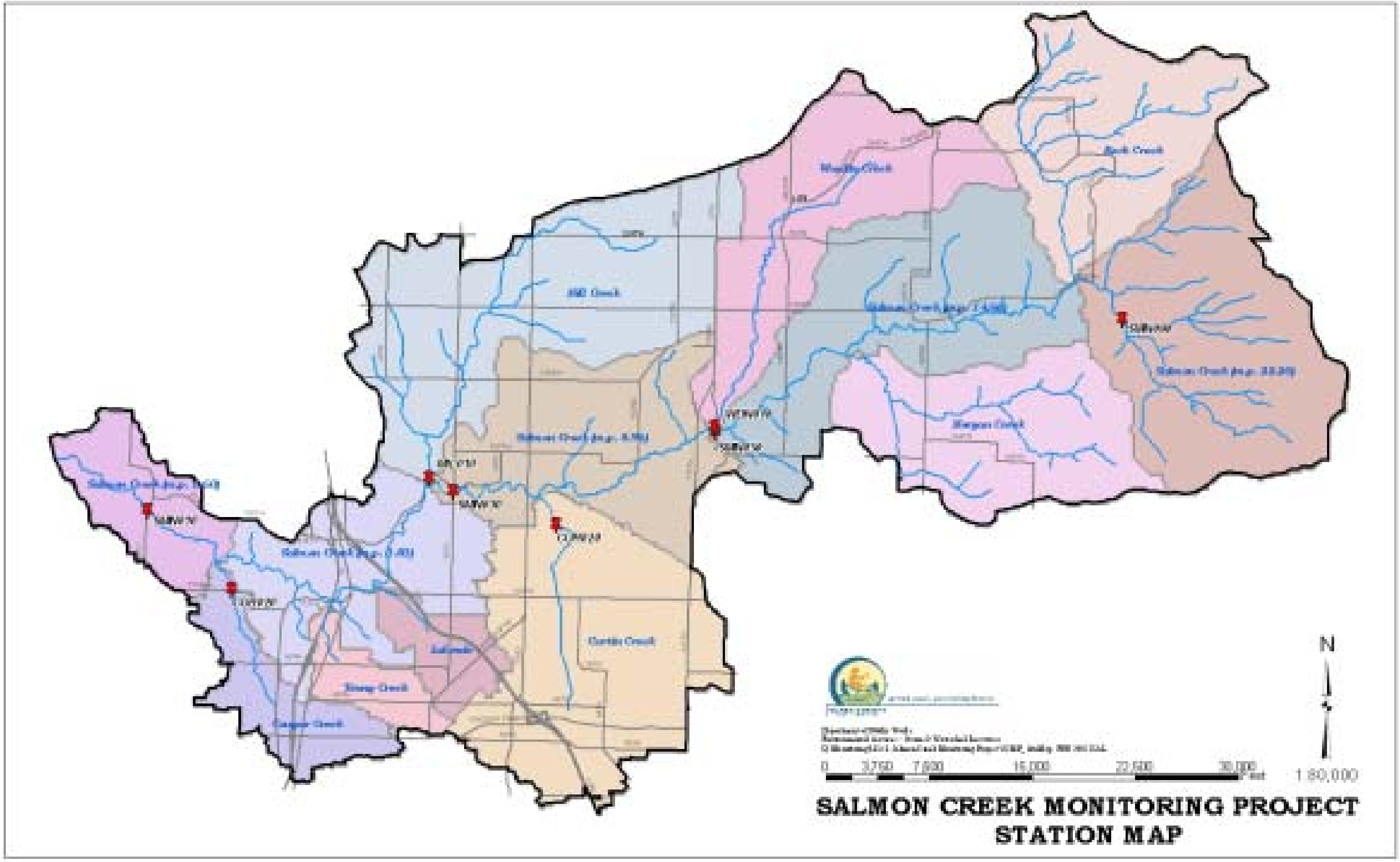


**Figure 1. Location of the eight SCMP monitoring sites**

*Sampling Schedule*

Physicochemical water quality characteristics are sampled at each of the eight sites during monthly grab sampling events. Stage measurements are recorded monthly at the CGR020, MIL010, CUR020, and WDN010 sites. Monthly sampling dates are randomly selected.

Table 3 summarizes the water quality characteristics, sampling frequency, and sample types used in the SCMP.

| Characteristic | Frequency | Sample Type |
|---|---|---|
| Temperature, water | monthly | field meter |
| Dissolved oxygen | monthly | field meter |
| pH | monthly | field meter |
| Conductivity | monthly | field meter |
| Turbidity | monthly | field meter |
| | | |
| Total solids | monthly | grab |
| Ammonia | monthly | grab |
| Nitrate + nitrite | monthly | grab |
| Total phosphorus | monthly | grab |
| | | |
| Fecal coliform/E.coli | monthly | grab |
| | | |
| Stage | monthly | instantaneous |

**Table 3. Characteristics, schedule, and sample type.**

*Representativeness*

SCMP data are intended to be representative of conditions at each sample station. Water Resources utilizes standard monitoring procedures which are designed to facilitate the collection of representative samples. Sampling on randomly-selected dates, sampling from within the thalweg, sampling well-mixed tributary flow, and utilizing standard procedures all facilitate the collection of representative samples.

The time of day when samples are collected is determined by the logistics of visiting all stations on a single day and coordinating with the laboratory for timely analysis of samples. However, in most cases sampling is performed following a standard route and at approximately the same time during each trip to minimize diurnal effects on characteristics which show large diurnal variations (temperature, pH, and dissolved oxygen).

*Data Comparability*

One of the objectives of the SCMP is to gather data that are comparable to other local and regional data. Long-term comparability of SCMP data with other data is facilitated by utilizing and documenting standard procedures for data collection and analyses.

The SCMP utilizes the same suite of water quality characteristics as the county's LISP, and has been modified somewhat from the characteristics studied in the original CPU Salmon Creek project. SCMP data will be comparable with current and future county and CPU monitoring.

However, since the dataset from the original CPU project is not identical to the SCMP, the period of record for certain CPU project characteristics ended in June 2002 when the SCMP was initiated. The Appendix contains a table comparing the water quality characteristics studied in the SCMP and the original CPU project.

## Quality Objectives

*Measurement Quality Objectives*

Analytical methods, detection or precision limits, and Measurement Quality Objectives (MQO) for accuracy, precision, and bias are listed in Table 4. MQOs for the SCMP are set at generally accepted targets for ambient water quality monitoring projects. Data quality objectives and quality control procedures for laboratory parameters are detailed in NCAs quality assurance documents (November, 2001).

Collection, preservation, transportation, and storage of samples follow standard procedures designed to reduce most sources of sampling bias. Analytical bias is minimized by adherence to the methods listed in Table 4. The laboratory employs quality control procedures appropriate to the analytical procedures, including analysis of method blanks, matrix spikes, and check standards.

| Characteristic | Method | Resolution/ Reporting Limit | Accuracy | Precision | Bias | Reference |
|---|---|---|---|---|---|---|
| | | conc./ units | Units / % error | %RSD | %REC | lab |
| Temperature (grab) | Thermistor | 0.01 C | ± 0.15 °C | NA | NA | |
| Dissolved oxygen | Membrane electrode | 0.01 mg/L | ± 0.2 mg/l | NA | NA | |
| pH | Glass electrode | 0.01 units | ± 0.2 pH units | NA | NA | |
| Conductivity | Electrode | 4 digits | ± 0.5% of reading | NA | NA | |
| Turbidity (field)<br>(lab) | Nephelometric<br>Nephelometric | 0.01 NTU<br>0.20 NTU | ± 2% of reading<br>25% | NA<br>10% | NA<br>5% | <br>EPA 180.1 |
| Total solids | Total residue | 10.0 mg/L | 25% | 10% | 5% | EPA 160.3 |
| Ammonia | Colorimetric | 0.05 mg/L | 25% | 10% | 5% | EPA 350.1 |
| Nitrate + nitrite | Colorometric/ Cadmium | 0.01 mg/L | 25% | 10% | 5% | EPA 353.2 |
| Total phosphorus | Colorometric | 0.02 mg/L | 25% | 10% | 5% | EPA 365.1 |
| Fecal coliform | Most Prob Number | 2 MPN/100 mL | NA | 28% | NA | *SM 9221 |
| E.coli | Most Prob Number | 1 MPN/100 mL | NA | 28% | NA | *SM 9223B |
| | | | | | | |

*Guidelines Establishing Test Procedures for the Analysis of Pollutants; Analytical Methods for Biological Pollutants in Ambient Water; Proposed Rule

**Table 4. SCMP analytical methods and detection or precision limits.**

## Field Procedures

Equipment calibration, quality assurance, and field data collection protocols for all data collected by the SCMP are described in: Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002). All field activities are conducted by 2-person field crews.

Sample containers for laboratory delivery are labeled in indelible ink with the following information:

- Clark County
- SCMP
- Station Name
- Date
- Time

Water quality samples are collected in properly preserved bottles prepared by the laboratory, and stored on ice or refrigerated until delivery to NCA. Water quality samples are picked up by laboratory personnel within 24 hours of collection. Formal Chain of Custody documentation is maintained for all samples sent to NCA.

Logs are kept of all field activities. Logs may consist of standardized field sheets as well as bound log books containing ancillary data and observations. Logs are waterproof and entries made with pencil or indelible ink. Corrections are made by drawing a single line through the error such that it remains legible, writing the correction adjacent to the error, and initialing the correction.

Records are cross-checked for consistency between labels, custody documents, data sheets, field logs, and other relevant data. Log books are archived in Water Resources files.

## Laboratory Procedures

Ammonia, nitrate + nitrite, total phosphorus, total solids, and bacteria analyses are conducted by NCA. Turbidity samples may be analyzed either in the field or by NCA. All procedures are performed according to NCA's Ecology-approved quality assurance program and according to accepted conventions for data manipulation and reporting as described in Standard Methods (APHA, 1992). Table 4 shows the constituents measured, analytical methods, and reporting limits.

## Quality Control

### *Laboratory QC*

Laboratory check standards, matrix spikes, analytical duplicates, and blanks are analyzed in accordance with the NCA Quality Assurance Program. All QC results are reported to Water Resources staff along with sample data. Laboratory data reduction, review, and reporting are performed according to the NCA Quality Assurance Program. Data are assessed and reported according to the methods described in the NCA Quality Assurance Program.

### *Field QC*

Field QC sample types, frequencies, and definitions for SCMP monthly water quality samples are found in Table 5. A standard 10% duplication rate is used for laboratory water quality samples and field meter measurements, except for bacteria samples which are duplicated at a rate of 20%. Transfer blanks are collected quarterly, and a transport blank is collected annually. Paired turbidity samples are collected semi-annually to compare field meter readings with laboratory measurements.

All meters are calibrated and maintained in accordance with the manufacturer's instructions. Check standards for conductivity and turbidity are used to verify the accuracy of field meters. An NIST-certified thermometer is used to verify the accuracy of temperature sensors. Calibration logs are completed during each calibration and are archived in Water Resources files. Calibration drift in pH meters is checked against pH buffer solutions and dissolved oxygen measurements are verified using a modified Winkler titration in the field. These activities are used to confirm that field instruments are attaining stated accuracy and resolution specifications.

| Field QC sample type | Frequency | Definition |
|---|---|---|
| Field measurement replicate | 10% of samples | repeat field meter measurements |
| Sample duplicate<br>(bacteria)<br>(all other) | <br>20% of samples<br>10% of samples | duplicate sample collected for laboratory analysis |
| Transfer blank | Quarterly | D.I. water sample collected in field with sampling equipment |
| Transport blank | Annually | D.I. water sample prepared in office and carried through field trip |
| Paired lab sample | Semi-annually | turbidity sample analyzed with field meter, and second sample submitted for lab analysis |

**Table 5. SCMP QC sample types, frequencies, and definitions.**

*Corrective Actions*

Data quality problems encountered in the analysis of QC samples are addressed as needed through re-calibration, modifications to the field procedures, increased staff training, or by qualifying results appropriately. Documentation of corrective action steps includes problem identification, investigation procedures, corrective action taken, and effectiveness of the corrective action.

## Data Management Procedures

Data management procedures for the SCMP will be revised as the project matures and as Water Resources develops a centralized data storage and retrieval system. In the interim, data management procedures for the SCMP are as follows:

Data are stored in an Excel spreadsheet at Water Resources, along with digital backup copies of laboratory reports. Hard copies of laboratory reports are stored in a project binder. Digital files are backed up on CD on an annual basis, and laboratory data packets are also archived on the county's Digital Imaging System. QC data, including field measurement replicates, sample duplicates, transfer and transport blanks, paired samples, and field checks for pH and dissolved oxygen, are stored in Excel spreadsheets at Water Resources. The QC coordinator and project manager are responsible for validating and cross-checking data entry.

Laboratory data are reported by NCA in both digital and hard copy formats. Laboratory data and field measurements are entered manually. Manually entered data are cross-checked by the project manager and/or QC coordinator for entry errors. The laboratory data package includes QC results and an explanation of any necessary data qualifiers.

## Audits and Reports

*Audits*

The project manager and QC coordinator periodically review the field data, methods, lab results, and data management activities to make an assessment of the program and identify corrective actions or method revisions.

*Reports*

Data are reported to CPU on a monthly basis. Data are sent via e-mail to John Louderback of CPU. Data analysis and reporting for CPU are performed by PGG.

Annual data summaries compiled by Water Resources address project methods, summarize data accuracy and completeness, describe any significant data quality problems, and suggest modifications for future monitoring. Reports are peer reviewed by Water Resources staff. SCMP summaries are generally incorporated as attachments to the county's annual NPDES permit compliance report to Ecology. Executive summaries, and full reports as warranted, are placed on the county's website to facilitate dissemination of information to the public.

The suite of SCMP water quality characteristics are used by Water Resources to assess current condition by comparing the data with established state standards and criteria. The monitored characteristics were also selected to allow calculation of the Oregon Water Quality Index (OWQI). OWQI parameters include temperature, dissolved oxygen, pH, ammonia, nitrate + nitrite nitrogen, total phosphorus, total solids, and fecal coliform bacteria. Biochemical oxygen demand (BOD) is also included in the OWQI, but will not be analyzed in this project. The OWQI is a useful reporting tool for summarizing large amounts of water quality data, and provides for regional comparisons with other monitoring projects.

## Data Review, Verification, and Validation

During each sample trip, field crews review field and sample logs to confirm that all necessary field measurements and samples have been collected. Laboratory QC results are reviewed and verified by NCA staff and documented in data reports to Water Resources. Upon receipt, laboratory data are reviewed for errors, omissions, and data qualifiers prior to data entry.

Data verification involves examination of QC results analyzed during the project to provide an indication of whether the precision and bias MQOs have been met. To evaluate whether precision targets have been met, pairs of duplicate sample results are pooled and an estimate of standard deviation is calculated. This estimate, divided by the mean concentration of the duplicate results and converted to percent, is used to judge whether the %RSD target has been met.

To evaluate whether bias targets have been met, the mean percent recovery of the check standards should be within +/- %bias target of the true value (e.g. true value +/- 10%). Unusually high blank results indicate bias due to contamination that may affect low-level results. To evaluate whether the target for reporting limit has been met, results will be examined to determine if any of the values exceed the required reporting limits.

Data validation consists of a detailed examination of the complete data package using professional judgement to assess whether the procedures in the SP's and QAPP have been followed. Data validation is performed by the project manager and QC coordinator during the preparation of annual reports to CPU.

## Data Quality Assessment

Taking into account the results of data review, verification, and validation, an assessment will be made as to whether the data are of sufficient quality to attain project objectives.

## References

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Lombard, S. and C. Kirchmer. (February 2001). *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies.* Washington State Department of Ecology. Publication No. 01-03-003, revision of Publication No. 91-16.

