



Streamflow Summary for Burnt Bridge Creek (Clark County), 2008



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Streamflow Summary for Burnt Bridge Creek (Clark County), 2008

by

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Table of Contents

	<u>Page</u>
List of Figures	4
Abstract	5
Introduction.....	6
Sampling Sites	7
Burnt Bridge Creek	7
Methods.....	9
Streamflow Measurements.....	9
Stage-Height Records	10
Error Assessments.....	11
High-Flow Modeling	11
Quality Assurance	13
Stage-Height Records	13
Streamflow Measurements.....	13
Results.....	15
Site 1: Burnt Bridge Creek at 2 nd Avenue (28C080)	15
Site 2: Burnt Bridge Creek at Vancouver (28C110).....	18
Site 3: Burnt Bridge Creek at Kevanna Park (28C150).....	21
References	25
Appendices.....	27
Appendix A. Average Daily Streamflows for Continuous Monitoring Stations	29
Table A-1: Site 1, Burnt Bridge Creek at 2 nd Avenue (28C080).....	30
Table A-2: Site 2, Burnt Bridge Creek at Vancouver (28C110)	31
Table A-3: Site 3, Burnt Bridge Creek at Kevanna Park (28C150)	32
Appendix B. Discrete Streamflow Measurements.....	33
Table B-1: Site 1, Burnt Bridge Creek at 2 nd Avenue (28C080).....	33
Table B-2: Site 2, Burnt Bridge at Vancouver (28C110).....	33
Table B-3: Site 3, Burnt Bridge Creek at Kevanna Park (28C150).	34
Appendix C. Glossary, Acronyms, and Abbreviations.....	35

List of Figures

	<u>Page</u>
Figure 1: Salmon-Washougal Water Resource Inventory Area (WRIA 28).	7
Figure 2: Burnt Bridge Creek study area.	8
Figure 3: Streamflow hydrograph for Site 1.	16
Figure 4: Discharge-rating curve for Site 1.	16
Figure 5: Streamflow exceedance graph for Site 1.	17
Figure 6: Linear regression of pre- versus post-adjusted streamflow data for Site 1.	17
Figure 7: Streamflow hydrograph for Site 2.	19
Figure 8: Discharge-rating curve for Site 2.	19
Figure 9: Streamflow exceedance graph for Site 2.	20
Figure 10: Linear regression of pre- versus post-adjusted streamflow data for Site 2.	20
Figure 11: Streamflow hydrograph for Site 3.	22
Figure 12: Streamflow exceedance graph for Site 3.	22
Figure 13: Linear regression of pre- versus post-adjusted stage data for Site 3.	23

Abstract

From May 2008 to November 2009, the Washington State Department of Ecology (Ecology) conducted a streamflow assessment on Burnt Bridge Creek in Clark County.

Ecology conducted this monitoring in support of a water quality Total Maximum Daily Load (TMDL) study. The purpose of the TMDL study was to characterize water quality, specifically fecal coliform, dissolved oxygen, and stream temperature, of Burnt Bridge Creek.

Continuous stage-height (water surface elevation) data loggers were installed at three sites: Burnt Bridge Creek at 2nd Avenue, Burnt Bridge Creek at Vancouver, and Burnt Bridge Creek at Kevanna Park. Discrete stage-height readings and streamflow measurements were taken at these sites to develop stage-discharge relationships.

Error assessments were conducted for each station for both the period of record and the low-flow period (July through September). Potential error for the streamflow data collected from these sites ranged from $\pm 18.5\%$ to $\pm 51.7\%$.

Introduction

From May 2008 to November 2009, the Washington State Department of Ecology (Ecology) conducted a streamflow assessment on Burnt Bridge Creek.

This monitoring was conducted in support of a bacteria, dissolved oxygen, and stream temperature Total Maximum Daily Load (TMDL) study. The purpose of the TMDL study was to ensure Burnt Bridge Creek attains compliance with water quality standards (Kardouni and Brock, 2008).

Sampling Sites

Burnt Bridge Creek

Burnt Bridge Creek is a highly modified, urban stream that flows westward 12.6 miles from its agricultural headwaters to the east, through the heart of Vancouver, Washington, to its terminus at Vancouver Lake. Burnt Bridge Creek's watershed is approximately 27 square miles (PBS, 2006). The Burnt Bridge Creek basin is located in the Salmon-Washougal Water Resource Inventory Area (WRIA 28, Figure 1).

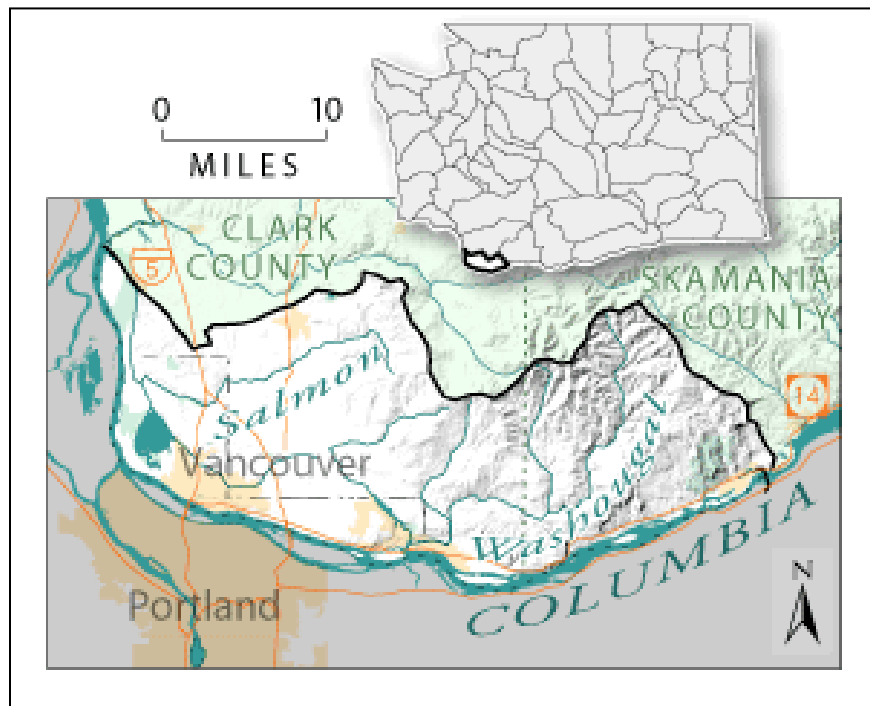


Figure 1: Salmon-Washougal Water Resource Inventory Area (WRIA 28).

The streamflow assessment took place from May 2008 to November 2009. The study consisted of three sites (Figure 2):

- Site 1: Burnt Bridge Creek at NE 2nd Avenue (site ID 28C080), located 1.2 miles upstream of Vancouver Lake at the 2nd Avenue bridge.
- Site 2: Burnt Bridge Creek at Vancouver (site ID 28C110), located at river mile 7.4 at the Burton Road bridge.
- Site 3: Burnt Bridge Creek at Kevanna Park (site ID 28C150), located at river mile 9.2 at the NE 110th Avenue bridge.

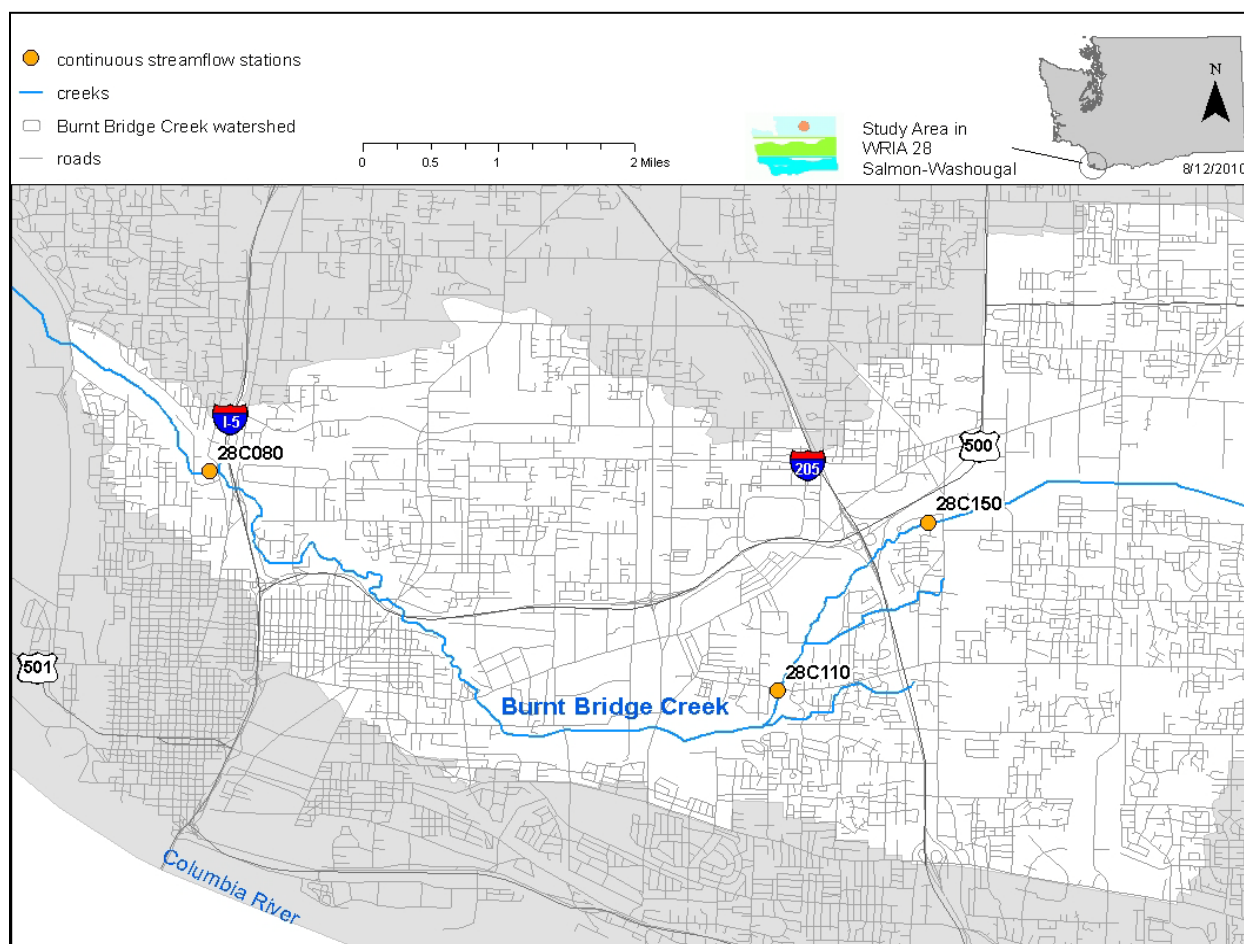


Figure 2: Burnt Bridge Creek study area.

Methods

All three gaging sites were equipped with a submersible pressure transducer and data logger that recorded water surface elevation (stage height) and water temperature at 15-minute intervals throughout the 2008-09 study period.

