Asotin Creek Water Quality Fecal Coliform Bacteria Study

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Cover photo: Asotin Creek near mouth (Department of Ecology)

Asotin Creek Water Quality

Fecal Coliform Bacteria Study

by

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Abstract

Asotin Creek is currently designated a Category 5 waterbody for fecal coliform (FC) bacteria, indicating a need for a Total Maximum Daily Load (TMDL) study.

Although much work had been completed in the upper watershed to eliminate pollution from livestock feeding and grazing operations, exceedances to Washington State water quality standards for FC bacteria continued to be found. It was postulated that failing on-site sewage systems located in the lower reaches of Asotin Creek (from Morgan Road to the creek mouth) were responsible for these exceedances.

If these sources could be isolated and remediated, the existing Category 5 listings could qualify for designation into Category 4b, eliminating the need for a formal TMDL study. Category 4b is intended for water bodies with a pollution control program in place that is expected to solve the pollution problems.

In 2011, Ecology's Environmental Assessment Program sampled up to nine sites on a bi-monthly basis during low-flow conditions. Parameters measured were flow, temperature, pH, dissolved oxygen, conductivity, FC bacteria, enterococci bacteria, chloride, and nitrate/nitrite nitrogen. Results indicated no significant FC pollution sources in the lowest reaches of Asotin Creek. The sampling also indicated that FC bacteria continues to exceed (not meet) state water quality standards in both Asotin and George Creek watersheds.

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- Mitch Dimke, Carl Flynn, Tom Tower, and Sam and Rose Gatherer for access from their property to conduct monitoring activities.
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Background

Asotin Creek is located in Asotin and Garfield Counties in southeast Washington. The headwaters are located in the Blue Mountains, at an elevation of 6200 feet. The mouth of the stream is located in the town of Asotin where it enters the Snake River at an elevation of 800 feet (WSU, 2000). The Asotin Creek watershed is approximately 208,000 acres. Major tributaries include George Creek, the North and South Forks of Asotin Creek, Lick Creek, and Charley Creek.

Rangeland, cropland, and forestland are the predominant land uses within the Asotin Creek subbasin (Stovall, 2001). Residential areas represent a small portion of the watershed, with single-family homes next to Asotin Creek between river mile 0.5 (just upstream of the Highway 129 Bridge) and river mile 1.6. Speculative comments from a watershed assessment report (HDR, 2005) and anecdotal information about potential failing on-site septic systems not connected to the local sewer system led to Ecology's Water Quality Program asking the Environmental Assessment Program to investigate sources of bacterial contamination in the lower reaches of Asotin Creek.

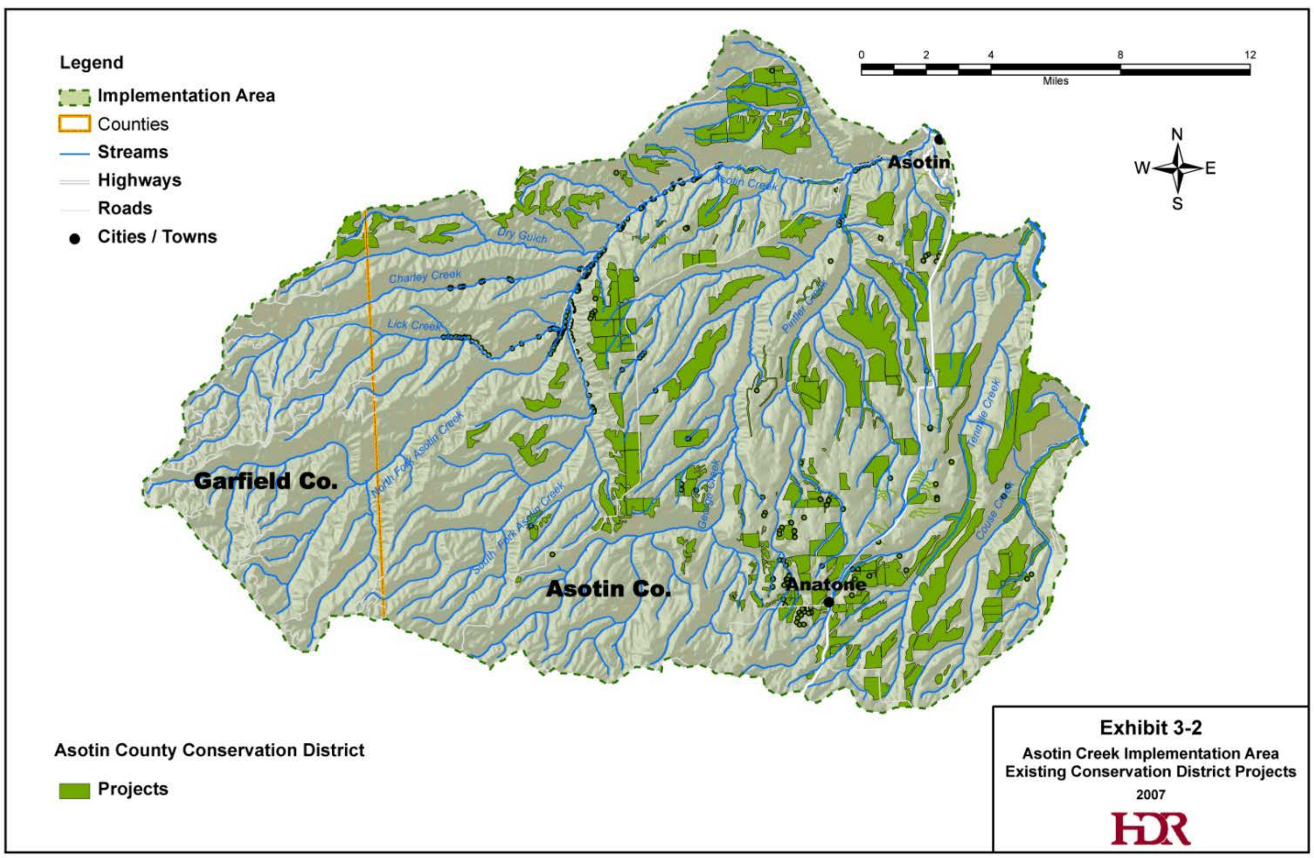

Figure 1. Asotin Creek Watershed Improvement Implementation Areas.

The Asotin Creek Model Watershed Plan (ACCDLSC) was completed in 1995. The plan and the associated projects (Figure 1, Table 1) serve as an indication of what can be accomplished on private lands in prioritized watersheds with public support. (Johnson 2002). Because of the plan's projects, many of the upper watershed water quality problems have been corrected.

Table 1. Asotin Watershed Improvement Activities.

Date	Activity/Accomplishment
mid-1980s	Past efforts include an Instream Habitat Improvement Project in the early to mid-1980s. This project included researching current knowledge of instream habitat improvement methods and implementing instream improvements on publicly-owned portions of Asotin Creek. A monitoring and evaluation study was included in this project.
1991	Asotin Creek Water Quality Monitoring Project implemented
1994	Asotin Creek watershed analysis completed
1995	Asotin Creek Model Watershed Plan completed Bonneville Power early action projects on Asotin Creek. Frost-free watering troughs installed at three locations in watershed
1996	Implemented Head gate Park pre- and post- monitoring of habitat restoration projects
1997	The installation and completion of fish and wildlife restoration projects on Asotin Creek included: 11 instream habitat restoration projects, 3 riparian exclusion fences, 6 riparian fences, 14 sediment basins, 54 sediment basin cleanouts, 1 multi-purpose pond construction, 1,800 ft. of terraces, and 1 three-month water quality study.
1998	246 projects completed through Asotin Creek Model Watershed Plan from 1995 to 1998, including construction of hard structures (e.g., vortex rock weirs), meander reconstruction, and placement of large woody debris and whole trees to create off-channel rearing habitat. A total of 139 pools were created with these structures. Three miles of stream benefited from riparian improvements such as fencing, vegetative plantings, and noxious weed control. Two alternative water developments were completed, providing off-stream watering sources for livestock. A total of 20,500 ft. of upland terraces, 7 sediment basins, 187 acres of grass seeding, 850 acres of direct seeding and 18 sediment basin cleanouts were implemented to reduce sediment production and delivery to streams in the watershed.
1999	A total of 38 pools were created using habitat structures. Three miles of stream benefited from riparian improvements such as vegetative plantings (17,000 trees and shrubs) and noxious weed control. Two sediment basins, 67 acres of grass seeding, and 745 acres of minimum till were implemented to reduce sediment production and delivery to streams in the watershed. (WDFW/ACCD baseline monitoring.)
2000	The Asotin Creek Riparian Tree Planting Project planted approximately 53,100 trees and shrubs in the Asotin Creek watershed. (Washington Department of Fish and Wildlife/ Asotin County Conservation District [WDFW/ACCD] baseline monitoring.) The ACCD partnered with the USFS to monitor sediment, cobble embeddedness, and macroinvertebrates. (WDFW/ACCD baseline monitoring.)
2001-2003	Projects were: 141,923 feet of fencing constructed, 186,300 trees planted, 13,045 acres of direct seed planted, 996 acres of pasture/hayland planted, 30 sediment basins constructed, 31,985 feet of terrace completed, 5 feedlot improvements, 31 water developments constructed, 7 sediment basins leaned/repaired, 8 ponds constructed, 1 windbreak completed, 27 Conservation Reserve Enhancement Program (CREP) contracts signed, 60.15 miles of CREP stream fenced, and 1152.4 acres of CREP acres protected. (WDFW/ACCD baseline monitoring.)
2002-2003	Lick Creek projects were: 28.5 miles of road surveyed, 21.3 miles of road decommissioned, 34 acres native grass seed planted, 7.2 miles of road abandoned; Charley Creek projects were: 19 miles of road surveyed, 5 stream banks repaired and stabilized. (WDFW/ACCD baseline monitoring.) Asotin Creek adult/juvenile fish trapping.
2004 - 2005	Charley Creek projects were: 19 miles of road decommissioned, 28 acres of native grass planted, 3 stream bank stabilized, 36 pieces of LWD, and 61 boulder placements for instream fish habitat enhancement. (WDFW/ACCD baseline monitoring.) Schlee property acquisition.