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## APPENDIX

| 1995 CPU Salmon Creek Project | 2003 Water Resources SCMP |
|---|---|
| Temperature | Temperature |
| Conductivity | Conductivity |
| pH | pH |
| Dissolved oxygen | Dissolved oxygen |
| Total suspended solids | |
| Fecal coliform | Fecal coliform |
| Total Kjeldahl nitrogen | |
| Nitrate-nitrogen | Nitrate + nitrite nitrogen |
| Nitrite | |
| Ammonia | Ammonia |
| Soluble reactive phosphorus | |
| Total phosphorus | Total phosphorus |
| Chloride | |
| Sulfate | |
| | E. coli |
| | Turbidity |
| | |

**Table X. Comparison of monitored characteristics in 1995 CPU Salmon Creek Project and 2003 Water Resources SCMP**

# Appendix C. Clark County Water Resources: Raw Data, 1988-2007.

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Table C-1. Clark County raw data for Salmon Creek @ Mouth (SMN010).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/10/1988 | 230 | 2.5 | 7.3 | 10.1 | 0.20 | 1.60 |
| 11/3/1988 | 930 | 17.0 | | | 0.22 | 2.00 |
| 11/21/1988 | | 13.0 | 6.9 | 10.0 | 0.16 | 1.30 |
| 12/5/1998 | 730 | 4.6 | 7.2 | 11.9 | 0.07 | 1.40 |
| 1/24/1989 | 230 | 5.5 | 6.3 | 11.9 | 0.08 | 1.40 |
| 2/14/1989 | 230 | 6.9 | 6.6 | 12.2 | 0.11 | 1.30 |
| 3/14/1989 | 1500 | 9.8 | 6.6 | 11.3 | 0.10 | 1.10 |
| 4/11/1989 | 430 | 4.5 | 7.7 | 10.4 | 0.11 | 1.90 |
| 5/2/1989 | 230 | 4.2 | 6.7 | 10.0 | 0.12 | 0.90 |
| 6/6/1989 | 230 | 7.1 | 7.0 | 6.5 | 0.16 | 1.20 |
| 7/10/1989 | 230 | 3.2 | 7.5 | 10.0 | 0.28 | 1.80 |
| 8/7/1989 | 210 | 3.0 | 7.0 | 9.5 | 0.17 | 1.20 |
| 9/11/1989 | 150 | 2.6 | 7.4 | 10.0 | 0.13 | 1.50 |
| 5/16/1991 | 430 | 3.2 | 7.3 | 11.0 | 0.11 | 0.90 |
| 6/18/1991 | 91 | 8.6 | 7.4 | 7.6 | 0.21 | 1.20 |
| 7/9/1991 | 91 | 5.3 | 7.5 | 7.8 | 0.17 | |
| 8/6/1991 | 230 | 4.5 | 7.4 | 8.9 | 0.16 | 2.10 |
| 9/10/1991 | 430 | 2.2 | 7.8 | 10.3 | 0.15 | 2.22 |
| 10/2/1991 | 91 | 2.1 | 7.1 | 10.1 | 0.19 | 2.48 |
| 11/5/1991 | 11000 | 65.0 | 6.7 | 10.0 | 0.48 | 1.63 |
| 12/3/1991 | 91 | 14.0 | 6.8 | 11.2 | 0.13 | 1.31 |
| 1/7/1992 | 91 | 5.5 | 6.9 | 11.9 | 0.14 | 1.52 |
| 2/10/1992 | 91 | 4.6 | 7.0 | 11.4 | 0.09 | 1.47 |
| 3/9/1992 | 430 | 4.4 | 6.9 | 12.0 | 0.11 | 1.46 |
| 4/13/1992 | 930 | 9.8 | 7.0 | 10.4 | 0.16 | 0.96 |
| 5/11/1992 | 150 | 4.8 | 7.3 | 10.9 | 0.11 | 1.34 |
| 6/15/1992 | 78 | 2.8 | 7.5 | 11.5 | 0.11 | 1.68 |
| 7/13/1992 | 130 | 1.8 | 7.7 | 11.7 | 0.12 | 1.73 |
| 8/10/1992 | 78 | 2.8 | 7.8 | 12.7 | 0.18 | 1.81 |
| 9/14/1992 | 45 | 2.0 | 7.6 | 12.4 | 0.21 | 2.23 |
| 10/12/1992 | 20 | 6.6 | 7.5 | 12.0 | 0.21 | 2.29 |
| 11/2/1992 | 490 | 11.4 | 7.1 | 10.3 | 0.12 | 1.56 |
| 12/8/1992 | 1300 | 12.0 | 7.1 | 12.0 | 0.11 | 1.34 |
| 1/4/1993 | 490 | 13.0 | 7.0 | 12.2 | 0.10 | 1.26 |
| 2/9/1993 | 45 | 3.8 | 7.1 | 11.6 | 0.08 | 1.47 |
| 3/9/1993 | 130 | 5.0 | 7.3 | 11.6 | 0.08 | 1.35 |
| 4/13/1993 | 220 | 7.8 | 7.0 | 10.5 | | |
| 5/11/1993 | 110 | 5.2 | 6.9 | 9.6 | 0.08 | 0.88 |
| 6/8/1993 | 45 | 6.7 | 7.1 | 8.3 | 0.15 | 1.01 |
| 7/13/1993 | 140 | 2.8 | 7.6 | 11.3 | 0.09 | 1.45 |
| 8/10/1993 | 78 | 2.6 | 7.6 | 9.5 | 0.09 | 1.46 |
| 9/14/1993 | 130 | 2.2 | 7.3 | 8.7 | 0.08 | 1.89 |
| 10/12/1993 | 78 | 2.0 | 7.1 | 8.5 | 0.09 | 1.93 |
| 11/9/1993 | 20 | 2.3 | 7.0 | 12.4 | 0.08 | 1.94 |
| 12/14/1993 | 170 | 11.0 | 6.9 | 10.6 | 0.09 | 1.43 |
| 7/18/1995 | 118 | | 7.5 | 7.2 | | 1.60 |
| 8/25/1995 | 333 | | 5.6 | 6.7 | | 2.00 |
| 10/3/1995 | 11200 | | 8.1 | 7.2 | | 1.30 |
| 10/31/1995 | | | 8.8 | 9.6 | | 1.30 |
| 12/13/1995 | | | 8.6 | 7.7 | | 1.10 |
| 1/18/1996 | 60 | | 6.3 | 12.3 | | 1.10 |
| 2/15/1996 | 16 | | 7.6 | 8.3 | | 1.20 |
| 3/18/1996 | 110 | | 9.1 | 7.6 | | 1.30 |
| 4/18/1996 | 137 | | 8.2 | | | 0.99 |
| 6/10/1996 | | 6.0 | 7.5 | 7.5 | | 0.52 |
| 7/19/1996 | 1180 | 13.0 | 7.3 | 8.7 | | 1.80 |
| 9/6/1996 | 157 | 9.0 | 5.9 | 7.6 | | 2.20 |
| 10/9/1996 | 89 | 9.0 | 7.0 | 9.0 | | 1.70 |
| 11/26/1996 | 85 | 13.0 | 6.2 | 9.7 | | 1.10 |
| 1/15/1997 | 36 | | 6.8 | 12.3 | | 1.30 |
| 2/24/1997 | 46 | | 6.3 | 11.0 | | 1.20 |
| 3/27/1997 | 44 | 4.0 | 7.9 | 9.4 | | 1.10 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 5/30/1997 | 30 | 4.0 | 7.3 | 10.5 | | 0.61 |
| 7/8/1997 | 350 | 9.0 | 6.5 | 7.5 | | 1.70 |
| 10/3/1997 | 1600 | 34.0 | 6.7 | 9.0 | | 1.10 |
| 11/21/1997 | 300 | | 6.3 | 12.1 | | 1.10 |
| 1/20/1998 | 170 | 186.0 | 6.0 | 11.5 | | 1.00 |
| 2/26/1998 | 435 | 9.0 | 6.7 | 11.5 | | 0.90 |
| 3/30/1998 | 80 | 0.1 | 6.1 | 10.3 | | 0.90 |
| 4/29/1998 | 130 | 17.0 | 7.3 | 8.9 | | 1.20 |
| 5/28/1998 | 170 | 8.0 | 5.8 | 8.6 | | 0.90 |
| 6/26/1998 | 1600 | 15.0 | 6.0 | 9.1 | | 1.20 |
| 7/22/1998 | 130 | 21.0 | 6.6 | 7.0 | | 1.70 |
| 8/19/1998 | 280 | 11.0 | 6.4 | 8.5 | | 1.80 |
| 9/28/1998 | 170 | 3.0 | 6.2 | 9.3 | | 1.60 |
| 10/28/1998 | 900 | 9.0 | 6.1 | 10.7 | | 1.50 |
| 12/4/1998 | 170 | 11.0 | 6.7 | 12.3 | | 1.30 |
| 1/19/1999 | 170 | 31.0 | 6.6 | 14.4 | | 1.10 |
| 2/25/1999 | 500 | 27.0 | 6.8 | 13.3 | | 0.90 |
| 3/15/1999 | 80 | 15.0 | 7.2 | 16.1 | | 1.00 |
| 4/22/1999 | 900 | 3.4 | 6.8 | 12.6 | | 1.20 |
| 6/1/1999 | 23 | 8.0 | 5.6 | | | 1.10 |
| 6/22/1999 | 240 | 6.0 | 5.9 | | | 1.10 |
| 7/29/1999 | 240 | 1.9 | 6.0 | | | 1.60 |
| 9/2/1999 | 220 | 2.0 | 7.4 | 6.8 | | 1.60 |
| 10/25/1999 | 30 | 2.0 | 7.2 | 7.6 | | 1.80 |
| 12/6/1999 | 130 | | 7.1 | 8.9 | | 1.10 |
| 6/21/2002 | 240 | 7.2 | 6.9 | 5.1 | 0.13 | |
| 7/17/2002 | 170 | 2.6 | 7.6 | 8.7 | 0.07 | |
| 8/28/2002 | 50 | 2.5 | 7.5 | 8.4 | 0.06 | 1.90 |
| 9/26/2002 | 30 | 2.4 | 7.7 | 11.6 | 0.06 | 1.48 |
| 10/11/2002 | 140 | 5.3 | 7.1 | 8.7 | 0.08 | 2.64 |
| 11/13/2002 | 13 | 7.3 | 7.1 | 10.0 | 0.07 | 0.86 |
| 12/9/2002 | 8 | 3.3 | 6.9 | 11.5 | 0.06 | 1.83 |
| 1/14/2003 | 110 | 11.7 | | 11.2 | 0.06 | 1.14 |
| 2/19/2003 | 30 | 18.1 | | 11.2 | 0.06 | 1.04 |
| 3/27/2003 | 30 | 8.2 | 7.0 | 11.7 | 0.04 | 0.86 |
| 4/15/2003 | 170 | 6.5 | 7.5 | 10.8 | 0.05 | 0.76 |
| 5/14/2003 | 80 | 3.3 | 7.2 | 11.3 | 0.04 | 0.82 |
| 6/10/2003 | 50 | 3.6 | 7.4 | 7.4 | 0.05 | 1.38 |
| 7/30/2003 | 130 | 2.2 | 7.4 | 7.1 | 0.05 | 1.98 |
| 8/12/2003 | 80 | 1.8 | 7.2 | 6.0 | 0.04 | 1.36 |
| 9/16/2003 | 30 | 2.4 | 7.5 | 9.7 | 0.05 | 1.39 |
| 10/9/2003 | 80 | 2.0 | 7.2 | 7.5 | 0.08 | 1.51 |
| 11/20/2003 | 500 | 23.4 | | 11.4 | 0.06 | 1.90 |
| 12/10/2003 | 13 | 6.0 | 7.6 | 10.8 | 0.03 | 1.55 |
| 1/22/2004 | 8 | 5.2 | | 13.1 | <0.02 | 1.26 |
| 2/18/2004 | 166 | 19.9 | 7.3 | 11.5 | 0.06 | 0.87 |
| 3/25/2004 | 2 | 4.4 | 7.5 | 10.4 | 0.04 | 0.88 |
| 4/27/2004 | 48 | 3.8 | 7.3 | 9.5 | 0.03 | 1.05 |
| 5/11/2004 | 79 | 3.8 | 7.6 | 9.0 | 0.05 | 0.90 |
| 6/23/2004 | 90 | 3.3 | 7.0 | 8.0 | 0.04 | 1.00 |
| 7/14/2004 | 130 | 2.3 | 7.8 | 8.7 | 0.05 | 0.87 |
| 8/18/2004 | 50 | 2.3 | 8.3 | 5.8 | 0.05 | 0.95 |
| 9/1/2004 | 180 | 10.8 | 8.1 | 6.7 | 0.10 | 0.61 |
| 10/13/2004 | 54 | 5.0 | 7.5 | 9.4 | 0.05 | 0.96 |
| 11/15/2004 | 16 | 3.7 | 7.2 | 9.3 | 0.05 | 0.92 |
| 12/22/2004 | 55 | 7.5 | 7.1 | 11.1 | 0.05 | 0.94 |
| 1/25/2005 | 19 | 5.6 | 7.5 | 10.8 | 0.03 | 1.02 |
| 2/8/2005 | 100 | 11.5 | 7.2 | 11.2 | 0.04 | 1.10 |
| 3/22/2005 | 70 | 6.2 | 7.3 | 9.9 | 0.05 | 0.89 |
| 4/28/2005 | 120 | 7.5 | 7.3 | 9.6 | 0.04 | 0.84 |
| 5/17/2005 | 1500 | 27.5 | 7.7 | 9.6 | 0.11 | 0.67 |
| 6/15/2005 | 57 | 4.6 | 8.1 | 10.2 | 0.05 | 0.88 |
| 7/13/2005 | 85 | 2.8 | 7.5 | 8.0 | 0.04 | 0.86 |
| 8/10/2005 | 140 | 3.3 | 7.5 | | 0.05 | 1.24 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 9/22/2005 | 39 | 2.6 | 7.5 | 8.8 | 0.05 | 1.35 |
| 10/27/2005 | 56 | 3.0 | 6.9 | 9.1 | 0.06 | 1.06 |
| 11/10/2005 | 17 | 6.4 | 7.2 | 13.6 | 0.03 | 1.16 |
| 12/6/2005 | 28 | 6.6 | 7.4 | 11.8 | 0.03 | 1.15 |
| 1/24/2006 | 21 | 9.5 | 7.0 | 11.0 | 0.04 | 1.33 |
| 2/15/2006 | 29 | 5.2 | 7.3 | 12.8 | 0.03 | 1.63 |
| 3/22/2006 | 130 | 6.4 | 7.1 | 10.6 | 0.03 | 1.11 |
| 4/25/2006 | 24 | 3.1 | 7.2 | 10.7 | <0.02 | 0.98 |
| 5/23/2006 | 400 | 4.8 | 6.7 | 6.2 | 0.06 | 1.01 |
| 6/7/2006 | 77 | 5.3 | 7.5 | 9.7 | 0.04 | 0.84 |
| 7/25/2006 | 133 | 6.5 | 7.2 | 5.3 | 0.07 | 1.53 |
| 8/10/2006 | 200 | 1.8 | 7.4 | 6.3 | 0.04 | 1.29 |
| 9/21/2006 | 153 | 3.5 | 7.1 | 7.9 | 0.08 | 1.25 |
| 10/12/2006 | 18 | 2.0 | 7.4 | 9.8 | 0.05 | 1.45 |
| 11/8/2006 | 580 | 25.5 | 5.8 | 7.2 | 0.08 | 1.29 |
| 12/12/2006 | 1630 | 21.3 | 6.9 | 10.1 | 0.09 | 0.68 |
| 1/17/2007 | 37 | 4.6 | 7.4 | 12.9 | 0.05 | 1.30 |
| 2/6/2007 | 16 | 3.8 | 7.4 | 11.6 | 0.05 | 1.25 |
| 3/7/2007 | 25 | 8.3 | 7.3 | 10.3 | 0.05 | 1.28 |
| 4/17/2007 | 49 | 4.5 | 7.4 | 10.4 | 0.05 | 0.95 |
| 5/30/2007 | 69 | 2.8 | 7.4 | 8.0 | 0.19 | 1.25 |
| 6/21/2007 | 89 | 2.5 | 7.4 | 8.1 | 0.13 | 1.41 |
| 7/10/2007 | 142 | 2.7 | 7.5 | 7.0 | 0.07 | 1.53 |
| 8/16/2007 | 53 | 2.0 | 7.3 | 5.9 | 0.07 | 1.55 |
| 9/27/2007 | 24 | 2.1 | 7.6 | 9.6 | 0.07 | 1.67 |
| 10/24/2007 | 29 | 5.3 | 6.6 | 9.6 | 0.06 | 1.17 |
| 11/8/2007 | 25 | 2.3 | 7.4 | 11.4 | 0.05 | 1.51 |
| 12/20/2007 | 310 | 31.4 | 6.4 | 11.4 | 0.13 | 0.89 |