At all three study sites, between 15 and 17 streamflow measurements were taken to establish a discharge-rating curve, which plots the stage-discharge relationship. These rating curves were then used to predict average daily flow for Site 1 and 2.

An accurate stage-discharge relationship could not be established at Site 3 due to extremely poor hydraulic site characteristics. Flow data from Site 1 were used to estimate continuous flow for Site 3.

Streamflow Measurements

Ecology took flow measurements at all three sites using one of three methods: acoustic Doppler current profiler (ADCP), acoustic Doppler velocimeter (ADV), or a mechanical current meter. Appendix B provides a table detailing the measurements and methods used to measure instantaneous flows during each site visit.

A majority of the flow measurements taken for this study were made using an ADCP mounted on a durable plastic trimaran vessel. ADCPs use sonar to measure the Doppler shift in acoustic frequency that occurs when sound waves reflect off particles suspended in the water column. The ADCP sends a signal from the surface downward into the water column once per second to determine a continuous profile of depth and velocity across the river channel. Four to eight measurements are made by towing or walking the ADCP vessel across the chosen transect, which must be between one and 15 feet deep and have moderate velocities (less than six feet per second). The result of these transects are then averaged (Shedd et al., 2008).

The continuous profiling capability of ADCPs make them an extremely accurate instrument for measuring flow, since water-column velocities and cross-sectional areas are measured more thoroughly than can be done using mechanical current meters. ADCP measurements were used for this study whenever stream conditions permitted.

When conditions were not appropriate to use an ADCP, a SonTek FlowTracker acoustic Doppler Velocimeter (ADV) was used. An ADV is a side-looking sonar sensor that is mounted on a top-set wading rod, similar to a mechanical current meter (Burks, 2009). Velocity measurements are taken at fixed points along a cross-section, and flow is calculated using the mid-section method (Shedd, 2009). Velocity measurements were taken at 60% of the stream depth when the total stream depth was less than 1.5 feet, and at 20% and 80% of the stream depth when the total depth was greater than 1.5 feet. In general, the cross-sections were divided so that no more than 10% of the total flow passed through any single cell. The width of the individual cells varied in keeping with the 10% streamflow criteria (Shedd, 2009).

A small number of measurements were taken using mechanical meters. Ecology did flow measurements using mechanical current meters following the USGS mid-section method (Rantz et al., 1982a, 1982b). Ecology has made minor modifications to the USGS method to accommodate its measurement equipment (Butkus, 2005; Holt, 2009; Shedd, 2009). The instream velocity measurements were taken using a standard USGS top-set wading rod fitted for Swoffer-type optical sensors and propellers. Streamflow was calculated using the USGS mid-section method with a specialized flow calculation software program developed by Ecology (Butkus, 2005; Shedd, 2009). In general, the cross-sections were divided so that no more than 10% of the total flow passed through any single cell. The width of the individual cells varied in keeping with the 10% streamflow criteria (Shedd, 2009).

Stage-Height Records

Continuous stage height was monitored at all three sites using a submersible pressure transducer connected to a data logger, which was calibrated to a primary gage index (PGI). Staff gages were installed as the PGI at all three locations. The stage heights observed from the PGI are used to develop the rating curve and to calibrate the data logger at sites where continuous data are collected (Shedd, 2008). The data loggers at each of the continuous monitoring sites were calibrated to the PGI at the time of installation and were subsequently recalibrated as necessary (Fisher and Holt, 2010; Myers, 2009). Secondary Gage Indexes (SGI) were also installed as a way to verify PGI readings and as a backup in the event of damage or inability to read the PGI. All three sites used tape-down reference points from over-passing bridges as the SGI.

Pressure transducers are inherently prone to drift, with the degree varying from instrument to instrument. Drift is essentially a migration of the instrument from its original calibration, and materializes as a difference between observed and logged stage-height values (Freeman et al., 2004). This instrument drift results in erroneous stage-height values that, when applied to the discharge-rating curve for a station, produces erroneous flow values. These erroneous stage-height values are typically corrected by applying time-weighted adjustments to the continuous data set, which pivot on the stage-height values observed on the PGI by field staff.

The adjusted stage-height values are then applied to the discharge-rating curve for the site, yielding a more accurate record of flow. The time-weighted adjustments are based on the assumption that instrument drift occurs gradually and evenly over time, which under conditions such as sedimentation and bio-fouling is generally true (Freeman et al., 2004).

Occasionally gaps in the continuous stage record can occur. This is often due to equipment or battery failure. Data from a neighboring and similar site are compared to data before and after the data gap to develop a regression equation. Data for the missing period are copied from the neighboring site, run through the regression equation, and applied to the data gap. Time-weighted adjustments to a PGI are then made. In the case of the study sites, all were upstream or downstream of each other increasing the strength of the relationship. The strength of this relationship is due to close proximity, similarities in storm events, and diurnal flow patterns.

Error Assessments

Error estimates were calculated for each site for the two primary sources of error: pressure-transducer drift and the discharge-rating curve. The error estimates were calculated for each site for the period of record for that site and for the low-flow season separately.

In the case of Site 3, due to a rating curve not being viable and a flow record being synthesized, error was calculated by comparing measured and regressed flows.

Error introduced by pressure-transducer drift was quantified using the following calculation:

$$\frac{1}{n} \sum_{i=1}^n \left(\frac{|Q_{rec} - Q_{obs}|}{Q_{obs}} \right)$$

where:

Q_{rec} is the corresponding flow for the recorded stage values.

Q_{obs} is the corresponding flow for the observed stage-height values.

Error in the discharge-rating curve is quantified using the following calculation:

$$\frac{1}{n} \sum_{i=1}^n \left(\frac{|Q_{pred} - Q_{adj}|}{Q_{pred}} \right)$$

where:

Q_{pred} is the flow predicted by the rating curve.

Q_{adj} is the measured flow plus or minus the maximum potential error, based on the professional quality rating of each flow measurement.

Error due to pressure-transducer drift and error inherent in the discharge-rating curve are mutually exclusive sources of error, and are thus treated as additive.

High-Flow Modeling

High-flow conditions and the timing of high-flow events often preclude direct measurement of peak flows at any given station. Wherever feasible, these high flows are modeled using a slope-conveyance model. The slope-conveyance method of high-flow modeling is based on Manning's velocity equation:

$$V = \frac{1.49}{n} \left(\frac{A}{P} \right)^{2/3} S^{1/2}$$

where:

V is average velocity across a given river cross-section in ft/sec.

n is Manning's roughness coefficient.

A is the area of a given river cross-section in ft².

P is the wetted perimeter of a given river cross-section in ft.

S is the energy slope of a given river segment.

Existing high-flow measurements, in conjunction with cross-sectional and longitudinal surveys, are used to determine Manning's roughness coefficient (n) and energy slope (S) for those measurements.

In cases where survey results do not give an acceptable Manning's roughness coefficient value, as was the case at Site 2, estimations are made considering streambed composition and the equation:

$$n=(n_b +n_1 +n_2 +n_3 +n_4)m$$

where:

n_b is a base value of n for a straight, uniform, smooth channel in natural materials.

n_1 is a correction factor for the effect of surface irregularities.

n_2 is a value for variations in shape and size of the channel cross-section.

n_3 is a value for obstructions.

n_4 is a value for vegetation and flow conditions.

m is a correction factor for meandering of the channel.

These results can then be extrapolated to determine flow at stages above the measured range for a station. The extrapolated results are then calibrated to measured flows using linear regression.

Modeled high flows are considered estimates of actual flow. For each model, potential error is calculated as the average difference between measured flow and calibrated modeled flow.

Quality Assurance

Quality assurance measures were taken during this study to address (1) error in stage-height record produced by the data logger at the continuous monitoring sites and (2) error inherent in the instream flow measurements at each site.

Stage-Height Records

Based on manufacturer specifications, the theoretical precision of the pressure transducers is less than or equal to 0.02% of the full-scale output. For the transducers used by Ecology, this precision is considered linear from 0 to 15 pounds per square inch (psi), or 0 to 34.6 feet of water (Fletcher, 1994).

During the study period, the accuracy of pressure transducers at each site was addressed by using the PGI versus pressure-transducer regressions. The correlation coefficients (r) values for the regression of raw pressure-transducer readings against the final data set, which had been adjusted to the discrete observed stage-height values, had values ranging from 0.698 to 0.998. Further discussion of error calculated at each site is provided in the *Results* section. This correlation provides an indication of the severity of pressure-transducer drift (discussed in the *Methods* section) at each site.

Streamflow Measurements

Because the largest potential source of error in a flow measurement is in the velocity measurement, site selection and equipment calibration are of high importance. In this study, the measured cross-sections were qualitatively rated from excellent to poor, based on physical conditions encountered during each measurement.

- An *excellent* cross-section, which lies in a straight channel segment with laminar flow and fairly fine-grained substrate, assumes an error of up to 2%.
- A *good* cross-section, which generally lies in a straight channel segment with predominantly laminar flow and courser-grained substrate, assumes an error of up to 5%.
- A *fair* cross-section, which may contain sections of angular flow, turbulence, or near-bank eddies, assumes an error of up to 8%.
- A *poor* cross-section, which lies in proximity to bends in the stream channel with predominantly turbulent flow and cobble or boulder substrate, assumes an error of over 8%.

Depending on the selected cross-section, a minimum of the assigned error is assumed and carried forward to the final flow calculation and rating curve development.

An additional source of error in velocity measurements made with mechanical current meters is the calibration of the Swoffer instruments. The ideal calibration setting of a Swoffer propeller is 186, which means that for every 186 revolutions of the propeller, 10 lineal feet of water has

passed the measurement point. The Swoffer meters tend to be temperature sensitive, and the calibration setting of a meter can change over the course of a flow measurement. The calibration setting for the Swoffer meter used during this project was checked before and after each flow measurement, with values ranging from 187 to 188. A calibration value of 187 and 188 underestimates the flow measurement by 0.5% and 1.0% respectively.

A discharge-rating curve was established for Sites 1 and 2. Flow measurements were tracked by comparing the measured flow values to the flow values predicted by the rating curve at the same stage. Measured and predicted flow differences for individual flow measurements ranged from 0.5% to 15%. This range of differences between measured and predicted flow demonstrates the ability of the rating curves to predict streamflow at each site.

The measurements taken at Site 3 were not compared to a rating curve due to the poor stage-discharge relationship. These flows were compared to a synthesized flow record where the range between measured and predicted flow ranged from 0% to 40%, with an outlier of 300% that was the lowest measured flow at 0.4 cfs.

Results

Site 1: Burnt Bridge Creek at 2nd Avenue (28C080)

The average daily streamflow for Site 1 ranged from 2.5 cubic feet per second (cfs) in early August 2009, to 102.0 cfs in early January 2009. Peak flow during the study was 163.0 cfs during a rain event in early January 2009 (Figure 3). Daily flow averages are presented in Appendix A, Table A-1.

