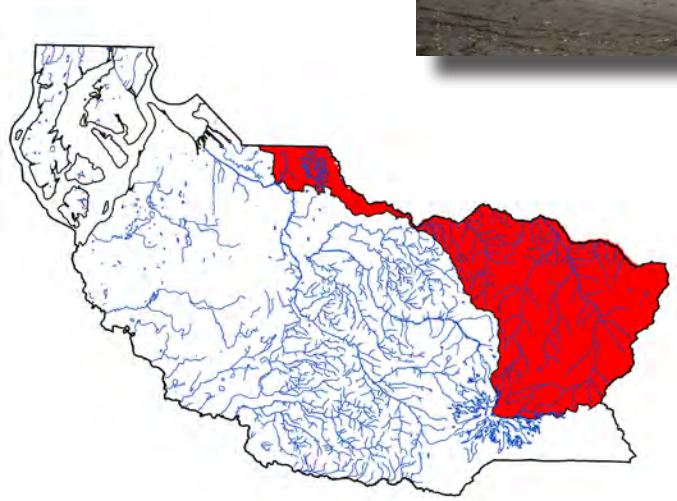
White River Basin Plan

VOLUME II - APPENDICES



Adopted: November 26, 2013
Ordinance: 2013 - 61

Pierce County
Public Works and Utilities
Surface Water Management

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix A

White River and Lake Tapps Basin Plan Questionnaire

Appendix A

White River and Lake Tapps Basin Plan Questionnaire

Pierce County Water Programs is preparing a surface water management plan for the White River Basin, including Lake Tapps. The plan will identify the actions necessary to provide safe storm drainage, reduce flooding, maintain water quality and protect natural streams and the fish and wildlife they support. Your completion of this questionnaire will help us make sure that the plan takes account of your views and any information you may have.

Please place completed questionnaires in the box provided at this public meeting or return by mail to the address provided at the end of the questionnaire. Please circle the letter of your choice. Questions 1 through 13 relate to Lake Tapps, questions 14 through 17 relate to flooding and habitat near the rivers and streams in this basin.

1. Which of the following best describes your property?
   a. Single family residential (primary residence).
   b. Single family residential (vacation/second residence).
   c. Single family residential (rental property).
   d. Multi-family residential.
   e. Commercial.
   f. Other. Please specify: _____

2. Which of the following best describes your property location?
   a. Lakefront, house within 500 feet of the waters edge.
   b. Lakefront, house between 500 and 1,000 feet from the waters edge.
   c. Riverfront.
   d. More than 1,000 feet from Lake Tapps or the White River or its tributaries.

3. Does your property have either or both of the following?
   a. boathouse
   b. boat dock

4. If your property has a septic system, what year was it installed?
   _____

5. If your property has a septic system, what year was it last checked?
   _____

6. If your property has a septic system, has it ever failed? If so, when?
   _____

7. Is your yard landscaped? _____ If so, do you water the landscaping?
   _____

   Do you fertilize? _____

8. Do you think water quality is a problem for the lake?
   a. Yes
   b. No

9. If you answered 'yes' to question 8, is it a problem all year or only at certain times of the year?
   a. All year
   b. Certain times of year

10. If water quality is a problem only at certain times of the year, during which season(s) does the problem seem to be greatest?
   a. Spring
   b. Summer
   c. Fall
   d. Winter

11. In this section, let us know what kind of problems Lake Tapps has, and in what season the problems appear.	Spring	Summer	Fall	Winter	All year	Not a problem
Weeds						
Siltation						
Bank erosion						
Lack of fish						
Swimmer's itch						
Algae and algal blooms						
Too many boats						
Odor from lake						

12. Would you be willing to accept some limitations on your use of private property to protect stream corridors, fish and other wildlife, or the water quality of Lake Tapps?

_____

_____

13. If 'yes', please indicate below which limits might be acceptable to you. (Circle all that apply.)
   a. maintenance of vegetated buffer zones along streams or Lake Tapps
   b. limits on extent of paved or other impermeable surfaces
   c. limits on fertilizer or pesticide use
   d. retention of a proportion of the tree canopy

Flooding and Habitat

14. Are you aware of any past flooding that have damaged buildings? If so, when and where did this happen and what were the circumstances?

_____

_____

Are you aware of any past road or driveway flooding? If so, when and where did this happen and what were the circumstances?

_____

_____

15. Are you aware of any locations where stream banks are collapsing or eroding severely? If so, when and where did this happen?

_____

_____

16. Are you aware of any problems with fish habitat on streams or rivers? If so, where? Are there any areas that would benefit from habitat enhancements? If so, where?

_____

_____

17. Which of the following have you experienced <u>in your present residence</u> because of floods? (Circle all that apply.)
    a. cracks in basement walls, floor, or foundation
    b. cracking or settlement in yard
    c. water damages to house or structure
    d. water damage to contents (furniture, appliances, personal effects, etc.)
    e. stormwater backup
    f. sanitary sewer backup
    g. evacuation from home
    h. transportation disruption
    i. lost income because of missed work or business closings
    j. bodily injury
    k. anxiety, mental distress
    l. disruption to your property by emergency flood fighting
    m. lowered property values
    n. other:_____
    o. none

Information

18. How would you like to be kept informed about this study? (Circle your preference.)
    a. public meetings
    b. newspaper
    c. brochures
    d. e-mail

19. What is your name, address, telephone number and email address? (OPTIONAL)

_____

_____

May we contact you for further information? _____

Additional comments:

_____

_____

_____

_____

_____

_____

_____

_____

Please return completed forms to: Heather Kibbey, Pierce County Water Programs, 9850 - 64th Street West, University Place, WA 98467-1078. (253) 798-2725

Memorandum

URS

To: Heather Kibbey, Pierce County Water Programs

From: Julie Blakeslee (Deputy PM) and Doug Sovern (Project Manager)

Date: March 8, 2005

Subject: Draft Technical Information Memorandum #4—Survey Comments Summary
White River and Lake Tapps Basin Study

The purpose of this memorandum is to report the comments collected from the questionnaire used for the White River Basin Study project. A four page *White River and Lake Tapps Basin Study Questionnaire* was distributed at the January 12, 2005 public meeting. Approximately 32 people signed-in at the meeting and 24 questionnaires were completed by participants. The meeting was held at North Tapps Middle School located at 20029 12th Street East in Sumner, Washington from 7:00 to 9:00 p.m. The questionnaire has been included in this memo in its entirety with the tabulated results to date. Not every question was answered on each questionnaire, therefore results show a different number of responses for each question. A list of public meeting attendees follows the questionnaire.

In general, the results of the questionnaire indicate that a majority of the participants own a single family, lakefront residence with landscaping that they water and fertilize. Over 60 percent of participants believe there is no water quality problem in Lake Tapps. However, over 80 percent believe there is a weed (primarily milfoil) problem in either the spring, summer, or fall. A majority believe there are too many boats on the lake in the summer.

A majority of the participants would be willing to accept some limitations on the use of their property if they understood those limitations, especially regarding limits on fertilizer or pesticide use. Most participants were not aware of flooding or habitat problems.

White River and Lake Tapps Basin Plan

Questionnaire

Pierce County Water Programs is preparing a surface water management plan for the White River Basin, including Lake Tapps. The plan will identify the actions necessary to provide safe storm drainage, reduce flooding, maintain water quality and protect natural streams and the fish and wildlife they support. Your completion of this questionnaire will help us make sure that the plan takes account of your views and any information you may have.

Please place completed questionnaires in the box provided at this public meeting or return by mail to the address provided at the end of the questionnaire. Please circle the letter of

your choice. Questions 1 through 13 relate to Lake Tapps, questions 14 through 17 relate to flooding and habitat near the rivers and streams in this basin.

1. Which of the following best describes your property?	***Responses***
a. Single family residential (primary residence).	***23***
b. Single family residential (vacation/second residence).	***0***
c. Single family residential (rental property).	***1***
d. Multi-family residential.	***0***
e. Commercial.	***0***
f. Other. Please specify: _____***Vacant***_____	***1***

2. Which of the following best describes your property location?	***Responses***
a. Lakefront, house within 500 feet of the waters edge.	***21***
b. Lakefront, house between 500 and 1,000 feet from the waters edge.	***0***
c. Riverfront.	***0***
d. More than 1,000 feet from Lake Tapps or the White River or its tributaries.	***2***

3. Does your property have either or both of the following?	***Responses***
a. Boathouse	***4***
b. boat dock	***22***

4. If your property has a septic system, what year was it installed? _____
   Responses: Prior to 1971 – 2, 1971 to 1980 – 8, 1981 to 1990 – 5, 1991 to 2001 - 4

5. If your property has a septic system, what year was it last checked? _____
   Responses: Prior to 2001 – 5, 2001 to 2004 – 13

6. If your property has a septic system, has it ever failed? If so, when? _____
   Responses: No – 16, Yes (2002) – 1

7.	
Is your yard landscaped?	***Yes – 23, No – 1***
If so, do you water the landscaping?	***Yes – 23, No – 1***
Do you fertilize?	***Yes – 18, No – 6***

8. Do you think water quality is a problem for the lake?	***Responses***
a. Yes	***9***
b. No	***15***

9. If you answered 'yes' to question 8, is it a problem all year or only at certain times of the year?	***Responses***
a. All year	***2***
b. Certain times of year	***6***

10. If water quality is a problem only at certain times of the year, during which season(s) does the problem seem to be greatest?

	Responses
a. Spring	***2***
b. Summer	***4***
c. Fall	***3***
d. Winter	***0***

11. In this section, let us know what kind of problems Lake Tapps has, and in what season the problems appear.	Spring	Summer	Fall	Winter	All year	Not a problem
Weeds	***4***	***12***	***4***	***0***	***0***	***3***
Siltation	***0***	***1***	***3***	***0***	***2***	***7***
Bank erosion	***1***	***2***	***1***	***0***	***0***	***9***
Lack of fish	***1***	***1***	***0***	***0***	***5***	***10***
Swimmer's itch	***0***	***0***	***0***	***0***	***0***	***11***
Algae and algal blooms	***1***	***6***	***1***	***0***	***0***	***7***
Too many boats	***4***	***14***	***4***	***0***	***2***	***4***
Odor from lake	***0***	***0***	***1***	***0***	***1***	***8***
Too many Canadian Geese (hand entered)					***2***	

12. Would you be willing to accept some limitations on your use of private property to protect stream corridors, fish and other wildlife, or the water quality of Lake Tapps?

Responses: No – 4, Yes – 11, Unsure/Depends on conditions – 6

13. If 'yes', please indicate below which limits might be acceptable to you. (Circle all that apply.)

	Responses
a. maintenance of vegetated buffer zones along streams or Lake Tapps	***7***
b. limits on extent of paved or other impermeable surfaces	***5***
c. limits on fertilizer or pesticide use	***12***
d. retention of a proportion of the tree canopy	***2***

Flooding and Habitat

14. Are you aware of any past flooding that have damaged buildings? If so, when and where did this happen and what were the circumstances?

Responses: No – 21, Yes – 0

15. Are you aware of any past road or driveway flooding? If so, when and where did this happen and what were the circumstances?

Responses: No – 20, Yes – 1 (Flooding on 9th Street E (north end of lake) and Kersey Way – down hill towards Auburn)

16. Are you aware of any locations where stream banks are collapsing or eroding severely? If so, when and where did this happen?

Responses: No – 20, Yes – 1 (For the last six years I have observed a small (200 sq.ft.) island eroding away – located 100 feet east of Interlake Island)

17. Are you aware of any problems with fish habitat on streams or rivers? If so, where? Are there any areas that would benefit from habitat enhancements? If so, where?

Responses: No – 17, Yes – 4
(occasionally by the outer island on Lake Tapps)
(Lake Tapps)
(Would like Trout planted in the lake and get rid of the Tiger Muske)
(Answer: Is the phosphate load from Buckley and Enumclaw causing rise to pH?)

18. Which of the following have you experienced in your present residence because of floods? (Circle all that apply.)

	Responses
a. cracks in basement walls, floor, or foundation	***0***
b. cracking or settlement in yard	***2***
c. water damages to house or structure	***0***
d. water damage to contents (furniture, appliances, personal effects, etc.)	***0***
e. storm water backup	***0***
f. sanitary sewer backup	***0***
g. evacuation from home	***0***
h. transportation disruption	***0***
i. lost income because of missed work or business closings	***0***
j. bodily injury	***0***
k. anxiety, mental distress	***0***
l. disruption to your property by emergency flood fighting	***0***
m. lowered property values	***0***
n. other:_____	***0***
o. none	***14***

Information

19. How would you like to be kept informed about this study? (Circle your preference.)

	Responses
a. public meetings	***13***
b. newspaper	***5***
c. brochures	***5***
d. e-mail	***12***

20. What is your name, address, telephone number and email address? (OPTIONAL)

See attendance list.

21. May we contact you for further information? _____

Additional comments:

- ***Use bulletin boards and newspaper ads for plan to lower and raise water levels in Lake Tapps***
- ***Keep flow in Lake for water quality and hydro-power source***
- ***Suggest extensive studies provided by PSE to DOE with Domestic Water Rights application must include available historic data***
- ***Please update FEMA maps***
- ***Lower the lake level and keep down all year round***
- ***Establish a 100-meter wetland buffer around the lake***
- ***Form a Lake Tapps LID and install sewer system all around the lake***
- ***Concerned about no data on water quality before the PSE flow change***
- ***Need to check for source of bacteria, especially geese***
- ***County should track milfoil issues in case it becomes a bigger problem***
- ***Slow down growth around the lake, quality of life is decreasing***

The following replied "yes" to being contacted.

Bernadine A. Repp
10936 SE 235th Place
Kent, WA 98031
253/852-6213

Dorothy Rose
4813 N. Island Drive
Bonney Lake, WA 98390
253/862-7867

Don and Ann Fisher
2705 185th Ave East
Sumner, WA 98390
253/891-4125

Duane and Susan Tibeau
19001 First Street East
Sumner, WA 98390
253/862-8851

Dennis Brown
21014 Snag Island Drive
Bonney Lake, WA 98390
253/862-8733

Dan Swatman
10209 218th Ave Ct East
Bonney Lake, WA 98390
Danswatman@sprynet.com
253/862-5621

Bob and Carol Rowan
4601 Lakeridge Drive East
Sumner, WA 98390
Cbrir@hotmail.com
253/826-2334

Bill and Karen Baker
2721 200th Ave East
Sumner, WA 98390
Tapps@foxinternet.net
253/862-3005

Dennis Fields
1400 112th Ave SE
Bellevue, WA ____
Dfields@cascadewater.org
425/453-1555

John Hazzard
11007 176th Ave East
Sumner, WA 98390
253/862-4344

Kirk and Michele Shuler
20702 Snag Island Drive
Sumner, WA 98390
Kirk1@wwdb.org
Michele@rainiermortgage.com
253/862-0444

Lawrence H. Schmick
3623 Deer Island Drive
Bonney Lake, WA 98390
Larryschmick@hotmail.com
253/862-8955

John R. Korn
18402 9th St East
Sumner, WA 98390
Jrkorn@gte.net
253/862-4193

Ralph Mason
2425 199th Ave Ct East
Sumner, WA 98390
Rl_mason@prodigy.net
253/862-7418

Chuck Romeo
18402 Driftwood Drive
Sumner, WA 98390
Cpromeo@comcast.net
253/862-6565

Bill Bunker
2615 204th Ave East
Sumner, WA 98390
Bill4728@aol.com
253/862-7313

Scott Bunker
2615 204th Ave East
Sumner, WA 98390
SimpsonswanSB@aol.com
253/862-7313

Everett Howe
4934 192nd Ave East
Sumner, WA 98390
Evhowe@hotmail.com
253/863-4879

Mary Brown
7620 W. Tapps Hwy
Sumner, WA 98390
Marybr@puyalluptribe.com
253/573-7852

Leon Stucki
21406 Snag Island Drive
Sumner, WA 98390
Lstucki@future-tech.com
253/939-7552

Joe and Toril Schoepfer
5312 195th Ave East
Bonney Lake, WA 98390
1toril@comcast.net
253/862-4736

John Wise
Mayor
City of Enumclaw
Johnwise@enumclaw.wa.us
360/802-0229

James Renz
18314 Driftwood Drive
Sumner, WA 98390
253/862-6379

Gene Galloway Jr.
8408 152nd Ave East
Puyallup, WA 98372
253/391-8117

Ken and Carol Castile
21210 23rd St Ct East
Sumner, WA 98390
Kencastile@comcast.net
253/862-6194

Gerald Sorensen
2709 214th Ave East
Sumner, WA 98390
253/862-8868

John Beaman
Tapps Island Association
Office@tappsisland.com
253/862-6616

Char Naylor
1850 Alexander Ave
Tacoma, WA 98421
Charna@puyalluptribe.com
253/573-7851

Ron Wilderman
2513 185th Ave East
Sumner, WA 98390
Brwilder@aol.com
253/862-6502

The following person responded "no" to being contacted:

Brandon Hazzard
8105 77th Ave Ct East
Sumner, WA 98390
253/863-1113

THIS PAGE INTENTIONALLY LEFT BLANK.