Table C-2. Clark County raw data for Cougar Creek (CGR020).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 5/16/1991 | 930 | 2.8 | 7.5 | 9.5 | 0.13 | 2.00 |
| 6/18/1991 | 430 | 1.8 | 7.6 | 10.1 | 0.11 | 2.90 |
| 7/9/1991 | 1500 | 4.9 | 7.9 | 9.0 | 0.12 | 3.10 |
| 8/6/1991 | 2400 | 3.8 | 8.0 | 9.7 | 0.12 | 4.00 |
| 9/10/1991 | 430 | 3.5 | 7.9 | 10.0 | 0.01 | 3.10 |
| 10/2/1991 | 930 | 4.4 | 7.5 | 10.2 | 0.17 | 3.25 |
| 11/5/1991 | 11000 | 50.0 | 6.6 | 10.0 | 0.32 | 0.97 |
| 12/3/1991 | 91 | 3.0 | 7.1 | 10.9 | 0.08 | 0.85 |
| 1/7/1992 | 91 | 2.7 | 7.1 | 11.8 | 0.12 | 2.49 |
| 2/10/1992 | 91 | 2.9 | 7.2 | 10.8 | 0.08 | 2.33 |
| 3/9/1992 | 430 | 1.8 | 7.2 | 11.2 | 0.09 | 2.42 |
| 4/13/1992 | 2400 | 18.0 | 7.0 | 10.1 | 0.21 | 0.82 |
| 5/11/1992 | 930 | 2.3 | 7.5 | 10.2 | 0.11 | 2.56 |
| 6/15/1992 | 700 | 2.4 | 7.5 | 10.1 | 0.11 | 3.14 |
| 7/13/1992 | 2200 | 1.6 | 7.5 | 9.6 | 0.12 | 3.18 |
| 8/10/1992 | 1100 | 1.7 | 7.5 | 9.1 | 0.16 | 3.14 |
| 9/14/1992 | 790 | 1.3 | 7.5 | 10.7 | 0.11 | 3.41 |
| 10/12/1992 | 490 | 1.4 | 7.6 | 10.5 | 0.10 | 3.29 |
| 11/2/1992 | 790 | 3.7 | 7.1 | 9.9 | 0.10 | 1.85 |
| 12/8/1992 | 16000 | 52.0 | 6.9 | 11.6 | 0.63 | 0.65 |
| 1/4/1993 | 490 | 18.0 | 7.2 | 11.9 | 0.11 | 1.21 |
| 7/18/1995 | 1540 | | 7.8 | 5.5 | 0.14 | 3.10 |
| 8/25/1995 | 622 | 1.5 | 7.6 | 7.2 | | 3.10 |
| 10/3/1995 | 400 | | 8.0 | 8.8 | 0.09 | 1.00 |
| 10/31/1995 | | | | | | 3.10 |
| 12/13/1995 | 100 | | 8.7 | 9.5 | | 1.10 |
| 1/18/1996 | 261 | | 7.0 | 12.9 | 0.10 | 2.20 |
| 2/15/1996 | 588 | | 7.8 | 9.3 | | 2.50 |
| 3/18/1996 | 270 | | 8.8 | 7.5 | | 2.70 |
| 4/18/1996 | 1770 | | 8.0 | 9.4 | 0.12 | 2.20 |
| 6/10/1996 | 113 | 29.0 | 7.8 | 9.8 | | 3.00 |
| 7/19/1996 | 1650 | 25.0 | 7.6 | 8.6 | 0.14 | 2.90 |
| 9/6/1996 | 800 | 9.0 | 7.3 | 10.2 | | 3.20 |
| 10/9/1996 | 87 | 8.0 | 7.6 | 11.4 | 0.17 | 3.10 |
| 11/26/1996 | 136 | 12.0 | 7.3 | 11.3 | | 2.10 |
| 1/15/1997 | 286 | | 7.5 | 12.5 | 0.11 | 2.60 |
| 2/24/1997 | 270 | 4.0 | 7.4 | 11.7 | | 2.60 |
| 3/27/1997 | 340 | 10.0 | 7.7 | 10.9 | | 2.40 |
| 5/30/1997 | 1100 | 23.0 | 7.3 | | | 2.40 |
| 7/8/1997 | 460 | 12.0 | 7.4 | 10.1 | | 3.00 |
| 10/3/1997 | 1600 | 11.0 | 7.0 | 9.6 | | 1.60 |
| 11/21/1997 | 500 | | 7.0 | 12.6 | 0.14 | 1.30 |
| 1/20/1998 | 170 | 8.0 | 6.9 | 11.4 | 0.12 | 2.00 |
| 2/26/1998 | 411 | 1.0 | 8.2 | 11.4 | | 2.10 |
| 3/30/1998 | 300 | 3.0 | 7.3 | 11.1 | | 2.50 |
| 4/29/1998 | 300 | 24.0 | 8.0 | 8.0 | 0.11 | 2.70 |
| 5/28/1998 | 1600 | 11.0 | 6.7 | 10.3 | | 2.40 |
| 6/26/1998 | 900 | 9.0 | 6.6 | 9.7 | | 2.30 |
| 7/22/1998 | 500 | 11.0 | 7.2 | 9.7 | 0.14 | 3.20 |
| 8/19/1998 | 500 | 5.0 | 7.2 | 10.8 | | 3.10 |
| 9/28/1998 | 300 | 2.0 | 6.8 | 10.7 | | 3.40 |
| 10/28/1998 | 1600 | 13.0 | 6.5 | 10.8 | 0.12 | 2.00 |
| 12/4/1998 | 500 | 12.0 | 6.9 | 13.6 | | 1.90 |
| 1/19/1999 | 170 | 64.0 | 7.0 | 12.3 | | 0.90 |
| 2/25/1999 | 420 | 20.0 | 7.0 | 15.4 | | 1.50 |
| 3/15/1999 | 220 | 10.0 | 7.3 | 15.8 | | 1.80 |
| 4/22/1999 | 900 | 4.4 | 7.3 | 17.5 | 0.10 | 2.20 |
| 6/1/1999 | 240 | 11.0 | 6.8 | | | 2.80 |
| 6/22/1999 | 1600 | 3.0 | 7.1 | | | 2.80 |
| 7/29/1999 | 900 | 3.1 | 7.1 | | 0.13 | 3.10 |
| 9/2/1999 | 500 | 1.0 | 8.2 | 9.3 | | 3.00 |
| 10/4/1999 | 500 | 6.0 | 7.7 | 9.3 | | 3.20 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/25/1999 | 900 | 3.0 | 7.9 | 8.7 | 0.11 | 3.20 |
| 12/6/1999 | 170 | | 6.9 | 9.6 | | 1.10 |
| 5/30/2002 | 480 | 3.9 | 7.8 | 9.5 | 0.10 | |
| 6/20/2002 | 900 | 3.0 | 7.7 | 9.5 | 0.11 | |
| 7/17/2002 | 500 | 3.2 | 7.8 | 9.6 | 0.11 | |
| 8/28/2002 | 240 | 2.1 | 7.7 | 9.0 | 0.12 | 4.13 |
| 9/26/2002 | 500 | 2.0 | 7.5 | 10.3 | 0.10 | 3.08 |
| 10/11/2002 | 500 | 2.5 | 7.8 | 10.8 | 0.09 | 3.08 |
| 11/13/2002 | 170 | 5.6 | 7.2 | 10.4 | 0.10 | 1.56 |
| 12/9/2002 | 50 | 0.9 | 7.1 | 11.5 | 0.09 | 3.07 |
| 1/14/2003 | 50 | 12.3 | 7.1 | 10.8 | 0.09 | 1.55 |
| 2/19/2003 | 240 | 12.1 | 7.3 | 11.2 | 0.09 | 1.48 |
| 3/27/2003 | 80 | 4.9 | 7.7 | 11.7 | 0.08 | 2.00 |
| 4/15/2003 | 300 | 4.8 | 7.5 | 10.7 | 0.08 | 1.86 |
| 5/14/2003 | 900 | 3.0 | 7.7 | 11.3 | 0.08 | 2.31 |
| 6/10/2003 | 500 | 5.6 | 7.8 | 10.1 | 0.11 | 2.84 |
| 7/30/2003 | 900 | 11.5 | 7.8 | 9.5 | 0.11 | 3.58 |
| 8/12/2003 | 500 | 2.7 | 7.7 | 8.9 | 0.09 | 2.72 |
| 9/16/2003 | 1600 | 3.1 | 7.7 | 9.6 | 0.10 | 2.67 |
| 10/9/2003 | 500 | 2.2 | 7.3 | 9.7 | 0.10 | 2.96 |
| 11/20/2003 | 1600 | 14.3 | 7.4 | 11.2 | 0.08 | 1.91 |
| 12/10/2003 | 900 | 12.1 | 6.9 | 11.1 | 0.11 | 1.69 |
| 1/22/2004 | | 5.2 | 7.5 | 12.8 | 0.05 | 2.74 |
| 2/18/2004 | 319 | 20.4 | 7.4 | 11.5 | 0.08 | 0.83 |
| 3/25/2004 | 506 | 10.5 | 7.7 | 10.9 | 0.07 | 1.56 |
| 4/27/2004 | 291 | 3.1 | 7.8 | 9.9 | 0.07 | 2.65 |
| 5/11/2004 | 173 | 3.0 | 7.5 | 9.6 | 0.08 | 2.52 |
| 6/23/2004 | 570 | 3.2 | 7.9 | 9.2 | 0.08 | 2.86 |
| 7/14/2004 | 760 | 4.3 | 7.6 | 9.4 | 0.10 | 2.91 |
| 8/18/2004 | 495 | 1.9 | 7.8 | 8.9 | 0.09 | 3.07 |
| 9/1/2004 | 850 | 2.8 | 7.8 | 10.1 | 0.10 | 3.40 |
| 10/13/2004 | 220 | 2.0 | 6.9 | 9.3 | 0.08 | 3.36 |
| 11/15/2004 | 70 | 1.4 | 6.9 | 9.0 | 0.09 | 2.96 |
| 12/22/2004 | 220 | 5.8 | 6.4 | 10.4 | 0.08 | 1.87 |
| 2/8/2005 | 140 | 4.3 | 7.7 | 10.8 | 0.06 | 2.33 |
| 3/22/2005 | 93 | 2.1 | 7.7 | 11.1 | 0.07 | 2.99 |
| 4/28/2005 | 470 | 4.0 | 6.8 | 10.1 | 0.09 | 2.32 |
| 5/17/2005 | 430 | 7.3 | 7.7 | 9.9 | 0.09 | 1.37 |
| 6/15/2005 | 510 | 2.9 | 8.1 | 8.9 | 0.09 | 3.42 |
| 7/13/2005 | 360 | 3.0 | 7.0 | 9.6 | 0.07 | 3.09 |
| 8/10/2005 | 530 | 3.4 | 7.9 | 10.0 | 0.08 | 3.15 |
| 9/22/2005 | 410 | 2.6 | 7.8 | 10.3 | 0.09 | 3.03 |
| 10/27/2005 | 590 | 1.2 | 6.7 | 9.7 | 0.08 | 2.44 |
| 11/10/2005 | 30 | 1.6 | 7.3 | 13.1 | 0.06 | 1.96 |
| 12/6/2005 | 160 | 1.7 | 7.5 | 12.1 | 0.07 | 2.13 |
| 1/24/2006 | 30 | 5.3 | 7.2 | 11.0 | 0.08 | 2.33 |
| 2/15/2006 | 83 | 3.4 | 7.7 | 12.8 | 0.06 | 2.72 |
| 3/22/2006 | 79 | 3.6 | 7.4 | 10.3 | 0.07 | 3.34 |
| 4/25/2006 | 129 | 2.8 | 7.6 | 12.4 | 0.05 | 2.50 |
| 5/23/2006 | 4700 | 194.0 | 6.6 | 9.4 | 0.41 | 0.42 |
| 6/7/2006 | 1530 | 3.1 | 7.8 | 9.8 | 0.08 | 2.31 |
| 7/25/2006 | 1240 | 3.8 | 7.8 | 8.7 | 0.11 | 3.28 |
| 8/10/2006 | 840 | 3.4 | 7.9 | 7.1 | 0.11 | 3.14 |
| 9/21/2006 | 810 | 4.2 | 7.6 | 8.9 | 0.10 | 1.60 |
| 10/12/2006 | 590 | 1.8 | 7.8 | 9.8 | 0.10 | 2.61 |
| 11/8/2006 | 630 | 10.6 | 7.1 | 8.4 | 0.12 | 1.61 |
| 12/12/2006 | 37 | 26.0 | 7.2 | 10.5 | 0.11 | 0.31 |
| 1/17/2007 | 123 | 3.5 | 7.6 | 12.2 | 0.09 | 2.44 |
| 2/6/2007 | 470 | 2.4 | 7.7 | 11.7 | 0.09 | 5.35 |
| 3/7/2007 | 510 | 22.9 | 7.6 | 10.3 | 0.19 | 0.93 |
| 4/17/2007 | 210 | 6.0 | 7.6 | 11.0 | 0.10 | 1.94 |
| 5/30/2007 | 1000 | 4.6 | 7.8 | 9.3 | 0.28 | 3.55 |
| 6/21/2007 | 880 | 4.2 | 8.1 | 9.6 | 0.21 | 2.77 |
| 7/10/2007 | 600 | 4.0 | 7.9 | 8.8 | 0.13 | 2.90 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 8/16/2007 | 660 | 5.4 | 7.9 | 9.1 | 0.11 | 4.40 |
| 9/27/2007 | 430 | 3.8 | 7.9 | 10.0 | 0.10 | 3.69 |
| 10/24/2007 | 430 | 1.6 | 7.1 | 10.1 | 0.10 | 3.55 |
| 11/8/2007 | 420 | 1.0 | 7.2 | 10.7 | 0.09 | 3.10 |
| 12/20/2007 | 570 | 24.4 | 6.6 | 11.4 | 0.12 | 0.57 |
| 8/10/2006 | 840 | 3.4 | 7.9 | 7.1 | 0.11 | 3.14 |
| 9/21/2006 | 810 | 4.2 | 7.6 | 8.9 | 0.10 | 1.60 |
| 10/12/2006 | 590 | 1.8 | 7.8 | 9.8 | 0.10 | 2.61 |
| 11/8/2006 | 630 | 10.6 | 7.1 | 8.4 | 0.12 | 1.61 |
| 12/12/2006 | 37 | 26.0 | 7.2 | 10.5 | 0.11 | 0.31 |
| 1/17/2007 | 123 | 3.5 | 7.6 | 12.2 | 0.09 | 2.44 |
| 2/6/2007 | 470 | 2.4 | 7.7 | 11.7 | 0.09 | 5.35 |
| 3/7/2007 | 510 | 22.9 | 7.6 | 10.3 | 0.19 | 0.93 |
| 4/17/2007 | 210 | 6.0 | 7.6 | 11.0 | 0.10 | 1.94 |
| 5/30/2007 | 1000 | 4.6 | 7.8 | 9.3 | 0.28 | 3.55 |
| 6/21/2007 | 880 | 4.2 | 8.1 | 9.6 | 0.21 | 2.77 |
| 7/10/2007 | 600 | 4.0 | 7.9 | 8.8 | 0.13 | 2.90 |
| 8/16/2007 | 660 | 5.4 | 7.9 | 9.1 | 0.11 | 4.40 |
| 9/27/2007 | 430 | 3.8 | 7.9 | 10.0 | 0.10 | 3.69 |
| 10/24/2007 | 430 | 1.6 | 7.1 | 10.1 | 0.10 | 3.55 |
| 11/8/2007 | 420 | 1.0 | 7.2 | 10.7 | 0.09 | 3.10 |
| 12/20/2007 | 570 | 24.4 | 6.6 | 11.4 | 0.12 | 0.57 |