Fecal Coliform Bacteria

Bacteria criteria are set to prevent waterborne illnesses in people who work and play in and on the water. Ecology's water quality standards use fecal coliform (FC) as an "indicator bacteria" for the state's fresh waters such as lakes and streams. FC in water may indicate the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that cause illness in humans than waste from cold-blooded animals. The FC criteria are set at levels shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

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, throat, and urogenital system. Since children are also the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. This is the default designation for all fresh water of the state, including Asotin Creek and its tributaries. To protect this use category: "FC organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent 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).

The 2011 revisions to the water quality standards (Table 2) designated the reach of Asotin Creek above the confluence with Charlie Creek (Figure 2) into the extraordinary primary contact recreation category, which lowered the FC geometric mean criterion from 100 to 50. It also lowered the 10% criterion from 200 to 100. For the purposes of this study, this only affects station 35D200, located highest in the watershed in this study.

Table 2. Water Contact Recreation Bacteria Criteria in Fresh Water.

Category	Bacteria Indicator
Extraordinary Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies / 100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies / 100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies /100 mL.

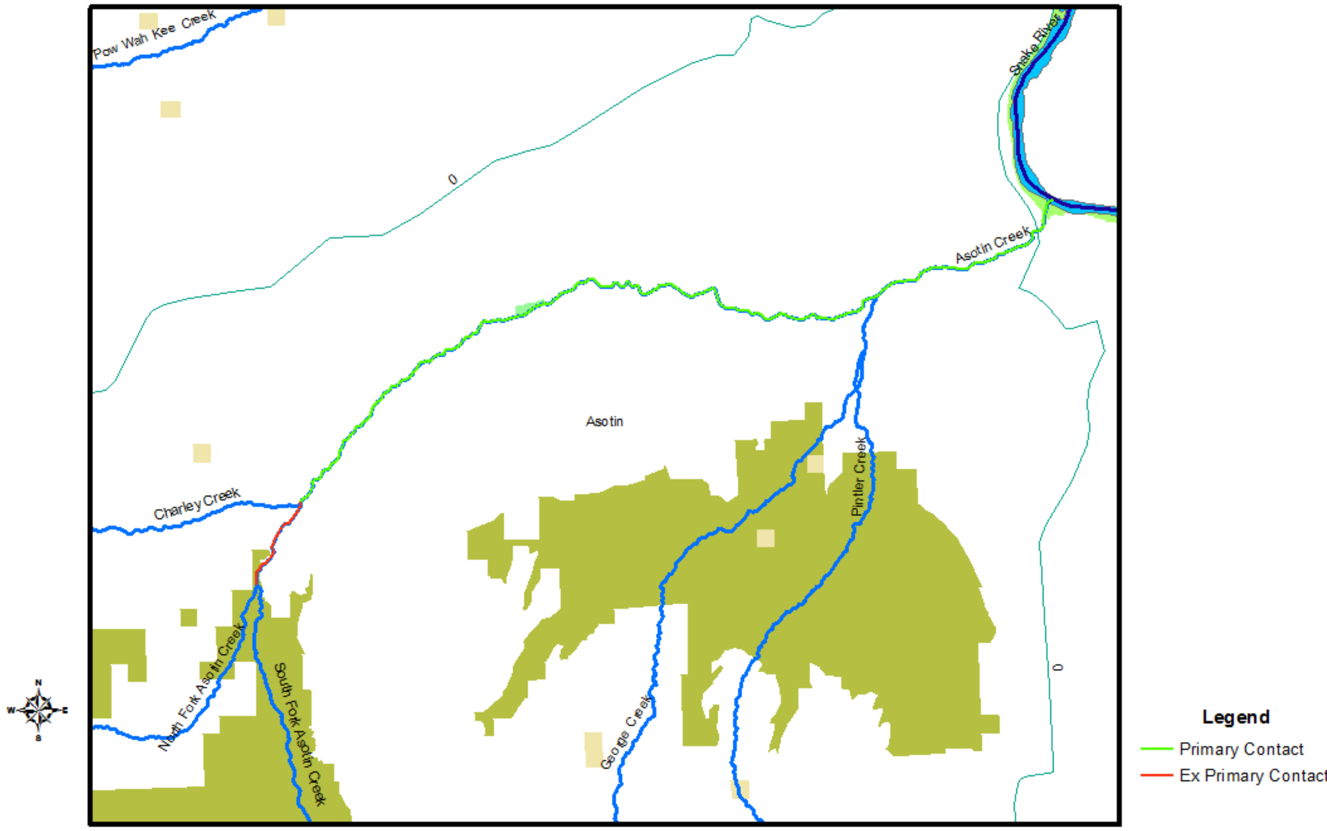

Figure 2. Asotin Creek Recreation Use Designations.

Figure 3 illustrates the section of Asotin Creek that is currently listed on the 303(d) list as a Category 5 waterbody for FC bacteria. Following Figure 3 is the listing basis from the most recent (2008) 303(d) list.

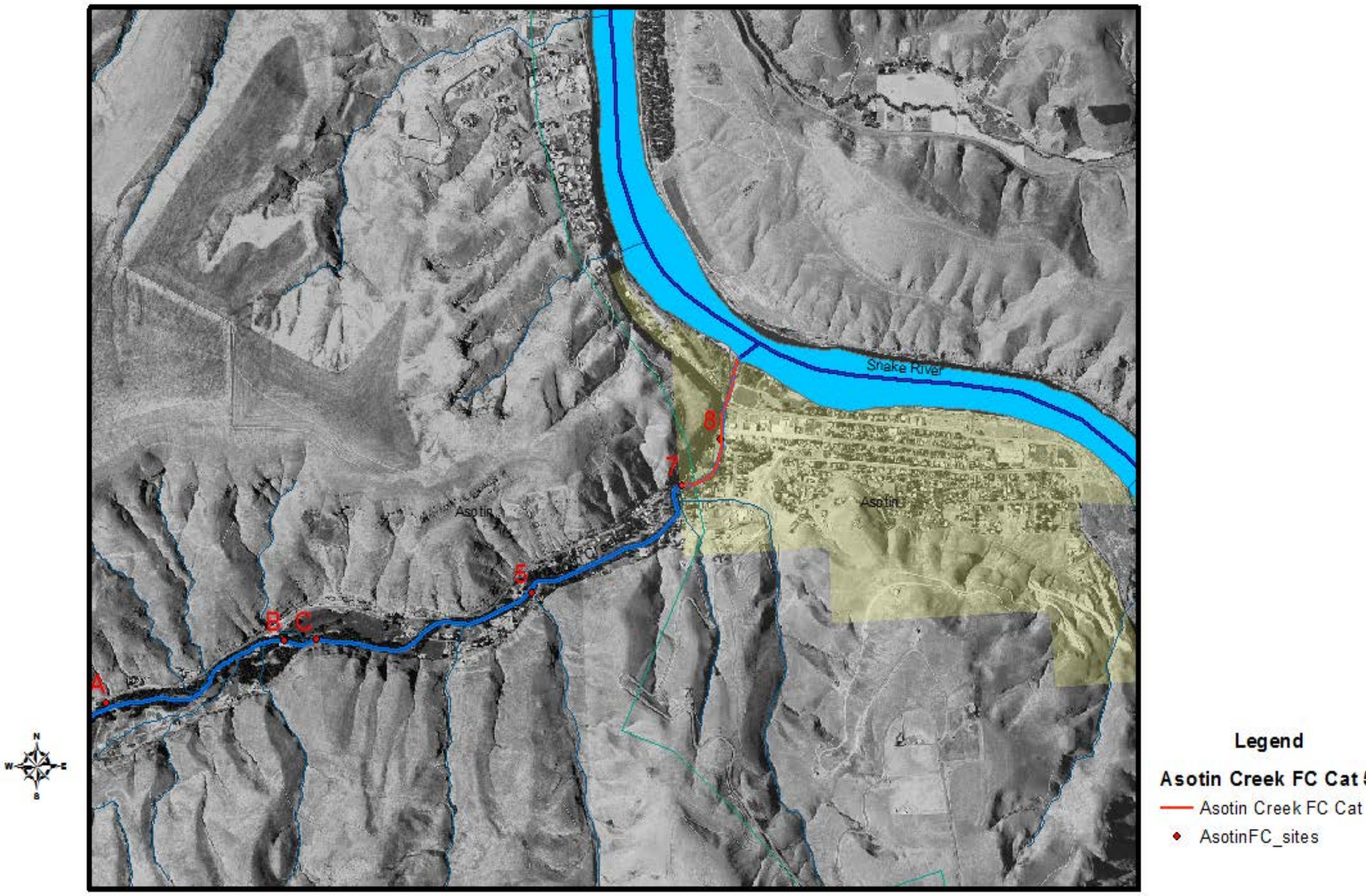

Figure 3. Asotin Creek Fecal Coliform 303(d) Listed Segment (Category 5).