The measured range of flow for this site encompassed 38% of the range of flow encountered, with flow measurements ranging from 3.7 to 73 cfs (Figure 4). However, flows exceeded the measured range only 5% of the time during the study. 4% of flows were less than the lowest measured flow, and 1% of flows were higher than the highest measured flow (Figure 5). The flow measurements taken at this site are listed in Appendix B, Table B-1.

Within the measured range of flows, the fit of the rating curve was fair. Twenty-one flow measurements taken at Site 1 were used to develop the rating curve. Eleven of these measurements were within 5% of the flow predicted by the rating curve, five were within 10%, and all were within 15%. Flows greater than 73 cfs were modeled using a slope-conveyance model. The average percent error between modeled and scaled flow, which reflects model confidence, is 3.1%.

Time-weighted adjustments were performed on the continuous data to correct for pressure-transducer drift. A linear regression of pre- versus post-adjusted continuous flow data showed a correlation coefficient (r) of 0.992 and a standard error of 1.3 cfs (12% of the mean flow for the study). This regression indicates slightly moderate and somewhat variable pressure-transducer drift at this site (Figure 6).

The total potential error for calculated flow data at this site is $\pm 18.5\%$. Of this, 5.7% of the potential error is from the continuous stage data, and 12.8% is from the rating curve. During the low-flow period (July through September), the potential error for flow data for this site is calculated to be $\pm 19.1\%$. Of this, 4.7% of the potential error is from the continuous stage data, and 14.4% is from the rating curve.

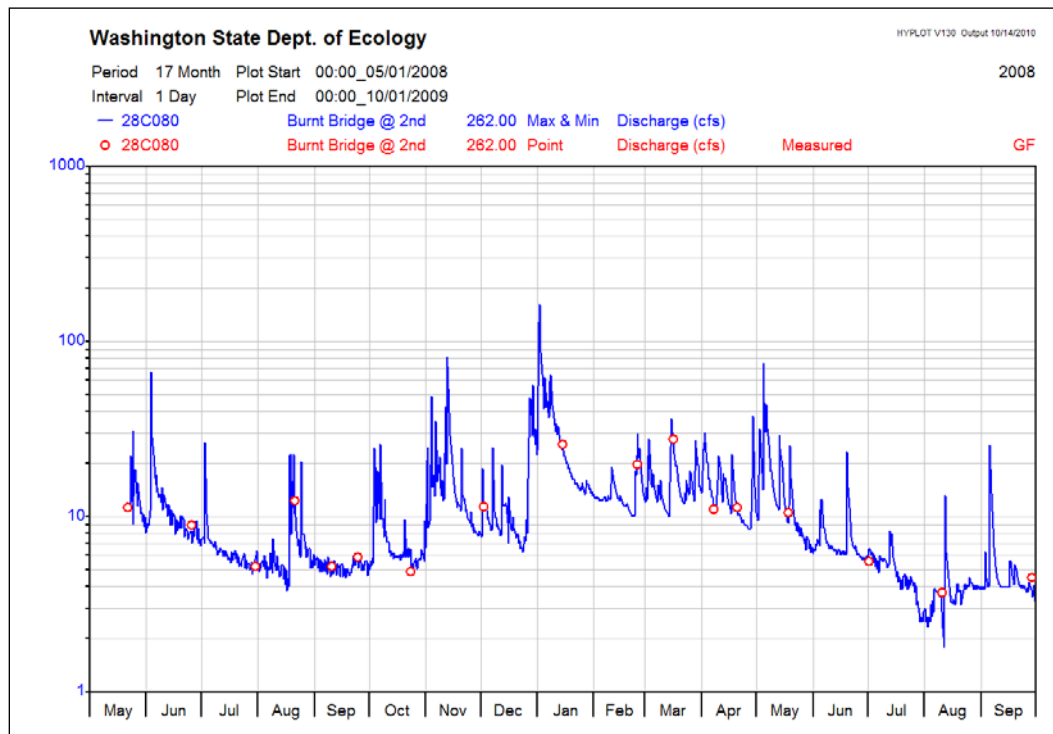


Figure 3: Streamflow hydrograph for Site 1.

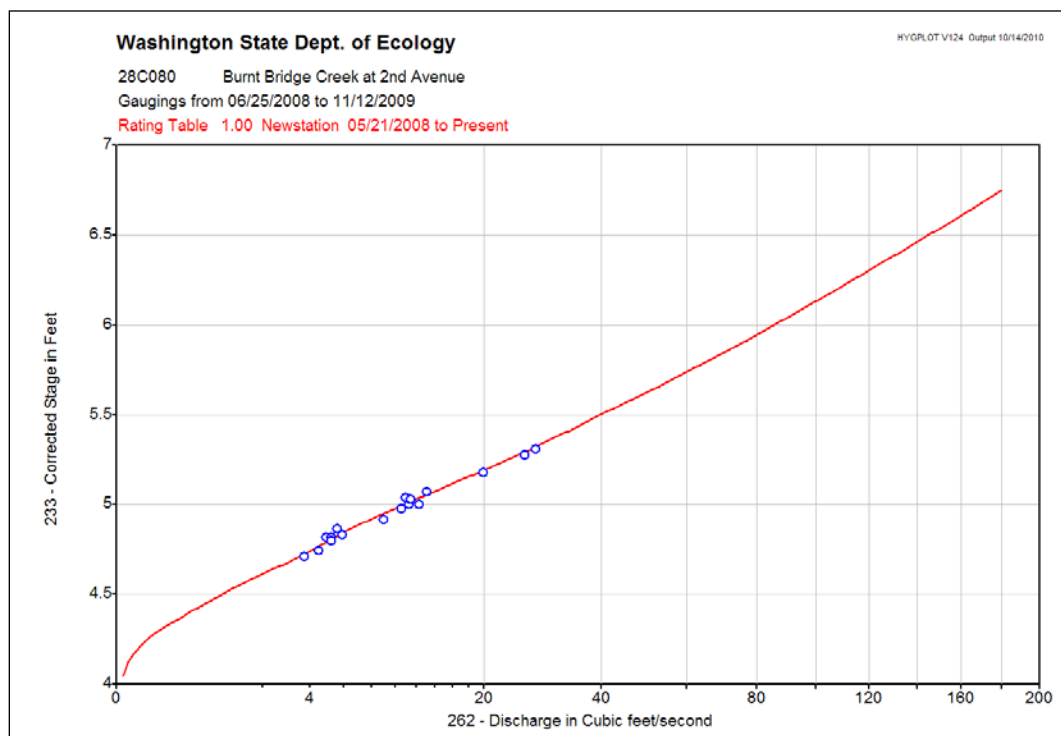


Figure 4: Discharge-rating curve for Site 1.

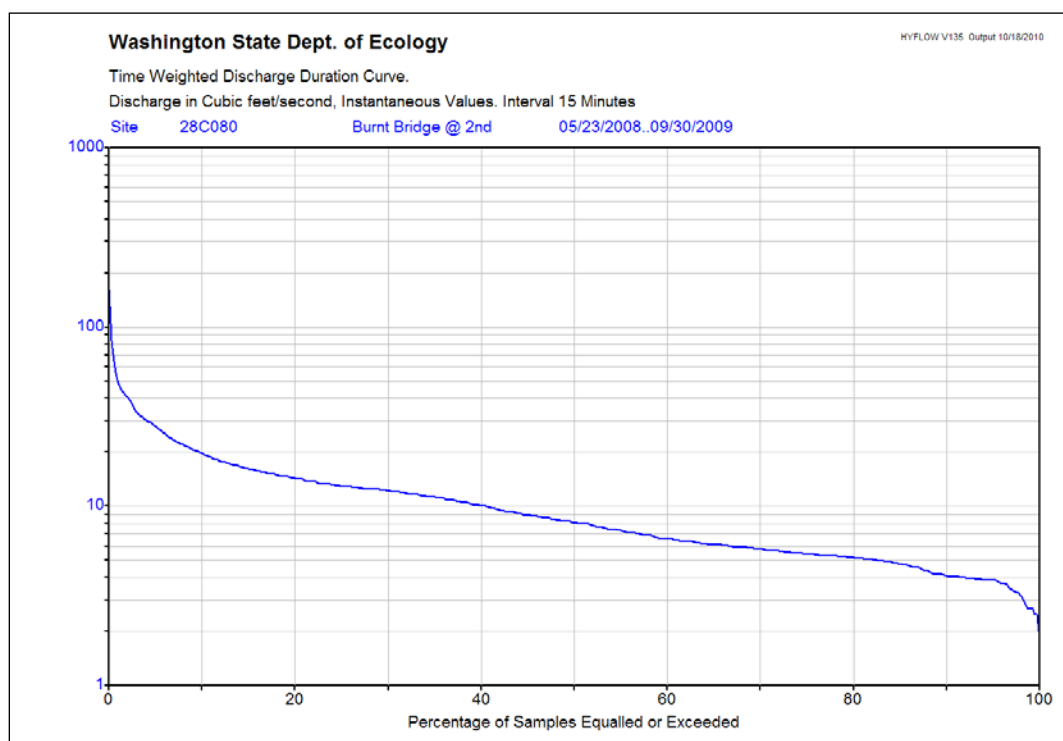


Figure 5: Streamflow exceedance graph for Site 1.

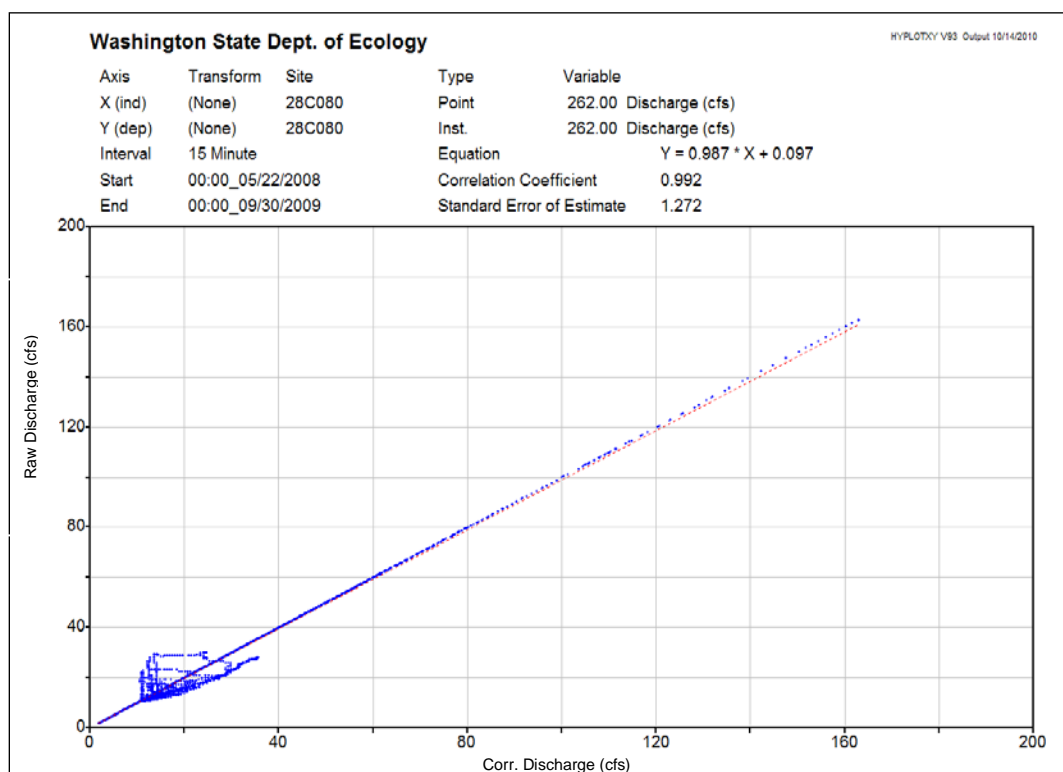


Figure 6: Linear regression of pre- versus post-adjusted streamflow data for Site 1. *Deviations from the red regression line indicate pressure-transducer drift.*

Site 2: Burnt Bridge Creek at Vancouver (28C110)

The average daily streamflow for Site 2 ranged from 1.8 cfs in early August 2009, to 28.9 cfs in early January 2009. Peak flow during the study was 45.5 cfs during a rain event in early January 2009 (Figure 7). The day with the highest average daily and peak flow is qualified as an unreliable estimate due to a large difference between raw and adjusted flows. Therefore this site's record does not coincide with the highest average daily and peak flow at Sites 1 and 2. Daily flow averages are presented in Appendix A, Table A-2.