Table C-3. Clark County raw data for Salmon Creek @ Lower (SMN030).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/10/1988 | 230 | 2.5 | 7.3 | 11.3 | 0.25 | 1.50 |
| 11/21/1988 | 4600 | 14.0 | 6.9 | 10.3 | 0.26 | 1.60 |
| 12/5/1988 | 430 | 3.6 | 7.0 | 12.2 | 0.08 | 1.50 |
| 1/24/1989 | 430 | 4.9 | 6.5 | 11.4 | 0.05 | 1.60 |
| 2/14/1989 | 430 | 5.2 | 6.6 | 12.4 | 0.08 | 1.30 |
| 3/14/1989 | 1500 | 9.4 | 6.7 | 11.8 | 0.09 | 1.20 |
| 4/11/1989 | 930 | 3.9 | 7.5 | 11.7 | 0.12 | 1.60 |
| 5/2/1989 | 430 | 4.5 | 6.5 | 10.8 | 0.10 | 0.90 |
| 6/6/1989 | 230 | 4.2 | 4.0 | 9.1 | 0.13 | 1.50 |
| 7/10/1989 | 430 | 4.8 | 7.3 | 10.4 | 0.34 | 2.00 |
| 8/7/1989 | 430 | 3.0 | 6.8 | 9.8 | 0.23 | 1.00 |
| 9/11/1989 | 430 | 2.8 | 7.2 | 10.4 | 0.21 | 3.00 |
| 5/16/1991 | 930 | 3.6 | 7.3 | 10.7 | 0.08 | 0.90 |
| 6/18/1991 | 230 | 3.1 | 7.3 | 9.9 | 0.16 | 2.00 |
| 7/9/1991 | 930 | 3.2 | 7.7 | 9.2 | 0.16 | |
| 8/6/1991 | 930 | 2.1 | 7.8 | 9.1 | 0.14 | 3.50 |
| 9/10/1991 | 91 | 1.8 | 7.6 | 9.6 | 0.21 | 3.10 |
| 10/2/1991 | 91 | 2.3 | 7.0 | 10.0 | 0.26 | 3.75 |
| 11/5/1991 | 4600 | 90.0 | 6.5 | 9.8 | 0.64 | 2.01 |
| 12/3/1991 | 36 | 5.8 | 6.7 | 11.1 | 0.06 | 1.28 |
| 1/7/1992 | 91 | 4.8 | 6.7 | 11.9 | 0.10 | 1.48 |
| 2/10/1992 | 73 | 4.5 | 6.9 | 11.2 | 0.07 | 1.42 |
| 3/9/1992 | 73 | 4.2 | 6.8 | 11.9 | 0.08 | 1.49 |
| 4/13/1992 | 1500 | 6.0 | 7.0 | 10.6 | 0.12 | 1.23 |
| 5/11/1992 | 230 | 3.6 | 7.3 | 10.8 | 0.10 | 1.46 |
| 6/15/1992 | 170 | 2.2 | 7.1 | 10.2 | 0.14 | 2.18 |
| 7/13/1992 | 170 | 1.7 | 7.7 | 9.6 | 0.18 | 2.39 |
| 8/10/1992 | 130 | 2.3 | 7.4 | 9.5 | 0.30 | 2.92 |
| 9/14/1992 | 790 | 2.3 | 6.8 | 10.8 | 0.43 | 3.35 |
| 10/12/1992 | 120 | 4.2 | 7.4 | 10.6 | 0.40 | 3.25 |
| 11/2/1992 | 330 | 3.8 | 6.8 | 10.3 | 0.12 | 1.72 |
| 12/8/1992 | 230 | 8.0 | 6.9 | 11.9 | 0.10 | 1.44 |
| 1/4/1993 | 920 | 11.0 | 7.0 | 12.3 | 0.09 | 1.20 |
| 2/9/1993 | 110 | 3.7 | 7.1 | 11.6 | 0.08 | 1.49 |
| 3/9/1993 | 20 | 5.3 | 7.2 | 11.9 | 0.11 | 1.37 |
| 4/13/1993 | 110 | 7.4 | 6.9 | 11.0 | | |
| 5/11/1993 | 230 | 5.3 | 7.1 | 10.1 | 0.05 | 0.90 |
| 6/8/1993 | 490 | 4.3 | 7.3 | 9.9 | 0.05 | 1.14 |
| 7/13/1993 | 490 | 3.1 | 7.5 | 10.0 | 0.05 | 1.62 |
| 8/10/1993 | 130 | 2.5 | 7.5 | 9.4 | 0.07 | 1.70 |
| 9/14/1993 | 490 | 1.7 | 7.4 | 9.7 | 0.07 | 2.35 |
| 10/12/1993 | 490 | 1.9 | 7.1 | 9.6 | 0.06 | 2.18 |
| 11/9/1993 | 170 | 2.2 | 7.0 | 12.1 | 0.06 | 2.18 |
| 12/14/1993 | 170 | 8.6 | 6.8 | 10.7 | 0.05 | 1.40 |
| 7/18/1995 | 630 | | 7.8 | 6.6 | 0.08 | 2.00 |
| 8/25/1995 | 512 | 2.0 | 8.5 | 7.0 | | 2.40 |
| 10/3/1995 | 400 | | 8.1 | 9.4 | | 1.30 |
| 10/31/1995 | | | 8.5 | 8.0 | 0.03 | 1.20 |
| 12/13/1995 | 300 | | 8.9 | 9.7 | | 1.10 |
| 1/18/1996 | 57 | | 8.3 | 13.2 | 0.03 | 1.20 |
| 2/15/1996 | 34 | | 8.4 | 9.1 | | 1.30 |
| 3/18/1996 | 100 | | 8.6 | 7.7 | | 1.40 |
| 4/18/1996 | 490 | | 8.4 | 9.7 | 0.03 | 1.00 |
| 6/10/1996 | 93 | 10.0 | 7.6 | 9.7 | | 1.60 |
| 7/19/1996 | 980 | 11.0 | 7.5 | 9.6 | 0.08 | 1.60 |
| 9/6/1996 | 320 | 4.0 | 7.2 | 9.9 | | 2.70 |
| 10/9/1996 | 483 | 5.0 | 7.4 | 10.9 | 0.06 | 2.20 |
| 11/26/1996 | 54 | 16.0 | 6.8 | 10.8 | | 1.10 |
| 1/15/1997 | 44 | 5.0 | 7.4 | 12.8 | 0.03 | 1.30 |
| 2/24/1997 | 572 | 7.0 | 6.9 | 12.1 | | 1.80 |
| 3/27/1997 | 374 | 9.0 | 7.6 | 11.3 | | 1.10 |
| 5/30/1997 | 242 | 5.0 | 7.2 | | | 1.40 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 7/8/1997 | 510 | 12.0 | 7.3 | 9.3 | | 1.90 |
| 10/3/1997 | 1600 | | 6.8 | 9.6 | | 1.10 |
| 11/21/1997 | 300 | | 6.6 | 12.4 | 0.07 | 1.00 |
| 1/20/1998 | 130 | 15.0 | 6.6 | 11.4 | 0.06 | 1.10 |
| 2/26/1998 | 194 | 4.0 | 7.6 | 12.1 | | 0.90 |
| 3/30/1998 | 90 | 1.0 | 7.2 | 11.8 | | 1.00 |
| 4/29/1998 | 80 | 5.0 | 7.5 | 11.3 | 0.04 | 1.20 |
| 5/28/1998 | 50 | 10.0 | 6.5 | 10.8 | | 0.90 |
| 6/26/1998 | 1600 | 95.0 | 6.5 | 9.9 | | 0.80 |
| 7/22/1998 | 240 | 7.0 | 7.1 | 8.2 | 0.07 | 1.80 |
| 8/19/1998 | 170 | 2.0 | 7.2 | 10.0 | | 2.00 |
| 9/28/1998 | 500 | 5.0 | 6.9 | 10.4 | | 1.80 |
| 10/28/1998 | 220 | 7.0 | 6.9 | 11.3 | 0.06 | 1.20 |
| 12/4/1998 | 50 | 16.0 | 6.6 | 12.8 | | 1.30 |
| 1/19/1999 | 130 | 31.0 | 6.8 | 15.0 | | 1.30 |
| 2/25/1999 | 80 | 25.0 | 6.6 | 14.3 | | 1.10 |
| 3/15/1999 | 70 | 11.0 | 6.9 | 16.1 | | 1.10 |
| 4/22/1999 | 170 | 3.4 | 7.2 | 17.5 | 0.04 | 1.20 |
| 6/1/1999 | 130 | 4.0 | 6.9 | 8.3 | | 1.20 |
| 6/22/1999 | 220 | 1.0 | 7.1 | 9.6 | 0.06 | 1.20 |
| 7/29/1999 | 130 | 2.0 | 7.4 | 9.2 | | 1.70 |
| 9/2/1999 | 170 | 1.0 | 7.9 | 9.7 | | 1.80 |
| 10/4/1999 | 170 | 2.0 | 7.2 | | | 2.10 |
| 10/25/1999 | 17 | 2.0 | 7.1 | | 0.07 | 2.00 |
| 12/6/1999 | 170 | 11.0 | 7.4 | | | 1.10 |
| 6/21/2002 | 240 | 3.6 | 7.4 | 8.9 | 0.04 | |
| 7/17/2002 | 80 | 2.4 | 7.8 | 9.4 | 0.14 | |
| 8/28/2002 | 170 | 1.9 | 7.6 | 8.8 | 0.06 | 2.92 |
| 9/26/2002 | 110 | 2.5 | 7.7 | 10.2 | 0.06 | 1.94 |
| 10/11/2002 | 130 | 2.7 | 7.5 | 10.7 | 0.05 | 1.81 |
| 11/13/2002 | 80 | 4.3 | 7.3 | 10.8 | 0.04 | 0.80 |
| 12/9/2002 | 17 | 2.4 | 6.9 | 13.3 | 0.05 | 1.75 |
| 1/14/2003 | 110 | 11.6 | | 11.2 | 0.05 | 1.20 |
| 2/19/2003 | 23 | 13.6 | | 11.2 | 0.04 | 1.00 |
| 3/27/2003 | 17 | 7.5 | 6.8 | 12.3 | 0.03 | 0.96 |
| 4/15/2003 | 50 | 6.2 | 6.9 | 11.3 | 0.03 | 0.84 |
| 5/14/2003 | 240 | 3.3 | 7.3 | 11.8 | 0.03 | 0.92 |
| 6/10/2003 | 300 | 3.2 | 7.6 | 9.7 | 0.04 | 1.24 |
| 7/30/2003 | 80 | 1.8 | 7.8 | 9.1 | 0.05 | 2.92 |
| 8/12/2003 | 80 | 1.8 | 7.5 | 8.6 | 0.05 | 2.16 |
| 9/16/2003 | 280 | 2.7 | 7.6 | 10.1 | 0.06 | 2.00 |
| 10/9/2003 | 170 | 3.7 | 7.4 | 9.3 | 0.06 | 1.34 |
| 11/20/2003 | 300 | 14.7 | | 11.7 | 0.04 | 2.27 |
| 12/10/2003 | 17 | 6.1 | 7.5 | 11.1 | 0.02 | 1.62 |
| 1/22/2004 | 22 | 4.0 | | 13.3 | <0.02 | 1.42 |
| 2/18/2004 | 95 | 13.9 | 7.2 | 11.3 | 0.04 | 0.89 |
| 3/25/2004 | 100 | 5.6 | 7.6 | 10.9 | 0.03 | 0.88 |
| 4/27/2004 | 106 | 4.0 | 7.4 | 10.7 | 0.02 | 0.93 |
| 5/11/2004 | 86 | 3.7 | 7.7 | 10.8 | 0.04 | 0.98 |
| 6/23/2004 | 130 | 3.8 | 7.7 | 9.2 | 0.03 | 0.86 |
| 7/14/2004 | 90 | 2.9 | 7.9 | 9.6 | 0.05 | 1.16 |
| 8/18/2004 | 81 | 2.3 | 8.4 | 8.8 | 0.06 | 1.43 |
| 9/1/2004 | 144 | 3.1 | 8.1 | 9.3 | 0.05 | 0.97 |
| 10/13/2004 | 85 | 4.4 | 7.4 | 10.0 | 0.03 | 1.01 |
| 11/15/2004 | 26 | 3.5 | 7.4 | 10.1 | 0.03 | 0.81 |
| 12/22/2004 | 140 | 9.0 | 7.0 | 11.1 | 0.04 | 0.97 |
| 1/25/2005 | 27 | 6.1 | 7.5 | 11.6 | 0.03 | 1.13 |
| 2/8/2005 | 25 | 10.5 | 7.3 | 11.6 | 0.02 | 1.18 |
| 3/22/2005 | 45 | 5.6 | 7.5 | 10.9 | 0.03 | 0.94 |
| 4/28/2005 | 100 | 7.8 | 7.3 | 10.4 | 0.03 | 0.69 |
| 5/17/2005 | 490 | 17.6 | 8.1 | 9.9 | 0.05 | 0.78 |
| 6/15/2005 | 90 | 4.2 | 8.2 | 9.8 | 0.04 | 0.89 |
| 7/13/2005 | 110 | 3.7 | 7.6 | | 0.03 | 1.03 |
| 8/10/2005 | 78 | 2.6 | 7.8 | 9.6 | 0.04 | 1.48 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 9/22/2005 | 400 | 2.9 | 7.7 | 9.3 | 0.05 | 1.80 |
| 10/27/2005 | 82 | 3.0 | 7.1 | 10.2 | 0.04 | 0.97 |
| 11/10/2005 | 100 | 7.2 | 7.3 | 13.8 | 0.03 | 1.17 |
| 12/6/2005 | 27 | 6.6 | 7.2 | 11.9 | 0.02 | 1.15 |
| 1/24/2006 | 38 | 9.8 | 6.5 | 11.6 | 0.03 | 1.21 |
| 2/15/2006 | 14 | 4.6 | 7.3 | 12.9 | 0.02 | 1.43 |
| 3/22/2006 | 65 | 5.9 | 7.2 | 10.9 | 0.02 | 1.16 |
| 4/25/2006 | 30 | 3.8 | 6.9 | 12.8 | <0.02 | 1.09 |
| 5/23/2006 | 560 | 7.1 | 7.2 | 8.9 | 0.05 | 1.09 |
| 6/7/2006 | 200 | 6.2 | 7.7 | 10.8 | 0.03 | 0.89 |
| 7/25/2006 | 83 | 1.8 | 7.6 | 8.0 | 0.05 | 2.05 |
| 8/10/2006 | 113 | 2.3 | 7.6 | 6.9 | 0.05 | 0.91 |
| 9/21/2006 | 330 | 9.0 | 7.4 | 9.1 | 0.08 | 1.04 |
| 10/12/2006 | 76 | 2.6 | 7.5 | 9.8 | 0.05 | 1.83 |
| 11/8/2006 | 290 | 22.9 | 6.3 | 8.5 | 0.06 | 1.30 |
| 12/12/2006 | 280 | 14.4 | 6.7 | 10.3 | 0.06 | 0.82 |
| 1/17/2007 | 11 | 4.1 | 7.3 | 12.7 | 0.03 | 1.32 |
| 2/6/2007 | 11 | 3.8 | 7.3 | 12.1 | 0.04 | 1.34 |
| 3/7/2007 | 34 | 6.2 | 7.1 | 11.0 | 0.03 | 0.96 |
| 4/17/2007 | 40 | 4.5 | 7.4 | 11.3 | 0.03 | 0.97 |
| 5/30/2007 | 52 | 3.4 | 7.6 | 9.1 | 0.19 | 1.39 |
| 6/21/2007 | 140 | 3.5 | 7.8 | 9.0 | 0.12 | 1.56 |
| 7/10/2007 | 84 | 2.6 | 7.8 | 8.5 | 0.08 | 1.84 |
| 8/16/2007 | 57 | 2.2 | 7.9 | 8.8 | 0.07 | 2.51 |
| 9/27/2007 | 66 | 2.6 | 7.8 | 10.2 | 0.05 | 2.46 |
| 10/24/2007 | 30 | 4.4 | 7.1 | 10.3 | 0.04 | 1.19 |
| 11/8/2007 | 41 | 2.4 | 7.4 | 11.6 | 0.04 | 1.70 |
| 12/20/2007 | 450 | 42.5 | 6.6 | 11.1 | 0.10 | 0.89 |