Memorandum

To: Heather Kibbey, Pierce County Water Programs

From: Michael Milne, Jennifer Belknap Williamson

Date: April 9, 2008

Subject: Appendix B for Technical Information Memorandum #3— Phase 2 Survey Comments Summary White River and Lake Tapps Basin Study

---

In the Fall of 2007 questionnaires were sent out to 2,400 property owners in the White River Basin. Questionnaires were sent to all properties within 150 feet of Lake Tapps and all properties in Greenwater. The questions focused on land use, septic system use, use of pesticides and fertilizers, water quality, flooding, and habitat issues. There were 375 completed questionnaires returned to Pierce County. The tabulated results of the Fall 2007 Questionnaire were provided to the County in electronic format.

In general, the results of the questionnaire indicate the following:

- Almost all of the respondents own a single-family, lakefront residence with landscaping that they water and fertilize.
- Greater than 70 percent of respondents believe that water quality is not a problem in Lake Tapps.
- More than 40 percent of respondents believe there is a weed (primarily milfoil) problem in the spring, summer, or fall.
- Approximately 18 percent of respondents indicated that algae blooms are a problem in Lake Tapps.
- Approximately 55 percent of respondents believe there are too many boats on the lake in the summer. Several respondents commented that speed limits and other safety practices need to be better enforced for lake boaters.
- Approximately half of the respondents would be willing to accept some limitations on the use of their property if they understood those limitations, especially regarding limits on fertilizer or pesticide use.
- Most respondents were not aware of specific flooding or habitat problems in the basin area. Twelve percent of respondents (44 respondents) identified past road or driveway flooding problems. The flooding problems identified in the Phase II survey are evaluated further in Chapter 5 of the Basin Plan.
- Only seven respondents (two percent) indicated that the septic system on their property had failed in the past. The average age of reported septic systems was 25 years, and the oldest septic system reported was 50 years old. Although not all respondents indicated that inspections were performed on their septic systems, the average date of last inspection of septic systems was 2004.

White River and Lake Tapps Basin Plan

Questionnaire

Please place completed questionnaires in the box provided at this public meeting or return by mail to the address provided at the end of the questionnaire. Please circle the letter of your choice. Questions 1 through 13 relate to Lake Tapps, questions 14 through 19 relate to flooding and habitat near the rivers and streams in this basin.

1. Which of the following best describes your property?	***Responses***
a. Single family residential (primary residence).	***361***
b. Single family residential (vacation/second residence).	***0***
c. Single family residential (rental property).	***1***
d. Multi-family residential.	***3***
e. Commercial.	***1***
f. Other. Please specify: _____	***0***

2. Which of the following best describes your property location?	***Responses***
a. Lakefront, house within 500 feet of the waters edge.	***299***
b. Lakefront, house between 500 and 1,000 feet from the waters edge.	***3***
c. Riverfront.	***22***
d. More than 1,000 feet from Lake Tapps or the White River or its tributaries.	***37***

3. Does your property have either or both of the following?	***Responses***
a. Boathouse	***51***
b. boat dock	***272***

4. If your property has a septic system, what year was it installed? _____
Responses: Prior to 1971 – 41, 1971 to 1980 – 51, 1981 to 1990 – 80, 1991 to 2000 – 60, 2001 to 2007 - 16

5. If your property has a septic system, what year was it last checked? _____
Responses: Prior to 2000 – 14, 2001 to 2004 – 65, 2005 to 2007 – 169

6. If your property has a septic system, has it ever failed? If so, when? _____
Responses: No – 251, Yes – 7

7.	
Is your yard landscaped?	***Yes – 347, No – 14***
If so, do you water the landscaping?	***Yes – 303, No – 54***
Do you fertilize?	***Yes – 273, No – 79***

8. Do you think water quality is a problem for the lake?	***Responses***
a. Yes	***87***
b. No	***262***

9. If you answered 'yes' to question 8, is it a problem all year or only at certain times of the year?

	Responses
a. All year	***25***
b. Certain times of year	***59***

10. If water quality is a problem only at certain times of the year, during which season(s) does the problem seem to be greatest?

	Responses
a. Spring	***10***
b. Summer	***50***
c. Fall	***12***
d. Winter	***8***

11. In this section, let us know what kind of problems Lake Tapps has, and in what season the problems appear.	Spring	Summer	Fall	Winter	All year	Not a problem
Weeds	***43***	***146***	***48***	***0***	***13***	***139***
Siltation	***35***	***26***	***10***	***6***	***13***	***223***
Bank erosion	***12***	***56***	***13***	***2***	***16***	***219***
Lack of fish	***11***	***16***	***14***	***14***	***54***	***211***
Swimmer's itch	***1***	***17***	***2***	***0***	***2***	***277***
Algae and algal blooms	***12***	***65***	***20***	***1***	***3***	***224***
Too many boats	***12***	***201***	***9***	***0***	***10***	***118***
Odor from lake	***8***	***8***	***11***	***16***	***0***	***277***

12. Would you be willing to accept some limitations on your use of private property to protect stream corridors, fish and other wildlife, or the water quality of Lake Tapps?

Responses: No – 167, Yes – 180

13. If 'yes', please indicate below which limits might be acceptable to you. (Circle all that apply.)

	Responses
a. maintenance of vegetated buffer zones along streams or Lake Tapps	***105***
b. limits on extent of paved or other impermeable surfaces	***118***
c. limits on fertilizer or pesticide use	***160***
d. retention of a proportion of the tree canopy	***88***

Flooding and Habitat

14. Are you aware of any past flooding that have damaged buildings? If so, when and where did this happen and what were the circumstances?

Responses: No – 329, Yes – 17

15. Are you aware of any past road or driveway flooding? If so, when and where did this happen and what were the circumstances?

Responses: No – 303 Yes – 44

16. Are you aware of any locations where stream banks are collapsing or eroding severely? If so, when and where did this happen?

Responses: No – 336, Yes – 10

17. Are you aware of any problems with fish habitat on streams or rivers? If so, where? Are there any areas that would benefit from habitat enhancements? If so, where?

Responses: No – 314, Yes – 27

18. Are there any areas that would benefit from habitat enhancements? If so, when and where?

Responses: No – 257, Yes – 27

19. Which of the following have you experienced in your present residence because of floods? (Circle all that apply.)

	Responses
a. cracks in basement walls, floor, or foundation	***9***
b. cracking or settlement in yard	***11***
c. water damages to house or structure	***10***
d. water damage to contents (furniture, appliances, personal effects, etc.)	***4***
e. storm water backup	***12***
f. sanitary sewer backup	***3***
g. evacuation from home	***0***
h. transportation disruption	***5***
i. lost income because of missed work or business closings	***3***
j. bodily injury	***0***
k. anxiety, mental distress	***6***
l. disruption to your property by emergency flood fighting	***5***
m. lowered property values	***5***
n. other:_____	***2***
o. none	***284***

Information

20. May we contact you for further information?
Responses: No – 87, Yes – 196

21. How would you like to be kept informed about this study? (Circle your preference.)

	Responses
a. public meetings	***51***
b. newspaper	***125***
c. brochures	***119***
d. e-mail	***242***

22. What is your name, address, telephone number and email address? (OPTIONAL)

Responses not included here

Additional comments:

283 people offered additional comments.

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix B

Subbasin Delineation Method

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix B

Subbasin Delineation Method

This appendix outlines the delineation methodology used to create 10 subbasins within the White River basin. Delineation of the subbasins allows the physical characteristics of the basin, major components of the river system, and land development to be discussed in logical geographic areas relative to issues Pierce County may need to address in developing a basin plan.

Subbasin delineation used the following procedure to delineate the subbasin boundaries and create a final polygon coverage:

- 10-Meter Digital Elevation Models (DEMs) were obtained from the Regional Ecosystem Office website on November 29, 2004 (http://www.reo.gov/gis/data/DEMFiles/northwest.asp). DEMs are a raster grid of elevation values derived from the U.S. Geological Service 7.5 minute topographic series. Complete meta-data for the DEMs is located at: http://edc.usgs.gov/products/elevation/dem.html.

- A mosaic was made of adjacent DEM grids to create, a continuous DEM, or merged grid, that covered the White River Basin and surrounding area. The mosaic process in ArcInfo Workstation uses a weighted average method to calculate values of grid cells in the overlapping area and minimizes abrupt transition between the grids.

- The merged grid was then used to create a three-dimensional depiction of topography (shaded relief), typically called a "hillshade map." The hillshade map provides an easy way to visually identify topographic divides in watersheds and basins.

- Initially, closed topographic drainage areas in the basin were delineated using an algorithm created by the GIS operator in ArcInfo 9. The divides were then further refined based on visual inspection and interpretation using WDFW river stream line coverage for comparison to drainage patterns, existing Pierce County basin boundary coverage and discussions with Pierce County.

- The final step was digitization of the subbasin boundaries into a ArcInfo polygon coverage. Coverage was developed according to Pierce County Basin Plan GIS standards.

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix C

Methods Used to Estimate Impervious Surfaces and Analyze Land Use and Zoning

Appendix C
Methods Used to Estimate Impervious Surfaces and Analyze Land Use and Zoning

The methods used to analyze land use, zoning and estimate percent impervious surface insubbasins of the White River Basin are described below. Data used in the analyses were provided by Pierce County and King County as GIS data sets, updated through January 2005.

Pierce County Published Estimates of Percent Impervious Surface

Land use affects surface water hydrology by altering the landscape from its natural condition and changing water drainage, storage, and evaporation characteristics. The creation of impervious surfaces such as roads, buildings, and parking areas has a particularly important impact. Impervious surfaces block precipitation from soaking into the ground (infiltration) and reduce the presence of vegetated areas available to take up precipitation, as occurs under natural conditions. Therefore, the effect of various land uses on surface water hydrology is taken into consideration by estimating the percentage of each subbasin area covered by impervious surfaces.

Pierce County has studied and published estimated percent pervious surface for a broad number of land uses. These estimates are found in the *Guidance for Basin Planning*, Appendix F (Pierce County 2000). Generally, the county used aerial photographs of representative parcels in Pierce County to determine the average percentage of parcel areas covered by impervious surfaces for specific types of land use ("impervious categories") present in the County. In the document, the County provides two estimates; an average percent impervious surface and an effective percent impervious surface.

Selection of Impervious Values

The imperviousness analysis in the *Guidance for Basin Planning* provided two possible results for each land use type: the average value calculated from the aerial photograph review ("the average value") and a modified value (effective impervious) that estimated the impact of hydraulically connected and unconnected surfaces on the average value ("the hydraulically connected value").

Although considering the impact of hydraulically connected and unconnected surfaces is important, it is a highly variable factor that is difficult to extrapolate from one parcel to the next due to differences in parcel slopes, vegetation, soils, and site design. The average values are either very similar to or slightly more conservative than the hydraulically connected values, and the average values provide a reasonable data set to utilize in the face of uncertainties about hydraulic connectivity related to individual parcels. Therefore, for the purposes of estimating impervious surfaces in the White River Basin, the average values of imperviousness were used instead of the hydraulically connected values.

A summary of the average values of imperviousness by land use category is provided in Tables C-1 and C-2. Impervious values are rounded to the nearest one percent. Table C-2 correlates parcel size and imperviousness for low density residential parcels. However, no reference was

provided in Appendix F of the Guidance for Basin Planning (Pierce County 2000) for use in selecting impervious values for resource land and open space parcels. Therefore, URS used the general guidelines developed for the Key Peninsula-Islands Basin Plan (Pierce County 2004b) to apply impervious values to parcels. The general guidelines are as follows:

- Except as listed below, the Open Space impervious category utilized the impervious values listed in Tables C-1 and C-2. For the Open Space impervious categories that are listed below, utilize the following impervious values unless aerial photograph analysis indicates another value is more appropriate:

  Communication (4700): 5%
  Utilities/Refuse (4800): 7%
  Well Sites (4836): 5%
  Cemeteries (6242): 9%
  Drainfields/Catchbasins (4830): 5%

- Except as listed below, the Resource Land impervious category utilized the impervious values listed in Tables C-1 and C-2. For the Resource Land impervious category listed below, utilize the following impervious values, unless aerial photograph analysis indicates another value is more appropriate:

  Fishing Activities (8400): 9%

Summary of White Rive Basin Methodology

It is important to note that the results of the impervious surface analysis are calculated estimates made with the best information available for a broad investigation. The results will be used in Phase II of this study, along with other data on physical basin characteristics, as inputs for hydrologic and hydraulic models of subbasins. These models will be used to evaluate potential existing and future areas of concern for flooding. In addition, the impervious surface analysis results will be a part of general information about subbasin characteristics as they relate to surface water and riparian habitat conditions.

It is possible that certain parcels may be incorrectly identified by the County Tax Assessor codes and thus may not be appropriately categorized for the impervious surface analysis. Extensive efforts have been made to ensure that this situation has not occurred on a widespread basis. However, resources are not available to analyze aerial photographs of each parcel to fully eliminate this uncertainty for a basin-wide analysis.

The impervious categories into which parcels in the White River Basin were grouped for the impervious surface analysis were more specific than is desirable for an overall analysis of land use and also focused on a different purpose than a land use analysis. Traditional land use categories are intended to group parcels according to similar functions or uses for society. Therefore, a separate land use analysis was performed for the White River Basin using land use categories evaluated in other Pierce County Basin Plans, such as the Key Island Peninsula Basin Plan. The impervious categories were grouped to simplify analysis.

The land use categories evaluated included the following (with examples of typical parcels in the White River Basin listed below each category):

- Civic: Schools, roads, religious centers, parks, libraries, fire stations, and post offices
- Commercial: Shopping centers, restaurants, gas stations, banks, offices, marinas, and motels
- Industrial: Furniture manufacturers, metal fabricators, and food product manufacturers
- Other: Golf courses, cemeteries, resort camps, communications, and utilities/refuse
- Residential: Single family homes, duplexes, apartment buildings, and manufactured homes
- Resource Use: Agriculture, fishing activities, quarries, and timberland
- Vacant: Vacant commercial, industrial, and residential land
- Water: Lakes and saltwater tidelands
- Unknown: Parcels with no GIS data provided

Based on the descriptions of the Use Codes provided by Pierce and King County, Use Codes were assigned to an impervious category. In most cases, the appropriate impervious category for a Use Code was easily determined. However, certain Use Codes were ambiguous or otherwise difficult to categorize. In such cases, URS analyzed aerial photographs of representative parcels in the ambiguous Use Codes to determine the appropriate impervious categories and corresponding impervious values. Aerial photographic analysis was performed to categorize the following Use Codes: unknown (0000), communications (4700), utilities/refuse (4800), drainfields (4830), well sites (4836), recreational activities (7400), and fishing activities (8400) in Pierce County, and sheds/garages (18300) in King County. In addition, URS supplemented Use Codes with zoning information to categorize the projected future conditions of currently undeveloped parcels.

For developed land, it was assumed that existing impervious categories would remain the same in the future. The future condition was assumed to describe full build-out of the basin. Full build-out of the basin was projected by assuming that vacant parcels identified by the County Tax Assessor will convert to the identified land uses of the parcels. For instance, parcels in Pierce County currently identified as “Residential Vacant Land” by the Tax Assessor (Use Code 9100) will convert from vacant land to low density residential land.

Tables C-3 and C-4 summarize land use and estimated percent of impervious surface by subbasin. The assignment of land use categories for parcels under existing and projected future conditions in Pierce and King Counties shown reflect the method described above. A complete list of Use Codes is not included in this appendix.