The measured range of flow for this site encompassed 25% of the range of flow encountered, with flow measurements ranging from 2.2 to 13 cfs (Figure 8). Flows exceeded the measured range 8% of the time during the study. 3% of flows were less than the lowest measured flow, and 5% of flows were higher than the highest measured flow (Figure 9). The flow measurements taken at this site are listed in Appendix B, Table B-2.

Within the measured range of flows, the fit of the rating curve was fair. All 15 flow measurements taken at Site 2 were used to develop the rating curve. Seven of these measurements were within 5% of the flow predicted by the rating curve, seven were within 10%, and all were within 15%. Flows greater than 13.3 cfs were modeled using a slope-conveyance model. The average percent error between modeled and scaled flow, which reflects model confidence, is 7%.

Time-weighted adjustments were performed on the continuous data to correct for pressure-transducer drift. A linear regression of pre- versus post-adjusted continuous flow data showed a correlation coefficient (r) of 0.698 and a standard error of 4.83 cfs (16% of the mean flow for the study). This regression indicates extreme and erratic pressure-transducer drift at this site (Figure 10). A large portion of data from December 14, 2008 to June 3, 2009 was replaced with data regressed from Site 1 due to equipment failure ($r^2=0.814$).

The total potential error during the period of record for calculated flow data at this site is $\pm 51.7\%$. Of this, 41.5% of the potential error is from the continuous stage data, and 10.2% is from the rating curve. During the low-flow period (July through September), the potential error for flow data for this site is calculated to be $\pm 40.2\%$. Of this, 30.5% of the potential error is from the continuous stage data, and 9.7% is from the rating curve.

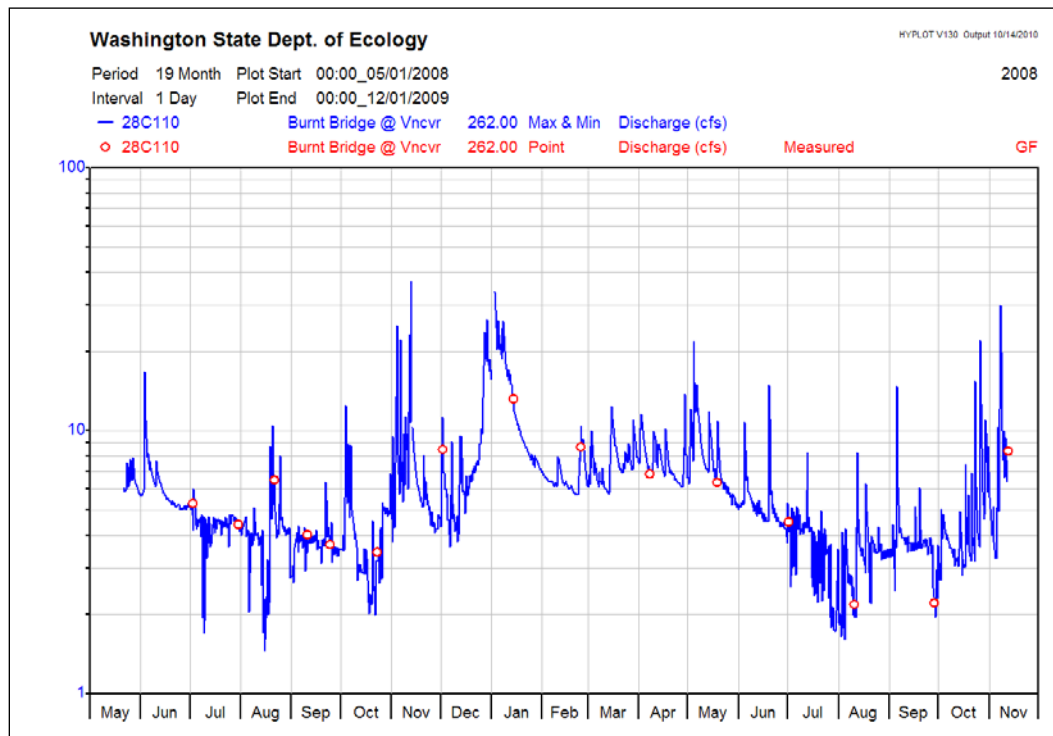


Figure 7: Streamflow hydrograph for Site 2.

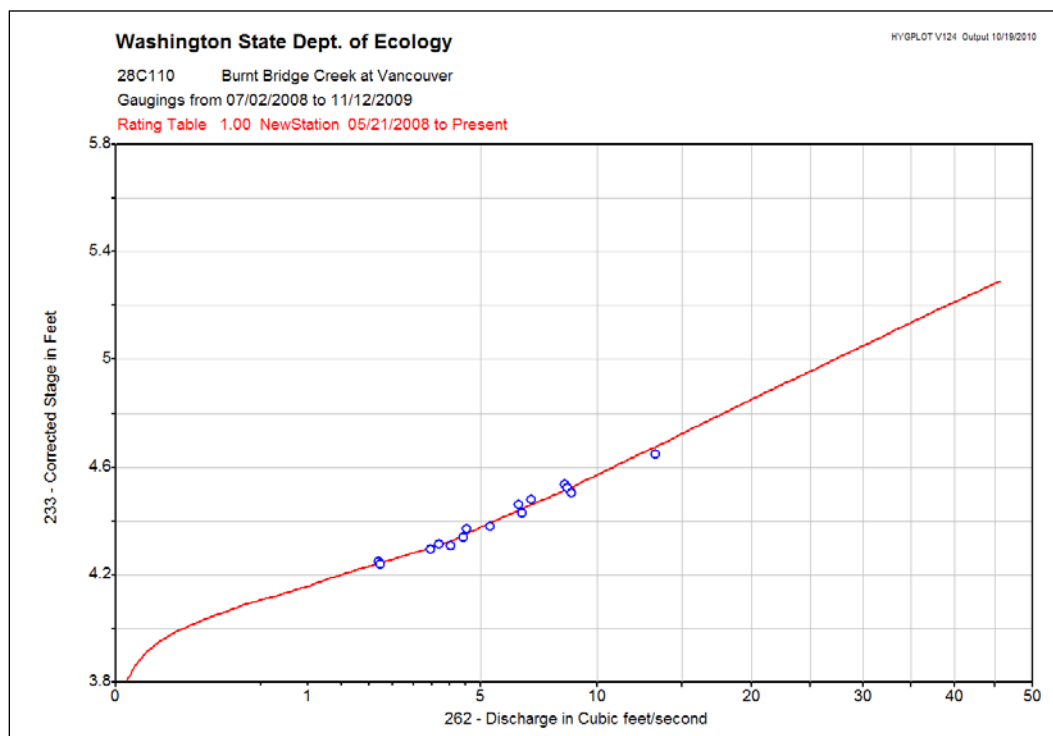


Figure 8: Discharge-rating curve for Site 2.

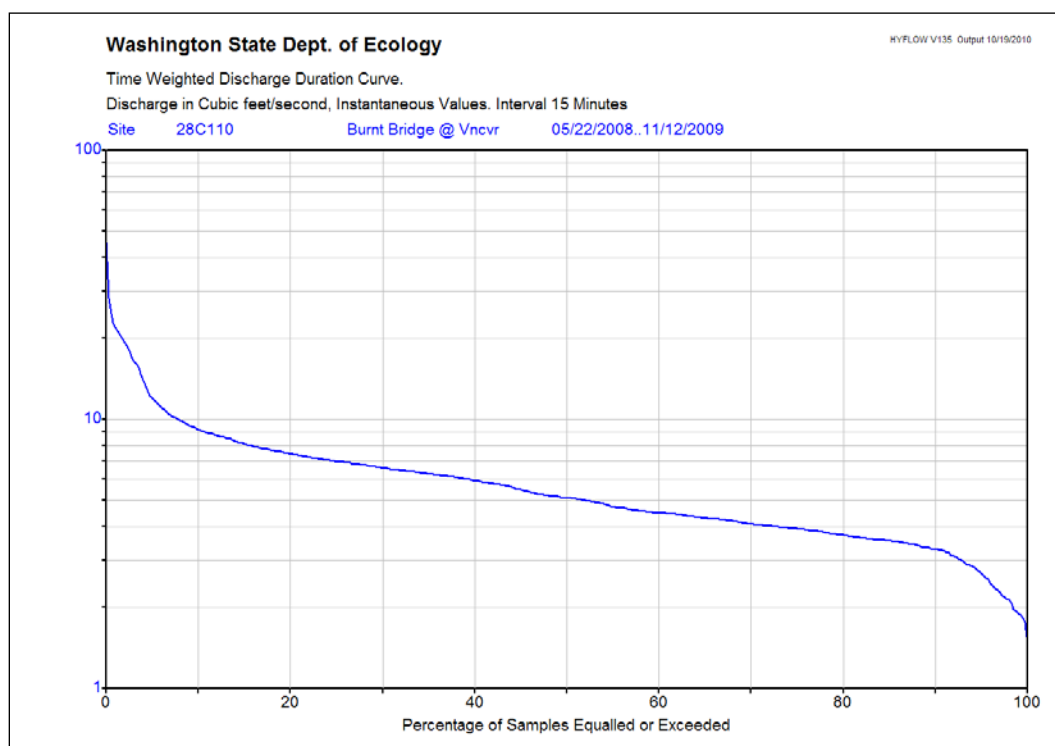


Figure 9: Streamflow exceedance graph for Site 2.