Table C-4. Clark County raw data for Mill Creek (MIL010).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 5/16/1991 | 91 | 4.3 | 10.0 | 7.4 | 0.23 | 0.70 |
| 6/18/1991 | 390 | 4.7 | 9.9 | 7.2 | 0.18 | 1.10 |
| 7/9/1991 | 91 | 2.4 | 8.7 | 7.8 | 0.56 | 3.30 |
| 8/6/1991 | 1500 | 4.0 | 8.5 | 7.8 | 1.20 | 3.70 |
| 9/10/1991 | 430 | 2.6 | 9.4 | 7.8 | 0.35 | 1.50 |
| 10/2/1991 | 430 | 2.4 | 10.2 | 7.1 | 0.27 | 1.62 |
| 11/5/1991 | 24000 | 85.0 | 2.6 | 6.8 | 1.60 | |
| 12/3/1991 | 200 | 9.1 | 10.6 | 6.6 | 0.19 | 1.76 |
| 1/7/1992 | 91 | 5.7 | 12.0 | 6.7 | 0.16 | 1.59 |
| 2/10/1992 | 230 | 5.8 | 11.5 | 6.9 | 0.16 | 1.41 |
| 3/9/1992 | 2400 | 8.7 | 11.1 | 6.9 | 0.47 | 1.73 |
| 4/13/1992 | 2400 | 16.0 | 9.8 | 7.0 | 0.21 | 0.58 |
| 5/11/1992 | 930 | 4.1 | 10.3 | 7.4 | 0.22 | 1.18 |
| 6/15/1992 | 45 | 1.8 | 10.2 | 7.4 | 0.19 | 1.29 |
| 7/13/1992 | 270 | 1.9 | 9.5 | 7.3 | 0.21 | 1.43 |
| 8/10/1992 | 950 | 12.6 | 8.4 | 7.8 | 1.53 | 2.06 |
| 9/14/1992 | 170 | | 10.4 | 7.5 | 0.32 | 1.49 |
| 10/12/1992 | 130 | 3.2 | 10.8 | 7.4 | 0.24 | 1.39 |
| 11/2/1992 | 130 | 9.3 | 9.6 | 7.2 | 0.23 | 2.09 |
| 12/8/1992 | 2500 | 12.0 | 12.0 | 7.1 | 0.14 | 1.92 |
| 1/4/1993 | 1100 | 14.0 | 12.0 | 6.8 | 0.17 | 1.59 |
| 7/18/1995 | 106 | | 6.2 | 7.7 | 0.22 | 1.40 |
| 8/25/1995 | 238 | 1.7 | 6.4 | 8.5 | | 1.60 |
| 10/3/1995 | 500 | | 8.9 | 8.2 | 0.15 | 0.87 |
| 10/31/1995 | | | | | | 0.98 |
| 12/13/1995 | 60 | | 9.2 | 8.7 | | 0.81 |
| 1/18/1996 | 55 | | 12.3 | 8.1 | 0.16 | 0.79 |
| 2/15/1996 | 176 | | 8.5 | 8.2 | | 1.00 |
| 3/18/1996 | 80 | | 7.2 | 8.7 | | 0.82 |
| 4/18/1996 | 279 | | 9.4 | 8.0 | 0.15 | 0.46 |
| 6/10/1996 | | 4.0 | 9.6 | 7.7 | | 1.40 |
| 7/19/1996 | 600 | 5.0 | 9.7 | 7.6 | 0.16 | 1.20 |
| 9/6/1996 | 36 | 1.0 | 9.8 | 7.1 | | 1.90 |
| 10/9/1996 | 58 | 3.0 | 10.6 | 7.4 | 0.15 | 1.40 |
| 11/26/1996 | 78 | 19.0 | 11.0 | 6.8 | 0.10 | 0.89 |
| 1/15/1997 | 85 | | 13.5 | 7.5 | 0.24 | 0.78 |
| 1/20/1998 | | | | | 0.14 | 0.67 |
| 2/24/1997 | 82 | | 12.5 | 7.3 | | 0.55 |
| 3/27/1997 | 214 | 1.0 | 11.3 | 7.6 | | |
| 5/30/1997 | 700 | 9.0 | | 7.3 | | 0.73 |
| 7/8/1997 | 250 | 2.0 | 9.3 | 7.4 | | 1.40 |
| 10/3/1997 | 240 | 2.0 | 9.6 | 7.1 | | 0.70 |
| 11/21/1997 | 1100 | | 11.7 | 6.6 | | 0.70 |
| 1/20/1998 | 50 | 11.0 | 11.2 | 6.7 | | 0.60 |
| 2/26/1998 | 66.9 | 6.0 | 11.7 | 8.0 | | 0.40 |
| 3/30/1998 | 80 | 1.0 | 11.0 | 7.3 | | 0.40 |
| 4/29/1998 | 220 | 4.0 | 11.7 | 7.8 | 0.13 | 0.50 |
| 5/28/1998 | 300 | 6.0 | 10.1 | 6.5 | | 0.40 |
| 6/26/1998 | 1600 | 8.0 | 9.5 | 6.8 | | 0.60 |
| 7/22/1998 | 50 | 1.0 | 7.9 | 7.2 | 0.17 | 1.10 |
| 8/19/1998 | 1600 | 0.1 | 9.4 | 7.2 | | 1.10 |
| 9/28/1998 | 30 | 7.0 | 10.0 | 6.9 | | 1.10 |
| 10/28/1998 | 900 | 5.0 | 10.7 | 6.8 | 0.13 | 0.70 |
| 12/4/1998 | 300 | 12.0 | 12.3 | 6.3 | | 1.10 |
| 1/19/1999 | 300 | 29.0 | 12.6 | 7.2 | | 1.00 |
| 2/25/1999 | 30 | 21.0 | 14.8 | 6.9 | | 0.60 |
| 3/15/1999 | 70 | 10.0 | 16.2 | 7.1 | | 0.60 |
| 4/22/1999 | 110 | 4.9 | 18.8 | 7.5 | 0.09 | 0.40 |
| 6/1/1999 | 30 | 6.0 | | 7.1 | | 1.00 |
| 6/22/1999 | 170 | 1.0 | | 7.2 | | 1.00 |
| 7/29/1999 | 30 | 1.6 | | 7.5 | 0.12 | 1.10 |
| 9/2/1999 | 170 | 2.0 | 8.4 | 8.0 | | 1.20 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/4/1999 | 30 | 3.0 | 9.0 | 7.2 | | 1.30 |
| 10/25/1999 | 23 | 1.0 | 8.2 | 7.2 | 0.12 | 1.00 |
| 12/6/1999 | 240 | 12.0 | 9.2 | 7.3 | | 0.80 |
| 8/27/2001 | | 5.5 | | | | |
| 10/17/2001 | | 3.1 | 9.7 | | | |
| 11/27/2001 | | 8.9 | 12.3 | | | |
| 12/26/2001 | | 6.1 | | | | |
| 1/17/2002 | | 9.0 | 12.4 | | | |
| 2/4/2002 | | 7.9 | | | | |
| 3/12/2002 | | 26.0 | 11.6 | 6.8 | | |
| 4/10/2002 | | 9.0 | 10.0 | 7.5 | | |
| 5/30/2002 | | 7.1 | 9.4 | 7.7 | 0.19 | |
| 6/20/2002 | 300 | 3.3 | 9.6 | 7.7 | 0.15 | |
| 7/17/2002 | 50 | 2.3 | 8.7 | 7.5 | 0.06 | |
| 8/28/2002 | 80 | 2.4 | 7.8 | 7.3 | 0.16 | 1.01 |
| 9/26/2002 | 30 | 1.9 | 9.5 | 7.4 | 0.13 | 0.60 |
| 10/11/2002 | 70 | 2.3 | 10.8 | 7.7 | 0.13 | 0.69 |
| 11/13/2002 | 4 | 2.0 | 10.0 | 7.8 | 0.10 | 0.25 |
| 12/9/2002 | 22 | 1.4 | 11.4 | 6.9 | 0.11 | 0.61 |
| 1/14/2003 | 80 | 11.6 | 11.0 | 6.9 | 0.10 | 0.99 |
| 2/19/2003 | 50 | 13.9 | 10.8 | 6.5 | 0.10 | 0.60 |
| 3/27/2003 | 50 | 6.8 | 11.5 | 7.3 | 0.09 | 0.47 |
| 4/15/2003 | 22 | 8.0 | 10.4 | 7.3 | 0.10 | 0.34 |
| 5/14/2003 | 300 | 4.0 | 10.9 | 7.6 | 0.12 | 0.26 |
| 6/10/2003 | 110 | 2.2 | 9.3 | 7.7 | 0.11 | 0.68 |
| 7/30/2003 | 30 | 1.6 | 8.6 | 7.7 | 0.12 | 0.80 |
| 8/12/2003 | 23 | 1.6 | 8.9 | 7.6 | 0.12 | 0.79 |
| 9/16/2003 | 170 | 3.0 | 9.9 | 7.6 | 0.13 | 0.80 |
| 10/9/2003 | 130 | 2.3 | 9.4 | 7.4 | 0.13 | 0.70 |
| 11/20/2003 | 130 | 6.7 | 11.0 | 7.2 | 0.09 | 1.66 |
| 12/10/2003 | 23 | 7.1 | 11.1 | 6.5 | 0.08 | 1.34 |
| 1/22/2004 | 13 | 4.6 | 13.5 | 6.6 | 0.04 | 0.93 |
| 2/18/2004 | 180 | 16.8 | 11.6 | 7.2 | 0.08 | 0.58 |
| 3/25/2004 | 387 | 5.4 | 10.8 | 7.6 | 0.10 | 0.30 |
| 4/27/2004 | 87 | 4.3 | 10.4 | 7.7 | 0.12 | 0.28 |
| 5/11/2004 | 94 | 3.9 | 10.2 | 7.7 | 0.14 | 0.39 |
| 6/23/2004 | 75 | 2.2 | 8.8 | 7.2 | 0.13 | 0.51 |
| 7/14/2004 | 62 | 2.0 | 9.1 | 7.7 | 0.13 | 0.44 |
| 8/18/2004 | 198 | 1.7 | 8.5 | 8.3 | 0.14 | 0.37 |
| 9/1/2004 | 101 | 2.8 | 9.0 | 7.9 | 0.19 | 0.34 |
| 10/13/2004 | 28 | 2.9 | 9.4 | 7.3 | 0.16 | 0.28 |
| 11/15/2004 | 16 | 3.7 | 9.8 | 7.2 | 0.11 | 0.32 |
| 12/22/2004 | 130 | 9.9 | 11.4 | 6.7 | 0.09 | 0.64 |
| 1/25/2005 | 15 | 5.5 | 11.2 | 7.6 | 0.07 | 0.60 |
| 2/6/2005 | 900 | 18.4 | 10.8 | 7.2 | 0.13 | 0.53 |
| 3/22/2005 | 54 | 6.3 | 10.3 | 6.8 | 0.12 | 0.34 |
| 4/17/2005 | 130 | 11.4 | 9.9 | 7.6 | 0.13 | 0.39 |
| 5/17/2005 | 750 | 13.9 | 9.1 | 7.2 | 0.19 | 0.27 |
| 6/15/2005 | 200 | 3.5 | 9.2 | 8.3 | 0.14 | 0.41 |
| 7/31/2005 | 130 | 2.1 | 7.4 | 7.7 | 0.19 | 0.55 |
| 8/10/2005 | 120 | 2.3 | 9.6 | 7.6 | 0.12 | 0.45 |
| 9/17/2005 | 270 | 2.8 | 9.7 | 7.8 | 0.16 | 0.57 |
| 10/27/2005 | 23 | 2.0 | 10.0 | 7.3 | 0.11 | 0.36 |
| 11/10/2005 | 12 | 6.8 | 13.6 | 7.2 | 0.19 | 0.79 |
| 12/6/2005 | 20 | 7.6 | 12.3 | 7.2 | 0.07 | 0.85 |
| 1/29/2006 | 110 | 22.1 | 16.3 | 7.2 | 0.13 | 0.58 |
| 2/15/2006 | 31 | 5.0 | 13.0 | 5.8 | 0.06 | 0.74 |
| 3/22/2006 | 31 | 5.3 | 10.7 | 7.4 | 0.06 | 0.49 |
| 4/25/2006 | 30 | 4.0 | 8.1 | 7.3 | 0.11 | 0.56 |
| 5/23/2006 | 1060 | 11.2 | 9.1 | 7.4 | 0.13 | 0.59 |
| 6/7/2006 | 250 | 3.4 | 10.4 | 7.2 | 0.11 | 0.53 |
| 7/30/2006 | 300 | 2.5 | 7.4 | 7.8 | 0.15 | 1.01 |
| 8/10/2006 | 80 | 2.1 | 7.1 | 7.3 | 0.13 | 0.73 |
| 9/21/2006 | 119 | 4.5 | 9.1 | 7.6 | 0.14 | 0.74 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/7/2006 | 130 | 2.5 | 9.7 | 7.4 | 0.14 | 0.94 |
| 11/8/2006 | 1030 | 16.6 | 7.9 | 7.4 | 0.20 | 0.91 |
| 12/12/2006 | 250 | 17.7 | 10.2 | 6.4 | 0.13 | 0.37 |
| 1/17/2007 | 14 | 5.8 | 12.5 | 6.7 | 0.08 | 0.72 |
| 2/6/2007 | 29 | 4.2 | 12.4 | 7.2 | 0.08 | 0.54 |
| 3/7/2007 | 71 | 7.1 | 10.4 | 7.3 | 0.09 | 0.39 |
| 4/29/2007 | 22 | 4.9 | 10.4 | 7.1 | 0.12 | 0.41 |
| 5/30/2007 | 30 | 3.4 | 8.3 | 7.7 | 0.25 | 0.75 |
| 6/21/2007 | 44 | 2.7 | 9.5 | 7.7 | 0.19 | 0.87 |
| 7/10/2007 | 107 | 2.2 | 8.5 | 7.8 | 0.14 | 1.07 |
| 8/8/2007 | 80 | 2.7 | 8.7 | 7.8 | 0.14 | 1.09 |
| 9/27/2007 | 88 | 3.4 | 9.5 | 7.6 | 0.14 | 1.27 |
| 10/24/2007 | 18 | 3.8 | 10.3 | 7.0 | 0.12 | 0.53 |
| 11/8/2007 | 29 | 1.9 | 11.0 | 7.4 | 0.08 | 0.79 |
| 12/20/2007 | 510 | 29.4 | 11.1 | 6.4 | 0.17 | 0.56 |