Table C-1
Percent of Impervious Surface Estimated by Land Use Categories

Land Use Category		Average % Imperviousness per Category
Residential	Low-Density Residential (includes single family residential, duplex, and triplex)	(see Table 2 for details)
	High-Density Residential (fourplex)	44
	Multi Family Residential	50
	Mobile Home	23
	RV Park	55
Institutional	Group Home	26
	College	37
	Secondary School	28
	Elementary School	24
	Religious Center	50
	Public Places	47
	Quasi Public	79
Industrial		67
Commercial		83
Agricultural Land		4
Resource Land (Quarry, etc.)		Will be evaluated individually
Open Space		5–9
Roadway – Local, Subdivision		46
Roadway – Major, Highway/Freeway		51

Source: Pierce County (2000)

Table C-2
Percent of Impervious Surface Estimated for Low Density Residential

Land Use Category	Lot size (acres)	Average Total % Imperviousness per Category
Low-Density Residential (includes single family residential, duplex, and triplex)	<0.25	35
	0.25-0.35	30
	0.35-0.50	25
	0.50-0.75	18
	0.75-1.00	16
	1.00-2.00	12
	2.00-5.00	8
	5.00-10.00	5
	10.00-20.00	3
	>20.00	2

Source: Pierce County (2000)

Table C-3

Summary of Current Land Use and Estimated Percent of Average Impervious Surface by Subbasin

Summary of Current land Use

	Lake Tapps	Lower White River	Mud Mountain	Middle White	Greenwater River	Claerwater River	Upper White	West Fork, Huckelberry, Frying Pan*	Total (acres)	Percent of Land Use in Basin
Agricultural Land	1,542	9,615	1,742	0	0	0	0	0	**12,899**	**4.1%**
College	253	0	0	0	0	0	0	0	**253**	**0.1%**
Commercial	142	894	150	142	0	0	0	0	**1,328**	**0.4%**
Elementary Schools	51	24	0	0	0	0	0	0	**75**	**0.0%**
Group Home	5	7	0	0	0	0	0	0	**12**	**0.0%**
High Density Residential	8	15	0	0	0	0	0	0	**23**	**0.0%**
Industrial	2	135	0	0	0	0	0	0	**137**	**0.0%**
Low Density Residential	3,588	4,437	2,096	28	7	0	4,316	0	**14,470**	**4.6%**
Mobile Home	549	633	9	0	0	0	8	0	**1,200**	**0.4%**
Multifamily Residential	13	1,465	0	0	0	0	0	0	**1,478**	**0.5%**
Open Space	4,261	4,473	2,176	62	5,403	0	103	0	**16,478**	**5.2%**
QuasiPublic	36	73	0	0	0	0	0	0	**109**	**0.0%**
Religious Center	25	25	0	0	0	0	0	0	**49**	**0.0%**
Resource Land	328	429	37,879	31,741	23,025	8,720	10,494	125,129	**237,745**	**74.9%**
Roads	79	471	0	0	0	0	0	0	**551**	**0.2%**
Roadways Major	5	0	0	0	0	0	0	0	**5**	**0.0%**
Secondary Schools	81	74	0	0	0	0	0	0	**155**	**0.0%**
Surface Water	1,743	48	0	1	0	0	0	0	**1,791**	**0.6%**
Unknown Land Use	11	14,173	5,558	5,087	3,916	0	0	0	**28,745**	**9.1%**
Total subbasin area	**12,722**	**36,990**	**49,610**	**37,061**	**32,351**	**8,720**	**14,921**	**125,129**	**317,504**	**100.0%**

Summary of Average Impervious Surface

	Lake Tapps	Lower White River	Mud Mountain	Middle White River	Greenwater River	Clearwater River	Upper White River	West Fork, Huckelberry, Frying Pan*
Agricultural Land (acres)	12.1%	26.0%	3.5%	0.0%	0.0%	0.0%	0.0%	0.0%
College (acres)	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Commercial (acres)	1.1%	2.4%	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%
Elemen-tary Schools (acres)	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Group Home (acres)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High Density Resi-dential (acres)	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Industrial (acres)	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low Density Resi-dential (acres)	28.2%	12.0%	4.2%	0.1%	0.0%	0.0%	28.9%	0.0%
Mobile Home (acres)	4.3%	1.7%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Multi-family Resi-dential (acres)	0.1%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Open Space (acres)	33.5%	12.1%	4.4%	0.2%	16.7%	0.0%	0.7%	0.0%
Quasi-Public (acres)	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Religious Center (acres)	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Resource Land (acres)	2.6%	1.2%	76.4%	85.6%	71.2%	100.0%	70.3%	100.0%
Roads (acres)	0.6%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Roadways Major (acres)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Secondary Schools (acres)	0.6%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Surface Water (acres)	13.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Unknown Land Use (acres)	0.1%	38.3%	11.2%	13.7%	12.1%	0.0%	0.0%	0.0%
Total sub-basin area (acres)	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Summary of Current land Use Using Aggreated Catagories

	Lake Tapps	Lower White River	Mud Mountain	Middle White	Greenwater River	Clearwater River	Upper White	West Fork, Huckelberry, Frying Pan*	Total	Percent of Land Use in Basin
Agricultural Land (acres)	1,542	9,615	1,742	0	0	0	0	0	**12899.4**	**4.1%**
Civic	530	667	0	0	0	0	0	0	**1,197**	**0.4%**
Commercial (acres)	142	894	150	142	0	0	0	0	**1,328**	**0.4%**
Residential	4,163	6,557	2,105	28	7	0	4,324	0	**17,184**	**5.4%**
Industrial (acres)	2	135	0	0	0	0	0	0	**137**	**0.0%**
Open Space (acres)	4,261	4,473	2,176	62	5,403	0	103	0	**16,478**	**5.2%**
Resource Land (acres)	328	429	37,879	31,741	23,025	8,720	10,494	125,129	**237,745**	**74.9%**
Surface Water (acres)	1,743	48	0	1	0	0	0	0	**1,791**	**0.6%**
Unknown Land Use (acres)	11	14,173	5,558	5,087	3,916	0	0	0	**28,745**	**9.1%**
Total sub-basin area (acres)	**12,722**	**36,990**	**49,610**	**37,061**	**32,351**	**8,720**	**14,921**	**125,129**	**317,504**	**100.0%**

Summary of Average Impervious Surface by Aggreated Catagories

	Lake Tapps	Lower White River	Mud Mountain	Middle White	Greenwater River	Clearwater River	Upper White	West Fork, Huckelberry, Frying Pan*
Agricultural Land (acres)	12.1%	26.0%	3.5%	0.0%	0.0%	0.0%	0.0%	
Civic	4.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	
Commercial (acres)	1.1%	2.4%	0.3%	0.4%	0.0%	0.0%	0.0%	
Residential	32.7%	17.7%	4.2%	0.1%	0.0%	0.0%	29.0%	
Industrial (acres)	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	
Open Space (acres)	33.5%	12.1%	4.4%	0.2%	16.7%	0.0%	0.7%	
Resource Land (acres)	2.6%	1.2%	76.4%	85.6%	71.2%	100.0%	70.3%	100.0%
Surface Water (acres)	13.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
Unknown Land Use (acres)	0.1%	38.3%	11.2%	13.7%	12.1%	0.0%	0.0%	
Total sub-basin area (acres)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes:

Basin areas are approximate because they are based on the nearest tax parcel boundary to the basin boundary. Tax parcels that spanned the basin boundary were included in one of the 2 basins (not both). For this reason these basir areas differ from those calculated by the basin boundary.

Table C-4

Summary of Future Land Use and Estimated Percent of Average Impervious Surface By Subbasin

Summary of Current land Use

	Lake Tapps	Lower White River	Mud Mountain	Middle White	Greenwater River	Claerwater River	Upper White	West Fork, Huckelberry, Frying Pan*	Total	Percent of Land Use in Basin
Agricultural Land (acres)	1,542	9,615	1,742	0	0	0	0		**12,899**	**4.1%**
College (acres)	253	0	0	0	0	0	0		**253**	**0.1%**
Commercial (acres)	521	1,534	150	145	0	0	0		**2,350**	**0.7%**
Elemen-tary Schools (acres)	51	24	0	0	0	0	0		**75**	**0.0%**
Group Home (acres)	5	7	0	0	0	0	0		**12**	**0.0%**
High Density Residential (acres)	8	15	0	0	0	0	0		**23**	**0.0%**
Industrial (acres)	2	811	0	0	0	0	0		**813**	**0.3%**
Low Density Resi-dential (acres)	5,463	6,524	4,142	85	15	0	4,405		**20,633**	**6.5%**
Mobile Home (acres)	549	633	9	0	0	0	8		**1,200**	**0.4%**
Multi-family Resi-dential (acres)	13	1,465	0	0	0	0	0		**1,478**	**0.5%**
Open Space (acres)	2,007	1,069	129	2	5,395	0	14		**8,616**	**2.7%**
Quasi-Public (acres)	36	73	0	0	0	0	0		**109**	**0.0%**
Religious Center (acres)	25	25	0	0	0	0	0		**49**	**0.0%**
Resource Land (acres)	328	429	37,879	31,741	23,025	8,720	10,494	125,129	**237,745**	**74.9%**
Roads (acres)	79	471	0	0	0	0	0		**551**	**0.2%**
Roadways Major (acres)	5	0	0	0	0	0	0		**5**	**0.0%**
Secondary Schools (acres)	81	74	0	0	0	0	0		**155**	**0.0%**
Surface Water (acres)	1,743	48	0	1	0	0	0		**1,791**	**0.6%**
Unknown Land Use (acres)	11	14,173	5,558	5,087	3,916	0	0		**28,745**	**9.1%**
Total sub-basin area (acres)	**12,722**	**36,990**	**49,610**	**37,061**	**32,351**	**8,720**	**14,921**	**125,129**	**317,504**	**100.0%**

Summary of Average Impervious Surface

	Lake Tapps	Lower White River	Mud Mountain	Middle White	Greenwater River	Claerwater River	Upper White	West Fork, Huckelberry, Frying Pan*
Agricultural Land (acres)	12.1%	26.0%	3.5%	0.0%	0.0%	0.0%	0.0%	
College (acres)	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Commercial (acres)	4.1%	4.1%	0.3%	0.4%	0.0%	0.0%	0.0%	
Elementary Schools (acres)	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
Group Home (acres)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
High Density Residential (acres)	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Industrial (acres)	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	
Low Density Residential (acres)	42.9%	17.6%	8.3%	0.2%	0.0%	0.0%	29.5%	
Mobile Home (acres)	4.3%	1.7%	0.0%	0.0%	0.0%	0.0%	0.1%	
Multi-family Residential (acres)	0.1%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Open Space (acres)	15.8%	2.9%	0.3%	0.0%	16.7%	0.0%	0.1%	
Quasi-Public (acres)	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	
Religious Center (acres)	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
Resource Land (acres)	2.6%	1.2%	76.4%	85.6%	71.2%	100.0%	70.3%	100.0%
Roads (acres)	0.6%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	
Roadways Major (acres)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Secondary Schools (acres)	0.6%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	
Surface Water (acres)	13.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
Unknown Land Use (acres)	0.1%	38.3%	11.2%	13.7%	12.1%	0.0%	0.0%	
Total sub-basin area (acres)	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Summary of Current land Use Using Aggreated Catagories

	Lake Tapps	Lower White River	Mud Mountain	Middle White	Greenwater River	Claerwater River	Upper White	West Fork, Huckelberry, Frying Pan*	Total	Percent of Land Use in Basin
Agricultural Land (acres)	1,542	9,615	1,742	0	0	0	0		**12,899**	**4.1%**
Civic	530	667	0	0	0	0	0	0	**1,197**	**0.4%**
Commercial (acres)	521	1,534	150	145	0	0	0		**2,350**	**0.7%**
Residential	6,038	8,644	4,151	85	15	0	4,413	0	**23,346**	**7.4%**
Industrial (acres)	2	811	0	0	0	0	0		**813**	**0.3%**
Open Space (acres)	2,007	1,069	129	2	5,395	0	14		**8,616**	**2.7%**
Resource Land (acres)	328	429	37,879	31,741	23,025	8,720	10,494	125,129	**237,745**	**74.9%**
Surface Water (acres)	1,743	48	0	1	0	0	0		**1,791**	**0.6%**
Unknown Land Use (acres)	11	14,173	5,558	5,087	3,916	0	0		**28,745**	**9.1%**
Total sub-basin area (acres)	**12,722**	**36,990**	**49,610**	**37,061**	**32,351**	**8,720**	**14,921**	**125,129**	**317,504**	**100.0%**

Summary of Average Impervious Surface by Aggreated Catagories

	Lake Tapps	Lower White River	Mud Mountain	Middle White	Greenwater River	Clearwater River	Upper White	West Fork, Huckelberry, Frying Pan*
Agri-cultural Land (acres)	12.1%	26.0%	3.5%	0.0%	0.0%	0.0%	0.0%	
Civic	4.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	
Commercial (acres)	4.1%	4.1%	0.3%	0.4%	0.0%	0.0%	0.0%	
Residential	47.5%	23.4%	8.4%	0.2%	0.0%	0.0%	29.6%	
Industrial (acres)	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	
Open Space (acres)	15.8%	2.9%	0.3%	0.0%	16.7%	0.0%	0.1%	
Resource Land (acres)	2.6%	1.2%	76.4%	85.6%	71.2%	100.0%	70.3%	100.0%
Surface Water (acres)	13.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	
Unknown Land Use (acres)	0.1%	38.3%	11.2%	13.7%	12.1%	0.0%	0.0%	
Total sub-basin area (acres)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes:

Basin areas are approximate because they are based on the nearest tax parcel boundary to the basin boundary. Tax parcels that spanned the basin boundary were included in one of the 2 basins (not both). For this reason these basin areas differ from those calculated by the basin boundary.

Appendix D

Lake Tapps Water Quality Monitoring Data

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	ECOLOGY
STATION NO./	**7/7/04**	**8/11/04**	**8/25/04**	**8/31/04**	**9/2/04**	**9/15/04**	**9/16/04**	**9/21/04**	**10/1/04**	**10/6/04**	**10/14/04**	**11/8/04**
FLOW (cfs) (Ecology, 2006)	**245**	**197**				**199**				**111**		**0**
Temperature (ºC)												
criterion	20	20	20	20	20	20	20	20	20	20	20	20
URS1(E7, inlet)			19.74		14.2		11.76				15.2	
URS2			20.35		19.86		15.9				15.9	
E6	21.9	24.7				18.4				17.3		
URS3(E1)	21.4	24.7	21.76		20.83	18.1	18.11			16.8	16.2	
URS4			21.89				18.25				16.1	
E4	21.7	24.8				18.6				17.4		
URS5			22.38		21.8		18.93				16.9	
URS6(E9, outlet)			22.22		21.27		18.66				16.1	
URS7					21.31		17.79				16.3	
URS8(E5)	21.5	24.8	21.96		21.27	18.6	18.63			17	16.4	
URS9			21.96		21.66		18.65				15.9	
Average	21.63	24.75	21.53		20.28	18.43	17.41			17.13	16.11	
upper 95% limit	21.85	24.81	22.48		22.80	18.66	19.71			17.40	16.57	
lower 95% limit	21.40	24.69	20.58		17.75	18.19	15.11			16.85	15.65	
Dissolved Oxygen (mg/L)												
criterion	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	
URS1(E7, inlet)			8.3		9.8		10.73				10.6	
URS2			8.38		8.5		9.41				10.6	
E6	8.4	8.5				9.66				9.26		
URS3(E1)	8.78	8.53	8.22		7.6	9.27	9.21			9.5	10	
URS4			8.89				9.69			9.5	10.1	
E4	8.5	8.3				8.55				9.21		
URS5			7.83		7.8		8.63				10.2	
URS6(E9, outlet)			8.07		8.3		8.76				10.5	
URS7					8.1		9.01				10.6	
URS8(E5)	8.6	8.41	8.11		8	8.38	8.79			9.44	10.5	
URS9	8.77	8.77	8.77		8.77	8.77	8.77			8.77	10.5	
Average	8.61	8.50	8.32		8.36	8.93	9.22			9.28	10.40	
upper 95% limit	8.78	8.68	8.68		9.05	9.46	9.89			9.56	10.63	
lower 95% limit	8.44	8.33	7.97		7.67	8.40	8.56			9.00	10.17	

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	URS	URS	ECOLOGY	ECOLOGY	ECOLOGY	ECOLOGY	URS	ECOLOGY	URS	ECOLOGY	URS
STATION NO./	**11/11/04**	**11/23/04**	**12/6/04**	**1/19/05**	**2/8/05**	**3/8/05**	**3/31/05**	**4/5/05**	**5/3/05**	**5/10/05**	**5/26/05**
FLOW (cfs) (Ecology, 2006)	**0**	**0**	**0**	**0**	**0**	**0**		**606**		**208**	
Temperature (ºC)											
criterion	20	20	20	20	20	20	20	20	20	20	20
URS1(E7, inlet)	8.9								14.3		15.6
URS2	9.3								14.8		16.8
E6										16.1	
URS3(E1)	10.7			5.6		12.1	8.2		15.2	15.5	16.9
URS4	10.8						8.6		15.2		16.2
E4				5.8		12.9				16.1	
URS5	10.7								16.3		17.5
URS6(E9, outlet)	10.7						8.9		15.2		16.4
URS7	9.3								15.8		18.1
URS8(E5)	10.5					12.8	8.9		15.5	15.8	17
URS9	10.7								15.2		16.5
Average	10.18			5.70		12.60	8.65		15.28	15.88	16.78
upper 95% limit	10.95			5.84		13.04	8.98		15.85	16.16	17.51
lower 95% limit	9.41			5.56		12.16	8.32		14.71	15.59	16.05
Dissolved Oxygen (mg/L)											
criterion	6.5	6.5					6.5		6.5		6.5
URS1(E7, inlet)	12.1								10.4		10.6
URS2	12.1								10.5		10.6
E6										10.34	
URS3(E1)	10.6						10.2		9.9		10.5
URS4	10.3			12.4		12.43	12.6		10.7		10.5
E4				12.7		11.68				10.76	
URS5	10.6								9.1		10
URS6(E9, outlet)	10.6						10.4		13.1		10
URS7	11								9.6		10
URS8(E5)	10.9					12.31	10.7		9.7	10.94	10
URS9	10.5								9.8		10.2
Average	10.97			12.55		12.14	10.98		10.31	10.68	10.27
upper 95% limit	11.64			12.76		12.54	12.08		11.47	10.99	10.55
lower 95% limit	10.29			12.34		11.74	9.87		9.15	10.37	9.99