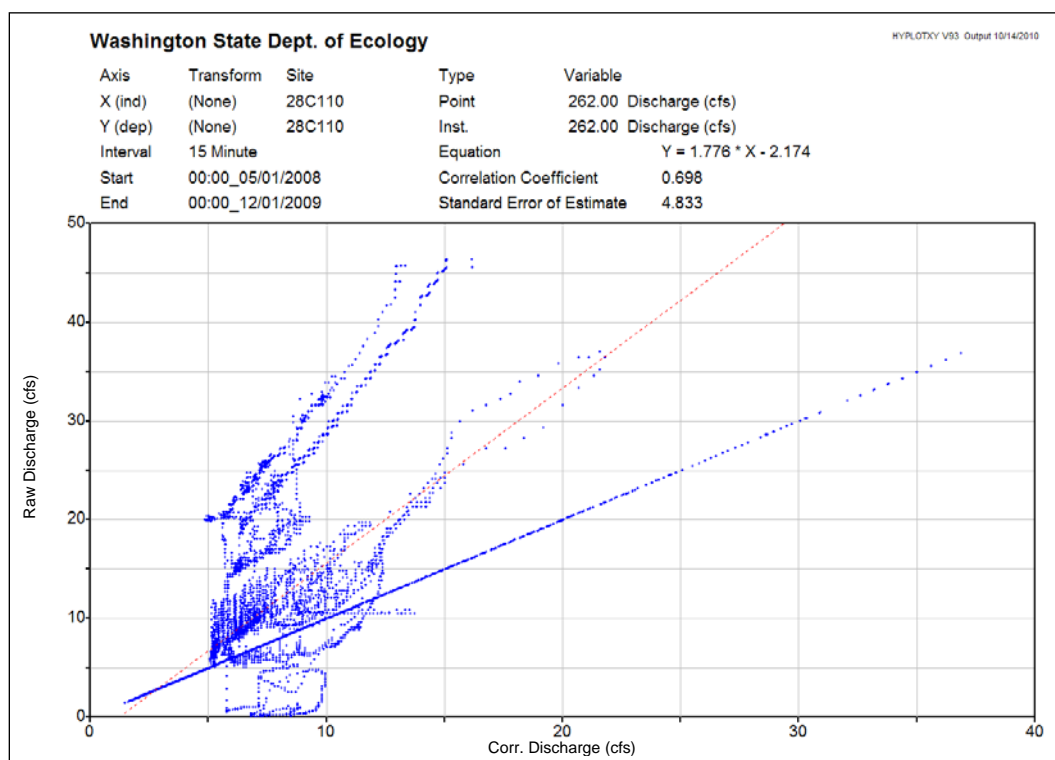


Figure 10: Linear regression of pre- versus post-adjusted streamflow data for Site 2.
Deviations from the red regression line indicate pressure-transducer drift.

Site 3: Burnt Bridge Creek at Kevanna Park (28C150)

Due to extremely poor site conditions and stage-discharge relationship, a rating for this site was not feasible. A flow record was synthesized by using stage data from Site 1. The stage data for Site 1 were converted to a continuous flow record. The flow record was regressed against the flow measurements taken at Site 3 ($r^2=0.953$). This regression was applied to the flow record, and time-weighted adjustments were then made to adjust to the measured flows. Sixteen flow measurements were taken at Site 3.

The average daily flow for Site 3 ranged from 0.2 cfs in early August 2009, to 45.2 cfs in early January 2009. Peak flow during the study was 62.9 cfs during a rain event in early January 2009 (Figure 11). Daily flow averages are presented in Appendix A, Table A-3.

The measured range of flow for this site encompassed 11% of the range of flow encountered, with flow measurements ranging from 0.37 to 7.1 cfs (Figure 11). Flows exceeded the measured range 12% of the time during the study. 1% of flows were less than the lowest measured flow, and 11% of flows were higher than the highest measured flow (Figure 12). The flow measurements taken at this site are listed in Appendix B, Table B-3.

Although the continuous stage record was not used to predict flow, it was kept for reference purposes. A linear regression of pre- versus post-adjusted continuous stage data showed a correlation coefficient (r) of 0.998 and a standard error of 0.03 ft. This regression indicates minor and consistent pressure-transducer drift at this site. (Figure 13)

The average potential error for calculated flow data at this site is $\pm 45.1\%$. The potential error was calculated by comparing the difference between the regressed flow record and the adjusted regressed flow record; the potential measurement error was included. During the low-flow period (July through September), the potential error for flow data for this site is calculated to be $\pm 68.7\%$.

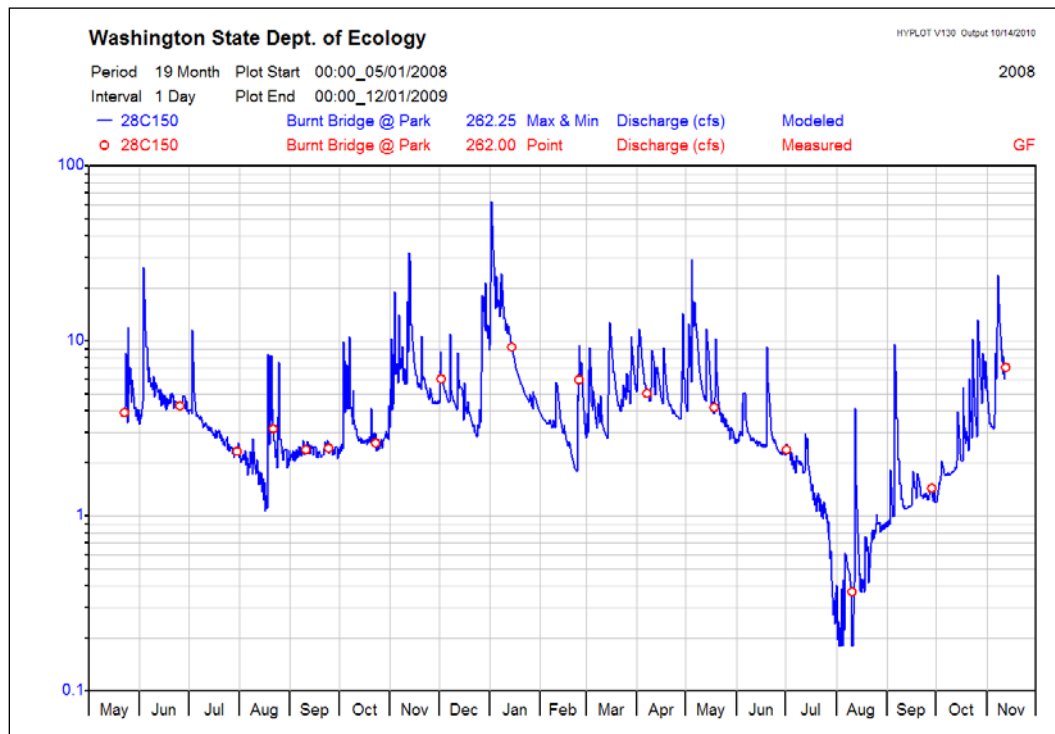


Figure 11: Streamflow hydrograph for Site 3.

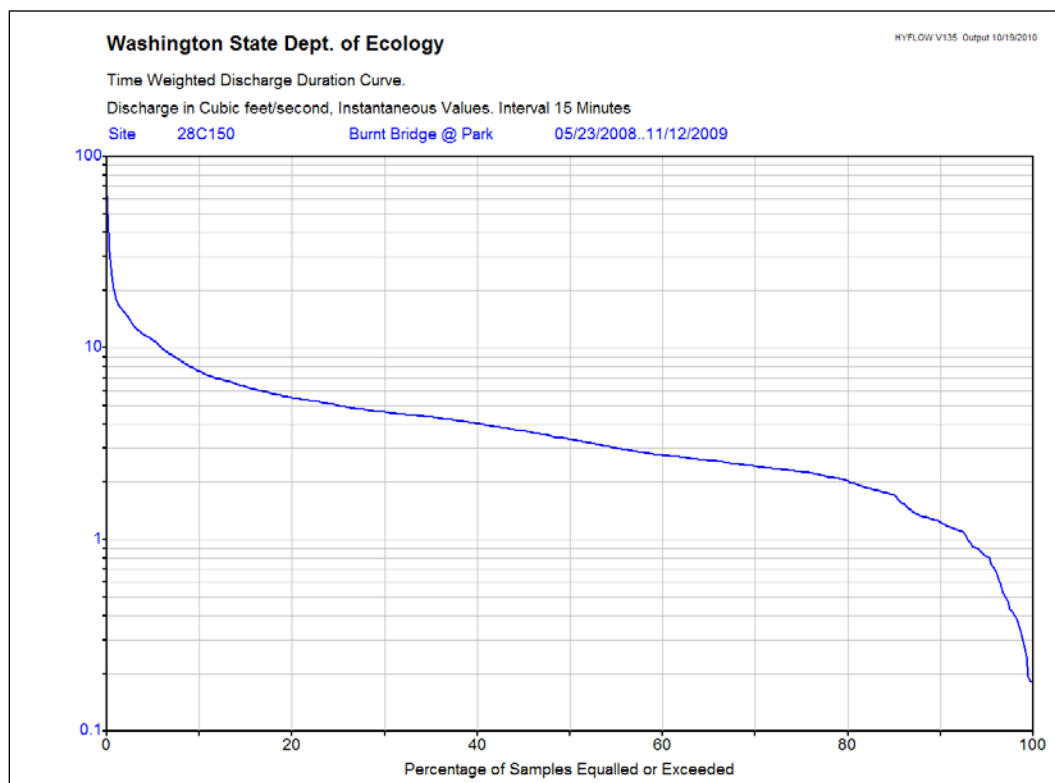


Figure 12: Streamflow exceedance graph for Site 3.