Table C-5. Clark County raw data for Curtin Creek (CUR020).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 5/16/1991 | 2400 | 3.3 | 9.1 | 7.3 | 0.11 | 3.50 |
| 6/18/1991 | 2400 | 1.1 | 8.7 | 6.9 | 0.08 | 4.90 |
| 7/9/1991 | 390 | 1.6 | 8.4 | 7.1 | 0.11 | |
| 8/6/1991 | 230 | 1.0 | 8.3 | 7.0 | 0.10 | 6.10 |
| 9/10/1991 | 430 | 1.0 | 8.2 | 7.0 | 0.08 | 6.45 |
| 10/2/1991 | 230 | 1.3 | 8.4 | 6.6 | 0.13 | 7.06 |
| 11/5/1991 | 4600 | 7.7 | 8.1 | 6.4 | 0.16 | 3.00 |
| 12/3/1991 | 930 | 4.7 | 9.0 | 6.6 | 0.06 | 4.08 |
| 1/7/1992 | 4600 | 4.8 | 10.0 | 6.7 | 0.07 | 4.18 |
| 2/10/1992 | 430 | 4.3 | 9.8 | 6.7 | 0.06 | 4.18 |
| 3/9/1992 | 430 | 3.2 | 11.1 | 6.7 | 0.06 | 4.60 |
| 4/13/1992 | 2400 | 5.2 | 10.0 | 6.9 | 0.10 | 3.09 |
| 5/11/1992 | 930 | 2.9 | 9.6 | 6.9 | 0.07 | 4.82 |
| 6/15/1992 | 3500 | 2.6 | 8.5 | 6.9 | 0.09 | 6.14 |
| 7/13/1992 | 790 | 1.6 | 8.5 | 7.0 | 0.12 | 6.85 |
| 8/10/1992 | 790 | 1.8 | 8.0 | 6.9 | 0.08 | 6.85 |
| 9/14/1992 | 1300 | 12.0 | 8.9 | 6.9 | 0.25 | 7.59 |
| 10/12/1992 | 210 | 0.8 | 8.7 | 6.9 | 0.08 | 7.26 |
| 11/2/1992 | 790 | 4.9 | 8.0 | 6.8 | 0.10 | 4.66 |
| 12/8/1992 | 1100 | 12.0 | 9.4 | 6.9 | 0.01 | 4.32 |
| 1/4/1993 | 330 | 13.0 | 10.5 | 6.8 | 0.08 | 2.70 |
| 7/18/1995 | 510 | | 5.3 | 7.0 | 0.09 | 5.60 |
| 8/25/1995 | 274 | 0.5 | 5.6 | 8.7 | | 6.30 |
| 10/3/1995 | 1100 | | 6.5 | 7.7 | 0.06 | 5.10 |
| 10/31/1995 | | | | | | 5.10 |
| 12/13/1995 | 30 | | 7.8 | 8.7 | | 2.10 |
| 1/18/1996 | 59 | | 12.2 | 8.1 | 0.07 | 3.00 |
| 2/15/1996 | 106 | | 8.4 | 8.1 | | 3.40 |
| 3/18/1996 | 70 | | 8.5 | 8.1 | | 4.40 |
| 4/18/1996 | 1330 | | | 7.8 | | 3.70 |
| 6/10/1996 | 491 | 4.0 | 8.6 | 7.1 | | 5.60 |
| 7/19/1996 | 1050 | 3.0 | 7.9 | 7.0 | 0.07 | 5.60 |
| 9/6/1996 | 3400 | 1.0 | 8.1 | 6.7 | 0.08 | 6.40 |
| 10/9/1996 | 579 | 2.0 | 8.8 | 6.8 | | 5.50 |
| 11/26/1996 | 55 | 5.0 | 8.2 | 6.6 | | 2.60 |
| 1/15/1997 | 48 | | 10.0 | 7.0 | 0.11 | 3.80 |
| 2/24/1997 | 52 | 4.0 | 10.1 | 6.8 | | 3.70 |
| 3/27/1997 | 125 | 3.0 | 9.9 | 6.8 | | 3.40 |
| 5/30/1997 | 800 | 6.0 | | 6.8 | | 3.80 |
| 7/8/1997 | 430 | 3.0 | 8.3 | 6.8 | | 4.90 |
| 10/3/1997 | 500 | 4.0 | 7.3 | 6.4 | | 3.30 |
| 11/21/1997 | 158 | | 9.7 | 6.4 | 0.08 | 1.80 |
| 1/20/1998 | 50 | 3.0 | 9.5 | 6.4 | 0.06 | 2.10 |
| 2/26/1998 | 38.9 | 4.0 | 9.7 | 7.4 | | 2.80 |
| 3/30/1998 | 26 | 3.0 | 10.1 | 6.9 | | 3.20 |
| 4/29/1998 | 240 | 3.0 | 10.8 | 7.3 | 0.06 | 4.20 |
| 5/28/1998 | 300 | 3.0 | 8.7 | 6.4 | | 3.00 |
| 6/26/1998 | 300 | 2.0 | 7.7 | 6.3 | | 3.40 |
| 7/22/1998 | 130 | 2.0 | 7.3 | 6.6 | 0.08 | 4.90 |
| 8/19/1998 | 300 | 0.0 | 8.1 | 6.3 | | 4.50 |
| 9/28/1998 | 50 | 7.0 | 8.0 | 6.5 | | 4.70 |
| 10/28/1998 | 130 | 1.0 | 8.6 | 6.3 | 0.07 | 4.20 |
| 12/4/1998 | 80 | 8.0 | 9.9 | 6.4 | | 2.20 |
| 1/19/1999 | 170 | 16.0 | 11.4 | 6.8 | | 1.30 |
| 2/25/1999 | 30 | 9.0 | 11.7 | 6.6 | | 1.70 |
| 3/15/1999 | 27 | 6.0 | 13.9 | 6.7 | 0.07 | 1.90 |
| 4/22/1999 | 300 | 2.9 | 15.3 | 6.8 | | 3.20 |
| 6/1/1999 | 500 | 3.0 | | 6.6 | | 3.80 |
| 6/22/1999 | 300 | 3.0 | | 6.7 | 0.10 | 3.80 |
| 7/29/1999 | 300 | 0.7 | | 7.1 | | 4.50 |
| 9/2/1999 | 220 | 2.0 | 7.6 | 7.2 | 0.08 | 4.00 |
| 10/4/1999 | | | | | | 4.30 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/25/1999 | 30 | 0.0 | 7.2 | 6.6 | | 4.40 |
| 12/6/1999 | 30 | 7.0 | 7.6 | 6.6 | | 2.70 |
| 10/17/2001 | | 0.7 | 8.0 | | | |
| 11/27/2001 | | 4.0 | | | | |
| 12/26/2001 | | 3.2 | 9.5 | | | |
| 1/17/2002 | | 5.7 | 9.9 | | | |
| 2/4/2002 | | 4.3 | | | | |
| 3/12/2002 | | 12.1 | 10.3 | 6.8 | | |
| 4/10/2002 | | 8.1 | 9.2 | 6.9 | | |
| 5/30/2002 | | 3.6 | 8.3 | 7.0 | 0.08 | |
| 6/20/2002 | 130 | 1.7 | 8.5 | 6.8 | 0.07 | |
| 7/17/2002 | 110 | 1.3 | 7.9 | 6.9 | 0.07 | |
| 8/28/2002 | 80 | 1.3 | 7.5 | 6.8 | 0.08 | 6.24 |
| 9/26/2002 | 80 | 1.1 | 8.0 | 6.8 | 0.07 | 5.16 |
| 10/11/2002 | 130 | 1.0 | 8.4 | 6.9 | 0.07 | 4.81 |
| 11/13/2002 | 13 | 1.1 | 7.8 | 6.9 | 0.08 | 3.54 |
| 12/9/2002 | 23 | 1.0 | 9.4 | 6.7 | 0.07 | 5.00 |
| 1/14/2003 | 30 | 9.1 | 9.0 | 6.5 | 0.05 | 2.04 |
| 2/19/2003 | 13 | 8.6 | 9.0 | 6.6 | 0.06 | 1.52 |
| 3/27/2003 | 8 | 5.1 | 10.3 | 6.8 | 0.05 | 2.62 |
| 4/15/2003 | 30 | 5.8 | 9.6 | 6.8 | 0.06 | 1.99 |
| 5/14/2003 | 170 | 2.7 | 9.3 | 6.8 | 0.06 | 3.51 |
| 6/10/2003 | 50 | 1.5 | 8.0 | 6.9 | 0.05 | 4.58 |
| 7/30/2003 | 130 | 1.0 | 7.9 | 7.1 | 0.06 | 5.68 |
| 8/12/2003 | 80 | 0.8 | 6.9 | 6.9 | 0.06 | 4.44 |
| 9/16/2003 | 80 | 0.9 | 7.4 | 6.8 | 0.06 | 4.60 |
| 10/9/2003 | 130 | 1.0 | 7.0 | 6.9 | 0.07 | 4.51 |
| 11/20/2003 | 80 | 5.3 | 8.0 | 6.6 | 0.07 | 3.49 |
| 12/10/2003 | 17 | 4.8 | 7.7 | 6.5 | 0.06 | 3.17 |
| 1/22/2004 | 2 | 3.9 | 10.3 | 6.7 | 0.03 | 2.68 |
| 2/18/2004 | 19 | 8.1 | 9.4 | 7.1 | 0.04 | 1.41 |
| 3/25/2004 | 123 | 3.5 | 8.8 | 7.2 | 0.05 | 3.15 |
| 4/27/2004 | 75 | 2.1 | 8.2 | 6.9 | 0.04 | 3.61 |
| 5/11/2004 | 94 | 2.2 | 7.9 | 7.3 | 0.05 | 3.46 |
| 6/23/2004 | 180 | 1.7 | 7.4 | 7.1 | 0.04 | 4.88 |
| 7/14/2004 | 1000 | 1.0 | 7.3 | 7.5 | 0.05 | 4.85 |
| 8/18/2004 | 126 | 1.1 | 7.3 | 8.1 | 0.06 | 4.15 |
| 9/1/2004 | 57 | 1.3 | 6.2 | 7.6 | 0.08 | 3.43 |
| 10/13/2004 | 26 | 0.8 | 7.6 | 7.2 | 0.05 | 4.26 |
| 11/15/2004 | 36 | 2.0 | 7.1 | 7.1 | 0.07 | 4.35 |
| 12/22/2004 | 12 | 3.8 | 8.6 | 6.9 | 0.06 | 3.26 |
| 1/25/2005 | 12 | 3.6 | 9.2 | 7.1 | 0.05 | 3.91 |
| 2/8/2005 | 14 | 6.8 | 9.4 | 6.9 | 0.04 | 2.49 |
| 3/22/2005 | 39 | 3.3 | 8.9 | 7.1 | 0.05 | 3.52 |
| 4/28/2005 | 10 | 3.2 | 8.1 | 7.1 | 0.05 | 2.59 |
| 5/17/2005 | 170 | 6.4 | 7.7 | 7.7 | 0.08 | 1.31 |
| 6/15/2005 | 36 | 3.0 | 8.3 | 7.8 | 0.07 | 4.06 |
| 7/13/2005 | 60 | 1.9 | | 6.8 | 0.06 | 4.76 |
| 8/10/2005 | 510 | 1.1 | 8.2 | 6.9 | 0.05 | 5.15 |
| 9/22/2005 | 150 | 1.1 | 7.5 | 7.1 | 0.06 | 5.01 |
| 10/27/2005 | 63 | 1.6 | 7.9 | 6.9 | 0.06 | 3.88 |
| 11/10/2005 | 43 | 3.6 | 10.3 | 6.9 | 0.05 | 2.67 |
| 12/6/2005 | 19 | 4.7 | 10.5 | 6.8 | 0.04 | 2.36 |
| 1/24/2006 | 3 | 4.8 | 8.8 | 6.4 | 0.05 | 2.55 |
| 2/15/2006 | 12 | 3.4 | 10.7 | 6.9 | 0.04 | 3.37 |
| 3/22/2006 | 18 | 3.5 | 10.4 | 7.0 | 0.04 | 3.16 |
| 4/25/2006 | 23 | 1.6 | 10.8 | 6.7 | 0.03 | 3.66 |
| 5/23/2006 | 1190 | 2.2 | 7.2 | 6.7 | 0.06 | 3.26 |
| 6/7/2006 | 84 | 2.5 | 9.0 | 7.2 | 0.05 | 3.00 |
| 7/25/2006 | 250 | 0.9 | 7.2 | 7.0 | 0.06 | 5.25 |
| 8/10/2006 | 138 | 1.2 | 6.3 | 6.7 | 0.06 | 5.03 |
| 9/21/2006 | 270 | 1.3 | 7.5 | 6.8 | 0.08 | 4.71 |
| 10/12/2006 | 52 | 1.7 | 7.7 | 6.8 | 0.08 | 4.57 |
| 11/8/2006 | 50 | 7.7 | 4.3 | 6.0 | 0.13 | 0.76 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 12/12/2006 | 420 | 10.8 | 7.9 | 6.4 | 0.07 | 2.64 |
| 1/17/2007 | 8 | 6.2 | 10.1 | 6.9 | 0.09 | 3.78 |
| 2/6/2007 | 6 | 3.4 | 10.0 | 7.0 | 0.07 | 3.99 |
| 3/7/2007 | 47 | 4.3 | 8.6 | 6.7 | 0.07 | 2.80 |
| 4/17/2007 | 54 | 3.1 | 9.0 | 7.0 | 0.07 | 3.53 |
| 5/30/2007 | 31 | 1.8 | 7.3 | 6.8 | 0.30 | 5.90 |
| 6/21/2007 | 660 | 1.9 | 7.9 | 7.1 | 0.17 | 4.97 |
| 7/10/2007 | 93 | 1.6 | 7.8 | 7.1 | 0.06 | 5.61 |
| 8/16/2007 | 73 | 1.5 | 7.0 | 7.1 | 0.08 | 4.86 |
| 9/27/2007 | 57 | 1.2 | 8.1 | 7.1 | 0.10 | 6.39 |
| 10/24/2007 | 23 | 1.1 | 7.8 | 6.6 | 0.06 | 3.71 |
| 11/8/2007 | 26 | 1.1 | 8.8 | 6.9 | 0.04 | 5.35 |
| 12/20/2007 | 50 | 12.3 | 10.2 | 6.6 | 0.07 | 2.00 |

Table C-6. Clark County raw data for Salmon Creek @ 122nd Ave (SMN050).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 5/16/1991 | 430 | 3.6 | | 10.1 | 0.08 | 0.50 |
| 6/18/1991 | 750 | 3.3 | 7.6 | 9.4 | 0.02 | 0.40 |
| 7/9/1991 | 1500 | 3.5 | 7.4 | 8.7 | 0.04 | |
| 8/6/1991 | 930 | 3.2 | 7.7 | 7.6 | 0.05 | 0.60 |
| 9/10/1991 | 430 | 3.0 | 7.7 | 8.3 | 0.06 | 0.76 |
| 10/2/1991 | 930 | 3.5 | 7.1 | 9.0 | 0.73 | 0.64 |
| 11/5/1991 | 12000 | 6.5 | 6.1 | 9.0 | 0.45 | 1.99 |
| 12/3/1991 | 91 | | 6.8 | 10.4 | 0.05 | 1.18 |
| 1/7/1992 | <30 | | 6.7 | 11.1 | 0.10 | 1.16 |
| 2/10/1992 | 91 | 4.1 | 6.8 | 11.4 | 0.07 | 1.00 |
| 3/9/1992 | 91 | 4.0 | 6.7 | 11.3 | 0.08 | 1.03 |
| 4/13/1992 | 930 | 8.3 | 6.9 | 9.8 | 0.15 | 0.78 |
| 5/11/1992 | 230 | 3.8 | 7.2 | 9.0 | 0.10 | 0.73 |
| 6/15/1992 | 490 | 3.1 | 7.4 | 9.2 | 0.18 | 0.99 |
| 7/13/1992 | 790 | 2.7 | 7.4 | 8.2 | 0.32 | 1.14 |
| 8/10/1992 | 330 | 3.0 | 7.5 | 8.1 | 0.66 | 2.41 |
| 9/14/1992 | 790 | 3.9 | 7.4 | 10.1 | 0.61 | 2.04 |
| 10/12/1992 | 490 | 5.7 | 7.4 | 9.0 | 0.69 | 2.04 |
| 11/2/1992 | 1100 | 13.0 | 7.0 | 9.5 | 0.11 | 1.32 |
| 12/8/1992 | 350 | 17.0 | 6.8 | 10.5 | 0.11 | 1.12 |
| 1/4/1993 | 1100 | | | 11.5 | 0.09 | 1.34 |
| 7/18/1995 | 860 | | 7.6 | 6.5 | 0.05 | 0.55 |
| 8/25/1995 | 395 | 2.7 | 8.5 | 6.3 | | 0.63 |
| 10/3/1995 | | | | 7.5 | | |
| 10/31/1995 | 82 | | 9.0 | 9.7 | 0.03 | 0.69 |
| 12/13/1995 | 240 | | 9.2 | 9.3 | | 0.94 |
| 1/18/1996 | 33 | | 8.5 | 13.1 | 0.03 | 0.90 |
| 2/15/1996 | 64 | | 8.2 | 9.3 | | 0.87 |
| 3/18/1996 | 30 | | 8.7 | 8.8 | | |
| 4/18/1996 | 580 | | 8.5 | | 0.03 | 0.64 |
| 6/10/1996 | 202 | 7.0 | 7.5 | 9.6 | | 0.46 |
| 7/19/1996 | 540 | 7.0 | 7.6 | 9.1 | 0.02 | 0.41 |
| 9/6/1996 | 309 | 4.0 | 7.2 | 9.6 | | 0.71 |
| 10/9/1996 | 177 | 5.0 | 7.3 | 10.5 | 0.03 | 0.46 |
| 11/26/1996 | 53 | 16.0 | 6.9 | 10.8 | 0.03 | 0.94 |
| 1/15/1997 | 59 | 1.0 | 7.4 | 12.8 | | 0.74 |
| 2/24/1997 | 224 | 5.0 | 7.1 | 12.2 | | 0.71 |
| 3/27/1997 | 380 | | 7.6 | 11.8 | | 0.55 |
| 5/30/1997 | 222 | 7.0 | 7.1 | | | 0.47 |
| 7/8/1997 | 640 | 4.0 | 7.3 | 9.1 | | 0.49 |
| 10/3/1997 | 1600 | 10.0 | 6.7 | 9.1 | | 0.70 |
| 11/21/1997 | 232 | 12.0 | 6.5 | 12.5 | | 0.90 |
| 1/20/1998 | 70 | 4.0 | 6.4 | 11.3 | 0.03 | 0.80 |
| 2/26/1998 | 128 | 2.0 | 7.5 | 12.0 | | 0.60 |
| 3/30/1998 | 30 | 3.0 | 7.4 | 11.9 | | 0.60 |
| 4/29/1998 | 220 | 10.0 | 7.7 | 12.0 | 0.03 | 0.50 |
| 5/28/1998 | 80 | 75.0 | 6.7 | 10.9 | | 0.60 |
| 6/26/1998 | 1600 | 5.0 | 6.7 | 9.0 | | 0.60 |
| 7/22/1998 | 300 | 2.0 | 7.2 | 7.6 | 0.05 | 0.50 |
| 8/19/1998 | 240 | 5.0 | 7.0 | 10.0 | | 0.50 |
| 9/28/1998 | 240 | 20.0 | 7.0 | 8.9 | | 0.60 |
| 10/28/1998 | 1600 | 13.0 | 6.2 | 9.7 | 0.12 | 0.40 |
| 12/4/1998 | 56 | 30.0 | 6.0 | 12.5 | | 1.10 |
| 1/19/1999 | 80 | 24.0 | 7.0 | 13.9 | | 1.20 |
| 2/25/1999 | 30 | 10.0 | 6.6 | 15.1 | | 1.00 |
| 3/15/1999 | 70 | 4.4 | 7.2 | 16.3 | | 0.90 |
| 4/22/1999 | 80 | 4.0 | 7.2 | 17.8 | 0.03 | 0.50 |
| 6/1/1999 | 110 | 3.0 | 6.3 | | | 0.60 |
| 6/22/1999 | 300 | 3.4 | 7.1 | | | 0.60 |
| 7/29/1999 | 240 | 3.0 | 6.9 | | 0.12 | 0.50 |
| 9/2/1999 | 240 | | 7.1 | 8.8 | | 0.60 |
| 10/4/1999 | 80 | 3.0 | 7.6 | 8.0 | | 0.70 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/25/1999 | 900 | 9.0 | 7.3 | 8.4 | 0.30 | 0.70 |
| 12/6/1999 | 140 | 15.0 | 6.6 | 9.5 | | 1.00 |
| 6/21/2002 | 110 | 3.9 | 7.4 | 9.1 | 0.02 | |
| 7/17/2002 | 170 | 3.3 | 7.4 | 9.0 | 0.03 | |
| 8/28/2002 | 110 | 3.0 | 7.6 | 8.0 | 0.04 | 0.68 |
| 9/26/2002 | 70 | 3.7 | 7.5 | 9.0 | 0.03 | 0.43 |
| 10/11/2002 | 240 | 3.8 | 7.5 | 10.8 | 0.03 | 0.37 |
| 11/13/2002 | 17 | 5.1 | 6.9 | 9.9 | 0.03 | 0.45 |
| 12/9/2002 | 11 | 2.7 | 7.1 | 12.9 | 0.02 | 0.48 |
| 1/14/2003 | 26 | 10.0 | 6.7 | 11.0 | 0.03 | 1.00 |
| 2/19/2003 | 17 | 12.4 | 7.2 | 11.2 | 0.03 | 0.85 |
| 3/27/2003 | 17 | 6.4 | 7.5 | 12.0 | <0.02 | 0.83 |
| 4/15/2003 | 30 | 6.0 | 7.5 | 11.1 | <0.02 | 0.59 |
| 5/14/2003 | 17 | 4.0 | 7.6 | 11.1 | <0.02 | 3.87 |
| 6/10/2003 | 130 | 3.7 | 7.4 | 8.6 | 0.02 | 0.39 |
| 7/30/2003 | 500 | 2.6 | 7.4 | 7.9 | 0.04 | 0.88 |
| 8/12/2003 | 300 | 3.0 | 7.0 | 8.1 | 0.03 | 0.62 |
| 9/16/2003 | 240 | 4.2 | | 9.0 | 0.04 | 0.57 |
| 10/9/2003 | 900 | 6.6 | | 8.4 | 0.05 | 0.35 |
| 11/20/2003 | 240 | 12.2 | | 11.1 | 0.02 | 2.04 |
| 12/10/2003 | 30 | 6.0 | | 10.6 | <0.02 | 1.48 |
| 1/22/2004 | 4 | 3.7 | | 13.1 | <0.02 | 1.02 |
| 2/18/2004 | 47 | 11.2 | 7.2 | 10.9 | 0.03 | 0.81 |
| 3/25/2004 | 204 | 5.4 | 7.4 | 10.9 | <0.02 | 0.49 |
| 4/27/2004 | 87 | 3.9 | 7.3 | 10.2 | <0.02 | 0.46 |
| 5/11/2004 | 152 | 4.2 | 7.8 | 9.6 | 0.03 | 0.39 |
| 6/23/2004 | 90 | 3.7 | 7.8 | 8.9 | <0.02 | 0.38 |
| 7/14/2004 | 100 | 9.7 | 7.9 | 8.4 | 0.02 | 0.28 |
| 8/18/2004 | 270 | 2.7 | 8.5 | 7.4 | 0.13 | 0.12 |
| 9/1/2004 | 71 | 3.9 | 8.3 | 8.6 | 0.03 | 0.35 |
| 10/13/2004 | 71 | 4.7 | 7.6 | 9.4 | <0.02 | 0.56 |
| 11/15/2004 | 42 | 4.0 | 7.3 | 9.7 | <0.02 | 0.54 |
| 12/22/2004 | 90 | 7.7 | 7.1 | 11.0 | 0.03 | 0.81 |
| 1/25/2005 | 20 | 5.1 | 7.5 | 11.4 | <0.02 | 0.83 |
| 2/8/2005 | 40 | 8.6 | 7.2 | 11.4 | <0.02 | 1.05 |
| 3/22/2005 | 39 | 5.7 | 7.6 | 10.2 | <0.02 | 0.54 |
| 4/28/2005 | 57 | 7.8 | 7.3 | 10.4 | <0.02 | 0.72 |
| 5/17/2005 | 320 | 14.5 | 7.7 | 9.7 | 0.03 | 0.80 |
| 6/15/2005 | 35 | 4.5 | 8.4 | 9.7 | 0.02 | 0.43 |
| 7/13/2005 | 84 | 4.3 | 7.5 | | 0.03 | 0.40 |
| 8/10/2005 | 80 | 3.4 | 7.7 | 9.2 | 0.03 | 0.34 |
| 9/22/2005 | 200 | 4.6 | 7.6 | 9.3 | 0.03 | 0.35 |
| 10/27/2005 | 44 | 3.4 | 7.3 | 10.0 | 0.03 | 0.31 |
| 11/10/2005 | 19 | 6.0 | 7.3 | 13.6 | 0.02 | 1.00 |
| 12/6/2005 | 21 | 6.2 | 7.2 | 12.6 | <0.02 | 1.01 |
| 1/24/2006 | 15 | 9.0 | 6.6 | 11.3 | <0.02 | 0.97 |
| 2/15/2006 | 5 | 4.8 | 7.3 | 13.0 | <0.02 | 0.81 |
| 3/22/2006 | 6 | 5.9 | 7.5 | 11.3 | <0.02 | 0.80 |
| 4/25/2006 | 18 | 4.5 | 7.3 | 12.5 | <0.02 | 0.61 |
| 5/23/2006 | 460 | 9.4 | 7.1 | 8.6 | <0.04 | 0.44 |
| 6/7/2006 | 118 | 6.2 | 7.6 | 11.0 | <0.02 | 0.14 |
| 7/25/2006 | 105 | 2.7 | 7.5 | 7.1 | 0.03 | 0.57 |
| 8/10/2006 | 120 | 3.2 | 7.5 | 6.4 | 0.03 | 0.43 |
| 9/21/2006 | 890 | 12.0 | 7.3 | 8.7 | 0.05 | 0.34 |
| 10/12/2006 | 47 | 4.3 | 7.3 | 9.7 | 0.04 | 0.36 |
| 11/8/2006 | 180 | 24.0 | 6.3 | 8.8 | 0.04 | 1.37 |
| 12/12/2006 | 400 | 15.4 | 6.6 | 10.3 | 0.05 | 0.74 |
| 1/17/2007 | 5 | 4.7 | 7.7 | 12.8 | 0.02 | 0.80 |
| 2/6/2007 | 13 | 4.0 | 7.4 | 12.2 | 0.02 | 0.67 |
| 3/7/2007 | 8 | 6.9 | 7.1 | 10.8 | <0.02 | 0.09 |
| 4/17/2007 | 50 | 4.9 | 7.5 | 11.2 | 0.02 | 0.64 |
| 5/30/2007 | 140 | 4.0 | 7.6 | 9.0 | 0.19 | 0.41 |
| 6/21/2007 | 69 | 4.5 | 7.6 | 9.0 | 0.07 | 0.41 |
| 7/10/2007 | 106 | 3.6 | 7.6 | 7.8 | 0.03 | 0.50 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 8/16/2007 | 159 | 3.7 | 7.7 | 7.9 | 0.05 | 0.74 |
| 9/27/2007 | 99 | 5.1 | 7.7 | 9.9 | 0.04 | 0.48 |
| 10/24/2007 | 33 | 5.2 | 7.0 | 10.4 | 0.03 | 0.59 |
| 11/8/2007 | 12 | 3.1 | 7.4 | 11.4 | <0.02 | 0.36 |
| 12/20/2007 | 260 | 33.9 | 6.9 | 10.9 | 0.08 | 0.90 |