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	URS	URS	URS	URS	MIFTD	URS	MIFTD	MIFTD	MIFTD
STATION NO./	6/7/05	6/9/05	6/23/05	7/14/05	7/28/05	7/28/05	8/11/05	8/17/05	8/31/05	9/28/05
FLOW (cfs) (Ecology, 2006)	286									
Temperature (ºC)										
criterion	20	20	20	20	20	20	20	20	20	20
URS1(E7, inlet)		10.9	19	19.9	23.2		22.8			
URS2		16.1	19.2	21.1	23.9		23.2			
E6	17.3									
URS3(E1)	17	17	19.5	20.9	24		23.1			
URS4		16.6	19.2	20.6	23.3		22.9			
E4	17.2									
URS5		17.3	19.7	21	23.9		23.5			
URS6(E9, outlet)		17.2	19.6	21	23.4		22.9			
URS7		17.3	20.1	21.4	24.6		23.2			
URS8(E5)	17.2	17	19.9	20.8	23.7		23.2			
URS9		17.4	20	20.9	23.1		23			
Average	17.18	16.31	19.58	20.84	23.68		23.09			
upper 95% limit	17.30	18.38	19.96	21.26	24.16		23.30			
lower 95% limit	17.05	14.24	19.19	20.43	23.20		22.87			
Dissolved Oxygen (mg/L)										
criterion		6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
URS1(E7, inlet)		11.5	9.3	8	8.2		7.6			
URS2		10.1	9	8.9	7.7		7.9			
E6	9.71									
URS3(E1)		9.8	8.8	8.6	7.8		7.8			
URS4	9.45	10.2	9	8.8	8.1		8.2			
E4	9.32									
URS5		9.4	9	8.4	7.6		7.7			
URS6(E9, outlet)		9.5	9.7	8.3	7.5		7.9			
URS7		9.2	8.1	8.3	7.8		7.4			
URS8(E5)	9.45	9.8	9.4	8.4	7.9		7.7			
URS9		9.6	9.1	8.6	8.5		7.9			
Average	9.48	9.90	9.04	8.48	7.90		7.79			
upper 95% limit	9.65	10.58	9.49	8.76	8.22		8.01			
lower 95% limit	9.32	9.22	8.60	8.20	7.58		7.56			

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	ECOLOGY
STATION NO./	**7/7/04**	**8/11/04**	**8/25/04**	**8/31/04**	**9/2/04**	**9/15/04**	**9/16/04**	**9/21/04**	**10/1/04**	**10/6/04**	**10/14/04**	**11/8/04**
FLOW (cfs) (Ecology, 2006)	**245**	**197**				**199**				**111**		**0**
pH (SU)												
criterion	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
criterion	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
URS1(E7, inlet)			6.17		6.7		7.75				7.21	
URS2			6.22		6.8		7.83				7.09	
E6	7.33	7.91				7.73				7.61		
URS3(E1)	7.46	8.16	6.39		7.11	7.7	8.25			7.48	7.18	
URS4							8.39				6.74	
E4		8.14				7.57				7.4		
URS5			6.14		6.74		7.68				7.18	
URS6(E9, outlet)			6.18		6.74		7.68				7.15	
URS7					6.78		7.77				7.27	
URS8(E5)		7.95	6.22		6.83	7.38	7.74			7.44	7.21	
URS9			6.11		6.76		7.67				7.1	
Average	7.39	8.03	6.20		6.79	7.57	7.81			7.48	7.10	
upper 95% limit	7.48	8.15	6.29		6.92	7.73	8.07			7.57	7.25	
lower 95% limit	7.30	7.90	6.11		6.66	7.41	7.54			7.38	6.94	
Total Phosphorous (mg/L)												
criterion	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Diversion	0.155	0.578		0.156		0.0677		0.024		0.0435		0.011
URS1(E7, inlet)	0.0411	0.0193	0.109	0.053	0.093	0.031	0.043	0.014	0.041	0.0055	0.019	0.0092
URS2			0.124		0.037		0.068		0.018		0.016	
E6	0.0077	0.0109				0.0095				0.0047		
URS3(E1)	0.0038	0.0041	0.008	0.01	0.008	0.0086	0.01	0.008	0.01	0.0034	0.01	
URS4			0.006		0.006		0.01		0.01		0.012	
E4	0.0039	0.0033				0.0057				0.0031		
URS5			0.012	0.008	0.005		0.008	0.008	0.007		0.009	
URS6(E9, outlet)	0.026		0.009	0.059	0.007	0.013	0.009	0.016	0.008	0.022	0.008	
URS7			0.018		0.011		0.071		0.014		0.009	
URS8(E5)	0.0039	0.0042	0.018		0.007	0.0049	0.015		0.01	0.0044	0.008	
URS9	0.0091	0.0258	0.006		0.006	0.0127	0.007		0.008	0.0224	0.011	0.0062
Average	0.014	0.011	0.034	0.033	0.020	0.012	0.027	0.012	0.014	0.009	0.011	0.008
upper 95% limit	0.028	0.021	0.081	0.060	0.049	0.021	0.053	0.016	0.025	0.018	0.015	0.010
lower 95% limit	-0.001	0.002	-0.012	0.005	-0.009	0.003	0.000	0.007	0.003	0.001	0.008	0.006

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	URS	URS	ECOLOGY	ECOLOGY	ECOLOGY	ECOLOGY	URS	ECOLOGY	URS	ECOLOGY	URS
STATION NO./	**11/11/04**	**11/23/04**	**12/6/04**	**1/19/05**	**2/8/05**	**3/8/05**	**3/31/05**	**4/5/05**	**5/3/05**	**5/10/05**	**5/26/05**
FLOW (cfs) (Ecology, 2006)	**0**	**0**	**0**	**0**	**0**	**0**		**606**		**208**	
pH (SU)											
criterion	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
criterion	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
URS1(E7, inlet)	6.8								8		7.5
URS2	7								7.6		7.8
E6										7.7	
URS3(E1)	6.45			7.6		8.8	7.2		7.6	8	7.9
URS4	6.1						7.5		7.6		7.7
E4				7.5		8.6				8.1	
URS5	7					8.9			7.9	8	7.8
URS6(E9, outlet)	7						7.7		7.6		7.7
URS7	6.9								8.1		7.6
URS8(E5)	7.1						7.6		7.6		7.8
URS9	7								7.5		7.7
Average	6.67			7.55		8.75	7.46		7.68	7.92	7.71
upper 95% limit	7.00			7.62		8.90	7.67		7.90	8.09	7.83
lower 95% limit	6.34			7.48		8.60	7.24		7.46	7.75	7.59
Total Phosphorous (mg/L)											
criterion	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Diversion			0.0116	0.734	0.0343	0.0084		0.0133		0.1	
URS1(E7, inlet)	0.017	0.02	0.022	0.258	0.0333	0.0616		0.0116	0.014	0.0095	0.013
URS2	0.008	0.02							0.013		0.015
E6										0.004	
URS3(E1)	0.011	0.009		0.0103		0.0124	0.015		0.01	0.0037	0.008
URS4	0.011	0.013					0.013		0.017		0.009
E4				0.0028		0.0039				0.0058	
URS5	0.008	0.014							0.009		0.029
URS6(E9, outlet)	0.007	0.008					0.011	0.0091	0.029		0.01
URS7	0.021	0.013							0.035		0.013
URS8(E5)	0.01	0.009				0.007	0.044		0.008	0.0036	0.01
URS9	0.007	0.009	0.0047	0.006	0.0078	0.0088		0.091	0.011	0.0058	0.008
Average	0.011	0.013	0.013	0.069	0.021	0.019	0.021	0.037	0.016	0.005	0.013
upper 95% limit	0.016	0.017	0.026	0.195	0.039	0.043	0.036	0.084	0.026	0.008	0.019
lower 95% limit	0.006	0.008	0.001	-0.057	0.003	-0.005	0.005	-0.009	0.007	0.003	0.006

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	URS	URS	URS	URS	MIFTD	URS	MIFTD	MIFTD	MIFTD
STATION NO./	6/7/05	6/9/05	6/23/05	7/14/05	7/28/05	7/28/05	8/11/05	8/17/05	8/31/05	9/28/05
FLOW (cfs) (Ecology, 2006)	286									
pH (SU)										
criterion	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
criterion	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
URS1(E7, inlet)		7.4	7.4	7.5	7.4		7.4			
URS2		7.6	7.4	7.6	7.4		7.3			
E6	8.4									
URS3(E1)	8.7	7.9	7.5	7.8	7.5		7.5			
URS4		7.8	7.7	7.8	7.5		7.5			
E4	8.5									
URS5	8.4	7.6	7.6	7.7	7.4		7.5			
URS6(E9, outlet)		7.7	7.5	7.7	7.3		7.4			
URS7		7.4	7.3	7.5	7.4		7.3			
URS8(E5)		7.7	7.5	7.7	7.4		7.4			
URS9		7.7	7.6	7.9	7.6		7.5			
Average	8.48	7.62	7.48	7.67	7.43		7.41			
upper 95% limit	8.63	7.78	7.61	7.81	7.51		7.50			
lower 95% limit	8.34	7.45	7.36	7.53	7.34		7.33			
Total Phosphorous (mg/L)										
criterion	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Diversion	0.0119					0.249		0.339	0.082	0.031
URS1(E7, inlet)	0.0131	0.011	0.025	0.04	0.053	0.036	0.042	0.024	0.010	0.010
URS2		0.014	0.03	0.035	0.039		0.001			
E6	0.0054									
URS3(E1)	0.0029	0.008	0.011	0.008	0.007	0.006	0.007	0.006	0.004	0.005
URS4		0.015	0.014	0.007	0.016		0.011			
E4	0.0028									
URS5		0.009	0.01	0.014	0.019		0.01			
URS6(E9, outlet)		0.013	0.009	0.004	0.008		0.008			
URS7		0.017	0.018	0.02	0.014		0.012			
URS8(E5)	0.0037	0.014	0.014	0.011	0.01		0.014			
URS9	0.0068	0.014	0.015	0.011	0.012		0.007			
Average	0.006	0.013	0.016	0.017	0.020	0.021	0.012	0.015	0.007	0.008
upper 95% limit	0.010	0.016	0.023	0.029	0.036	0.042	0.024	0.028	0.011	0.011
lower 95% limit	0.002	0.010	0.009	0.004	0.004	0.000	0.001	0.002	0.003	0.004

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	ECOLOGY
STATION NO./	**7/7/04**	**8/11/04**	**8/25/04**	**8/31/04**	**9/2/04**	**9/15/04**	**9/16/04**	**9/21/04**	**10/1/04**	**10/6/04**	**10/14/04**	**11/8/04**
FLOW (cfs) (Ecology, 2006)	**245**	**197**				**199**				**111**		**0**
Ammonia (mg/L)												
criterion	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
Diversion	0.01	0.01				0.01				0.01		0.01
URS1(E7, inlet)			<0.04		0.07		<0.04		<0.04		0.16	0.01
URS2					0.12		<0.04		<0.04		0.16	
E6	0.01	0.01				0.01				0.01		
URS3(E1)	0.01	0.01	<0.04		0.04	0.01	<0.04		<0.04	0.01	0.15	
URS4			<0.04		<0.04		<0.04		<0.04		0.11	
E4	0.01	0.01				0.01				0.01		
URS5					0.04		<0.04		<0.04		0.14	
URS6(E9, outlet)	0.01	0.01			<0.04	0.01	<0.04		<0.04	0.01	0.16	0.01
URS7			<0.04		0.05		<0.04		<0.04		0.12	
URS8(E5)	0.01	0.01	0.05		<0.04	0.01	<0.04		<0.04	0.01	0.15	
URS9					0.05		<0.04		<0.04		0.14	
Average	0.01	0.01	0.04		0.05	0.01	0.04		0.04	0.01	0.14	0.01
upper 95% limit	0.01	0.01	0.05		0.08	0.01	0.04		0.04	0.01	0.16	0.01
lower 95% limit	0.01	0.01	0.04		0.03	0.01	0.04		0.04	0.01	0.13	0.01
Total Kjeldahl Nitrogen (TKN) (mg/L)												
criterion												
URS1(E7, inlet)			<0.5		<0.5		<0.5		<0.5		<0.5	
URS2			<0.5		<0.5		<0.5		<0.5		<0.5	
E6												
URS3(E1)			<0.5		<0.5		<0.5		<0.5		<0.5	
URS4			<0.5		0.5		<0.5		1		<0.5	
E4												
URS5			2.8		<0.5		<0.5		0.5		<0.5	
URS6(E9, outlet)			<0.5		<0.5		<0.5		<0.5		<0.5	
URS7			<0.5		<0.5		0.5		0.8		<0.5	
URS8(E5)			<0.5		<0.5		<0.5		<0.5		<0.5	
URS9			0.8		<0.5		<0.5		0.6		<0.5	
Average			0.8		0.5		0.5		0.6		0.5	
upper 95% limit			1.5		0.5		0.5		0.8		0.5	
lower 95% limit			0.0		0.5		0.5		0.4		0.5	

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	URS	URS	ECOLOGY	ECOLOGY	ECOLOGY	ECOLOGY	URS	ECOLOGY	URS	ECOLOGY	URS
STATION NO./	11/11/04	11/23/04	12/6/04	1/19/05	2/8/05	3/8/05	3/31/05	4/5/05	5/3/05	5/10/05	5/26/05
FLOW (cfs) (Ecology, 2006)	0	0	0	0	0	0		606		208	
Ammonia (mg/L)											
criterion	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
Diversion			0.01	0.01	0.01	0.01		0.017		0.01	
URS1(E7, inlet)	<0.04	<0.04	0.027	0.292	0.038	0.209		0.017	0.00	0.01	0.04
URS2	<0.04	<0.04							0.04		0.11
E6										0.01	
URS3(E1)	<0.04	<0.04		0.024		0.011	0.18		0.14	0.015	0.1
URS4	<0.04	<0.04					0.11		0.08		0.12
E4				0.01		0.01				0.014	
URS5	<0.04	<0.04							0.06		0.11
URS6(E9, outlet)	<0.04	<0.04	0.01	0.01	0.01	0.01	0.28	0.023	0.00	0.02	<0.04
URS7	<0.04	<0.04							0.08		<0.04
URS8(E5)	<0.04	<0.04					0.22		0.16		<0.04
URS9	<0.04	<0.04							0.07		<0.04
Average	0.04	0.04	0.02	0.08	0.02	0.06	0.20	0.02	0.07	0.01	0.07
upper 95% limit	0.04	0.04	0.03	0.22	0.04	0.16	0.27	0.02	0.12	0.02	0.11
lower 95% limit	0.04	0.04	0.01	-0.05	0.00	-0.04	0.13	0.02	0.02	0.01	0.03
Total Kjeldahl Nitrogen (T											
criterion											
URS1(E7, inlet)	<0.5	0.8							0.6		<0.5
URS2	<0.5	<0.5							0.8		<0.5
E6											
URS3(E1)	<0.5	<0.5					<0.5		0.8		<0.5
URS4	<0.5	<0.5					<0.5		1.3		0.5
E4											
URS5	<0.5	<0.5							1		<0.5
URS6(E9, outlet)	<0.5	<0.5					<0.5		0.7		<0.5
URS7	<0.5	0.6							0.8		<0.5
URS8(E5)	0.7	0.25					<0.5		0.5		0.7
URS9	<0.5	0.7							0.6		<0.5
Average	0.5	0.5					0.5		0.8		0.5
upper 95% limit	0.6	0.7					0.5		1.0		0.6
lower 95% limit	0.5	0.4					0.5		0.5		0.5

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	URS	URS	URS	URS	MIFTD	URS	MIFTD	MIFTD	MIFTD
STATION NO./	6/7/05	6/9/05	6/23/05	7/14/05	7/28/05	7/28/05	8/11/05	8/17/05	8/31/05	9/28/05
FLOW (cfs) (Ecology, 2006)	286									
Ammonia (mg/L)										
criterion	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
Diversion	0.01									
URS1(E7, inlet)	0.01	<0.04	<0.04	<0.04	<0.04		<0.04			
URS2		<0.04	<0.04	<0.04	<0.04		<0.04			
E6	0.01									
URS3(E1)	0.01	<0.04	<0.04	<0.04	<0.04		<0.04			
URS4		<0.04	<0.04	<0.04	<0.04		<0.04			
E4	0.01									
URS5		<0.04	<0.04	0.05	<0.04		<0.04			
URS6(E9, outlet)	0.01	<0.04	<0.04	<0.04	<0.04		<0.04			
URS7		<0.04	<0.04	<0.04	<0.04		<0.04			
URS8(E5)		0.07	0.13	0.08	0.09		0.23			
URS9		<0.04	<0.04	<0.04	<0.04		<0.04			
Average	0.01	0.04	0.05	0.05	0.05		0.06			
upper 95% limit	0.01	0.05	0.08	0.06	0.06		0.12			
lower 95% limit	0.01	0.03	0.02	0.03	0.03		0.00			
Total Kjeldahl Nitrogen (T										
criterion										
URS1(E7, inlet)		0.75	0.67	0.74	0.64		0.25			
URS2		0.53	0.86	0.59	<0.5		0.53			
E6										
URS3(E1)		0.54	0.68	0.69	<0.5		<0.5			
URS4		0.78	0.59	0.65	0.67		<0.5			
E4										
URS5		0.87	0.62	0.67	0.59		0.69			
URS6(E9, outlet)		0.56	2.9	0.64	<0.5		<0.5			
URS7		0.55	0.56	0.7	0.65		0.59			
URS8(E5)		0.74	0.73	0.82	0.63		0.9			
URS9		0.64	0.98	0.82	0.7		<0.5			
Average		0.7	1.0	0.7	0.6		0.6			
upper 95% limit		0.8	1.7	0.8	0.7		0.7			
lower 95% limit		0.5	0.2	0.6	0.5		0.4			