2008 303(d) Listing Basis

*** 2008 Basis Statement (carried forward from 2004) ***

Hallock (2004) Dept. of Ecology Ambient Monitoring Station 35D070 shows 1 of 9 samples (11.1%) in year 2002 exceeded the percentile criterion.

Hallock (2001) Dept. of Ecology Ambient Monitoring Station 35D070 (Asotin Creek at Asotin) shows a geometric mean of 26 does not exceed the criterion and that 0% of the samples does not exceed the percentile criterion from 9 samples collected during 1997.

Hallock (2001) Dept. of Ecology Ambient Monitoring Station 35D070 (Asotin Creek at Asotin) shows a geometric mean of 20 does not exceed the criterion and that 0% of the samples does not exceed the percentile criterion from 3 samples collected during 1996.

Hallock (2001) Dept. of Ecology Ambient Monitoring Station 35D070 (Asotin Creek at Asotin) shows a geometric mean of 149 exceeds the criterion and that 33% of the samples exceeds the percentile criterion from 9 samples collected during 1993.

Category 5 sites require a TMDL study or a similar pollution control plan. Ecology would like to designate Asotin Creek into the 4b category. Before that can be done, the downstream bacteria concentrations and loads need to be addressed. If the FC bacteria can be traced to one or more sources, and these can be mitigated, the 4b designation could be attained. The pollution control plan must meet all of the following criteria:

- Be problem-specific and waterbody-specific.
- Have reasonable time limits established for correcting the specific problem, including load reduction or interim targets when appropriate.
- Have a monitoring component to evaluate effectiveness.
- Have adaptive management built into the plan to allow for course corrections if necessary.
- Have enforceable pollution controls or actions stringent enough to attain the water quality standards.
- Be feasible, with enforceable legal or financial guarantees that implementation will occur.
- Be actively and successfully implemented and show progress on water quality improvements in accordance with the plan.

In addition to the conditions above, the project is more likely to gain approval if the following elements are included:

- A description of management measures.

- An implementation schedule and measurable milestones.
- A description of criteria that are used to determine loading reductions achieved over time.
- An information/education component.

Historic Data and Water Quality Studies

Table 3. Historic data for Mouth of Asotin Creek.

Year	investigator	# Samples	FC Geomean cfu/100 mL	% of samples exceeding 200 cfu/100 mL
1993	Ecology	12	101	25
1997	Ecology	12	25	0
2002	Ecology	12	45	8
2005	Asotin CD	12	63	25
2006	Ecology	4	59	0
2006	Asotin CD	12	32	0

Monitoring conducted by Ecology in 1993 at the mouth of Asotin Creek was the basis for the Category 5 designation of Asotin Creek (Table 3). Three of 12 samples exceeded 200 cfu/100 mL and the geometric mean was 101 cfu/100 mL.

Ecology monitoring in between October 1996 and September 1997 (water year 1997) showed no exceedance of state bacteria standards. Water year 2002 had one sample over the 200 cfu/100 mL threshold, but that did not result in exceedance of the 10% standard. .

In 2005, HDR performed a data assessment for the water resource inventory area (WRIA) 35 planning committee, based on data collected by Washington State University (WSU) between 1997 and 1999 (HDR, 2005). HDR estimated (Oppenheimer 2005), using drainage areas, that George Creek provided 57% of the FC load to the lower basin of Asotin Creek. HDR suggested septic systems may have contributed to FC loads during 1998 but could not make the same determination for 1999. HDR also stated that their conclusions should be verified with flow and FC data from both Asotin and George Creeks.

Between March 2005 and February 2006, ACCD monitoring at the mouth of Asotin Creek indicated a geometric mean of 63 cfu/100 mL, but 3 of the 12 samples collected exceeded 200 cfu/100 mL. The ACCD data for the mouth of Asotin Creek from March 2006 through February 2007 returned a geomean of 31 cfu/100 mL, with no samples exceeding the 200 cfu/100 mL standard.

Data collected by Ecology in 2006 indicated no water quality exceedances during four low-flow sampling events.

Methods

Sampling methods and data quality objectives are discussed in detail in the Asotin Creek Fecal Coliform Bacteria Study Quality Assurance Project Plan, Ecology publication 10-03-106 (Ross, 2010).

The watershed was sampled twice a month from July through October 2011. Sites listed in Table 4 were sampled for lab and field parameters. Sites 1 - 8 were sampled throughout the entire course of field data collection. Sites A - C were added in order to source-identify reaches of the stream where FC loads were originating. Figure 4 illustrates locations of the sampling sites. The report cover photo and Figures 5 -12 illustrate each of the sampling sites.

Field samples were collected for FC, enterococci (ENT), chloride, and nitrate/nitrite.

Field measurements were conducted for instantaneous flow, pH, dissolved oxygen, conductivity, and temperature.

Table 4. Asotin Watershed Sampling Sites.

Map ID	Site ID	Site	Rationale	Latitude	Longitude
1	35D200	Asotin Cr ds confluence	Reference Site	46.273594	-117.292383
3	35P050	George Cr @ mouth	Load from George Creek	46.325278	-117.106944
4	35D090	Asotin Cr us George Cr	Load above George Creek	46.325600	-117.108375
5	35D085	Asotin Cr @ Morgan Rd	Upper residences	46.333640	-117.069387
7	35D075	Asotin Cr @ Costley Rd	Middle residences	46.337804	-117.058890
8	35D070	Asotin Cr @ mouth	End of residences	46.340214	-117.055980
A	35D089	Mitch Dimke Bridge	Additional site mid project	46.328849	-117.100938
B	35D087	Flynn abv water gap	Additional site mid project	46.3314	-117.087951
C	35D086	Flynn blw water gap	Additional site mid project	46.331373	-117.085692

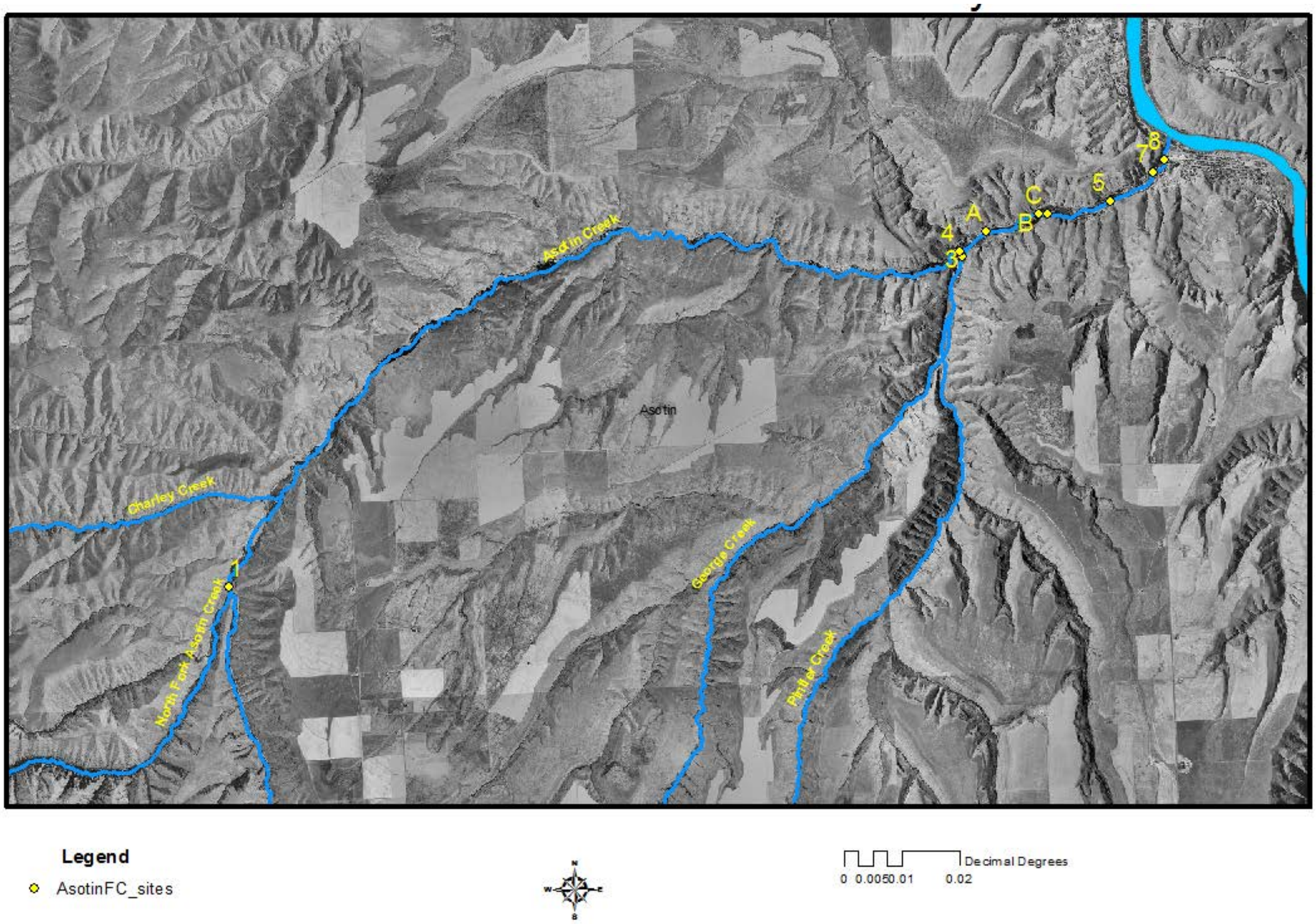

Figure 4. Asotin Watershed Fecal Coliform Sampling Location Map.