Table C-7. Clark County raw data for Weaver Creek (WDN).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 5/16/1991 | 430 | 3.4 | 10.1 | | 0.39 | 1.40 |
| 6/18/1991 | 930 | 2.6 | 9.4 | 7.4 | 1.10 | 3.50 |
| 7/9/1991 | 4600 | 3.2 | 8.7 | 7.5 | 0.88 | 4.90 |
| 8/6/1991 | 4600 | 3.0 | 7.6 | 7.7 | 2.00 | 4.00 |
| 9/10/1991 | 2400 | 1.8 | 8.3 | 7.6 | 2.20 | 6.50 |
| 10/2/1991 | 11000 | 2.1 | 9.0 | 7.2 | 2.90 | 8.94 |
| 11/5/1991 | 46000 | 38.0 | 9.0 | 6.4 | 0.53 | 2.25 |
| 12/3/1991 | 930 | 5.2 | 10.4 | 6.7 | 0.20 | 1.79 |
| 1/7/1992 | 91 | 5.0 | 11.1 | 6.8 | 0.47 | 1.96 |
| 2/10/1992 | 91 | 3.9 | 11.4 | 7.1 | 0.27 | 2.07 |
| 2/10/1992 | 73 | 4.2 | 11.3 | 6.9 | 0.25 | 2.07 |
| 3/9/1992 | 91 | 4.3 | 11.3 | 6.8 | 0.29 | 2.30 |
| 4/13/1992 | 4600 | 14.0 | 9.8 | 6.9 | 0.64 | 1.68 |
| 5/11/1992 | 36 | 5.2 | 9.0 | 7.0 | 0.64 | 2.31 |
| 6/15/1992 | 230 | 3.5 | 9.2 | 7.3 | 1.42 | 5.84 |
| 7/13/1992 | 490 | 2.4 | 8.2 | 7.6 | 1.48 | 5.13 |
| 8/10/1992 | 1300 | 2.5 | 8.1 | 7.5 | 2.97 | 9.36 |
| 9/14/1992 | 270 | 2.4 | 10.1 | 7.3 | 2.60 | 7.34 |
| 10/12/1992 | 490 | 4.3 | 9.0 | 7.5 | 3.11 | 9.33 |
| 11/2/1992 | 78 | 6.3 | 9.5 | 7.2 | 0.79 | 3.09 |
| 12/8/1992 | 1300 | 22.0 | 10.5 | 7.0 | 0.46 | 1.92 |
| 1/4/1993 | 260 | 13.0 | 11.5 | 6.8 | 0.25 | 1.58 |
| 7/18/1995 | 656 | | 6.5 | 7.7 | 0.16 | 0.72 |
| 8/25/1995 | 688 | 2.9 | 6.3 | 7.7 | | 0.66 |
| 10/3/1995 | 1900 | | 7.5 | 8.0 | | 0.59 |
| 10/31/1995 | | | 9.7 | 8.5 | 0.06 | 1.00 |
| 12/13/1995 | 270 | | 9.3 | 9.0 | | 1.30 |
| 1/18/1996 | 142 | | 13.1 | 8.2 | 0.03 | 1.30 |
| 2/15/1996 | 140 | | 9.3 | 8.2 | | 1.30 |
| 3/18/1996 | 130 | | 8.8 | 8.3 | | 1.20 |
| 4/18/1996 | 204 | | | 8.1 | 0.03 | 0.75 |
| 6/10/1996 | 137 | 8.0 | 9.6 | 7.5 | | 0.98 |
| 7/19/1996 | 480 | 10.0 | 9.1 | 7.5 | 0.11 | 0.56 |
| 9/6/1996 | 560 | 3.0 | 9.6 | 7.3 | | 0.57 |
| 10/9/1996 | 97 | 3.0 | 10.5 | 7.5 | 0.11 | 0.66 |
| 11/26/1996 | 109 | 11.0 | 10.8 | 6.7 | | 1.10 |
| 1/15/1997 | 84 | 1.0 | 12.8 | 7.2 | 0.03 | 1.20 |
| 2/24/1997 | 58 | 6.0 | 12.2 | 7.0 | | 1.10 |
| 3/27/1997 | 34 | | 11.8 | 7.2 | | 0.95 |
| 5/30/1997 | 2000 | | | 7.2 | | 0.75 |
| 7/8/1997 | 330 | 11.0 | 9.1 | 7.2 | | 0.83 |
| 10/3/1997 | 1600 | 34.0 | 9.1 | 6.8 | | 0.70 |
| 11/21/1997 | 372 | | 12.5 | 6.5 | 0.11 | 1.00 |
| 1/20/1998 | 50 | 11.0 | 11.3 | 6.5 | 0.05 | 1.10 |
| 2/26/1998 | 83.3 | 2.0 | 12.0 | 6.8 | | 0.90 |
| 3/30/1998 | 110 | 2.0 | 11.9 | 7.6 | | 0.80 |
| 4/29/1998 | 300 | 6.0 | 12.0 | 7.6 | 0.07 | 0.70 |
| 5/28/1998 | 130 | 9.0 | 10.9 | 6.0 | | 0.80 |
| 6/26/1998 | 1600 | 47.0 | 9.0 | 5.9 | | 0.70 |
| 7/22/1998 | 170 | 9.0 | 7.6 | 7.1 | 0.10 | 0.70 |
| 8/19/1998 | 300 | 1.0 | 10.0 | 7.0 | | 0.60 |
| 9/28/1998 | 220 | 1.0 | 8.9 | 6.9 | | 0.60 |
| 10/28/1998 | 1600 | 23.0 | 9.7 | 6.2 | 0.10 | 0.70 |
| 12/4/1998 | 500 | 9.0 | 12.5 | 6.1 | | 1.40 |
| 1/19/1999 | 500 | 30.0 | 13.9 | 6.4 | | 1.30 |
| 2/25/1999 | 50 | 15.0 | 15.1 | 6.6 | | 1.20 |
| 3/15/1999 | 280 | 8.0 | 16.3 | 6.8 | | 1.10 |
| 4/22/1999 | 1600 | 3.2 | 17.8 | 7.3 | 0.05 | 0.90 |
| 6/1/1999 | 300 | 4.0 | | 6.5 | | 0.80 |
| 6/22/1999 | 240 | 0.0 | | 7.1 | | 0.80 |
| 7/29/1999 | 500 | 2.6 | | 7.0 | 0.13 | 0.50 |
| 9/2/1999 | 80 | 1.0 | 8.8 | 8.0 | | 0.60 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/4/1999 | 170 | 3.0 | 8.0 | 7.5 | | 0.60 |
| 10/25/1999 | 240 | 1.0 | 8.4 | 7.3 | 0.41 | 0.50 |
| 12/6/1999 | 500 | 19.0 | 9.5 | 6.3 | | 1.10 |
| 6/21/2002 | 130 | 4.7 | 9.1 | 7.4 | 0.09 | |
| 7/17/2002 | 30 | 4.3 | 9.0 | 7.5 | 0.11 | |
| 8/28/2002 | 130 | 5.9 | 8.0 | 7.5 | 0.11 | 0.36 |
| 9/26/2002 | 240 | 4.9 | 9.0 | 7.3 | 0.09 | 0.20 |
| 10/11/2002 | 170 | 4.5 | 10.8 | 7.6 | 0.09 | 0.34 |
| 11/13/2002 | 110 | 5.4 | 9.9 | 7.0 | 0.06 | 0.44 |
| 12/9/2002 | 300 | 2.4 | 12.9 | 7.0 | 0.05 | 0.75 |
| 1/14/2003 | 80 | 8.7 | 11.0 | | 0.04 | 1.42 |
| 2/19/2003 | 110 | 11.7 | 11.2 | | 0.05 | 1.15 |
| 3/27/2003 | 13 | 5.2 | 12.0 | 7.2 | 0.03 | 1.24 |
| 4/15/2003 | 50 | 6.4 | 11.1 | 7.0 | 0.04 | 0.88 |
| 5/14/2003 | 130 | 4.7 | 11.1 | 7.6 | 0.03 | 0.72 |
| 6/10/2003 | 50 | 4.7 | 8.6 | 7.3 | 0.07 | 0.53 |
| 7/30/2003 | 220 | 3.8 | 7.9 | 7.5 | 0.10 | 0.34 |
| 8/12/2003 | 300 | 4.8 | 8.1 | 7.5 | 0.09 | 0.25 |
| 9/16/2003 | 1600 | 11.2 | 9.0 | 7.3 | 0.10 | 0.28 |
| 10/9/2003 | 900 | 5.7 | 8.4 | 7.2 | 0.12 | 0.36 |
| 11/20/2003 | 900 | 9.8 | 11.1 | | 0.05 | 1.66 |
| 12/10/2003 | 30 | 7.7 | 10.6 | | 0.05 | 1.48 |
| 1/22/2004 | 13 | 4.0 | 13.1 | | <0.02 | 1.47 |
| 2/18/2004 | | 14.4 | 10.9 | 7.1 | 0.04 | 1.03 |
| 3/25/2004 | 174 | 5.3 | 10.9 | 7.5 | 0.04 | 0.94 |
| 4/27/2004 | 67 | 5.0 | 10.2 | 7.4 | 0.05 | 0.64 |
| 5/11/2004 | 300 | 6.0 | 9.6 | 7.7 | 0.07 | 0.46 |
| 6/23/2004 | 150 | 4.8 | 8.9 | 7.7 | 0.09 | 0.54 |
| 7/14/2004 | 230 | 4.4 | 8.4 | 7.7 | 0.09 | 0.20 |
| 8/18/2004 | 38 | 5.3 | 7.4 | 8.1 | 0.04 | 0.40 |
| 9/1/2004 | 115 | 4.0 | 8.6 | 7.9 | 0.12 | 0.48 |
| 10/13/2004 | 47 | 5.6 | 9.4 | 7.3 | 0.07 | 0.63 |
| 11/15/2004 | 160 | 5.4 | 9.7 | 7.3 | 0.06 | 0.74 |
| 12/22/2004 | 40 | 6.7 | 11.0 | 7.3 | 0.06 | 1.27 |
| 1/25/2005 | 150 | 6.5 | 11.4 | 7.4 | 0.05 | 1.25 |
| 2/8/2005 | 110 | 10.3 | 11.4 | 7.2 | 0.03 | 1.30 |
| 3/22/2005 | 90 | 4.9 | 10.2 | 7.6 | 0.05 | 0.79 |
| 4/28/2005 | 110 | 8.3 | 10.4 | 7.3 | 0.04 | 1.01 |
| 5/17/2005 | 500 | 10.6 | 9.7 | 7.7 | 0.06 | 0.96 |
| 6/15/2005 | 101 | 5.0 | 9.7 | 8.2 | 0.05 | 0.80 |
| 7/13/2005 | 270 | 5.0 | | 7.5 | 0.07 | 0.51 |
| 8/10/2005 | 320 | 4.7 | 9.2 | 7.7 | 0.08 | 0.35 |
| 9/22/2005 | 110 | 4.7 | 9.3 | 7.6 | 0.08 | 0.29 |
| 10/27/2005 | 105 | 3.8 | 10.0 | 7.0 | 0.09 | 0.50 |
| 11/10/2005 | 110 | 6.4 | 13.6 | 7.2 | 0.03 | 1.46 |
| 12/6/2005 | 34 | 6.0 | 12.6 | 7.2 | 0.03 | 1.36 |
| 1/24/2006 | 72 | 6.4 | 11.3 | 6.7 | 0.03 | 2.07 |
| 2/15/2006 | 9 | 4.4 | 13.0 | 7.3 | 0.02 | 1.54 |
| 3/22/2006 | 60 | 5.0 | 11.3 | 7.3 | 0.03 | 1.12 |
| 4/25/2006 | 34 | 4.1 | 12.5 | 7.2 | 0.02 | 1.02 |
| 5/23/2006 | 720 | 9.0 | 8.6 | 7.0 | 0.08 | 0.62 |
| 6/7/2006 | 78 | 5.2 | 11.0 | 7.6 | 0.05 | 0.70 |
| 7/25/2006 | 169 | 3.8 | 7.1 | 7.5 | 0.12 | 0.47 |
| 8/10/2006 | 115 | 4.0 | 6.4 | 7.6 | 0.12 | 0.20 |
| 9/21/2006 | 1100 | 7.4 | 8.7 | 7.2 | 0.10 | 0.36 |
| 10/12/2006 | 78 | 3.2 | 9.7 | 7.6 | 0.11 | 0.48 |
| 11/8/2006 | 580 | 12.4 | 8.8 | 6.1 | 0.40 | 1.67 |
| 12/12/2006 | 1290 | 8.8 | 10.3 | 6.7 | 0.05 | 0.91 |
| 1/17/2007 | 16 | 4.1 | 12.8 | 7.2 | 0.04 | 1.50 |
| 2/6/2007 | 23 | 3.4 | 12.2 | 7.4 | 0.04 | 1.30 |
| 3/7/2007 | 75 | 7.9 | 10.8 | 7.1 | 0.07 | 1.02 |
| 4/17/2007 | 510 | 10.0 | 11.2 | 7.4 | 0.06 | 0.79 |
| 5/30/2007 | 420 | 3.4 | 9.0 | 7.7 | 0.27 | 0.66 |
| 6/21/2007 | 200 | 3.4 | 9.0 | 7.8 | 0.12 | 0.57 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 7/10/2007 | 380 | 3.8 | 7.8 | 7.8 | 0.11 | 0.39 |
| 8/16/2007 | 240 | 3.4 | 7.9 | 7.8 | 0.16 | 0.49 |
| 9/27/2007 | 210 | 3.3 | 9.9 | 7.7 | 0.11 | 0.34 |
| 10/24/2007 | 29 | 3.8 | 10.4 | 7.1 | 0.07 | 0.82 |
| 11/8/2007 | 23 | 2.0 | 11.4 | 7.5 | 0.03 | 0.70 |
| 12/20/2007 | 330 | 20.1 | 10.9 | 6.6 | 0.09 | 0.99 |

Table C-8. Clark County raw data for Salmon Creek @ Headwaters (SMN080).