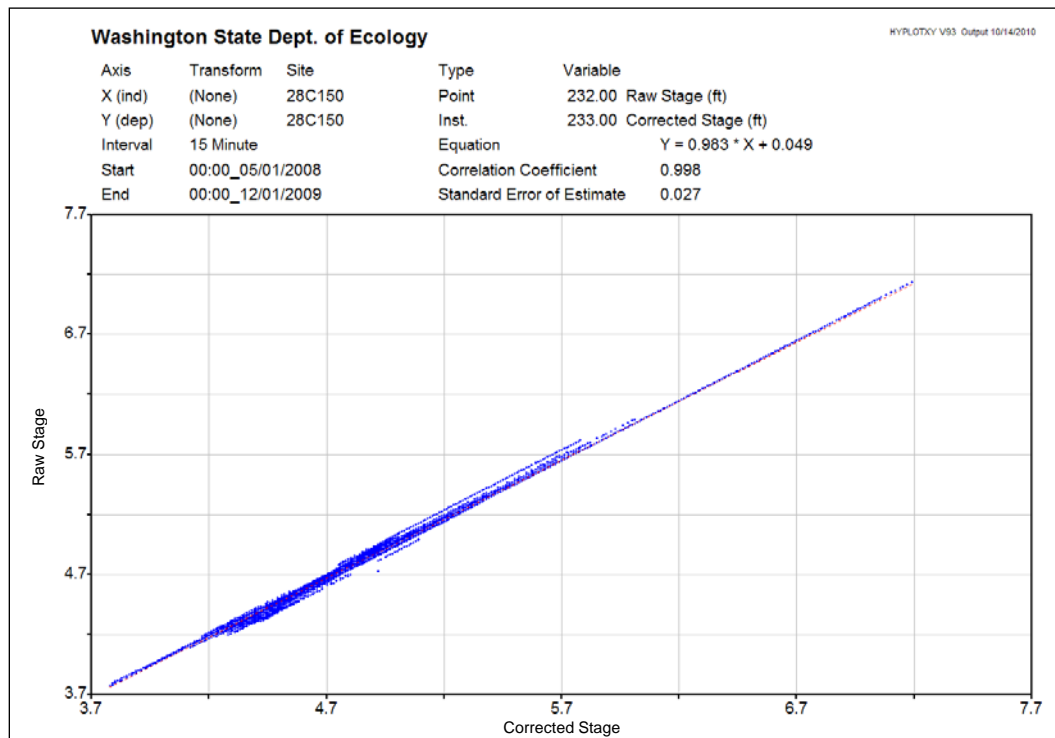


Figure 13: Linear regression of pre- versus post-adjusted stage data for Site 3.
Deviations from the red regression line indicate pressure-transducer drift.

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Appendices

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Appendix A. Average Daily Streamflows for Continuous Monitoring Stations

Table A-1: Site 1, Burnt Bridge Creek at 2nd Avenue (28C080).

	2008								2009								
Day	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	☐	8.9	7.2	5.2	5.4	5.3	8.4	8.1	60.4M	13.1	12.6	18.5J	10.2	6.4	6.3	2.8	3.9
2	☐	9.3	7.3	5.2	5.5	5.4	13.6	13.4	117M	12.8	17.1	28.1J	20.7	6.8	6.5	2.5	3.9
3	☐	35.7	13.6	5.4	5.3	10.3	17	11.8	70.0M	12.7	20.4	23.6J	22.5	7.2	5.9	2.6	4.8
4	☐	25.7	8.4	5.5	5.3	12.7	23.6	10.4	46.8	12.4	16.6	18.2J	27.3M	7.7	5.7	2.8	4.3
5	☐	20.7	7.4	5.2	5.2	11.7	15.2	9.4	49.8	12.4	15.5	15.2	34.3	10.9	5.5	3.1	14.2
6	☐	15.4	7.2	4.9	5.3	11.1	23.3	8.7	42.4	12.8	14.1	13.4	36.4	9.8	5.3	3.6	11.9
7	☐	13.7	7	5.5	5.2	12.5	16.1	11.3	42.2	12.7	12.7	12.2	28.7	8	5.7	3.8	8.3
8	☐	12.7	7	5.2	5.3	9.3	17.4	10.4	49.1	12.4	14	11.2Q	21.8	7.3	5.7	3.7	5.9
9	☐	12.8	6.5	5.6	5	8.6	14.3	9.5	40.2	12.9	13.6	11.3Q	16.4	6.9	5.7	3.6	4.8
10	☐	12.3	6.3	5.3	4.8	7.5	13.6	8.7	33.4	14.8	12.8	20.5J	13.9	6.7	5.6	3.2J	4.3
11	☐	12.2	6.5	5.3	5.1	6.9	20.8	8.2	31.3	17.6	11.6	15.9	12.4	6.6	5.3	2.2J	4.1
12	☐	11.3	6.3	5	5	6.3	36.1M	12	30.9	14.9	11	13.7	11.5	6.5	5.5	7.9J	4
13	☐	10.6	6.2	4.9	5	6.2	33.5	12	27.9	13.3	10.2	16.6J	15.7	6.4	7.7	5.2J	3.9
14	☐	9.8	6.1	4.9	5	6.1	26.3	11.9	25.2	12.6	13.6	15.3J	21.9	6.3	6.8	4.0J	3.9
15	☐	9.7	5.9	4.7	5	5.9	20	10.7	22.8	12.6	33.0*	12.5J	15.8	6.5	5.6	3.4J	3.9
16	☐	9.2	5.8	4.4	5	5.9	15.2	9.2	21.1	12.2	26.4J	11.2J	11.9	6.3	5	3.3J	4.2
17	☐	8.9	5.9	4.2	4.8	5.9	12.8	8.9	19.6	11.5	20.7	17.3J	10.5	6.3	4.6	3.3	5
18	☐	8.9	5.8	7.7	4.9	5.9	11.7	8.9	18.5	11.6	17.9	16.4J	9.8	6.2	4.3	3.7	4.4
19	☐	9.2	6.1	12.6	4.8	6	11.3	8.4	17.4	11.3	14.8	12.4	18.5	12	4.1	4	4.7
20	☐	9.3	5.8	14.3	4.7	6.7	15.2	7.8	16.5	10.7	13.3	10.9	13.6	12.5	4.3	3.7	4.8
21	☐	8.9	5.6	9.8	5.1	6.3	12.7	7.4	15.8	10.4	12.4	10.3	10.4	9	4.4	3.4	4.3
22	☐	8.1	5.4	7.9	5.5	6.2	11.6	7.0J	15.4	10.1	12.6	9.9	9.1	7.3	4.3	3.9	4.1
23	13.4	7.9	5.5	6.8	5.7	5.6	10.5	6.5J	14.8	12.8	13.5	9.4	8.7	6.7	4.1	4	4
24	12.2	7.7	5.7	7.8	5.7	5.3	9.5	6.7J	14.3	20.5	14.8	9.2	8.5	6.6	4.4	4	3.9
25	18.5	7.6	5.4	10.5	5.3	5.3	9.2	8.2J	14.7	22.7	16.4J	8.9	8.2	6.1	4.3	4.2	3.9
26	14.8	7.8	5.3	7.4	5.3	5.5	8.8	10.5J	14.3	20.3	16.3J	8.5	7.8	6.1	4	4.2	3.8
27	12.6	8.3	5.2	6.2	5.1	5.3	8.3	38.1J	14.2	15.5	13.1J	8.6	7.2	5.9	3.7	4.1	4.1
28	11.5	8.5	5.2	6.1	5.2	5.7	8.1	36.8J	15.3	13	17.9J	15.5	7.2	5.8	3.1	3.9	4
29	10.2	7.7	5.1	6.1	5.2	6.1	8	37.7J	14.7		22.4J	22.8	7.1	5.8	2.7	3.9	3.7
30	9.7	7.1	5.3	5.4	5	5.9	8.1	28.3J	13.9		16.6J	12.5	6.6	5.9	2.6	3.9	3.6
31	9.2		5.8	5.4		6.9		26.1J	13.4		14.3J		6.5		2.6	3.9	
Mean	12.5	11.5	6.4	6.5	5.2	7.1	15.3M	13.3J	30.4M	13.7	15.9*	14.3Q	14.9M	7.3	4.9	3.7J	4.9
Median	12.2	9.2	5.9	5.4	5.1	6.1	13.6M	9.5J	21.1M	12.7	14.3*	13.0Q	11.9M	6.6	5	3.7J	4.1
Max.Daily Mean	18.5	35.7	13.6	14.3	5.7	12.7	36.1M	38.1J	117M	22.7	33.0*	28.1Q	36.4M	12.5	7.7	7.9J	14.2
Min.Daily Mean	9.2	7.1	5.1	4.2	4.7	5.3	8.0M	6.5J	13.4M	10.1	10.2*	8.5Q	6.5M	5.8	2.6	2.2J	3.6
Inst.Max	31.1	67.4	26.4	22.7	6.2	25.8	80.8M	56.5J	163M	29.5	36.0*	37.2Q	74.7M	23.3	8.3	13.1J	25.7
Inst.Min	8.1	6.8	4.7	3.8	4.5	5	6.7M	6.3J	13.3M	10.1	10.0*	8.5Q	6.1M	5.7	2.5	1.8J	3.3
Missing Days	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Recorded data are continuous and reliable except where the following tags are used:

* - Data estimated based on other stations; ? – Unreliable estimate, data will not be reported; J – Estimated data; M – Data based on modeled streamflow;
Q – Questionable estimate; [] – Data not recorded; U – Unknown flow, less than value shown; B - Below rating, reliable extrapolation

Table A-2: Site 2, Burnt Bridge Creek at Vancouver (28C110).