Figure 5. Asotin Creek ds Confluence (Map 1)

Figure 6. Asotin Ck abv George Ck (Map 4)

Figure 7. George Ck at Mouth (Map 3)

Figure 8. Asotin Ck at Dimke Bridge (Map A)

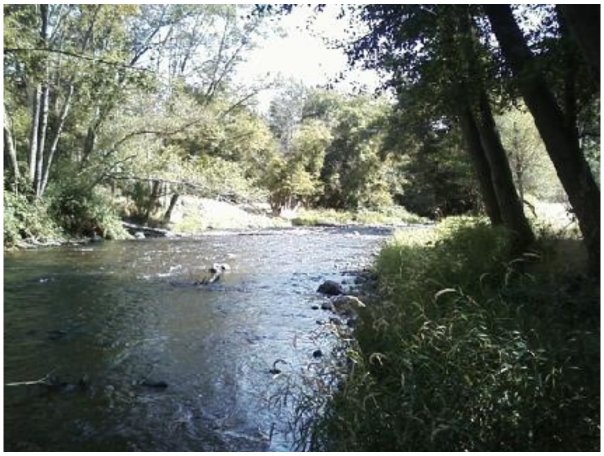

Figure 9. Asotin Ck abv Flynn water bar (Map B) Figure 10. Asotin Ck blw Flynn water bar (Map C)

Figure 11. Asotin Ck at Morgan Rd (Map 5) Figure 12. Asotin Ck at Costley Rd (Map 7)

Results and Discussion

Once all permissions were obtained, Ecology successfully collected samples at all sites for the entire monitoring period. In addition, three sites were added for source tracing after high fecal concentrations were found in mid-August.

Continuous flow data were obtained from the USGS and Ecology's stream gaging unit. Locations of these gages are illustrated in Figure 13. Appendix A contains hydrographs from USGS gaging stations on Asotin Creek (USGS 13334450, Ecology 35D200 and USGS 13335050, Ecology 35D070) and from Ecology's gages on Asotin Creek and George Creek (35D100 and 35P050). Data from the USGS gage at the mouth of Asotin Creek (35D070) have not been verified and should be considered estimates. Instantaneous flows and field data measured by Ecology staff are summarized in Appendix B.

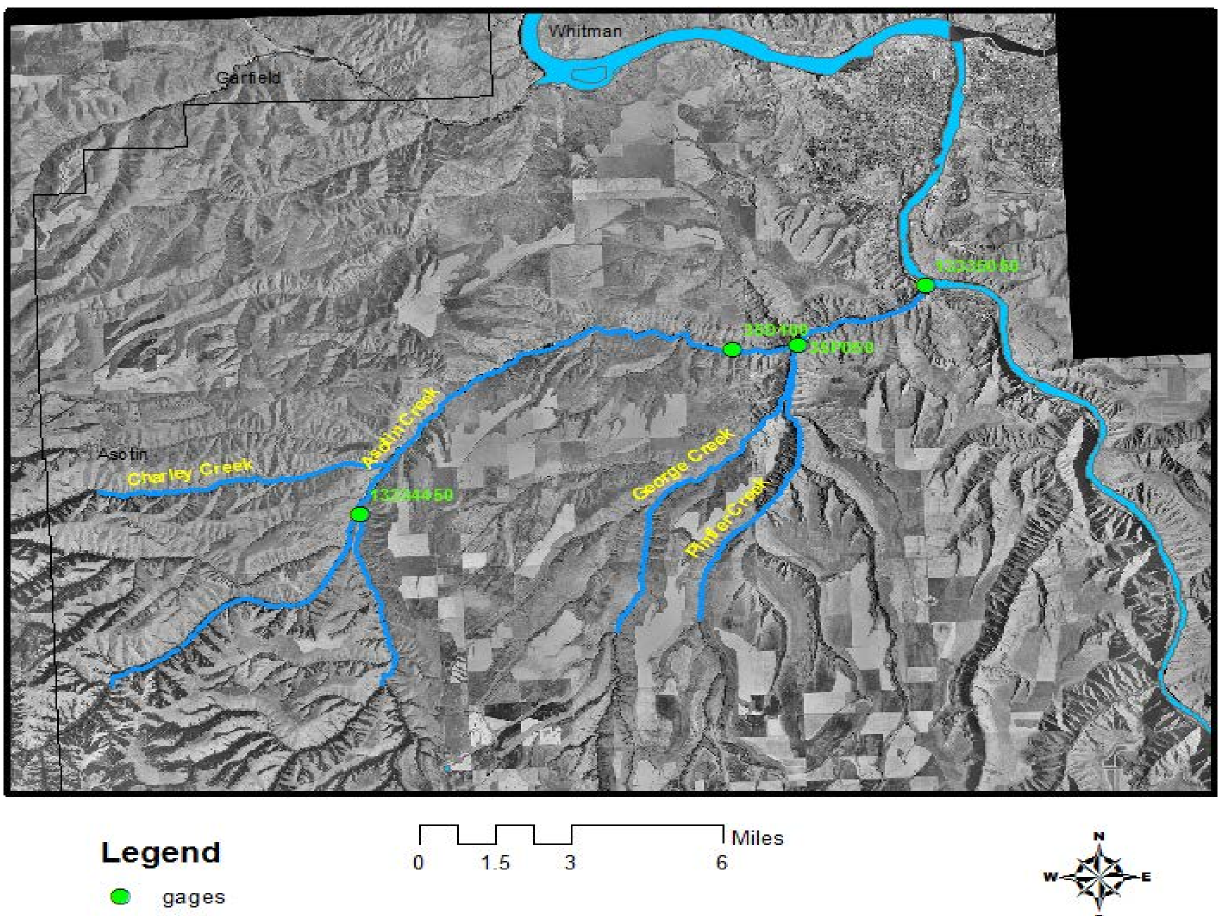

Figure 13. Asotin Creek Watershed Continuous Streamflow Gage Locations.

Field measurements for pH, conductivity, dissolved oxygen and temperature were collected with a hydrolab (multimeter).

Samples were collected and sent to Manchester Environmental Lab for chloride, nitrate/nitrite, FC, and enterococci analysis. Results were complete and met the project objectives. Appendix C summarizes the laboratory data from the project.

Elevated chloride levels in surface waters can indicate contamination from faulty septic systems or other anthropogenic sources. Chloride concentration generally increased as flows decreased. Site 35P050, at the mouth of George Creek, showed significantly higher chloride concentrations than any site along Asotin Creek.

Additional chloride samples were taken during high-flow conditions in the spring of 2012 in an attempt to determine if there is a terrestrial source of chloride in the George Creek watershed. Even during high flows, the chloride concentration in George Creek was substantially higher (3-5 times) than in Asotin Creek.

Nitrate concentrations were generally low throughout Asotin Creek. The nitrate concentrations increased only slightly after the spring freshet and did not increase longitudinally going downstream, except for the impact of George Creek. As with chloride, George Creek nitrate concentrations were 3-5 times higher than Asotin Creek, and did tend to increase with decreasing flows.

Table 5 and Figure 14 summarize the FC sample results for the project. The geometric mean of the FC samples was below 100 cfu/100 mL for every site. Stations 35P050 (George Creek), 35D090 (Asotin Creek above George Creek), 35D087 (Flynn above water bar), and 35D086 (Flynn below water bar) each had one sample over 200 cfu/100 mL (Appendix C).