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	ECOLOGY
STATION NO./	**7/7/04**	**8/11/04**	**8/25/04**	**8/31/04**	**9/2/04**	**9/15/04**	**9/16/04**	**9/21/04**	**10/1/04**	**10/6/04**	**10/14/04**	**11/8/04**
FLOW (cfs) (Ecology, 2006)	**245**	**197**				**199**				**111**		**0**
Fecal Coliform (collonies/100 ml)												
criterion	100	100	100	100	100	100	100	100	100	100	100	
URS1(E7, inlet)			340		12		40		10		9	
URS2			315		130		40		0		1	
E6												
URS3(E1)			<2				5		10		4	
URS4			25		<2		<2		<2		<2	
E4												
URS5			10		<2		0		10		3	
URS6(E9, outlet)			55		6		10		<2		3	
URS7			10				<2		5		0	
URS8(E5)			<2		4		<2		<2		3	
URS9			15		14		20		<2		<2	
Average			86		24		13				3	
upper 95% limit			224		71		30		–		6	
lower 95% limit			-52		-23		-3		–		0	
Chlorophyll-a (µg/L)												
criterion	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
URS1(E7, inlet)			1.1				0.5		0.5		2.7	
URS2			2.7		2.7		1.6		0.5		2.4	
E6	3.29	3.29				2.41				1.94		
URS3(E1)	2.07	1.69	2.7	2.4	2.1	1.89	0.9	1.4	1.1	2.08	0.5	
URS4			1.9		1.3		0.7		1.4		2.7	
E4	2.56	1.02				1.51				2.04		
URS5			6	1.9	1.3		1.2	1.4	1.2		1.6	
URS6(E9, outlet)			1.9		1.9		1.1		1.1		1.6	
URS7			5.6		2.9		9.6		1.3		1.9	
URS8(E5)	2.82	1.82	2.7		1.6	1.08	1.3		1.1	1.95	2.4	
URS9			1.4		1.3		0.9		1.1		2.4	
Average	2.7	2.0	2.9	2.2	1.9	1.7	2.0	1.4	1.0	2.0	2.0	
upper 95% limit	3.2	2.9	4.6	2.5	2.5	2.3	4.9	1.4	1.4	2.1	2.7	
lower 95% limit	2.2	1.0	1.1	1.8	1.2	1.2	0.0	0.0	0.7	1.9	1.3	

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	URS	URS	ECOLOGY	ECOLOGY	ECOLOGY	ECOLOGY	URS	ECOLOGY	URS	ECOLOGY	URS
STATION NO./	**11/11/04**	**11/23/04**	**12/6/04**	**1/19/05**	**2/8/05**	**3/8/05**	**3/31/05**	**4/5/05**	**5/3/05**	**5/10/05**	**5/26/05**
FLOW (cfs) (Ecology, 2006)	**0**	**0**	**0**	**0**	**0**	**0**		**606**		**208**	
Fecal Coliform (collonies/1											
criterion	100	100					100		100		100
URS1(E7, inlet)	3	6							28		14
URS2	0	2							16		8
E6											
URS3(E1)	10	182					24		4		<2
URS4	1	32					<2		<2		<2
E4											
URS5	<2	ND							<2		<2
URS6(E9, outlet)	<2	12					<2		<2		2
URS7	<2	ND							6		<2
URS8(E5)	<2	ND					420		2		<2
URS9	<2	ND							2		<2
Average	3	–					112		7		4
upper 95% limit	6	–					318		16		8
lower 95% limit	0	–					-94		-2		0
Chlorophyll-a (µg/L)											
criterion	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
URS1(E7, inlet)	4.5	1.5							4.3		4.3
URS2	1.6	4							3.5		6.4
E6										3.21	
URS3(E1)	2.9	4		3.97		1.35	3.7		6.1	3.14	4.8
URS4	2.1	2.9					4.8		4		3.7
E4				4.15		3.35				3.87	
URS5	3.2	3.5							3.5		5.3
URS6(E9, outlet)	1.9	2.1					4		2.7		2.7
URS7	7.5	11							2.7		6.4
URS8(E5)	2.7	2.7				10.1	3.7		1.9	3.51	2.9
URS9	2.7	2.1							6.9		3.2
Average	3.2	3.8		4.1		4.9	4.1		4.0	3.4	4.4
upper 95% limit	5.0	6.6		4.2		9.5	4.6		5.6	3.8	5.8
lower 95% limit	1.4	0.9		3.9		0.3	3.5		2.3	3.1	3.0

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	URS	URS	URS	URS	MIFTD	URS	MIFTD	MIFTD	MIFTD
STATION NO./	6/7/05	6/9/05	6/23/05	7/14/05	7/28/05	7/28/05	8/11/05	8/17/05	8/31/05	9/28/05
FLOW (cfs) (Ecology, 2006)	286									
Fecal Coliform (collonies/1										
criterion		100	100	100	100	100	100	100	100	100
URS1(E7, inlet)		14	68	38	28		36			
URS2		8	20	24	14		4			
E6										
URS3(E1)		<2	<2	2	<2		<2			
URS4		2	6	2	<2		4			
E4										
URS5		<2	<2	<2	<2		<2			
URS6(E9, outlet)		2	2	6	2		14			
URS7		<2	<2	<2	2		6			
URS8(E5)		<2	<2	2	<2		2			
URS9		6	6	12	12		4			
Average		4	12	10	7		8			
upper 95% limit		9	34	23	16		19			
lower 95% limit		0	-9	-3	-2		-3			
Chlorophyll-a (µg/L)										
criterion	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
URS1(E7, inlet)		1.1	1.6	1.6	0.8		1.1			
URS2		5.9	2.7	2.1	1.6		1.6			
E6	6.4									
URS3(E1)	6.4	5.1	2.7	2.4	0.8		0.9			
URS4		5.9	3.2	2.9	1.9		1.1			
E4	5									
URS5		5.6	3.5	4.3	3.5		3.2			
URS6(E9, outlet)		4.5	3.5	4	2.4		2.7			
URS7		3.7	4.3	5.3	1.6		3.5			
URS8(E5)	5.2	3.5	2.1	2.4	1.9		1.6			
URS9		7.7	4.3	4.8	2.1		1.3			
Average	5.8	4.8	3.1	3.3	1.8		1.9			
upper 95% limit	6.5	6.7	4.0	4.6	2.7		2.9			
lower 95% limit	5.0	2.9	2.2	2.0	1.0		0.9			

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	MITFD	URS	ECOLOGY	URS	ECOLOGY
STATION NO./	**7/7/04**	**8/11/04**	**8/25/04**	**8/31/04**	**9/2/04**	**9/15/04**	**9/16/04**	**9/21/04**	**10/1/04**	**10/6/04**	**10/14/04**	**11/8/04**
FLOW (cfs) (Ecology, 2006)	**245**	**197**				**199**				**111**		**0**
Secchi Depth (m)												
criterion	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	
URS1(E7, inlet)			4.9		6.9		0.3				7.5	
URS2			9.2				0.7				4.3	
E6												
URS3(E1)			0.8	1.6			4.3	1.4			6.6	
URS4			6.6				3.9				9.8	
E4												
URS5			1.3	2.3			5.9	2.1			9.2	
URS6(E9, outlet)			6.9		6.2		4.9				10.2	
URS7					3.9		3.6				8.9	
URS8(E5)			6.6				5.9				5.2	
URS9			5.9		6.6		5.2				8.9	
Average			5.3	2.0	5.9		3.9	1.8			7.8	
upper 95% limit			8.1	2.4	7.2		5.9	2.2			9.9	
lower 95% limit			2.4	1.5	4.6		1.8	1.3			5.8	

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	URS	URS	ECOLOGY	ECOLOGY	ECOLOGY	ECOLOGY	URS	ECOLOGY	URS	ECOLOGY	URS
STATION NO./	**11/11/04**	**11/23/04**	**12/6/04**	**1/19/05**	**2/8/05**	**3/8/05**	**3/31/05**	**4/5/05**	**5/3/05**	**5/10/05**	**5/26/05**
FLOW (cfs) (Ecology, 2006)	**0**	**0**	**0**	**0**	**0**	**0**		**606**		**208**	
Secchi Depth (m)											
criterion	3.5	3.5					3.5		3.5		3.5
URS1(E7, inlet)	6.2								7.5		4.6
URS2	5.9								8.5		5.9
E6											
URS3(E1)	6.9						6.6		9.8		13.4
URS4	4.6						5.6		12.5		14.1
E4											
URS5	6.6								13.4		14.1
URS6(E9, outlet)	5.9						6.6		18.7		13.4
URS7	4.3								8.9		4.9
URS8(E5)	7.2						2.0		14.4		11.8
URS9	5.2								10.8		12.1
Average	5.9						5.2		11.6		10.5
upper 95% limit	6.9						7.3		15.2		14.6
lower 95% limit	4.9						3.0		8.1		6.4

Appendix D - Surface Water Quality Data, Lake Tapps, Washington

SOURCE:	ECOLOGY	URS	URS	URS	URS	MIFTD	URS	MIFTD	MIFTD	MIFTD
STATION NO./	6/7/05	6/9/05	6/23/05	7/14/05	7/28/05	7/28/05	8/11/05	8/17/05	8/31/05	9/28/05
FLOW (cfs) (Ecology, 2006)	286									
Secchi Depth (m)										
criterion		3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
URS1(E7, inlet)		8.2	4.9		2.3		4.9			
URS2		5.2	6.6		4.3		4.9			
E6										
URS3(E1)		11.8	8.5		12.5	3.6	13.8	3.6	3.3	4.2
URS4		9.5	10.8		13.1		14.1			
E4										
URS5		10.2	15.1		11.2		13.4			
URS6(E9, outlet)		10.8	9.5		11.5		11.8			
URS7		4.3	3.0		5.9		3.3			
URS8(E5)		10.2	9.5		11.8		9.8			
URS9		8.9	9.5		11.2		11.2			
Average		8.8	8.6		9.3		9.7			
upper 95% limit		11.3	12.1		13.3		13.9			
lower 95% limit		6.3	5.1		5.3		5.5			

Notes:

- Data Not Available
mg/L Milligrams per Liter
µg/L Micrograms per Liter
SU Standard Units
ºC Degrees Celsius
<# Constituent was not detected; laboratory reporting detection limit is given.

Appendix E

Stream Survey Methods Ecosystem Diagnosis and Treatment Method

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix E
Stream Survey Methods Ecosystem Diagnosis and Treatment Method
EDT Level 2 Parameters Rated by URS
During Fall 2004 Stream Survey

This appendix provides a brief summary of the stream survey method. Stream reaches were numbered consecutively from one, starting at the mouth of the stream and moving upstream (if logistics dictated starting at the origin of a stream, a number higher than the estimated stream reaches was chosen and then the stream reaches were numbered by counting down from the origin number). After the survey was complete, the numbering was adjusted to correspond with the actual number of reaches encountered during the survey. For example, in a survey that began at the origin of the stream (headwaters), the survey would start with stream reach 10 and if it ended with reach 6 (5 reaches), then the numbers were adjusted to reach one to five. That way all streams began with reach one at the mouth.

Reaches began and ended at major breaks in stream characteristics. This usually was because of a change in channel type (floodplain, palustrine, etc.), but could be for other reasons, such as stream channels becoming channelized, major changes in stream gradient, a tributary stream entering the stream being surveyed, major changes in riparian vegetation, etc.). Reasons for ending stream reaches were noted. All data was noted in a data logger connected to a Trimble GPS unit and downloaded daily at the office. URS developed the programming and analyzed the data. Data was QCed by those conducting the field work.

After recording the starting point of a reach, the survey crew walked the stream, recorded data, and made determinations for each of the EDT, physical, and Tri-county data points (usually the crew walked a fair portion of a reach before an assessment was made for each characteristic). After ending a reach, the crew would mark the beginning of the next reach and repeat the process. Culverts, falls, and velocity barriers were measured and determinations made if they were barriers to fish passage. Notes were entered in the database, but notebooks were also used to enter additional notes and draw maps. The crew carried aerial photos, topos, and maps from the Washington Stream catalog in the field. Measurements were obtained with folding rulers and tape measures. Stream velocities were estimated by the distance a floating object moved in the main body of a stream's current in a 10-second period. The White River was floated in a raft and velocities were estimated with a hand held Garmin GPS unit. Gradients were measured with a handheld clinometer. The survey crew wore polarized glasses and noted fish presence and identity if it was possible to visually identify the fish. Reaches were photographed wherever possible. Stream channel locations were noted on aerial photos and GIS measurements were taken if they did not appear to correspond to available maps. The survey crew drew stream channel locations on aerial photos to digitize them when they did not correspond to available maps (many streams had new channels or were not on the maps). The survey crew also corrected break points between reaches occasionally when data was missing or incorrect. The types of stream categories are defined below.

Channel Width - Month Maximum Width (ft)

Definition/Usage: Average width of the wetted channel during a high flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.

Channel Width - Month Minimum Width (ft)

Definition/Usage: Average width of the wetted channel during a low flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.

Confinement – Natural

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
Reach mostly unconfined by natural features -- Average valley width > 4 channel widths.	Reach composed approximately equally of unconfined and moderately confined sections.	Reach mostly moderately confined by natural features -- Average valley width 2 - 4 channel widths.	Reach composed approximately equally of moderately confined and unconfined sections.	Reach mostly confined by natural features -- Average valley width < 2 channel widths.

Confinement – Hydromodifications

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
The stream channel within the reach is essentially fully connected to its floodplain. Very minor structures may exist in the reach that do not result in flow constriction or restriction. Note: this describes both a natural condition within a naturally unconfined channel as well as the natural condition within a canyon.	Some portion of the stream channel, though less than 10% (of the sum of lengths of both banks), is disconnected from its floodplain along one or both banks due to man-made structures or ditching.	More than 10% and less than 40% of the entire length of the stream channel (sum of lengths of both banks) within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching.	More than 40% and less than 80% of the entire length of the stream channel (sum of lengths of both banks) within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching.	Greater than 80% of the entire length of the stream channel (sum of lengths of both banks) within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching.

Embeddedness

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
< 10% of surface covered by fine sediment	> 10 and < 25% covered by fine sediment	> 25 and < 50% covered by fine sediment	> 50 and < 90% covered by fine sediment	> 90% covered by fine sediment

Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.

Gradient

Categorical conclusions: Average gradient of the main channel of the reach over its entire length. Gradient is entered as a point estimate (percentage).

Habitat Type - Backwater Pools

Definition/Usage: Percentage of the wetted channel surface area comprising backwater pools. Backwater pools are habitat units located along the channel margins but are otherwise enclosed—though still connected to the main channel (or side channel). Note: backwater pools as defined here include "alcoves" as described by Nickleson et al. (1992).

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Habitat Type – Beaver Ponds

Definition/Usage: Percentage of the wetted channel surface area comprising beaver ponds. Note: this includes only those sites associated with the main channel or its side channels. Off-channel sites are addressed through the Off-Channel Habitat Factor.

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Habitat Type – Large Cobble/Boulder Riffles

Definition/Usage: Percentage of the wetted channel surface area comprising large cobble/boulder riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Habitat Type – Off-Channel Habitat Factor

Definition/Usage: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of all combined in-channel habitat. Off-channel habitat consist of oxbows, backswamps, riverine ponds, and the channels that connect them to the main channel or its side channels.

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Habitat Type – Pool Tailouts

Definition/Usage: Percentage of the wetted channel surface area comprising pool tailouts.

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Habitat Type –Glides

Definition/Usage: Percentage of the wetted channel surface area comprising glides, a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Habitat Type – Primary Pools

Definition/Usage: Percentage of the wetted channel surface area comprising pools, excluding beaver ponds.

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Habitat Type – Small Cobble/Gravel Riffles

Definition/Usage: Percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Categorical Conclusions: Habitat types are entered as a point estimate of the percentage of the stream reach wetted width in this particular habitat type.