Day	2008								2009										
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	[]	5.7*	5.1*	4.3J	3	3.5	4.8J	4.8J	[]?	6.8Q	6.3Q	8.8*	6.5*	5.2*	4.8	1.8	3.5	2.9	4.8
2	[]	5.8*	5.0*	4.4J	3.1	3.6	6.3J	8.5J	[]?	6.7Q	7.4J	11.2*	9.4*	5.3*	4.2	1.9	3.4	3.4	4.2
3	[]	12.9M	4.7	4.5J	3.7	4.9	6.4J	6.4J	28.9Q	6.6Q	8.3J	10.1*	9.9*	5.3*	4	2.2	3.6	4.3	4.1
4	[]	9.2*	4.5	4.4J	3.9	8.9	14.4M	5.9J	22.2Q	6.5Q	7.3J	8.7*	10.9M	7	4	2.6	3.3	4.5	3.6
5	[]	7.8*	4.4	3.7J	3.9	7	6.9J	4.8J	22.8Q	6.4Q	7.0J	7.9*	12.7M	7.3	3.9	3.3	8.9M	3.9	3.6
6	[]	7.3*	4.5J	3.7J	3.9	5.5	12.6M	4.2J	20.5Q	6.4Q	6.7J	7.3*	13.3M	6.3	4.1	3	5.1	3.9	7.1
7	[]	7.0*	4.3J	3.9J	3.9	6.4	7.0J	5.1J	20.2Q	6.3Q	6.3J	7.2*	11.5*	5.8	4.5	2.8	4.3	3.7	15.6M
8	[]	6.6*	3.7J	3.9J	4	4.7	7.2J	4.9J	21.8Q	6.2Q	6.7J	6.9Q	9.8*	5.6	4.3	2.7	4.1	3.6	14.7M
9	[]	6.3*	2.9J	4.3J	3.9	4.1	7.5J	4.6J	19.2Q	6.3Q	6.5J	7.0Q	8.5*	5.4	4.4	2.6	3.9	3.5	8.9
10	[]	7.0*	4.0J	4.0J	3.7	3.8	7.1J	4.4J	17.0Q	6.8Q	6.3J	9.6Q	7.8*	5.1	4.3	2.3	3.9	3.4	7.7
11	[]	6.8*	4.0J	4.0J	3.8	2.9	13.0M	4.3J	16.2Q	7.5Q	6.0J	8.4Q	7.4*	5.1	4.3	2.3	3.9	3.3	7.5
12	[]	6.5*	4.3J	3.9J	3.9	3	18.1M	6.5J	15.8Q	6.9Q	5.9J	7.7Q	7.2*	5	4.7	5.9	3.8	3.3	[]
13	[]	6.2*	4.0J	3.7	3.9	3	[]?	7.4J	14.1Q	6.4Q	5.8Q	8.6*	8.3*	5	5.1	3.9	3.7	3.4	[]
14	[]	5.9*	4.2J	3.2	3.9	2.9	9.3J	6.4Q	12.4Q	6.3Q	6.8Q	8.2*	10.1*	5	4.3	3.4	3.7	4.2	[]
15	[]	5.8*	4.4	1.9	4	3.1	7.6J	5.7Q	11.5Q	6.3Q	11.7Q	7.4*	8.6*	4.8	3.9	3.4	3.7	3.3	[]
16	[]	5.6*	4.3	2	3.9	3.2	6.6J	5.6Q	10.9Q	6.2Q	10.2Q	6.9*	7.5*	4.7	3.4	3.2	3.9	3.2	[]
17	[]	5.5*	4.4	2.6	3.6	2.8	6.1J	5.9Q	10.3Q	6.0Q	9.0Q	8.7*	7.0*	4.6	3.2	4.2	4	4.6	[]
18	[]	5.4*	4.5	4	3.6	2.2	5.6J	6.3Q	9.9Q	6.1Q	8.4Q	8.5*	6.7*	4.6	2.9	4.2	3.7	3.9	[]
19	[]	5.4*	4.4	6.2	3.5	2.3	5.3J	6.6Q	9.5Q	6.0J	7.6*	7.3*	9.2*	7.8M	3.3	3.4	4.4	3.9	[]
20	[]	5.3*	4.3	7.3	3.7	3	6.5J	6.8Q	9.1Q	5.8J	7.2*	7.0*	7.8*	7.3	3.7	2.9	3.8	3.3	[]
21	[]	5.3*	4.4	5.6	4.3	2.5	5.8J	7.1Q	8.8Q	5.8J	7.0*	6.9*	6.8*	5.5	3.4	3.7	3.6	4.7	[]
22	6.0*	5.2*	4.5	4.2	4.5	2.7J	5.7J	7.3Q	8.5Q	5.7Q	7.2*	6.7*	6.3*	5.1	3.1	3.5	3.8	3.6	[]
23	6.5*	5.2*	4.4	4	4.1	3.4J	5.2J	7.6Q	8.2Q	6.4Q	7.5*	6.5*	6.2*	4.9	3.8	3.6	3.7	7.6M	[]
24	6.4*	5.2*	3.9	4.3	3.9	3.5J	4.7J	8.2Q	7.9Q	8.3Q	8.0*	6.4*	6.1*	4.7	3.7	3.4	3.6	4.7	[]
25	7.0*	5.1*	4.4	5.6	3.8	4.0J	4.5J	9.4Q	7.9Q	8.9Q	8.4*	6.3*	6.0*	4.6	3.5	3.6	3.8	3.8	[]
26	6.6*	5.1*	4.6	4.5	3.5	3.8J	4.4J	10.8Q	7.6Q	8.2Q	8.4*	6.1*	5.8*	4.5	3	3.5	3.7	11.5M	[]
27	6.8*	5.1*	4.6	4.3	3.5	5.0J	4.3J	20.3Q	7.5Q	7.0Q	7.4*	6.1*	5.6*	4.5	2.3	3.4	3.5	8.4	[]
28	6.4*	5.1*	4.6	4.2	3.4	5.0J	4.2J	20.6Q	7.8Q	6.4Q	8.7*	8.2*	5.5*	4.3	2	3.4	2.2	5	[]
29	6.2*	5.1*	4.5J	4.2	3.5	4.9J	4.6J	20.9Q	7.5Q		9.9*	10.1*	5.5*	4.3	2	3.4	2.3	8.5	[]
30	6.0*	5.2*	4.4J	4.2	3.6	5.0J	4.6J	17.7Q	7.2Q		8.4*	7.3*	5.3*	4.4	1.9	3.4	2.6	7.5	[]
31	5.8*		4.3J	3.1		5.4J		16.8Q	7.0Q		7.7*		5.2*		2.2	3.5		6.9	
Mean	6.4*	6.2M	4.3*	4.1J	3.8	4.1J	7.1M	8.5Q	13.0Q	6.6Q	7.6Q	7.8Q	7.9M	5.3M	3.6	3.2	3.9M	4.7M	7.4M
Median	6.4*	5.6M	4.4*	4.2J	3.9	3.6J	6.3M	6.5Q	10.3Q	6.4Q	7.4Q	7.4Q	7.4M	5.0M	3.8	3.4	3.7M	3.9M	7.1M
Max.Daily Mean	7.0*	12.9M	5.1*	7.3J	4.5	8.9J	18.1M	20.9Q	28.9Q	8.9Q	11.7Q	11.2Q	13.3M	7.8M	5.1	5.9	8.9M	11.5M	15.6M
Min.Daily Mean	5.8*	5.1M	2.9*	1.9J	3	2.2J	4.2M	4.2Q	7.0Q	5.7Q	5.8Q	6.1Q	5.2M	4.3M	1.9	1.8	2.2M	2.9M	3.6M
Inst.Max	7.9*	16.7M	6.0*	10.5J	6.4	12.5J	36.9M	26.5Q	33.8Q	10.4Q	12.4Q	13.7Q	21.8M	14.9M	8.2	8.2	14.8M	22.1M	30.1M
Inst.Min	5.7*	5.1M	1.7*	1.5J	2.6	2.0J	3.8M	3.6Q	6.9Q	5.7Q	5.8Q	6.1Q	5.0M	3.8M	1.7	1.6	2.0M	2.7M	3.3M
Missing Days	21	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	19

All recorded data are continuous and reliable except where the following tags are used:

* - Data estimated based on other stations; ? - Unreliable estimate, data will not be reported; J - Estimated data; M - Data based on modeled streamflow;
Q - Questionable estimate; [] - Data not recorded; U - Unknown flow, less than value shown; B - Below rating, reliable extrapolation

Table A-3: Site 3, Burnt Bridge Creek at Kevanna Park (28C150).

Day	2008								2009										
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	[]	3.7*	4.0*	2.2*	2.1*	2.4*	3.9*	4.6*	23.1*	3.8*	3.0*	7.1*	4.2*	2.7*	2.5*	0.3*	0.9*	1.3*	4.5*
2	[]	3.9*	3.9*	2.1*	2.2*	2.4*	5.9*	6.6*	45.2*	3.6*	4.8*	11.1*	8.3*	2.9*	2.5*	0.2U	0.9*	1.4*	3.6*
3	[]	14.0*	6.4*	2.2*	2.2*	4.3*	7.2*	5.9*	26.7*	3.6*	6.2*	9.3*	9.1*	3.0*	2.3*	0.2U	1.3*	1.6*	3.3*
4	[]	10.5*	4.3*	2.2*	2.3*	5.3*	9.7*	5.4*	17.4*	3.4*	4.7*	7.1*	10.8*	3.2*	2.2*	0.3U	1.1*	1.9*	3.3*
5	[]	8.5*	3.9*	2.0*	2.3*	4.9*	6.6*	4.9*	18.5*	3.4*	4.4*	6.0*	13.4*	4.4*	2.1*	0.3*	5.0*	1.8*	3.2*
6	[]	6.4*	3.8*	1.9*	2.3*	4.6*	9.8*	4.6*	15.8*	3.5*	3.9*	5.4*	14.2*	4.0*	2.0*	0.5*	4.1*	1.7*	6.9*
7	[]	5.8*	3.7*	2.1*	2.4*	5.2*	7.0*	5.6*	15.7*	3.4*	3.4*	5.0*	11.6*	3.3*	2.1*	0.6*	2.7*	1.7*	13.2*
8	[]	5.5*	3.6*	1.9*	2.5*	3.9*	7.5*	5.2*	18.2*	3.3*	4.0*	4.6Q	8.8*	3.0*	2.1*	0.5*	1.8*	1.8*	14.4*
9	[]	5.6*	3.4*	2.0*	2.4*	3.7*	6.4*	4.8*	14.8*	3.4*	3.9*	4.6Q	6.6*	2.8*	2.0*	0.4*	1.4*	1.7*	10.1*
10	[]	5.4*	3.3*	1.9*	2.4*	3.2*	6.1*	4.4*	12.4*	4.1*	3.6*	8.2*	5.7*	2.8*	2.0*	0.3U	1.2*	1.8*	7.4*
11	[]	5.4*	3.4*	1.9*	2.5*	3.0*	8.9*	4.2*	11.7*	5.1*	3.2*	6.4*	5.1*	2.7*	1.8*	0.2U	1.1*	1.8*	7.0*
12	[]	5.1*	3.3*	1.7*	2.4*	2.8*	14.8*	5.6*	11.5*	4.1*	3.0*	5.6*	4.8*	2.7*	1.9*	2.1*	1.1*	1.9*	[]
13	[]	4.9*	3.2*	1.6*	2.4*	2.8*	13.9*	5.6*	10.5*	3.4*	2.8*	6.7*	6.4*	2.6*	2.7*	1.1*	1.1*	2.0*	[]
14	[]	4.6*	3.1*	1.6*	2.4*	2.7*	11.4*	5.5*	9.3*	3.1*	4.2*	6.2*	8.8*	2.6*	2.3*	0.7*	1.1*	3.2*	[]
15	[]	4.6*	3.0*	1.5*	2.4*	2.7*	8.7*	5.0*	8.3*	3.1*	11.7*	5.1*	6.4*	2.7*	1.9*	0.4*	1.1*	2.5*	[]
16	[]	4.5*	2.9*	1.3*	2.4*	2.7*	6.9*	4.3*	7.5*	2.9*	9.4*	4.6*	4.9*	2.6*	1.6*	0.4*	1.3*	2.1*	[]
17	[]	4.4*	2.9*	1.2*	2.3*	2.7*	6.0*	4.2*	6.9*	2.6*	7.1*	7.0*	4.4*	2.6*	1.4*	0.4*	1.6*	3.2*	[]
18	[]	4.5*	2.9*	2.5*	2.3*	2.7*	5.6*	4.1*	6.4*	2.6*	6.0*	6.6*	4.1*	2.5*	1.3*	0.6*	1.4*	3.3*	[]
19	[]	4.6*	2.9*	4.4*	2.3*	2.7*	5.5*	3.9*	5.9*	2.4*	4.9*	5.1*	7.5*	4.8*	1.2*	0.7*	1.5*	2.8*	[]
20	[]	4.7*	2.8*	5.0*	2.2*	3.0*	7.0*	3.6*	5.6*	2.1*	4.4*	4.5*	5.5*	4.9*	1.2*	0.6*	1.6*	2.6*	[]
21	[]	4.6*	2.7*	3.2*	2.3*	2.8*	6.1*	3.4*	5.3*	2.0*	4.1*	4.3*	4.3*	3.6*	1.2*	0.5*	1.4*	4.1*	[]
22	[]	4.3*	2.6*	2.6*	2.5*	2.8*	5.7*	3.2*	5.0*	1.8*	4.2*	4.1*	3.8*	2.9*	1.1*	0.7*	1.3*	3.4*	[]
23	5.0*	4.3*	2.6*	2.2*	2.5*	2.6*	5.3*	2.9*	4.8*	2.8*	4.6*	3.9*	3.6*	2.7*	1.0*	0.8*	1.3*	5.8*	[]
24	4.6*	4.3*	2.6*	2.6*	2.5*	2.5*	4.9*	3.0*	4.6*	5.8*	5.2*	3.8*	3.5*	2.6*	1.2*	0.8*	1.3*	4.7*	[]
25	7.1*	4.3*	2.5*	3.7*	2.4*	2.5*	4.8*	3.5*	4.7*	6.8*	5.9*	3.7*	3.4*	2.5*	1.1*	0.9*	1.3*	3.2*	[]
26	5.7*	4.3*	2.4*	2.6*	2.4*	2.6*	4.7*	4.4*	4.5*	5.8*	5.9*	3.6*	3.3*	2.4*	1*	0.9*	1.3*	7.7*	[]
27	4.9*	4.5*	2.4*	2.2*	2.3*	2.6*	4.5*	14.7*	4.4*	4.0*	4.7*	3.6*	3.0*	2.3*	0.8*	0.9*	1.4*	8.1*	[]
28	4.5*	4.5*	2.4*	2.2*	2.3*	2.7*	4.5*	14.2*	4.8*	3.1*	6.7*	6.3*	3.0*	2.3*	0.6*	0.8*	1.4*	5.2*	[]
29	4.0*	4.2*	2.3*	2.2*	2.3*	2.9*	4.4*	14.5*	4.5*		8.5*	9.1*	3.0*	2.3*	0.4*	0.8*	1.3*	6.6*	[]
30	3.9*	3.9*	2.3*	2.0*	2.3*	2.9*	4.5*	11.3*	4.2*		6.2*	5.1*	2.8*	2.3*	0.3B	0.9*	1.3*	6.2*	[]
31	3.8*		2.4*	2.1*		3.3*		10.3*	4.0*		5.4*		2.7*		0.3B	0.9*		6.2*	
Mean	4.8*	5.3*	3.2*	2.3*	2.3*	3.2*	6.9*	5.9*	11.0*	3.5*	5.2*	5.8Q	6.0*	3.0*	1.5*	0.6U	1.5*	3.3*	7.0*
Median	4.6*	4.6*	2.9*	2.1*	2.3*	2.8*	6.1*	4.8*	7.5*	3.4*	4.7*	5.3Q	4.9*	2.7*	1.6*	0.6U	1.3*	2.6*	6.9*
Max.Daily Mean	7.1*	14.0*	6.4*	5.0*	2.5*	5.3*	14.8*	14.7*	45.2*	6.8*	11.7*	11.1Q	14.2*	4.9*	2.7*	2.1U	5.0*	8.1*	14.4*
Min.Daily Mean	3.8*	3.7*	2.3*	1.2*	2.1*	2.4*	3.9*	2.9*	4.0*	1.8*	2.8*	3.6Q	2.7*	2.3*	0.3*	0.2U	0.9*	1.3*	3.2*
Inst.Max	12.0*	26.1*	11.6*	8.3*	2.7*	10.5*	32.1*	21.4*	62.9*	9.4*	12.7*	14.4Q	29.1*	9.2*	3.0*	4.1U	9.6*	13.1*	23.7*
Inst.Min	3.3*	3.4*	2.1*	1.1*	2.1*	2.3*	3.2*	2.8*	3.9*	1.8*	2.8*	3.6Q	2.6*	2.3*	0.2*	0.2U	0.9*	1.2*	3.1*
Missing Days	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19