Table 5. Asotin Creek Fecal Coliform Summary.

site	# samples	geomean standard	geomean	10% exceedance standard	# samples exceeding 10% criteria	% samples exceeding 10% criteria
35D200	8	50	10	100	0	0
35D090	7	100	48	200	1	14%
35D089	4	100	72	200	0	0
35D087	4	100	74	200	1	25%
35D086	4	100	68	200	1	25%
35D085	8	100	51	200	0	0
35D075	8	100	50	200	0	0
35D070	8	100	52	200	0	0
35P050	7	100	42	200	1	14%

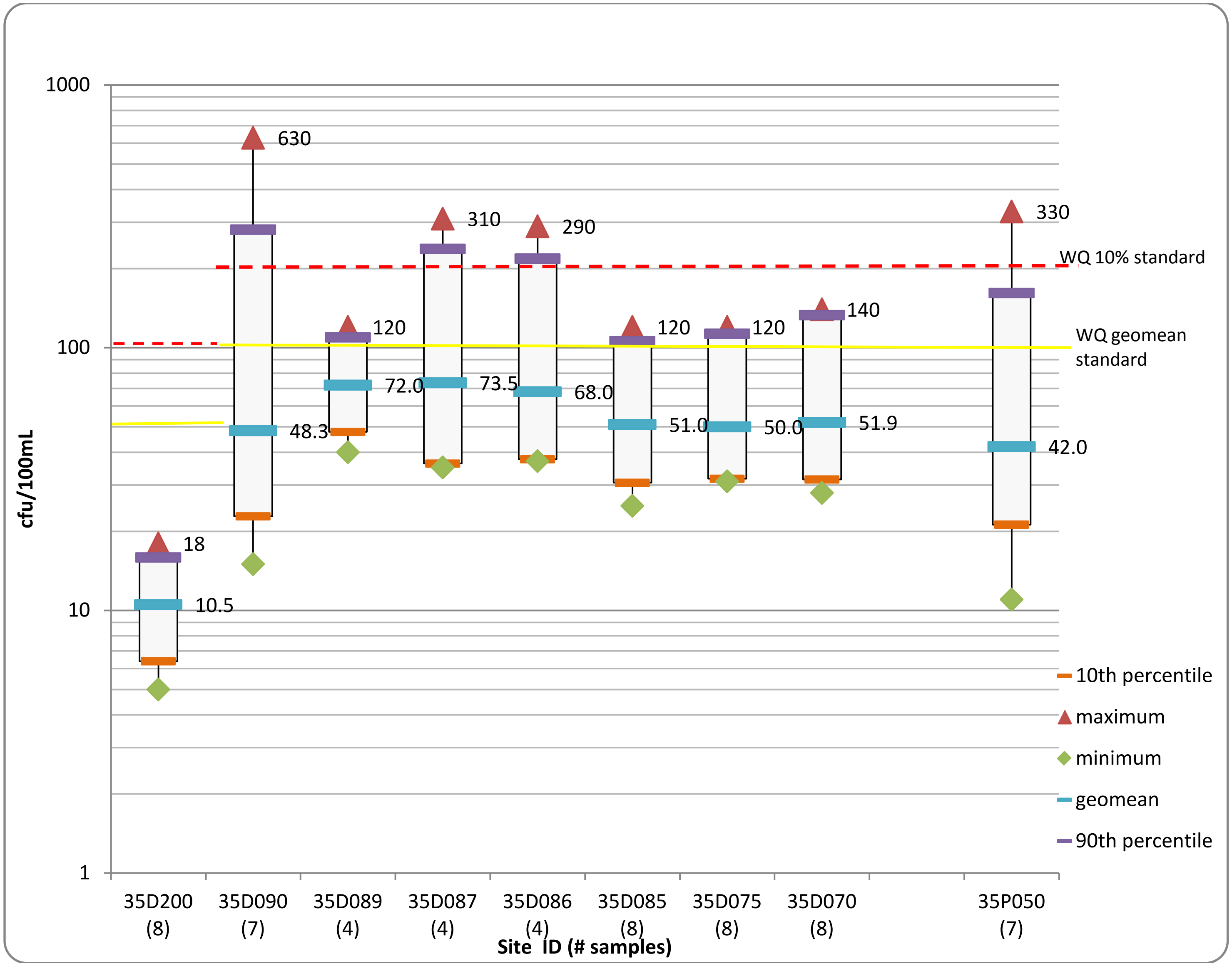

Figure 14. Box Plots of Asotin Creek Basin Fecal Coliform Statistics.

Figure 15 summarizes FC loads at sites where flow data were available. It highlights the minor impact George Creek had on the overall FC loading of the Asotin Basin. It also illustrates the spike in FC loading measured during the August 30 sampling. The July 19 flow for station 35D090 was estimated as a minimum, using the daily mean measured flow from station 35D100.

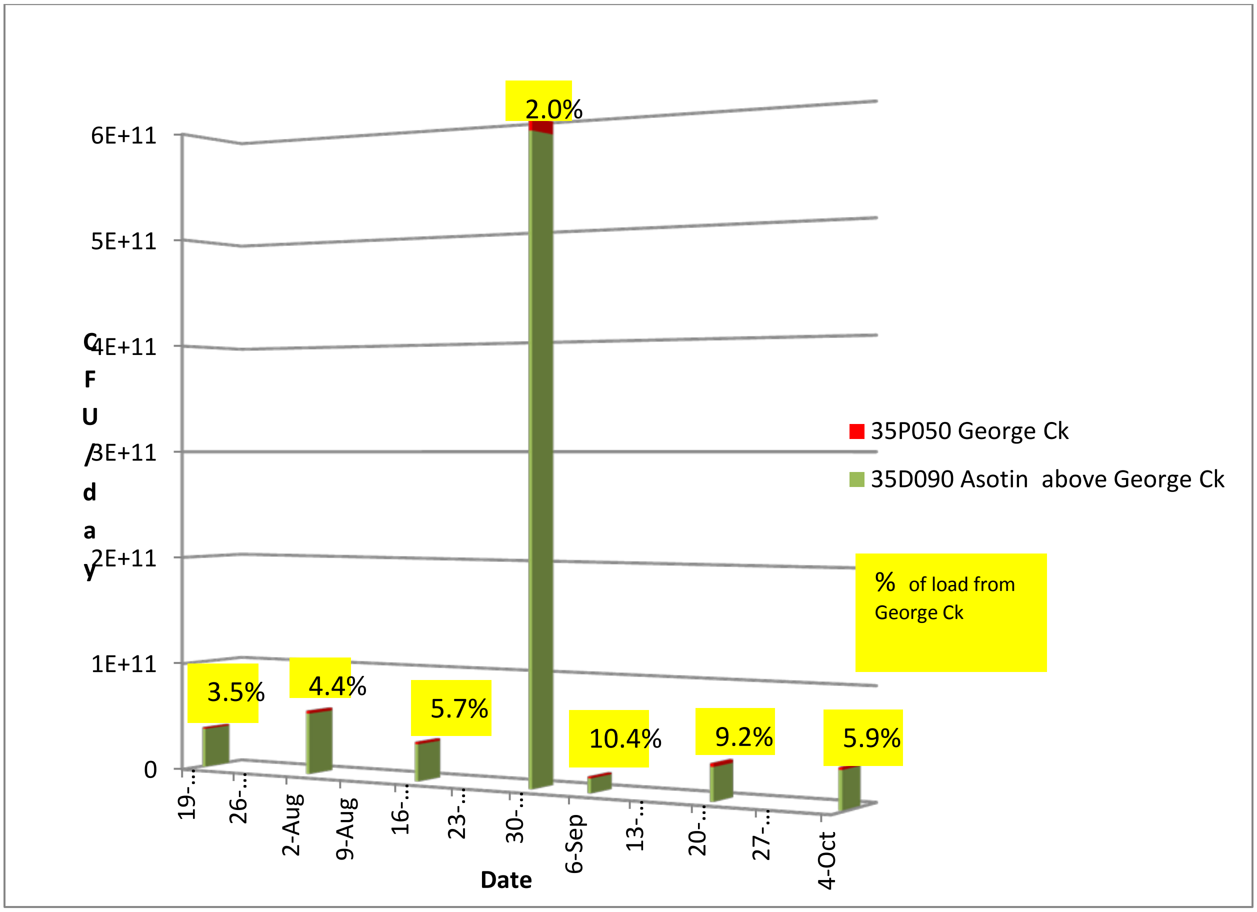

Figure 15. Fecal Coliform Loads from Upper Asotin and George Creeks.

Entering into the project, we thought that looking at ratios of FC bacteria to enterococci (EC), and ratios of nitrate to chloride might give insight into sources of FC contamination.

Figure 16 summarizes the FC:EC ratios. Since FC:EC ratios from a source of contamination are generally consistent, and the spike in the ratio during the August 30 sample event corresponds to a spike in bacteria concentration on the same day, this may indicate a different source of pollution than what was observed during the bulk of the project.

The August 30 sampling event had substantially higher levels of bacterial contamination than other events had. There were no recent storm events that would have accounted for the general increase in contamination due to a runoff event. The fact that both George (P050) and Asotin creeks were impacted would seem to rule out localized streamside activities like vegetation management, in-stream work (which could resuspend bacteria in soil and sediment), or grazing. Field observations did not indicate any unusual activity or stream conditions, such as turbidity, floating vegetation, or animals in the stream). Previous studies indicated the same pattern (water generally meeting state WQ standards, followed by an incident where the FC concentrations surge).