Nutrient Enrichment

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
Unenriched streams (corresponding to benthic chlorophyll *a* values 0.5-3 mg/m2). Nutrient levels typical of oligotrophic conditions (small supply of nutrients, low production of organic matter, low rates of decomposition, and high DO). No enrichment is occurring nor is suspected. Green filamentous algae may be present at certain times of year, particularly in unshaded areas.	Very small amount of enrichment suspected to be occurring through land use activities (corresponding to benthic chlorophyll *a* values 3-20 mg/m2). Green filamentous algae present in summer months in unshaded reaches.	Nutrient levels typical of oligotrophic conditions (small supply of nutrients, low production of organic matter, low rates of decomposition, and high DO). Some enrichment known to be occurring (corresponding to benthic chlorophyll *a* values 20-60 mg/m2), often associated with failing septic tanks or runoff from areas of heavy fertilizer usage. Dense mats of green or brown filamentous algae present in summer months.	Euthrophic (abundant nutrients associated with high level of primary production, frequently resulting in oxygen depletion).Very obvious enrichment of reach is occurring from point sources or numerous non-point sources (corresponding to benthic chlorophyll *a* values 60-600 mg/m2). Large, dense mats of green or brown filamentous algae will be present during summer months.	Super enrichment of reach is strongly evident. Known, major point sources of organic waste inputs, such as runoff from large feedlot operation, wash water from farm products processing, or significant sewage facilities with inadequate treatment (corresponding to benthic chlorophyll *a* values 600-1200 mg/m2). In most severe cases, filamentous bacteria abundant, associated with low DO and hydrogen sulfide. In less severe cases, large dense mats of green or brown filamentous algae generally cover the substrate.

Predation Risk

Note presence of fish-eating species (leave room for written notes).

Riparian Function

Definition/Usage: A measure of riparian function that has been altered within the reach.

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
Strong linkages with no anthropogenic influences.	>75-90% of functional attributes present (overbank flows, vegetated streambanks, groundwater interactions typically present).	50-75% functional attribute rating-significant loss of riparian functioning-minor channel incision, diminished riparian vegetation structure and inputs etc.	25-50% similarity to natural conditions in functional attributes-many linkages between the stream and its floodplain are severed.	< 25% functional attribute rating: complete severing of floodplain-stream linkages

Salmon Carcasses

Note presence of salmon carcasses (leave room for written notes).

Temperature - Spatial Variation

Definition/Usage: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
Groundwater discharge into surface waters is the major source of flow in reach.	Abundant sites of groundwater discharge into surface waters.	Intermittent sites of groundwater discharge into surface waters and total quantity of groundwater discharge not a major source of flow in reach.	Infrequent sites of groundwater discharge into surface waters and total quantity of groundwater discharge not a major source of flow in reach.	No evidence of concentrated groundwater inputs.

Turbidity (or suspended sediment)

Estimate in field. Rate the month when suspended sediment is likely to be highest.

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
Clear with infrequent (short duration-- several days per year) concentrations of low concentrations (< 50 mg/l) of suspended sediment. No adverse effects on biota of these low doses.	Occasional episodes (days) of low to moderate concentrations (<500 mg/L), though very short duration episodes (hours) may occur with of higher conc. (500 to 1000). These conc. are always sublethal to juvenile and adult salmonids-though some behavioral modification may occur.	Occasional episodes of moderate to relatively high concentrations (>500 and <1000 mg/L), though shorter duration episodes (<1 week) may occur with higher concentrations (1000-5000 mg/L). Higher conc. expected to result in major behavioral modification, severe stress, severely reduced forage success and direct mortality.	On-going or occasional episodes (periodic events annually lasting weeks at a time) of high conc. of suspended sediment (>5000 and <10000 mg/L), or shorter duration episodes lasting hours or days of higher concentrations. These conditions result in direct, high mortality rates.	Extended periods (month) of very high concentrations (>10000 mg/L). These represent the most extreme severe conditions encountered and result in very high mortality of fish species.

Water Withdrawals

The number and relative size of water withdrawals in the stream reach. Rate the month when water withdrawals are greatest.

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
No withdrawals.	Very minor water withdrawals with or without screening (entrainment probability considered very low).	Several significant water withdrawals along reach though all sites known or believed to be screened with effective screening devices. (Note: one site that withdraws substantial portion of flow without screening falls into this category.)	Several sites of significant water withdrawals along reach without screening or screening believed to be ineffective. (Note: one site that withdraws substantial portion of flow without screening falls into this category.)	Frequent sites of significant water withdrawals along reach without screening or screening believed to be ineffective.

Wood

The amount of large woody debris within the reach. Large woody debris are defined here as pieces >0.1 m diameter and >2 m in length.

Note: channel widths here refer to average wetted width during the high flow month. Reference to "large" pieces in index values uses the standard timber, fish, and wildlife definition as those > 50 cm diameter at midpoint.

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
A complex mixture of single large pieces and accumulations consisting of all sizes, decay classes, and species origins; cross-channel jams are present where appropriate vegetation and channel conditions facilitate their existence; large wood pieces are a dominant influence on channel diversity (e.g., pools, gravel bars, and mid-channel islands) where channel gradient and flow allow such influences. Density of LWD (pieces per channel width CW) consistent with the following: channel width <25 ft -- 3-10 pieces/CW, 25-50 ft -- 3-10 pieces/CW	Complex array of large wood pieces but fewer cross channel bars and fewer pieces of sound large wood due to less recruitment than index level 1; influences of large wood and jams are a prevalent influence on channel morphology where channel gradient and flow allow such influences. Density of LWD (pieces per channel width CW) consistent with the following: channel width <25 ft -- 2-3 pieces/CW, 25-50 ft -- 2-4 pieces/CW	Few pieces of large wood and their lengths are reduced and decay classes older due to less recruitment than in index level 1; small debris jams poorly anchored in place; large wood habitat and channel features of large wood origin are uncommon where channel gradient and flow allow such influences. Density of LWD (pieces per channel width CW) consistent with the following: channel width <25 ft -- 1-2 pieces/CW, 25-50 ft -- 1-2 pieces/CW,	Large pieces of wood rare and the natural function of wood pieces limited due to diminished quantities, sizes, decay classes and the capacity of the riparian streambank vegetation to retain pieces where channel gradient and flow allow such influences. Density of LWD (pieces per channel width CW) consistent with the following: channel width <25 ft -- 0.33-1 pieces/CW, 25-50 ft -- 0.33-1 pieces/CW	Pieces of LWD rare. Density of LWD (pieces per channel width CW) consistent with the following: channel width <25 ft -- <0.33 pieces/CW, 25-50 ft -- <0.33 pieces/CW

THIS PAGE INTENTIONALLY LEFT BLANK.

Urban Stream Baseline Evaluation Method (USBEM)--Habitat Value Rating Criteria

Habitat Parameter	Stream Type	Good	Fair	Poor
Recruitment Potential (USBEM)	ES and PA	Riparian vegetation is continuous and dominated by native species typical of the channel type	Riparian vegetation is discontinuous or <50% are native species typical of the channel type	Riparian area is dominated by land use alterations or invasive non-native species
	FP, AF, LC, MM, MC, HC	High recruitment potential: Medium/Large Conifer (DBH > 12) or Medium/Large Mixed (DBH > 12); <30% of ground is exposed	Medium recruitment potential: Small/Large Conifer. Medium/Large Hardwood or Small Mixed vegetation type; <30% of ground is exposed	Low recruitment potential: Small Conifer (DBH<12) or Small/Large Hardwood; >30% of ground is exposed
Substrate Composition (USBEM)	FP, AF	Gravel or cobble is dominant. (Dominance = more than half of the surface area is composed of a single size class)	Gravel or cobble is subdominant	Sand or silt is dominant
	LC, MM, MC	Gravel or cobble is dominant (Dominance = more than half of the surface area is composed of a single size class)	Gravel or cobble is subdominant	Bedrock, boulder, sand, or silt is dominant
	HC	Gravel or cobble is dominant (Dominance = more than half of the surface area is composed of a single size class)	Gravel or cobble is subdominant	Bedrock or boulder is dominant
Embeddedness (USBEM)	FP, LC, MM, MC	<20 % in riffle and pool tailout units	20-40% in riffle and pool tailout units	>40% in riffle and pool tailout units
	AF	<20%	20-40%	>40%
Bank Condition (USBEM)	PA	Undercut areas frequent; >80% of banks with dense vegetation and not artificially hardened	Undercut areas sparse; 50-80% of banks with dense vegetation and not artificially hardened	>50% of banks are exposed soil or artificially hardened
	FP, AF	Perennial vegetation exists along >/=80% of banks; <20% of banks are exposed soil or artificially hardened	Perennial vegetation exists along >/=50% of banks; 20-50% of banks are exposed soil or artificially hardened	>50% of banks are exposed soil or artificially hardened
	LC	Few sideslope failures; where present, revegetation is well established	Few sideslope failures; where present, <50% revegetated	Sideslope failures are common and actively eroding
	MM, MC	>80% of banks are vegetated and not artificially hardened Few sideslope failures; where present, revegetation is well established	50-80% of banks are vegetated and not artificially hardened Sideslope failures scarce, or if present, >50% are revegetated	>50% of banks are exposed soil or artificially hardened Sideslope failures are common and actively eroding
	HC	Few sideslope failures; where present, revegetation is well established	Sideslope failures scarce, or if present, >50% are revegetated	Sideslope failures are common and actively eroding
Pool Frequency (USBEM)	FP, LC	If CW>60 feet, <5CW/pool; If CW<60 feet, <2CW/pool	If CW>60 feet, 5-7CW/pool; If CW<60 feet, 2-4CW/pool	If CW>60 feet, >7CW/pool; If CW<60 feet, >4CW/pool
	AF, MM, MC, HC	<2CW/pool	2-4CW/pool	>4CW/pool

Urban Stream Baseline Evaluation Method (USBEM)--Habitat Value Rating Criteria (Continued)

Habitat Parameter	Stream Type	Good	Fair	Poor
Channel Pattern and Bedform (USBEM)	ES	Complex network of distributaries with intact connections to adjacent wetlands or open saltwater	Some distributary channels connected to adjacent wetlands or open saltwater	Single thread channel; channel is disconnected from adjacent wetlands or open saltwater
	PA, FP	Sinuous pattern with intact connections to adjacent wetlands or side-channels	Sinuous pattern and with few connections to adjacent wetlands or side-channels	Straightened pattern; channel is disconnected from adjacent wetlands or side-channels
	MM, MC	Sinuous pattern with well developed step-pool or pool-riffle bedform	Sinuous pattern with irregular or poorly defined step-pool or pool-riffle bedform	Straightened pattern, plane-bed
	HC	Well developed step-pool bedform	Irregularly spaced or poorly defined step-pool bedform separated by cascades	Cascade bedform
Large Woody Debris (USBEM)	FP	If CW is >66 feet, accumulations with at least one key piece are frequent at the outside of meander bends, side-channel inlets, and bar apexes. If CW is 33 to 66 feet, >0.50 pieces/CW; If CW<33 feet, >0.30 pieces/CW	If CW is >66 feet, accumulations with at least one key piece are scarce at the outside of meander bends, side-channel inlets, and bar apexes. If CW is 33 to 66 feet, 0.20 to 0.50 pieces/CW; If CW<33 feet, 0.15 to 0.30 pieces/CW	If CW is >66 feet, accumulations with at least one key piece are not present at the outside of meander bends, side-channel inlets, and bar apexes. If CW is 33 to 66 feet, <0.20 pieces/CW; If CW<33 feet, <0.15 pieces/CW
	AF, LC, MM, MC, HC	If CW is 33 to 66 feet, >0.50 pieces/CW If CW<33 feet, >0.30 pieces/CW	If CW is 33 to 66 feet, 0.20 to 0.50 pieces/CW If CW<33 feet, 0.15 to 0.30 pieces/CW	If CW is 33 to 66 feet, <0.20 pieces/CW If CW<33 feet, <0.15 pieces/CW
Riparian Buffer Width (VSAT)	All	Natural vegetation extends at least two active channel widths on each side	Natural vegetation extends one third to two active channel widths on each side	Natural vegetation extends less than a third of the active channel width on each side
Riparian Cover (U.S. Forest Service)	All	Shrubs are the dominant (>50%) streamside vegetation	Trees are the dominant (>50%) streamside vegetation	Grass or forbs are the dominant (>50%) streamside vegetation
Canopy Cover (VSAT)	All	>75% of water surface shaded	20-75% of water surface shaded	<20% of water surface shaded
Structural Diversity	All	4-5 vegetation layers are present	2-3 vegetation layers are present	1-2 vegetation layers are present
Invasive Species	All	<10% cover by invasive species	10% to 25% cover by invasive species	>25% cover by invasive species
Snags	All	>3 per acre	1-3 per acre	<1 per acre
Dead and Down	All	Abundant dead and down material, some large (>20”), various stages of decay	Limited dead and down material, typically small (<20”) and fresh	No dead and down material
Percent of Reach as Riffle	FP, AF, LC, MM, MC, HC	< 10% of reach as riffle	10% to 30% of reach as riffle	> 30% of reach as riffle
Distance Between Holding Areas	FP, AF, LC, MM, MC, HC	< 40 feet between pools	40 ft to 60 ft between pools	> 60 feet between pools
Storm Refuge	FP, AF, LC, MM, MC, HC	> 2 refuge areas (offstream channel or pools/ponds)	1 - 2 refuge areas (offstream channel or pools/ponds)	No refuge areas (offstream channel or pools/ponds)
Coho Pools	FP, AF, LC, MM, MC, HC	< 40 feet between pools	40 ft to 60 ft between pools	> 60 feet between pools

CW = Channel width at bankfull flows.

Stream Reach Channel Type:

Estuarine (ES)
Tidally influenced estuary/delta.

Palustrine (PA)
Wetland channels, beaver complexes or sloughs. Velocity is generally slow, substrates are composed of fine sediment or organic matter, and channel morphology is sinuous or irregular and dominated by pools or glides.

Floodplain (FP)
Low-gradient depositional channels. Substrates are typically small gravel to cobble, and the bedform is typically regularly spaced pool-riffles. LWD is important for forming pools and providing cover. These channels migrate freely across alluvial floodplains and off-channel habitats are normally abundant.

Alluvial Fan (AF)
Moderate gradient depositional channels in the transitional area between steep slopes and valley floodplains. Stream power decreases longitudinally down the fan, and deposition results in channels that migrate across the fan. Substrates are gravel to cobble, pools are often relatively small and shallow, and off-channel habitats typically do not persist over the long-term.

Large Contained (LC)
Low to moderate gradient channels that are moderately to deeply incised. Stream power is moderate to high with coarse substrates. LWD is easily transported and generally located along channel margins. These channels rarely have extensive off-channel habitats.

Moderate Gradient Mixed Control (MM)
Transport dominated channels with moderate to high stream power. LWD is important for forming pools and storing sediment, thus substrates and bedforms are highly variable. Off-channel habitats may be present, but are not abundant.

Moderate Gradient Contained (MC)
Transport dominated channels with moderate to high stream power. LWD is important for forming pools and storing sediment, thus substrates and bedforms are highly variable. Off-channel habitats are rare.

High Gradient Contained (HC)
Moderate to deeply incised channels with high stream power. Most sediment is easily transported, thus gravel and small cobbles deposit only in hydraulically protected areas. Pools tend to be small and shallow, although LWD and bedrock may form large deep pools.

Tri-County Urban Issues ESA Study, Chapter 5: Evaluation of Baseline Habitat Conditions
http://www.salmoninfo.org/tricounty/documents/urban56.pdf

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix F

Stream Survey Results

THIS PAGE INTENTIONALLY LEFT BLANK.

APPENDIX F

Photo 1: Eroding Bank in Tributary 0036, reach 2 - This photo is typical of sections of streams crossing the White River floodplain agricultural lands that have developed incised channels in deep alluvial soils. Bank erosion of the unstable side slopes contributes fine sediments and sands, embedding spawning gravels utilized by spawning chum and coho salmon.

Photo 2: Outlet of Railroad Culvert in Tributary 0038 at Head of Reach 2 - There is a small amount of spawning habitat available in Tributary 0038 immediately below and above the East Valley Highway, but most of the spawning habitat along Forest Canyon road has been lost, because the creek is directed through a culvert for most of its length along the road downstream from where the stream crosses Forest Canyon Road. There are extensive connected wetlands available for coho rearing on the east side of the railroad tracks, but this habitat is inaccessible because the culvert under the tracks is impassable.

Photo 3: Old Channel Above East Valley Highway and Reach 2 - Although Tributary 0039 doesn't represent usable (or even restorable) fish habitat, this is an example of destruction of salmonid habitat that has and is occurring in the Lower White River Basin. Before the construction of the culverts on Tributaries 0038 and 0039, both tributaries probably provided good coho and chum salmon habitat. Now, both streams are completely culverted or ditched across the White River floodplain and the spawning habitat above the East Valley Highway has been lost, due to the streams being directed through culverts.

Photo 4: Waterfall at Upstream End of Reach 2 in Tributary 0033 - This fall is a partial barrier to coho salmon spawners trying to enter Jovita Creek. The culverts under the freeway also may represent a partial barrier to fish migration, blocking salmon from entering the 40-80 feet of Jovita Creek between the freeway ramp and Tributary 0032 during some years. This not only limits spawning habitat, it restricts rearing to Tributary 0032 (Jovita Creek has far better rearing habitat than Tributary 0032).