All recorded data are continuous and reliable except where the following tags are use:

* - Data estimated based on other stations; ? – Unreliable estimate, data will not be reported; J – Estimated data; M – Data based on modeled streamflow;
Q – Questionable estimate; [] – Data not recorded; U – Unknown flow, less than value shown; B - Below rating, reliable extrapolation.

Appendix B. Discrete Streamflow Measurements

Table B-1: Site 1, Burnt Bridge Creek at 2nd Avenue (28C080).

Date	Time	Stage (ft)	Flow (cfs)	Area (ft ²)	Velocity (ft/sec.)	Method	Quality**	% Deviation
05/21/2008	1345	5.03	11.3	16.77	0.7	Current meter	Good	4.7%
06/25/2008	1202	4.92	9.0	16.21	0.6	Current meter	Fair	15.1%
07/30/2008	1025	4.82	5.2	14.78	0.4	ADCP	Poor	5.3%
08/21/2008	838	5.00	12.3	16.74	0.7	ADCP	Good	13.0%
09/10/2008	1220	4.80	5.2	13.70	0.4	ADCP	Poor	2.3%
09/24/2008	1415	4.84	5.9	13.90	0.4	ADCP	Poor	1.9%
10/23/2008	1202	4.82	4.9	13.49	0.4	ADCP	Poor	10.5%
12/02/2008	1243	5.03	11.4	16.53	0.4	ADCP	Good	5.3%
01/14/2009	1339	5.28	25.9	22.45	1.2	ADCP	Poor	2.7%
02/24/2009	1445	5.18	19.9	23.24	0.9	ADCP	Fair	2.9%
03/16/2009	906	5.31	27.7	22.90	1.2	ADCP	Good	2.6%
04/07/2009	1200	5.04	11.0	18.21	0.6	ADCP	Fair	11.9%
04/20/2009	1350	5.00	11.3	17.30	0.7	ADCP	Fair	3.8%
05/18/2009	1340	4.98	10.6	17.60	0.6	ADCP	Fair	4.7%
07/01/2009	1156	4.87	5.6	15.20	0.4	ADV	Good	13.6%
08/10/2009	1142	4.71	3.7	13.67	0.3	ADV	Good	6.1%
09/28/2009	1336	4.75	4.5	14.13	0.3	ADV	Good	9.2%
11/12/2009	1310	5.07	13.1	17.72	0.7	ADCP	Fair	5.1%
12/16/2009	1218	5.87	73.0	40.73	1.9	ADCP	Poor	0.4%
01/28/2010	1022	5.26	24.6	22.37	1.1	ADCP	Good	4.0%
01/28/2010	1045	5.26	24.4	22.37	1.1	ADCP	Good	3.2%

*Quality ratings of measurements are discussed in the *Quality Assurance* section.

Table B-2: Site 2, Burnt Bridge at Vancouver (28C110).

Date	Time	Stage (ft)	Flow (cfs)	Area (ft ²)	Velocity (ft/sec.)	Method	Quality**	% Deviation
07/02/2008	1500	4.38	5.3	4.3	1.22	Current meter	Good	4.9%
07/30/2008	1343	4.34	4.4	4.3	1.04	ADV	Good	2.7%
08/21/2008	1017	4.43	6.5	5.0	1.31	ADV	Good	5.9%
09/10/2008	1033	4.31	4.0	3.9	1.05	ADV	Fair	9.6%
09/24/2008	1144	4.32	3.7	3.5	1.05	ADV	Fair	3.1%
10/23/2008	1013	4.30	3.5	4.0	0.87	ADV	Good	4.1%
12/02/2008	1129	4.53	8.5	6.0	1.41	ADV	Good	2.7%
01/14/2009	1204	4.65	13.3	7.6	1.74	ADV	Good	6.9%
02/24/2009	1156	4.51	8.7	5.9	1.48	ADV	Good	7.2%
04/07/2009	1017	4.48	6.9	5.5	1.24	ADV	Good	7.3%
05/18/2009	1148	4.46	6.4	5.9	1.09	ADV	Good	7.5%
07/01/2009	1014	4.37	4.5	4.5	1.01	ADV	Good	7.1%
08/10/2009	953	4.25	2.2	3.7	0.60	ADV	Good	6.2%
09/28/2009	1118	4.24	2.2	3.5	0.64	ADV	Good	3.3%
11/12/2009	1111	4.54	8.4	6.6	1.26	ADV	Good	6.7%

*Quality ratings of measurements are discussed in the *Quality Assurance* section.

Table B-3: Site 3, Burnt Bridge Creek at Kevanna Park (28C150).

Date	Time	Stage (ft)	Flow (cfs)	Area (ft ²)	Velocity (ft/sec.)	Method	Quality**	% Deviation
05/22/2008	1205	4.79	3.9	18.6	0.21	Current meter	Poor	N/A*
06/25/2008	910	4.66	4.3	15.9	0.27	ADCP	Poor	N/A*
07/30/2008	840	4.48	2.3	14.4	0.16	ADCP	Poor	N/A*
08/21/2008	1126	4.72	3.2	17.1	0.19	ADCP	Poor	N/A*
09/10/2008	857	4.35	2.4	13.0	0.19	ADCP	Good	N/A*
09/24/2008	941	4.31	2.5	13.0	0.19	ADCP	Poor	N/A*
10/23/2008	905	4.20	2.6	11.3	0.23	ADCP	Poor	N/A*
12/02/2008	1011	4.66	6.1	17.7	0.34	ADCP	Good	N/A*
01/14/2009	1100	5.08	9.3	21.9	0.43	ADCP	Poor	N/A*
02/24/2009	1030	4.52	6.0	13.2	0.46	ADCP	Estimate	N/A*
04/07/2009	850	4.48	5.1	13.5	0.37	ADCP	Poor	N/A*
05/18/2009	950	4.62	4.2	16.5	0.25	ADCP	Estimate	N/A*
07/01/2009	859	4.34	2.4	14.3	0.17	ADV	Good	N/A*
08/10/2009	834	3.80	0.4	7.6	0.05	ADV	Poor	N/A*
09/28/2009	953	4.03	1.4	10.6	0.14	ADV	Poor	N/A*
11/12/2009	926	5.06	7.1	24.3	0.29	ADCP	Poor	N/A*

* No % Deviation calculated due to lack of rating.

**Quality ratings of measurements are discussed in the *Quality Assurance* section.

Appendix C. Glossary, Acronyms, and Abbreviations

Glossary

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

Clean Water Act: A 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.

Discharge: The rate of streamflow at a given instant in terms of volume per unit of time, typically cubic feet per second.

Discharge-rating curve: A mathematical model relating water surface elevation, or stage, to discharge at a given point on a river or stream. Stage and discharge typically form a logarithmic relationship.

Diurnal: Pertaining to the day or each day; daily.

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.

Reach: A specific portion or segment of a stream.

Stage height: Water surface elevation.

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 allocations constitute one type of water quality-based effluent limitation.

Acronyms and Abbreviations

ADCP	Acoustic Doppler current profiler
ADV	Acoustic Doppler velocimeter

cfs	Cubic feet per second
Ecology	Washington State Department of Ecology
ft	Feet
Inst.	Instantaneous
PGI	Primary gage index
SOP	Standard operating procedures
TMDL	(See Glossary above)
USGS	U.S. Geological Survey
WRIA	Water Resource Inventory Area