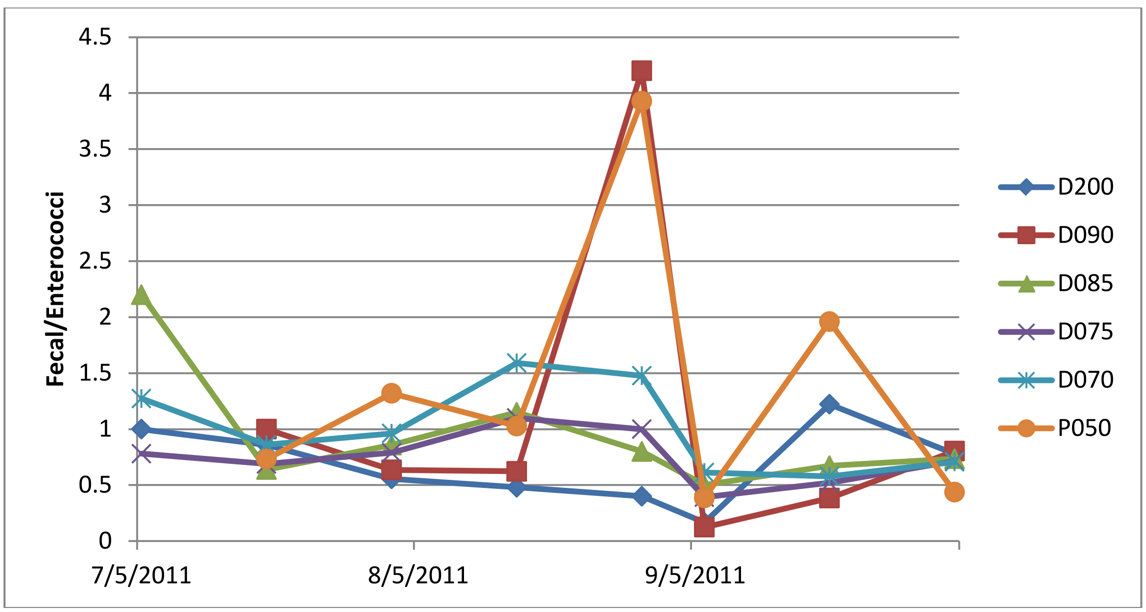

Figure 16. Fecal Coliform/Enterococci Ratios in Asotin Creek.

Figure 17 compares the chloride and nitrogen concentrations throughout the project area. Lack of variability in Asotin Creek chloride concentrations, even as nitrogen and FC increases, likely indicates a non-anthropogenic source. The George Creek linearity may indicate an anthropogenic source or a high chloride groundwater source. An additional chloride sample was taken in May 2012. The lower chloride concentration of just over 2 mg/L did not add clarity to the potential source. Additional sampling at several sites along George Creek is recommended to attempt to determine the source of the chloride.

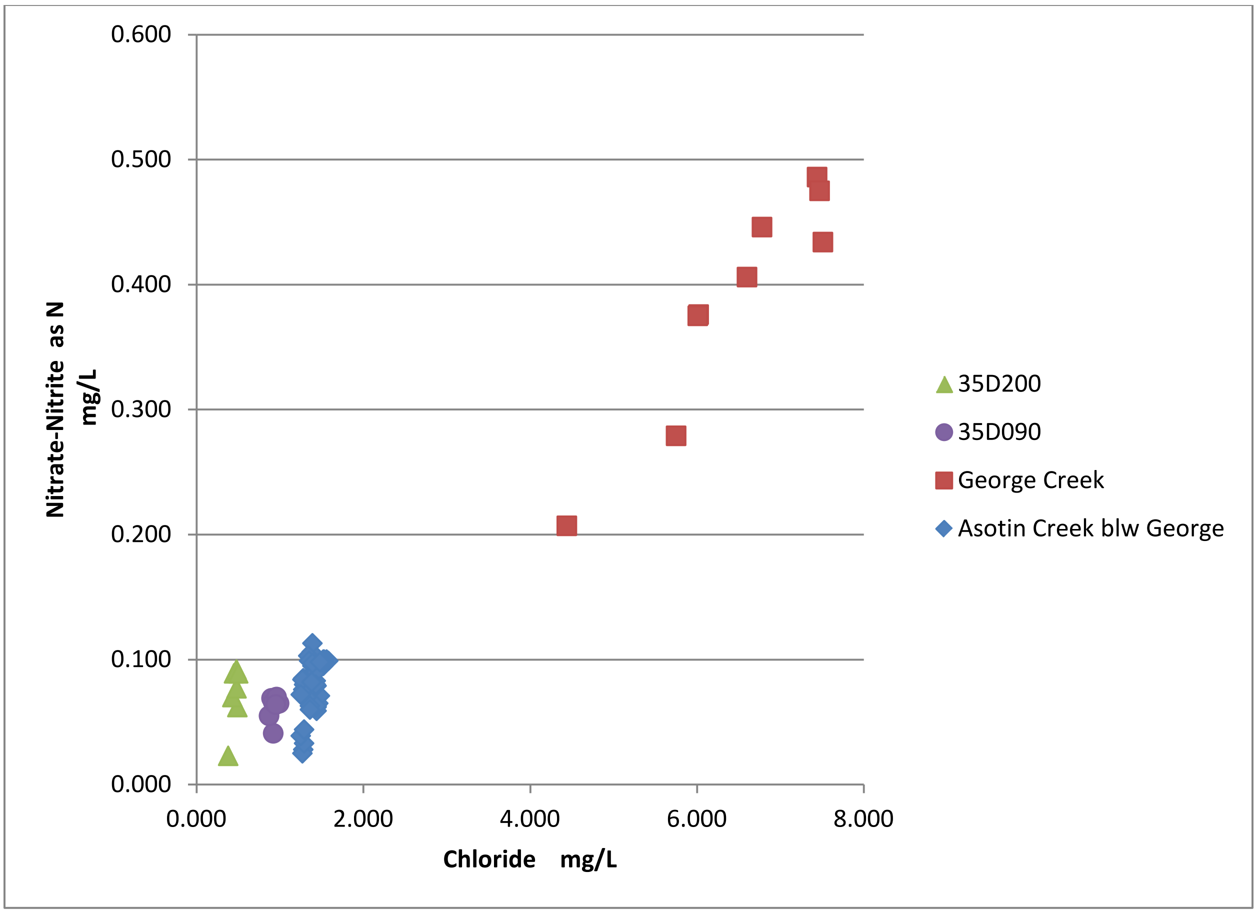

Figure 17. Chloride/Nitrate Ratios in Asotin Creek Watershed.

Conclusions and Recommendations

Results of this 2011 study support the following conclusions:

- Episodic bacterial contamination events continue in the Asotin watershed.
- The area of interest driving this study, between Morgan Road and the city park, was not a significant contributor of FC loading to Asotin Creek.
- The chloride and nitrate levels in George Creek may indicate potential anthropogenic influence.
- The HDR estimation that George Creek supplies a majority of the FC load to the lower Asotin basin was not supported with Ecology's use of actual loading calculations instead of HDR's drainage areas calculation.

Results of this study support the following recommendations:

- The mouth of Asotin Creek should be monitored for nutrients and FC contamination. Including it as a basin station in the ambient monitoring program every five years should be a minimum.
- High FC results should be rapidly followed up with sampling sites upstream to attempt to locate sources of pollution. Analyzing samples for %KES might provide valuable information when FC results are elevated.
- To determine the source of elevated concentrations of chlorides, nitrates, and FC bacteria in the watershed, additional monitoring should be conducted on George Creek. Both the mouth and at least one site upstream, above most residences, should be included.
- Local education efforts should continue for residences along Asotin and George Creeks. Areas to emphasize should be on-site sewage system maintenance, livestock management, and riparian zone vegetation buffer maintenance.