Photo 5: Horse Ranch on North Side of Reach 4 - This photo shows a potential source of e. coli exceedances referenced on the 303d list. With the exception of a small development near the headwaters of Tributaries 0052 and 0053, there are no developments in the floodplain of the river or the valley walls. This area is forested.

Photo 6: Typical Floodplain Habitat in Reach 1- Reach 1 of Tribuatary0051 flows through an old side channel of the White River.

Photo 7: Tributary 0035, water from Storm Drain at Head of Reach 12

Photo 8: Tributary 0035, ditch above First Culvert in Reach 3

Many ditches carry untreated roadside runoff or agricultural runoff to Strawberry Creek. Aside from chemical pollutants, ditches from cultivated fields transport fines in stream channels.

Photo 9: Tributary 0035, reach 13 Alongside Road - Portions of Strawberry Creek are now roadside ditches.

Photo 10: Tributary 0035, outlet of Culvert Under Meat Packing Plant in Reach 14 - A large reach of Strawberry Creek flows through culverts under this plant and it's parking lot.

THIS PAGE INTENTIONALLY LEFT BLANK.

Table F-1
White River Basin Stram Surveys
Field Observations Using Tri-county Guidance Fall 2004

WRIA Stream #	Stream Reach	Stream Reach Channel Type	Aquatic Habitat Parameter Ratings							Riparian Corridor Parameter Ratings							Add'l Parameter Ratings					Habitat Notes
			Recruitment Potential	Substrate Composition	Embeddedness	Bank Condition	Pool Frequency	Channel Pattern/Bedform	Large Woody Debris	Riparian Buffer Width	Riparian Cover	Canopy Cover	Structural Diversity	Invasive Species	Snags	Dead and Down	% Reach as Riffle	Distance Between Holding Areas	Storm Refuge	Coho Pools	Sediment Cloud	
31	1	LC	Fair	Poor	Poor	Good	Poor	NA	Fair	Poor	Good	Fair	Fair	Poor	Poor	Fair	Good	Poor	Poor	Poor	Poor	
31	2	LC	Fair	Poor	Poor	Good	Poor	NA	Good	Fair	Good	Fair	Fair	Poor	Poor	Fair	Good	Poor	Fair	Poor	Poor	
31	3	FP	Fair	Good	Fair	Fair	Poor	Fair	Poor	Fair	Good	Fair	Fair	Poor	Poor	Fair	Fair	Poor	Good	Poor	Poor	
31	4	FP	Fair	Good	Good	Fair	Poor	Good	Poor	Good	Good	Fair	Fair	Poor	Fair	Good	Poor	Poor	Good	Poor	Fair	
31	5	FP	Fair	Good	Good	Fair	Fair	Good	Good	Good	Good	Poor	Fair	Poor	Good	Good	Poor	Poor	Good	Poor	Fair	
31	6	FP	Fair	Good	Good	Fair	Poor	Good	Poor	Good	Good	Poor	Fair	Poor	Good	Good	Poor	Poor	Good	Poor	Fair	
31	7	FP	Fair	Good	Good	Good	Poor	Good	Poor	Good	Good	Fair	Fair	Fair	Good	Good	Poor	Poor	Good	Poor	Fair	
32	1	FP	Fair	Poor	Poor	Fair	Poor	Poor	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Poor	Good	Fair	Good	Poor	
32	2	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	
32	3	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	
32	4	FP	Fair	Poor	Poor	Good	Poor	Poor	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	
32	5	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Good	Poor	Fair	Poor	Poor	
32	6	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Good	Poor	Fair	Poor	Poor	
33	1	FP	Poor	Good	Fair	Good	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Fair	
33	2	FP	Poor	Poor	Poor	Fair	Fair	Poor	Poor	Fair	Poor	Fair	Fair	Poor	Poor	Poor	Fair	Good	Poor	Good	Poor	2 concrete weirs
33	3	MM	Fair	Poor	Poor	Good	Poor	Fair	Fair	Good	Good	Fair	Good	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Fair	choked w/weeds
33	4	MC	Fair	Poor	Poor	Good	Poor	Poor	Poor	Fair	Good	Fair	Good	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Fair	
33	5	MM	Fair	Good	Fair	Good	Poor	Fair	Poor	Good	Fair	Fair	Good	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Fair	
34	1	MM	Fair	Poor	Poor	Fair	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Poor	
34	2	MM	Fair	Poor	Poor	Fair	Poor	Fair	Poor	Good	Good	Good	Fair	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Poor	
34	3	MC	Fair	Poor	Poor	Fair	Poor	Fair	Poor	Good	Good	Good	Fair	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Poor	
35	1	FP	Poor	Good	Good	Fair	Good	Fair	Poor	Fair	Good	Fair	Fair	Poor	Poor	Fair	Fair	Good	Good	Good	Fair	
35	2	FP	Poor	Fair	Fair	Fair	Good	Good	Poor	Fair	Good	Fair	Fair	Poor	Poor	Fair	Good	Good	Good	Good	Fair	

Table F-1
White River Basin Stram Surveys
Field Observations Using Tri-county Guidance Fall 2004

WRIA Stream #	Stream Reach	Stream Reach Channel Type	Aquatic Habitat Parameter Ratings							Riparian Corridor Parameter Ratings							Add'l Parameter Ratings					Habitat Notes
			Recruitment Potential	Substrate Composition	Embeddedness	Bank Condition	Pool Frequency	Channel Pattern/Bedform	Large Woody Debris	Riparian Buffer Width	Riparian Cover	Canopy Cover	Structural Diversity	Invasive Species	Snags	Dead and Down	% Reach as Riffle	Distance Between Holding Areas	Storm Refuge	Coho Pools	Sediment Cloud	
35	3	FP	Poor	Fair	Fair	Fair	Good	Good	Poor	Fair	Good	Fair	Fair	Poor	Poor	Poor	Good	Good	Fair	Good	Fair	
35	4	FP	Poor	Fair	Fair	Fair	Good	Good	Poor	Fair	Good	Poor	Poor	Poor	Poor	Poor	Good	Good	Poor	Good	Fair	
35	5	FP	Poor	Good	Good	Good	Good	Good	Fair	Good	Fair	Fair	Good	Fair	Poor	Fair	Poor	Good	Poor	Good	Fair	many riffle end rch 0037 constr
35	6	FP	Poor	Good	Good	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good	one long riffle good spawning habitat
35	7	FP	Fair	Good	Fair	Good	Poor	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	
35	8	FP	Fair	Poor	Fair	Fair	Poor	Good	Fair	Good	Fair	Good	Fair	Fair	Poor	Fair	Good	Good	Fair	Good	Poor	pool dominated 2 long pools
35	9	FP	Poor	Poor	Poor	Good	Poor	Good	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Good	Good	Fair	Good	Poor	all glide
35	10	FP	Poor	Poor	Poor	Good	Poor	Good	Poor	Fair	Good	Poor	Fair	Poor	Poor	Poor	Good	Good	Fair	Good	Poor	
35	11	FP	Poor	Poor	Poor	Good	Poor	Good	Poor	Fair	Good	Poor	Fair	Poor	Poor	Poor	Good	Good	Fair	Good	Poor	same chnl characts
35	12	FP	Poor	Poor	Poor	Good	Poor	Good	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Poor	Good	Good	Fair	Good	Poor	
35	13	FP	Poor	Good	Fair	Good	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	
35	14	FP	Poor	Fair	Fair	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	
35	15	FP	Poor	Fair	Fair	Fair	Poor	Poor	Poor	Poor	Good	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	
35	16	FP	Poor	Poor	Poor	Fair	Poor	Fair	Poor	Good	Good	Fair	Fair	Poor	Poor	Fair	Good	Poor	Poor	Poor	Poor	
35	17	FP	Poor	Poor	Poor	Fair	Poor	Fair	Poor	Fair	Good	Poor	Poor	Poor	Poor	Fair	Good	Poor	Poor	Poor	Poor	
35	18	FP	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Fair	Good	Fair	Fair	Poor	Poor	Fair	Good	Poor	Poor	Poor	Poor	
36	1	AF	Fair	Good	Good	Good	Poor	Good	Good	Good	Fair	Fair	Good	Good	Poor	Good	Poor	Poor	Poor	Poor	Good	velocity limit at top
36	2	HC	Fair	Good	NA	Good	Fair	Good	Good	Good	Fair	Good	Good	Fair	Fair	Good	Poor	Poor	Poor	Poor	Good	
37	1	FP	Poor	Good	Good	Fair	Fair	Good	Fair	Poor	Poor	Poor	Poor	Good	Poor	Fair	Poor	Good	Poor	Good	Fair	
38	1	FP	Fair	Poor	Poor	Fair	Poor	Poor	Poor	Fair	Good	Fair	Fair	Poor	Poor	Fair	Fair	Poor	Poor	Poor	Poor	
38	2	FP	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	
38	3	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	

Table F-1
White River Basin Stram Surveys
Field Observations Using Tri-county Guidance Fall 2004

WRIA Stream #	Stream Reach	Stream Reach Channel Type	Aquatic Habitat Parameter Ratings							Riparian Corridor Parameter Ratings							Add'l Parameter Ratings					Habitat Notes
			Recruitment Potential	Substrate Composition	Embeddedness	Bank Condition	Pool Frequency	Channel Pattern/Bedform	Large Woody Debris	Riparian Buffer Width	Riparian Cover	Canopy Cover	Structural Diversity	Invasive Species	Snags	Dead and Down	% Reach as Riffle	Distance Between Holding Areas	Storm Refuge	Coho Pools	Sediment Cloud	
38	4	PA	Poor	NA	NA	Good	NA	Fair	NA	Fair	Good	Poor	Poor	Poor	Poor	Fair	NA	NA	NA	NA	NA	2 culverts large open PEM wetland unmaintained ditches along farm fields not defined to confined channel
38	5	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Fair	Fair	Poor	Poor	Poor	Fair	Poor	Fair	Poor	Fair	Poor	Poor	paving company on stream left and primary road directly upstream
38	6	AF	Fair	Good	Good	Good	Poor	NA	Poor	Good	Good	Fair	Fair	Fair	Poor	Fair	Poor	Poor	Poor	Poor	Good	stream bed good mostly gravel cobble needs pools and glides good potential. Velocity barrier (steep cascade) present about 30' upstream from end of reach (above culvert)
39	1	FP	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Good	Good	Poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	adjacent to and receives runoff from golf course
39	2	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	roadside ditch
39.5	1	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	tailrace
40	1	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Good	Good	Fair	Fair	Poor	Poor	Fair	Good	Poor	Poor	Poor	Poor	
40	2	FP	Poor	Good	Poor	Good	Good	Poor	Poor	Good	Good	Fair	Fair	Poor	Poor	Fair	Good	Good	Good	Good	Fair	
40	3	FP	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	
40.5	1	PA	Poor	NA	NA	Good	NA	Fair	NA	Good	Good	Poor	Poor	Fair	Fair	Fair	NA	NA	NA	NA	NA	
40.5	2	FP	Poor	Fair	Poor	Good	Fair	Fair	Fair	Good	Good	Poor	Fair	Poor	Poor	Fair	Fair	Fair	Fair	Poor	Poor	
51	1	FP	Good	Poor	Poor	Good	Good	Good	Fair	Good	Fair	Fair	Good	Poor	Fair	Fair	Good	Good	Good	Good	Good	fair coho rearing habitat barrier at mouth
51	2	MM	Good	Good	Good	Good	Good	Good	Fair	Good	Fair	Fair	Good	Poor	Fair	Good	Fair	Good	Good	Good	Good	no coho observed
51	3	HC	Good	Good	NA	Fair	Good	Good	Good	Good	Fair	Fair	Good	Poor	Fair	Good	Poor	Good	Good	Good	Good	coho may not get up this far
51	4	PA	Fair	NA	NA	Good	NA	Poor	NA	Fair	Fair	Fair	Fair	Poor	Poor	Fair	NA	NA	NA	NA	NA	
51	5	PA	Poor	NA	NA	Good	NA	Poor	NA	Poor	Poor	Poor	Poor	Poor	Poor	Poor	NA	NA	NA	NA	NA	

Table F-1
White River Basin Stram Surveys
Field Observations Using Tri-county Guidance Fall 2004

			Aquatic Habitat Parameter Ratings							Riparian Corridor Parameter Ratings							Add'l Parameter Ratings					
WRIA Stream #	Stream Reach	Stream Reach Channel Type	Recruitment Potential	Substrate Composition	Embeddedness	Bank Condition	Pool Frequency	Channel Pattern/Bedform	Large Woody Debris	Riparian Buffer Width	Riparian Cover	Canopy Cover	Structural Diversity	Invasive Species	Snags	Dead and Down	% Reach as Riffle	Distance Between Holding Areas	Storm Refuge	Coho Pools	Sediment Cloud	Habitat Notes
52	1	PA	Fair	NA	NA	Good	NA	Good	NA	Good	Fair	Good	Good	Poor	Poor	Good	NA	NA	NA	NA	NA	
52	2	PA	Poor	NA	NA	Good	NA	Good	NA	Poor	Good	Fair	Fair	Poor	Poor	Good	NA	NA	NA	NA	NA	
52	3	PA	Fair	NA	NA	Good	NA	Good	NA	Good	Fair	Good	Good	Poor	Poor	Good	NA	NA	NA	NA	NA	
53	1	PA	Fair	NA	NA	Good	NA	Good	NA	Good	Fair	Good	Good	Poor	Poor	Good	NA	NA	NA	NA	NA	
53	2	PA	Poor	NA	NA	Good	NA	Good	NA	Poor	Good	Fair	Fair	Poor	Poor	Good	NA	NA	NA	NA	NA	
53	3	PA	Fair	NA	NA	Good	NA	Good	NA	Good	Fair	Good	Good	Poor	Poor	Good	NA	NA	NA	NA	NA	
122	1	LC	Good	Good	Good	Good	Poor	Fair	Poor	Good	Fair	Fair	Good	Good	Fair	Good	Poor	Poor	Fair	Poor	Good	
122	2	FP	Good	Good	Good	Fair	Fair	Good	Fair	Good	Fair	Fair	Good	Good	Fair	Fair	Poor	Poor	Good	Poor	Good	
122	3	FP	Poor	Good	Fair	Good	Poor	Fair	Poor	Good	Good	Poor	Fair	Good	Fair	Good	Poor	Poor	Poor	Poor	Fair	
122	4	FP	Good	Good	Good	Fair	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair	Good	Poor	Good	Good	Good	Good	
122	5	FP	Good	Good	Good	Fair	Fair	Good	Fair	Good	Fair	Fair	Good	Good	Good	Good	Poor	Fair	Fair	Fair	Good	
122	6	FP	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Fair	Good	Good	Good	Good	Poor	Fair	Good	Fair	Good	
122	7	LC	Good	Good	Good	Fair	Poor	NA	Poor	Good	Fair	Fair	Good	Good	Good	Good	Poor	Poor	Poor	Poor	Good	
122	8	FP	Good	Good	Good	Fair	Good	Good	Good	Good	Fair	Fair	Good	Good	Good	Good	Poor	Poor	Good	Poor	Good	
186	1	LC	Good	Good	Good	Fair	Poor	Fair	Poor	Good	Fair	Fair	Good	Good	Good	Good	Poor	Poor	Poor	Poor	Good	
186	2	FP	Poor	Good	Good	Poor	Poor	Good	Poor	Good	Fair	Poor	Fair	Good	Good	Good	Poor	Poor	Poor	Poor	Fair	

Notes:
AF - alluvial fan
ES - estuarine
FP - floodplain
HC - high gradient contained
LC - large contained
MC - moderate gradient contained
MM - moderate gradient mixed control
PA - palustrine

Numerical rating breaks: 1.67 break between poor and fair; 2.33 break between fair and gooc

Table F-2
White River Basin Stream Surveys
Field Observations Using EDT Level 2 Parameters Fall 2004