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/10/1988 | 150 | | 10.3 | 7.2 | <0.01 | 0.10 |
| 11/21/1988 | 30 | | 10.6 | 6.8 | 0.03 | 0.70 |
| 12/5/1988 | 30 | | 12.6 | 6.7 | 0.02 | 0.50 |
| 1/24/1989 | <30 | | 11.8 | 6.7 | 0.03 | 0.90 |
| 2/14/1989 | <30 | | 12.4 | 6.7 | <0.01 | 0.50 |
| 3/14/1989 | <30 | | 12.5 | 6.9 | 0.01 | 1.10 |
| 4/11/1989 | <30 | | 11.5 | 7.7 | 0.01 | 0.40 |
| 5/2/1989 | <30 | | 10.8 | 7.3 | <0.01 | 0.60 |
| 6/6/1989 | 30 | | 9.2 | 7.0 | 0.03 | 0.60 |
| 7/10/1989 | 140 | | 10.1 | 6.9 | 0.03 | 0.40 |
| 8/7/1989 | 36 | | 9.0 | 7.2 | 0.03 | 0.20 |
| 9/11/1989 | 91 | | 9.3 | 7.3 | 0.02 | 0.60 |
| 5/16/1991 | <30 | 3.6 | 10.6 | | 0.03 | 0.30 |
| 6/18/1991 | 36 | 3.3 | 10.7 | 6.7 | 0.03 | 0.20 |
| 7/9/1991 | 30 | 3.5 | 9.9 | 7.2 | 0.07 | |
| 8/6/1991 | <30 | 3.2 | 9.1 | 7.3 | 0.02 | 0.10 |
| 9/10/1991 | 36 | 3.0 | 9.6 | 7.2 | 0.05 | 0.12 |
| 10/2/1991 | 91 | 3.5 | 9.7 | 6.8 | 0.05 | 0.08 |
| 11/5/1991 | 4600 | 90.0 | 10.5 | 6.4 | 0.16 | 1.36 |
| 12/3/1991 | <30 | 6.5 | 11.2 | 6.6 | 0.05 | 0.48 |
| 1/7/1992 | 36 | 4.7 | 12.0 | 6.7 | 0.01 | 0.36 |
| 2/10/1992 | <30 | 4.1 | 11.4 | 6.6 | 0.04 | 0.32 |
| 3/9/1992 | <30 | 4.0 | 12.0 | 6.7 | 0.01 | 0.31 |
| 4/13/1992 | 73 | 8.3 | 10.6 | 6.8 | 0.07 | 0.31 |
| 5/11/1992 | <30 | 3.8 | 11.0 | 6.9 | <0.02 | 0.21 |
| 6/15/1992 | 170 | 3.1 | 10.2 | 7.0 | <0.02 | 0.11 |
| 7/13/1992 | 2400 | 2.7 | 8.9 | 7.1 | <0.015 | 0.18 |
| 8/10/1992 | 490 | 3.0 | 9.2 | 7.1 | 0.01 | 0.13 |
| 9/14/1992 | 45 | 3.9 | 10.3 | 7.1 | 0.02 | 0.10 |
| 10/12/1992 | <18 | 5.7 | 10.1 | 7.0 | <0.015 | 0.43 |
| 11/2/1992 | 20 | 13.0 | 10.3 | 6.9 | 0.02 | 0.49 |
| 1/4/1993 | <18 | 11.0 | 12.5 | 6.8 | 0.06 | 0.36 |
| 8/25/1995 | | 2.7 | | | | |
| 10/3/1995 | 143 | | 8.2 | 8.2 | | 0.34 |
| 10/31/1995 | | | 9.6 | 8.6 | <0.05 | 0.33 |
| 12/13/1995 | 10 | | 7.4 | 9.2 | | 0.41 |
| 1/18/1996 | 10 | | 13.4 | 8.4 | <0.05 | 0.40 |
| 2/15/1996 | 2 | | 9.2 | 8.3 | | 0.35 |
| 3/18/1996 | 3 | | 7.5 | 8.7 | | 0.26 |
| 4/18/1996 | 36 | | | 8.1 | <0.05 | 0.31 |
| 6/10/1996 | 11 | 7.0 | 9.8 | 7.4 | | 0.17 |
| 7/19/1996 | 56 | 7.0 | 9.5 | 7.2 | <0.05 | 0.10 |
| 9/6/1996 | 20 | 4.0 | 9.7 | 7.0 | | 0.10 |
| 10/9/1996 | 51 | 5.0 | 10.5 | 7.1 | <0.05 | 0.09 |
| 11/26/1996 | | 16.0 | 11.3 | 6.8 | | 0.39 |
| 1/15/1997 | 1 | | 13.1 | 7.4 | <0.05 | 0.31 |
| 2/24/1997 | 6 | 1.0 | 12.5 | 6.8 | | 0.31 |
| 3/27/1997 | 5 | 5.0 | 11.6 | 7.6 | | 0.25 |
| 5/30/1997 | 36 | 7.0 | | 6.9 | | 0.15 |
| 7/8/1997 | 100 | 4.0 | 9.5 | 7.2 | | 0.13 |
| 10/3/1997 | 130 | 10.0 | 9.7 | 6.4 | | 0.30 |
| 11/21/1997 | 14 | 12.0 | 12.8 | 6.4 | 0.01 | 0.50 |
| 1/20/1998 | 11 | 4.0 | 11.5 | 6.8 | <0.05 | 0.40 |
| 2/26/1998 | 3.1 | 2.0 | 12.3 | 7.5 | | 0.30 |
| 3/30/1998 | 4 | 3.0 | 12.1 | 7.4 | | 0.30 |
| 4/29/1998 | 70 | 10.0 | 12.0 | 7.6 | <0.05 | 0.20 |
| 5/28/1998 | 8 | 75.0 | 11.1 | 6.0 | | 0.70 |
| 6/26/1998 | 240 | 5.0 | 11.5 | 5.8 | | 0.50 |
| 7/22/1998 | 50 | 2.0 | 8.8 | 7.1 | 0.02 | 0.20 |
| 8/19/1998 | 240 | 5.0 | 9.4 | 6.9 | | 0.20 |
| 9/28/1998 | 240 | 20.0 | 10.4 | 7.1 | | 0.80 |
| 10/28/1998 | 130 | 13.0 | 11.3 | 6.2 | 0.01 | 0.30 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 12/4/1998 | 80 | 30.0 | 13.4 | 6.1 | | 0.50 |
| 1/19/1999 | 7 | 24.0 | 14.2 | 7.1 | | 0.60 |
| 2/25/1999 | | | 15.5 | 6.7 | | 0.60 |
| 3/15/1999 | 12 | 10.0 | 16.5 | 6.8 | | 0.50 |
| 4/22/1999 | 4 | 4.4 | 17.7 | 6.9 | 0.01 | 0.20 |
| 6/1/1999 | 12 | 4.0 | | 6.6 | | 0.40 |
| 6/22/1999 | 130 | 3.0 | | 6.9 | | 0.40 |
| 7/29/1999 | 30 | 3.4 | | 6.9 | 0.03 | 0.20 |
| 9/2/1999 | 240 | 3.0 | 8.7 | 6.9 | | 0.40 |
| 10/4/1999 | 30 | 3.0 | 9.1 | 7.2 | | 0.30 |
| 10/25/1999 | 17 | 9.0 | 8.4 | 6.9 | 0.21 | <0.01 |
| 12/6/1999 | 2 | 15.0 | 9.9 | 6.3 | | 0.60 |
| 6/21/2002 | 30 | 3.9 | 10.1 | 7.1 | <0.02 | |
| 7/17/2002 | 80 | 3.3 | 10.4 | 6.9 | <0.02 | |
| 8/28/2002 | 23 | 3.0 | 8.6 | 7.3 | <0.02 | 0.18 |
| 9/26/2002 | 40 | 3.7 | 9.8 | 7.3 | 0.02 | 0.07 |
| 10/11/2002 | 23 | 3.8 | 11.2 | 7.0 | <0.02 | 0.07 |
| 11/13/2002 | 80 | 5.1 | 10.6 | 6.6 | <0.02 | 0.16 |
| 12/9/2002 | 2 | 2.7 | 13.1 | | <0.02 | 0.16 |
| 1/14/2003 | 11 | 10.0 | 11.2 | | <0.02 | 0.44 |
| 2/19/2003 | 2 | 12.4 | 11.2 | | <0.02 | 0.44 |
| 3/27/2003 | 4 | 6.4 | 12.1 | 7.1 | <0.02 | 0.43 |
| 4/15/2003 | 2 | 6.0 | 11.2 | 7.2 | <0.02 | 0.30 |
| 5/14/2003 | 2 | 4.0 | 11.7 | 7.2 | <0.02 | 0.19 |
| 6/10/2003 | 80 | 3.7 | 10.4 | 7.2 | <0.02 | 0.15 |
| 7/30/2003 | 80 | 2.6 | 8.6 | 6.9 | <0.02 | 0.13 |
| 8/12/2003 | 50 | 3.0 | 8.6 | 7.2 | <0.02 | 0.15 |
| 9/16/2003 | 300 | 4.2 | 9.8 | 6.7 | <0.02 | 0.19 |
| 10/9/2003 | 50 | 6.6 | 9.4 | 6.7 | <0.02 | 0.06 |
| 11/20/2003 | 50 | 12.2 | 11.8 | | <0.02 | 4.47 |
| 12/10/2003 | 8 | 6.0 | 11.2 | 7.3 | <0.02 | 0.54 |
| 1/22/2004 | 2 | 3.7 | 13.0 | | <0.02 | 0.45 |
| 2/18/2004 | 7 | 11.2 | 11.4 | 7.2 | <0.02 | 0.43 |
| 3/25/2004 | 3 | 5.4 | 11.6 | 7.3 | <0.02 | 0.22 |
| 4/27/2004 | 9 | 3.9 | 10.6 | 7.3 | <0.02 | 0.25 |
| 5/11/2004 | 33 | 4.2 | 10.7 | 7.7 | <0.02 | 0.16 |
| 6/23/2004 | 22 | 3.7 | 9.8 | 7.6 | <0.02 | 0.18 |
| 7/14/2004 | 70 | 9.7 | 10.4 | 8.0 | <0.02 | 0.14 |
| 8/18/2004 | 99 | 2.7 | 8.1 | 7.9 | <0.02 | 0.10 |
| 9/1/2004 | 44 | 3.9 | 9.1 | 8.3 | <0.02 | 0.17 |
| 10/13/2004 | 18 | 4.7 | 11.9 | 7.4 | <0.02 | 0.25 |
| 11/15/2004 | 10 | 4.0 | 10.1 | 7.5 | <0.02 | 0.23 |
| 12/22/2004 | 1 | 7.7 | 11.0 | 7.5 | <0.02 | 0.34 |
| 1/25/2005 | 2 | 5.1 | 11.6 | 7.6 | <0.02 | 0.32 |
| 2/8/2005 | 8 | 8.6 | 12.0 | 7.3 | <0.02 | 0.52 |
| 3/22/2005 | 4 | 5.7 | 10.3 | 7.5 | <0.02 | 0.30 |
| 4/28/2005 | 6 | 7.8 | 10.8 | 7.2 | <0.02 | 0.37 |
| 5/17/2005 | 28 | 14.5 | 10.6 | 7.6 | <0.02 | 0.42 |
| 6/15/2005 | 9 | 4.5 | 10.2 | 8.4 | <0.02 | 0.25 |
| 7/13/2005 | 39 | 4.3 | | 7.4 | <0.02 | 0.17 |
| 8/10/2005 | 69 | 3.4 | 10.1 | 7.4 | <0.02 | 0.13 |
| 9/22/2005 | 130 | 4.6 | 9.6 | 7.6 | <0.02 | 0.01 |
| 10/27/2005 | 25 | 3.4 | 10.4 | 7.3 | <0.02 | 0.12 |
| 11/10/2005 | 5 | 6.0 | 13.5 | 7.3 | <0.02 | 0.40 |
| 12/6/2005 | 6 | 6.2 | 13.2 | 7.2 | <0.02 | 0.44 |
| 1/24/2006 | 4 | 9.0 | 11.4 | 6.8 | <0.02 | 0.45 |
| 2/15/2006 | 8 | 4.8 | 13.2 | 7.3 | <0.02 | 0.38 |
| 3/22/2006 | 1 | 5.9 | 10.9 | 7.5 | <0.02 | 0.41 |
| 4/25/2006 | 4 | 4.5 | 13.7 | 7.0 | <0.02 | 0.31 |
| 5/23/2006 | 56 | 9.4 | 10.1 | 7.1 | <0.02 | 0.19 |
| 6/7/2006 | 14 | 6.2 | 10.8 | 7.5 | <0.02 | 0.29 |
| 7/25/2006 | 33 | 2.7 | 8.3 | 7.4 | <0.02 | 0.16 |
| 8/10/2006 | 37 | 3.2 | 6.8 | 7.4 | <0.02 | 0.09 |
| 9/21/2006 | 190 | 12.0 | 9.3 | 7.3 | <0.02 | 0.28 |

| Date | Fecal coliform (cfu) | Turbidity (NTU) | Dissolved oxygen (mg/L) | pH | Total phosphorus (mg/L) | Nitrate-nitrogen (mg/L) |
|---|---|---|---|---|---|---|
| 10/12/2006 | 33 | 4.3 | 9.8 | 6.9 | <0.02 | 0.07 |
| 11/8/2006 | 21 | 24.0 | 9.4 | 5.9 | 0.03 | 0.67 |
| 12/12/2006 | 9 | 15.4 | 10.4 | 6.3 | 0.02 | 0.41 |
| 1/17/2007 | 52 | 4.7 | 12.6 | 7.1 | <0.02 | 0.38 |
| 2/6/2007 | 1 | 4.0 | 12.0 | 7.2 | <0.02 | 0.35 |
| 3/7/2007 | 8 | 6.9 | 11.0 | 7.1 | <0.02 | 0.34 |
| 4/17/2007 | 12 | 4.9 | 11.4 | 7.2 | <0.02 | 0.34 |
| 5/30/2007 | 70 | 4.0 | 9.7 | 7.4 | 0.07 | 0.17 |
| 6/21/2007 | 39 | 4.5 | 9.4 | 7.3 | 0.02 | 0.12 |
| 7/10/2007 | 34 | 3.6 | 8.4 | 7.5 | <0.02 | 0.15 |
| 8/16/2007 | 15 | 3.7 | 8.8 | 7.5 | 0.03 | 0.16 |
| 9/27/2007 | 34 | 5.1 | 9.9 | 7.4 | 0.04 | 0.10 |
| 10/24/2007 | 9 | 5.2 | 10.3 | 6.8 | 0.02 | 0.27 |
| 11/8/2007 | 13 | 3.1 | 11.1 | 7.0 | <0.02 | 0.13 |
| 12/20/2007 | 14 | 33.9 | 11.2 | 6.7 | <0.02 | 0.63 |