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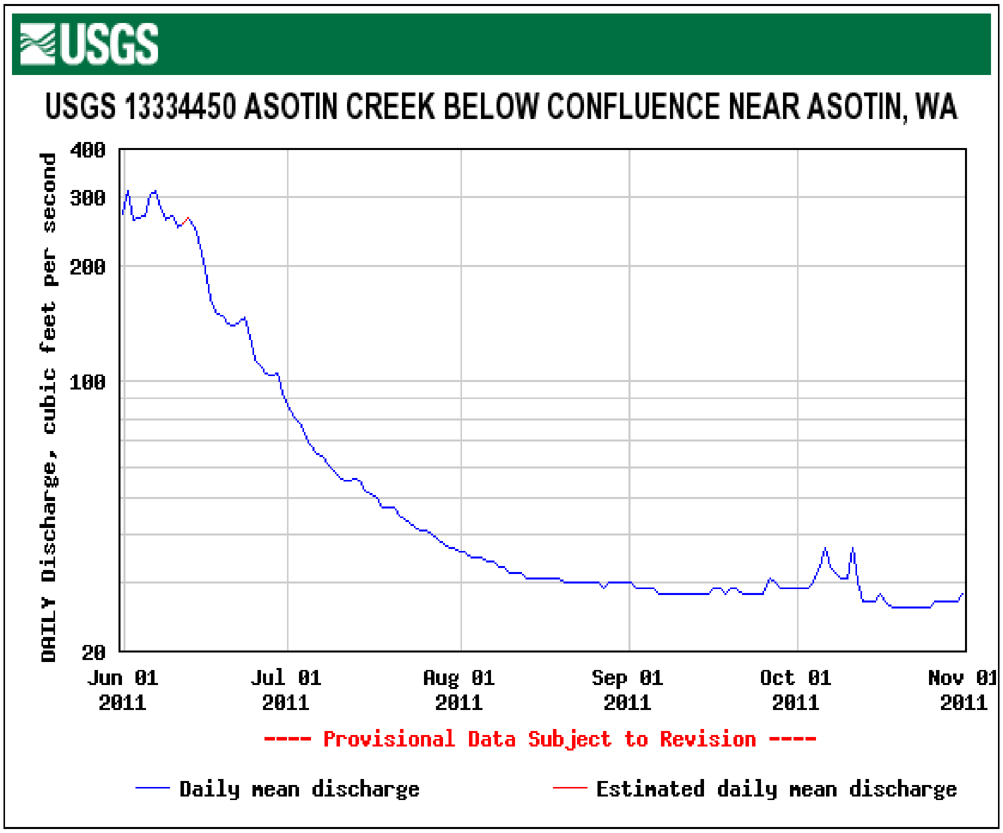
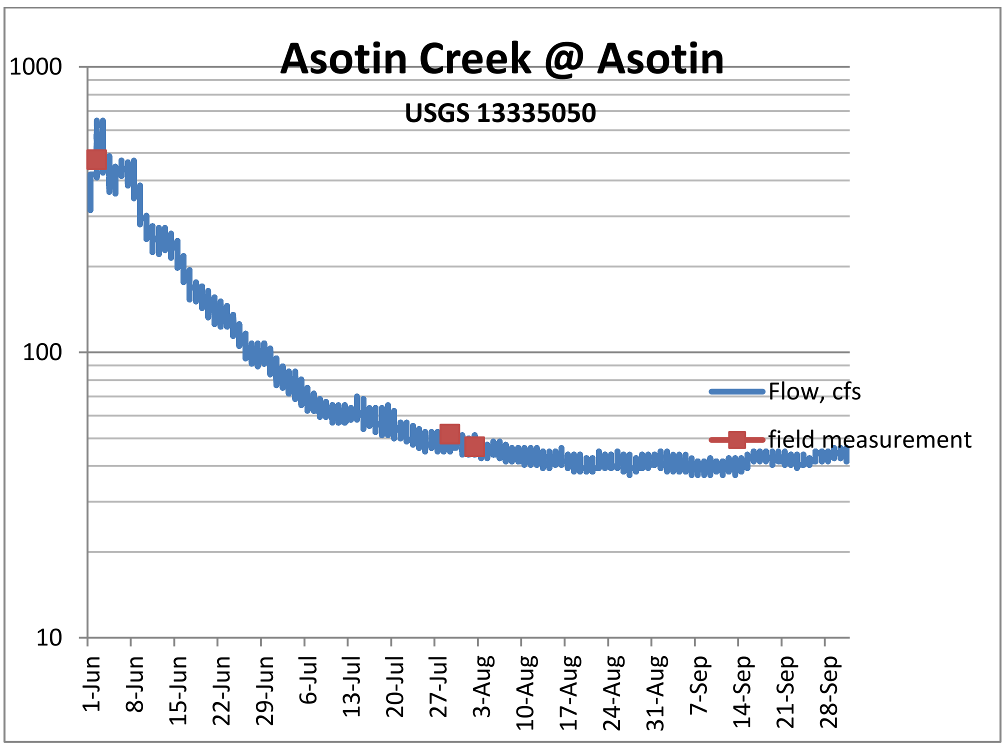
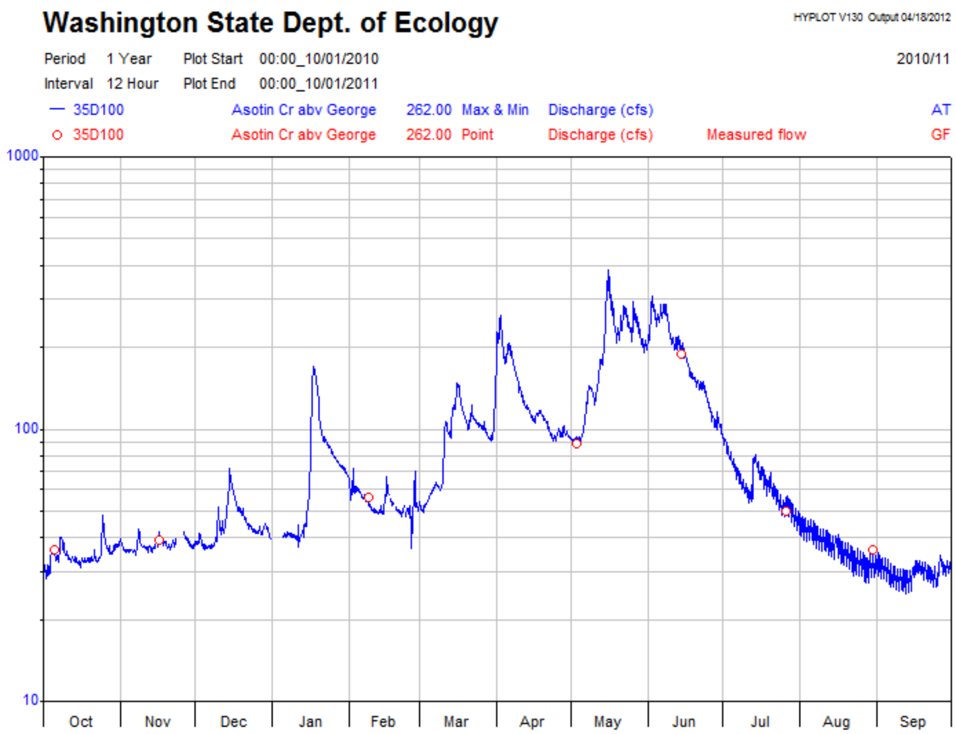
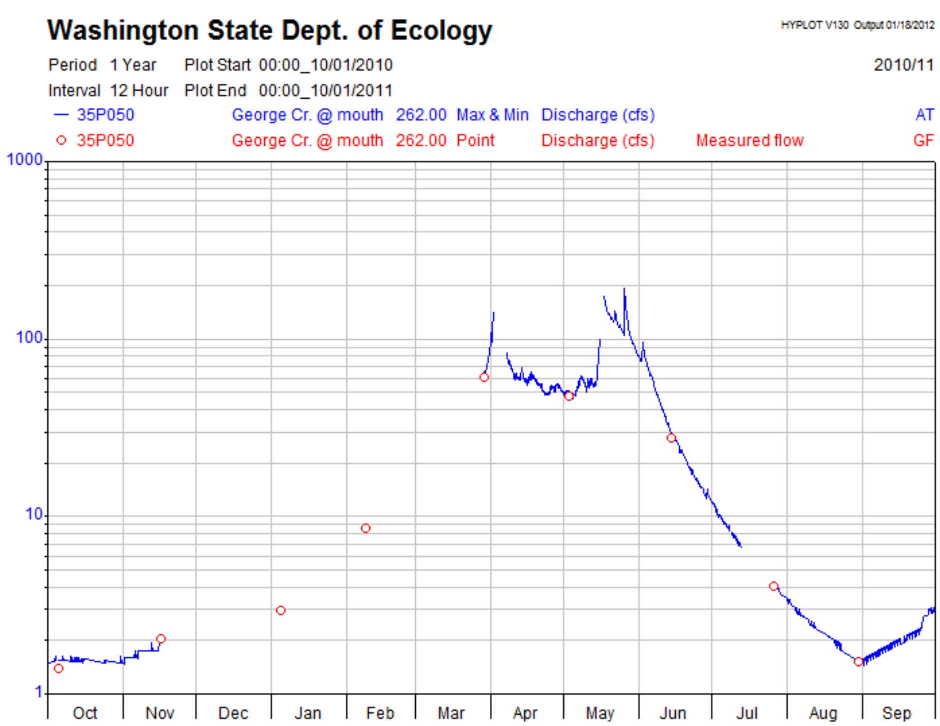
Appendices

Appendix A: Streamflow






Washington State Dept. of Ecology
HYPLOT V130 Output 04/18/2012
Period 1 Year Plot Start 00:00_10/01/2010
Interval 12 Hour Plot End 00:00_10/01/2011
2010/11
35D100 Asotin Cr abv George 262.00 Max & Min Discharge (cfs) AT
35D100 Asotin Cr abv George 262.00 Point Discharge (cfs) Measured flow GF
1000
100
10
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep


Washington State Dept. of Ecology
HYPLOT V130 Output 01/18/2012
Period 1 Year Plot Start 00:00_10/01/2010
Interval 12 Hour Plot End 00:00_10/01/2011
2010/11
35P050 George Cr. @ mouth 262.00 Max & Min Discharge (cfs) AT
35P050 George Cr. @ mouth 262.00 Point Discharge (cfs) Measured flow GF
1000
100
10
1
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep

Appendix B: Field Data

Site	Date	pH s.u.	Conductivity us/cm	Dissolved oxygen mg/L	Temp deg C	Flow cfs
35D200	7/5/2011	7.82	66.8	10.12	12.91	70.0
35D200	7/19/2011					
35D200	7/19/2011	8.00	77.8		13.99	48.0
35D200	8/2/2011	7.96	83.9	9.76	13.89	36.0
35D200	8/16/2011	7.82	87.5	11.27	12.34	31.0
35D200	8/30/2011	7.57	90.7	9.92	13.90	30.0
35D200	9/6/2011	7.86	91.7	10.12	12.63	28.0
35D200	9/20/2011	7.72	93.4	10.32	12.09	29.0
35D200	10/4/2011	7.64	71.6	10.28	12.04	30.0
35D090	7/19/2011	8.23	92.0		15.91	53(estimate)
35D090	8/2/2011	8.20	98.7	9.46	17.09	47.0
35D090	8/16/2011	8.07	101.9	11.13	14.79	42.0
35D090	8/30/2011	8.02	105.2	9.93	16.52	38.0
35D090	9/6/2011	7.10	106.2	10.30	14.43	36.0
35D090	9/20/2011	8.01	109.0	10.51	13.52	35.0
35D090	10/4/2011	7.94	110.3	10.61	13.15	34.0
35D090	5/15/2012					182
35D089	8/30/2011	8.04	112.7	10.01	16.83	
35D089	9/6/2011	8.10	113.9	10.32	14.90	
35D089	9/20/2011	8.09	116.0	10.44	13.93	
35D089	10/4/2011	7.89	119.2	10.39	13.33	
35D087	8/30/2011	8.01	114.2	9.80	17.01	
35D087	9/6/2011	8.08	115.2	10.17	15.04	
35D087	9/20/2011	7.97	118.0	10.38	14.13	37.0
35D087	10/4/2011	7.94	120.6	10.37	13.48	35.0
35D086	8/30/2011	8.06	114.0	9.96	17.20	
35D086	8/30/2011					
35D086	9/6/2011	8.11	115.6	10.29	15.19	
35D086	9/20/2011	8.19	118.0	10.66	14.24	
35D086	10/4/2011	7.96	120.5	10.45	13.49	

Site	Date	pH	Conductivity	Dissolved oxygen	Temp	Flow
		s.u.	us/cm	mg/L	deg C	cfs
35D085	7/5/2011	8.29	91.4	10.19	16.53	89.0
35D085	7/19/2011	8.26	104.3	9.74	16.67	60.0
35D085	8/2/2011	8.14	112.4	9.41	17.73	47.0
35D085	8/2/2011					
35D085	8/16/2011	7.99	114.1	10.96	15.55	40.0
35D085	8/30/2011	7.97	117.3	9.77	17.49	40.0
35D085	9/6/2011	8.05	119.1	10.17	15.45	41.0
35D085	9/20/2011	8.11	121.0	10.46	14.59	37.0
35D085	10/4/2011	7.93	123.8	10.40	13.60	40.0
35D075	7/5/2011	8.34	91.8	10.00	17.22	
35D075	7/19/2011	8.37	104.7	9.88	16.82	
35D075	8/2/2011	8.33	111.9	9.47	18.29	
35D075	8/16/2011	8.08	114.9	10.95	16.06	
35D075	8/30/2011	8.09	117.1	9.75	17.97	
35D075	9/6/2011	8.13	118.9	10.19	15.90	
35D075	9/20/2011	8.30	121.0	10.59	14.93	37.0
35D075	10/4/2011	8.09	124.0	10.62	13.77	37.0
35D075	10/4/2011					
35D070	7/5/2011					
35D070	7/5/2011	8.45	91.8	10.02	17.51	70.0
35D070	7/19/2011	8.38	104.7	9.87	16.87	57.0
35D070	8/2/2011	8.37	111.9	9.54	18.44	44.0
35D070	8/16/2011	8.11	114.8	10.97	16.18	42.0
35D070	8/30/2011	8.11	117.1	9.81	18.07	40.0
35D070	9/6/2011	8.14	118.1	10.22	16.01	37.0
35D070	9/6/2011					
35D070	9/20/2011	8.33	121.0	10.50	15.09	42.0
35D070	10/4/2011	8.09	124.3	10.48	13.79	44.0
35P050	7/19/2011	7.91	182.9		15.82	4.9
35P050	8/2/2011	7.92	204.0	9.39	15.43	3.2
35P050	8/16/2011	7.79	222.1	10.56	14.82	2.2
35P050	8/16/2011					
35P050	8/30/2011	7.65	233.0	9.67	15.18	1.5
35P050	9/6/2011	7.10	225.7	9.64	15.11	1.7
35P050	9/20/2011					2.1
35P050	9/20/2011	7.70	251.0	9.50	15.00	
35P050	10/4/2011	7.66	255.8	9.48	14.58	3.1
35P050	5/15/2012					29.8

Appendix C: Laboratory Results

Site	Date	Chloride mg/L	NO2/NO3 mg/L	Enterococci #/100 ml	Fecal Coliform #/100 ml
35D200	7/5/2011	0.38	0.02	5	5
35D200	7/19/2011	0.50	0.04	11	13
35D200	7/19/2011	0.47	0.04	14	12
35D200	8/2/2011	0.49	0.06	27	15
35D200	8/16/2011	0.43	0.07	25	12
35D200	8/30/2011	0.45	0.09	45	18
35D200	9/6/2011	0.48	0.09	60	10
35D200	9/20/2011	0.48	0.08	9	11
35D200	10/4/2011	0.50	0.09	9	7
35D090	7/19/2011	0.92	0.04	28	28
35D090	8/2/2011	0.99	0.07	77	49
35D090	8/16/2011	0.87	0.06	53	33
35D090	8/30/2011	0.90	0.07	150	630
35D090	9/6/2011	0.92	0.07	120	15
35D090	9/20/2011	0.96	0.07	91	35
35D090	10/4/2011	0.95	0.06	51	41
35D090	5/15/2012	0.71			
35D089	8/30/2011	1.27	0.08	150	66
35D089	9/6/2011	1.25	0.07	140	120
35D089	9/20/2011	1.29	0.04	100	85
35D089	10/4/2011	1.38	0.08	100	40
35D087	8/30/2011	1.28	0.09	92	310
35D087	9/6/2011	1.28	0.08	250	69
35D087	9/20/2011	1.36	0.06	84	39
35D087	10/4/2011	1.43	0.08	57	35
35D086	8/30/2011	1.30	0.08	200	290
35D086	8/30/2011	1.29	0.08	190	160
35D086	9/6/2011	1.32	0.07	140	51
35D086	9/20/2011	1.36	0.06	77	39
35D086	10/4/2011	1.44	0.08	66	37

Site	Date	Chloride mg/L	NO2/NO3 mg/L	Enterococci #/100 ml	Fecal Coliform #/100 ml
35D085	7/5/2011	1.25	0.04	15	33
35D085	7/19/2011	1.40	0.06	61	39
35D085	8/2/2011	1.53	0.10	56	48
35D085	8/2/2011	1.50	0.10	43	74
35D085	8/16/2011	1.34	0.10	87	100
35D085	8/30/2011	1.35	0.10	150	120
35D085	9/6/2011	1.39	0.10	150	75
35D085	9/20/2011	1.44	0.06	49	33
35D085	10/4/2011	1.48	0.10	34	25
35D075	7/5/2011	1.29	0.03	41	32
35D075	7/19/2011	1.44	0.06	45	31
35D075	8/2/2011	1.58	0.10	57	45
35D075	8/16/2011	1.39	0.11	100	110
35D075	8/30/2011	1.40	0.10	120	120
35D075	9/6/2011	1.42	0.09	130	51
35D075	9/20/2011	1.48	0.07	71	37
35D075	10/4/2011	1.52	0.10	49	35
35D075	10/4/2011	1.53	0.10	61	47
35D070	7/5/2011	1.28	0.03	22	36
35D070	7/5/2011	1.27	0.03	22	28
35D070	7/19/2011	1.44	0.06	43	37
35D070	8/2/2011	1.56	0.10	53	51
35D070	8/16/2011	1.38	0.11	88	140
35D070	8/30/2011	1.39	0.10	88	130
35D070	9/6/2011	1.40	0.09	80	49
35D070	9/6/2011	1.43	0.08	84	40
35D070	9/20/2011	1.46	0.07	57	33
35D070	10/4/2011	1.52	0.10	48	34
35P050	7/19/2011	4.44	0.21	15	11
35P050	8/2/2011	5.75	0.28	25	33
35P050	8/16/2011	6.02	0.38	37	38
35P050	8/16/2011	6.01	0.38	30	35
35P050	8/30/2011	6.60	0.41	84	330
35P050	9/6/2011	6.78	0.45	96	37
35P050	9/20/2011	7.44	0.49	56	59
35P050	9/20/2011	7.47	0.47	25	49
35P050	10/4/2011	7.51	0.43	64	28
35P050	5/15/2012	2.04			

Appendix D: Glossary, Acronyms, and Abbreviations

Glossary

Anthropogenic: Human-caused.

Ambient: Background or away from point sources of contamination.

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.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen: A measure of the amount of oxygen dissolved in water.

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 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria 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 10 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.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but 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 NPDES 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.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

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

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Pollution: 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 are 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.

Reach: A specific portion or segment of a stream

Riparian: Relating to the banks along a natural course of water.

Streamflow: Discharge of water in a surface stream (river or creek).

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (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.

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.

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 beneficial 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.

Acronyms and Abbreviations

ACCD	Asotin County Conservation District
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
FC	Fecal coliform bacteria
QA	Quality assurance
TMDL	(See Glossary above)
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

cfs	cubic feet per second
mg/L	milligrams per liter (parts per million)
mL	milliliters
s.u.	standard units
uS/cm	microsiemens per centimeter, a unit of conductivity
#/100 ml	bacteria colony forming units per 100 mL