					Habitat Types (%)								Ratings (0–4)									
WRIA Stream #	Stream Reach	Grandient (%)	Channel Width (max)	Channel Width (min)	Backwater Ponds	Beaver Ponds	Large Cobble/Boulder Riffles	Off Channel Habitat Factor	Pool Tailouts	Glides	Primary Pools	Small Cobble/Gravel Riffles	Confinement Natural	Confinement Hydromodifications	Embeddedness	Nutrient Enrichment	Riparian Function	Temperature Variation	Turbidity	Water Withdrawals	Wood	Notes
31	1	0.75	80	45	0	0	0	0	0	100	0	0	4	4	4	0	4	4	2	0	2	
31	2	1	165	50	0	0	10	5	0	80	3	2	4	3	3	0	4	4	2	0	1	
31	3	1.25	200	65	0	0	37	10	0	40	5	8	0	2	2	0	3	4	2	0	4	
31	4	1.75	200	70	0	0	35	5	0	50	5	5	0	0	1	0	2	4	2	0	4	
31	5	1.5	500	80	5	0	20	25	3	17	10	20	0	0	1	0	1	4	2	0	2	
31	6	1.75	300	74	5	0	35	15	0	30	5	10	0	0	1	0	2	4	2	0	4	
31	7	2	200	70	0	0	48	5	0	42	5	0	0	0	1	0	1	4	2	0	3	
32	1	1.5	18	10	0	2	0	3	0	90	5	0	2	4	4	1	3	4	1	0	4	
32	2	1	12	6	0	0	0	0	0	100	0	0	2	4	4	1	4	4	1	0	4	
32	3	1	12	6	0	0	0	0	0	100	0	0	2	4	4	1	4	4	1	0	4	
32	4	1.5	18	6	0	2	0	0	0	93	5	0	2	3	4	1	3	4	4	0	4	
32	5	1	12	4.5	0	0	0	5	0	90	5	0	2	4	4	1	3	3	1	0	4	
32	6	0.5	12	4.5	0	0	0	5	0	90	5	0	2	4	4	1	3	3	1	0	4	
33	1	1.5	9.5	2.5	0	0	0	0	0	0	0	100	2	3	2	0	3	4	1	0	4	
33	2	1.1	10	1.5	0	0	0	0	1	24	50	25	4	4	3	1	3	4	1	0	4	
33	3	2	8	1.5	0	0	0	0	0	0	0	0	2	2	2	1	2	3	1	0	3	some open channels
33	4	4	8	1.5	0	0	0	0	5	10	15	70	2	3	2	1	2	3	1	0	4	
33	5	1	4.5	1.5	0	0	0	0	0	0	15	85	0	1	1	1	2	4	1	0	4	
34	1	1	6	1.5	0	0	0	0	0	20	0	80	0	1	3	1	2	4	1	0	4	
34	2	1	6	1	0	0	0	0	0	10	0	90	1	0	4	1	2	3	0	0	4	leaf and silty bottom riffles - no cobble+
34	3	1.5	5	1	0	0	0	0	0	0	20	80	4	0	3	1	2	1	0	0	4	
35	1	1.5	12.5	9.5	0	0	5	0	15	0	50	30	4	0	0	1	2	4	1	0	3	
35	2	0.5	14	7	5	0	0	5	5	0	70	15	2	1	2	1	2	4	1	0	3	
35	3	0.5	14	6	5	0	0	0	5	0	80	15	2	1	2	1	3	4	1	0	4	
35	4	1	8	4	0	0	0	0	5	15	65	15	2	1	1	1	3	4	1	0	4	

Table F-2
White River Basin Stream Surveys
Field Observations Using EDT Level 2 Parameters Fall 2004

					Habitat Types (%)								Ratings (0–4)									
WRIA Stream #	Stream Reach	Grandient (%)	Channel Width (max)	Channel Width (min)	Backwater Ponds	Beaver Ponds	Large Cobble/Boulder Riffles	Off Channel Habitat Factor	Pool Tailouts	Glides	Primary Pools	Small Cobble/Gravel Riffles	Confinement Natural	Confinement Hydromodifications	Embeddedness	Nutrient Enrichment	Riparian Function	Temperature Variation	Turbidity	Water Withdrawals	Wood	Notes
35	5	1	16	7	1	0	0	0	5	0	47	47	2	1	0	1	1	0	1	0	4	reach ends at E Valley Hwy bridge
35	6	1	7.5	7	0	0	0	0	1	0	10	89	4	2	0	1	3	4	1	0	0	
35	7	1	15	8	0	0	0	0	5	0	15	80	3	2	1	1	2	4	1	0	3	
35	8	0.5	9	8	0	0	0	0	1	30	64	5	3	1	3	2	2	4	1	0	4	
35	9	0.5	13	12	0	0	0	0	0	100	0	0	2	1	4	1	2	3	1	0	4	
35	10	0.5	13	12	0	0	0	0	0	98	0	2	2	1	4	1	2	2	1	0	4	
35	11	0.5	13	12	0	0	0	0	0	98	2	0	2	1	4	1	2	2	1	0	4	spring fed by multiple springs
35	12	0.5	13	11	0	0	0	0	0	100	0	0	2	1	4	1	2	2	1	0	4	
35	13	1	10	6	0	0	0	0	0	54	1	45	4	3	2	1	3	3	1	0	4	
35	14	1	11	4	0	0	0	0	0	30	35	35	3	3	2	2	4	4	1	0	4	
35	15	1	11	4	0	0	0	0	0	30	35	35	3	3	2	2	3	4	1	0	4	
35	16	0.5	14	8	0	0	0	0	0	100	0	0	2	1	4	1	2	4	1	0	4	
35	17	1	5	4	0	0	0	0	0	95	0	5	2	2	3	2	2	4	1	0	4	
35	18	0.5	0	0	0	0	0	0	0	100	0	0	3	3	4	3	3	4	1	0	4	
36	1	4	17	4	0	0	0	0	0	0	2	98	1	0	1	0	0	0	0	0	1	
36	2	8	14	4	0	0	20	0	0	0	0	80	2	0	0	0	0	0	0	0	1	
37	1	0.5	9	2.5	0	0	0	0	0	0	50	50	0	0	0	2	1	4	1	0	3	large woody debris located too high on bank to be available
38	1	0.5	6	3	0	0	0	0	0	75	15	10	2	4	4	1	4	4	1	0	4	
38	2	0.75	6	4	0	0	0	0	0	85	10	5	2	4	4	1	4	4	1	0	4	
38	3	0.5	16	8	0	0	0	0	0	85	5	10	1	3	3	1	2	4	1	0	4	
38	4	0.5	28	10	20	80	0	0	0	0	0	0	1	2	4	1	2	4	1	0	4	
38	5	0.5	8	5	0	0	0	0	0	80	5	15	1	1	3	1	1	4	1	0	4	
38	6	3	8	1	0	0	40	10	0	0	0	50	0	1	1	1	1	4	0	0	4	
39	1	0.5	12	1	0	0	0	0	0	95	5	0	4	4	4	4	4	4	2	0	4	adjacent to and receives runoff from golf course upstream reach is long culvert

Table F-2
White River Basin Stream Surveys
Field Observations Using EDT Level 2 Parameters Fall 2004

WRIA Stream #	Stream Reach	Grandient (%)	Channel Width (max)	Channel Width (min)	Habitat Types (%)								Ratings (0–4)									Notes
					Backwater Ponds	Beaver Ponds	Large Cobble/Boulder Riffles	Off Channel Habitat Factor	Pool Tailouts	Glides	Primary Pools	Small Cobble/Gravel Riffles	Confinement Natural	Confinement Hydromodifications	Embeddedness	Nutrient Enrichment	Riparian Function	Temperature Variation	Turbidity	Water Withdrawals	Wood	
39	2	0.5	8	4	0	0	0	0	0	90	0	10	4	4	4	1	4	1	2	0	4	roadside ditch with upstream water quality issues related to continuous stream mods by landowner
39.5	1	0.5	70	65	0	0	0	0	0	100	0	0	4	4	4	2	4	4	1	0	4	powerhouse tailrace is a very straight fast channel
40	1	0.5	7	2	0	0	10	0	0	90	0	0	2	4	4	1	3	4	1	0	4	
40	2	0.5	9	4	0	0	0	0	2	0	88	10	2	4	4	1	3	0	3	0	4	
40	3	0.5	14	8	0	0	0	0	0	100	0	0	2	4	4	1	4	0	1	0	4	
40.5	1	-1	50	50	0	0	0	0	0	0	100	0	2	2	4	1	2	0	1	0	3	
40.5	2	0.5	11	3	0	0	0	0	0	60	30	10	2	2	4	1	2	0	1	0	3	
51	1	0.5	12	6	0	0	0	0	0	0	98	2	0	0	4	0	1	3	0	0	2	
51	2	6	18	2.5	0	0	25	0	0	0	75	0	1	0	0	0	1	4	0	0	2	
51	3	11	17	4	0	0	60	0	0	0	40	0	2	0	0	0	1	4	0	0	0	
51	4	-1	10	5	0	0	0	0	0	0	98	2	4	4	4	2	3	4	0	0	4	
51	5	-1	10	5	0	0	0	0	0	0	95	5	4	4	4	2	4	4	0	0	4	
52	1	-1	12	10	20	20	0	20	0	0	40	0	0	0	4	0	1	2	0	0	2	
52	2	-1	12	9	20	40	0	20	0	0	20	0	0	0	4	0	2	2	0	0	2	
52	3	-1	10	8	20	30	0	20	0	0	30	0	0	0	4	0	1	3	0	0	2	
53	1	-1	12	10	15	50	0	20	0	0	15	0	0	0	4	0	1	1	0	0	2	
53	2	-1	10	8	30	30	0	20	0	0	20	0	0	0	4	0	2	2	0	0	2	
53	3	-1	9	7	30	30	0	20	0	0	20	0	0	0	4	0	1	2	0	0	2	
122	1	2.5	100	40	0	0	80	0	0	5	5	10	4	2	0	0	1	0	1	0	4	
122	2	1.5	80	40	0	0	70	0	5	5	10	10	1	1	0	0	1	0	1	0	3	
122	3	1	95	35	0	0	40	0	0	10	2	48	1	1	1	0	2	0	1	0	4	
122	4	2.5	80	35	0	0	58	2	5	0	30	5	1	1	1	0	1	0	1	0	2	
122	5	1.5	70	45	0	0	40	5	5	5	25	20	3	1	0	0	1	0	1	0	3	
122	6	1.75	80	35	20	0	60	8	5	5	15	5	3	0	1	0	1	0	1	0	2	

Table F-2
White River Basin Stream Surveys
Field Observations Using EDT Level 2 Parameters Fall 2004

					Habitat Types (%)								Ratings (0–4)									
WRIA Stream #	Stream Reach	Grandient (%)	Channel Width (max)	Channel Width (min)	Backwater Ponds	Beaver Ponds	Large Cobble/Boulder Riffles	Off Channel Habitat Factor	Pool Tailouts	Glides	Primary Pools	Small Cobble/Gravel Riffles	Confinement Natural	Confinement Hydromodifications	Embeddedness	Nutrient Enrichment	Riparian Function	Temperature Variation	Turbidity	Water Withdrawals	Wood	Notes
122	7	3	70	30	0	0	100	0	0	0	0	0	3	2	0	0	1	0	1	0	4	
122	8	2	92	30	2	0	40	10	5	13	30	0	2	1	0	0	1	0	1	0	1	
186	1	1.75	125	50	0	0	88	2	0	10	0	0	4	1	0	0	1	0	2	0	4	
186	2	2	150	45	0	0	83	0	0	7	2	3	0	0	1	0	2	0	2	0	4	

Table F-3
White River Basin Stream Surveys
Physical Characteristics of Streams

WRIA Stream #	Stream Reach	Reach Length (ft)	Floodplain Width (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Avg. Flow Width (ft)	Avg. Flow Depth (ft)	Avg. Riffle Depth (in)	Flow Velocity (fps)	Velocity Limitations	Gradient (%)	Notes
31	1	19500	90	80	6	70	3	24	2	No	0.75	mouth of stream at confluence with puyallup
31	2	6900	325	165	6	54	3	24	2	No	1	dierenger confluence
31	3	18600	700	200	5.5	65	2.5	22	2.5	No	1.25	stewart street bridge
31	4	12000	550	200	5.5	95	2.5	22	3	No	1.75	
31	5	18000	1000	500	4.5	150	2	16	2.5	No	1.5	location approximate (manually selected)
31	6	22800	700	300	5.5	125	2.5	22	3	No	1.75	location approximate (manually selected)
31	7	27600	400	200	5.5	125	2.5	22	3.5	No	2	location approximate (manually selected)
32	1	1100	80	18	7	10	3	2.2	0.6	No	1.5	stream mouth is offset 75' from GPS point (340 degrees azmuth)
32	2	4940	25	12	6	6	3	-1	1.5	No	1	
32	3	2540	150	12	6	6	3	-1	1.5	No	1	
32	4	2960	40	18	7	12	2	-1	1.5	No	1.5	
32	5	4480	20	12	6	6	3	-1	0.9	No	1	tarp world
32	6	2400	50	12	5.5	7	2.5	-1	0.5	No	0.5	jovita creek confluence
33	1	410	40	9.5	2.5	3	0.7	0.7	2	No	1.5	jovita below 167
33	2	180	30	10	1.5	6	0.5	0.5	0	No	1.1	2 culverts under 167
33	3	2060	200	8	1.5	3	0.5	3	1	No	2	box under valley road
33	4	2360	15	5	1.5	3	0.4	3	2	No	4	
33	5	440	30	4.5	1.5	3.5	0.25	3	1.2	No	1	
34	1	700	150	6	1.4	4	0.3	4	0.7	No	1	
34	2	200	150	5.6	1.3	4	0.25	3	0.8	No	1	114th street
34	3	400	20	5	2	3	0.3	4	1.2	No	1.5	
35	1	360	16	12.5	3	9.5	1	6	3.5	No	1.5	confluence with white river
35	2	600	26	14	2	11	1	6	3	No	0.5	reach adjacent to sod farm
35	3	150	20	14	3	11.5	1	6	3	No	0.5	
35	4	240	20	8	3	7.5	1.6	12	3	No	1	railroad
35	5	240	20	16	3	11.5	0.8	3	1.1	No	1	
35	6	405	12	7.5	3	6.5	0.75	8	2.5	No	1	downstream box culvert
35	7	60	20	15	2	13	0.9	9	2.1	No	1	wider channel
35	8	180	15	9	3	8	1.5	4	1.1	No	0.5	off to side about 5 feet data read
35	9	360	150	13	2.5	12	1.2	-1	0.8	No	0.5	long glide silt rock bottom

Table F-3
White River Basin Stream Surveys
Physical Characteristics of Streams

WRIA Stream #	Stream Reach	Reach Length (ft)	Floodplain Width (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Avg. Flow Width (ft)	Avg. Flow Depth (ft)	Avg. Riffle Depth (in)	Flow Velocity (fps)	Velocity Limitations	Gradient (%)	Notes
35	10	570	45	13	2.5	12	1.2	-1	0.8	No	0.5	same as 09 except shrubs dominate banks
35	11	780	25	13	2.5	12	1.2	-1	0.8	No	0.5	with hardhack + vine maple started + bl maple + conifers start
35	12	1350	25	13	3.2	11	2	-1	0.8	No	0.5	
35	13	300	10	10	3	6	0.8	4	1.1	No	1	rdside ditch - run / riffle
35	14	330	11	11	2	4	0.5	3	1.1	No	1	2nd culvert 50 feet upstream 3-foot diameter
35	15	180	11	11	2	4	0.5	3	1.1	No	1	
35	16	840	14	12	2	8	0.8	3	0.8	No	0.5	
35	17	2130	50	5	2	4	0.7	8	0.4	No	1	2 culverts near hwy
35	18	1050	15	8	3	4	1.5	3	0.5	No	0.5	offset about 15 feet to west
36	1	240	30	17	2	10	0.4	3	2.5	No	4	tributary in reach 7 - offset 20 feet south
36	2	420	20	14	2	6	0.5	4	3.5	Yes	8	cascade at end of reach is a barrier to fish passage
37	1	1500	200	9	0.8	5	0.2	2	0.7	No	0.5	recently restored channel and wetland; reach upstream of culvert is too shallow and steep for fish passage
38	1	600	6	6	3	4	0.6	4	0.5	No	0.5	location approximate (manually selected)
38	2	380	6	6	3	5	0.8	4	1.2	Yes	0.75	location approximate (manually selected)
38	3	700	300	16	2.5	8	1.3	8	1	No	0.5	blocking culvert under railroad tracks; location approximate (manually selected)
38	4	2200	300	28	2.5	12	2	-1	-1	Yes	-1	inlet to culvert at end of reach not passible by juvinile salmonids; entering palustrine emergent wetland with somewhat defined channel
38	5	540	200	7	1.5	6	1	8	1	No	0.5	large palustrian wetland
38	6	1620	60	7	1	5	0.4	5	2	No	3	splits into 2 channels for short distance
39	1	2360	200	12	4	3	1	0	0	Yes	0.5	location approximate (manually adjusted)
39	2	180	10	8	3.5	4	8	0	2	Yes	0.5	property owner upstream Reach 2 has significantly altered channel--Reach 2 fed by property and seep on E side road, appears to be steep upstream of property

Table F-3
White River Basin Stream Surveys
Physical Characteristics of Streams

WRIA Stream #	Stream Reach	Reach Length (ft)	Floodplain Width (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Avg. Flow Width (ft)	Avg. Flow Depth (ft)	Avg. Riffle Depth (in)	Flow Velocity (fps)	Velocity Limitations	Gradient (%)	Notes
39.5	1	1160	500	70	0	65	0	0	1.3	No	0.5	power house tailrace
40	1	220	20	7	2.5	3	0.5	0	0.4	No	0.5	mapped channel
40	2	240	12	9	2	4	0.8	7	0.5	No	0.5	
40	3	260	16	12	2.5	9	1	0	0.3	No	0.5	
40.5	1	160	100	50	1	50	1	-1	-1	No	-1	
40.5	2	880	25	11	1	5	1	8	0.5	No	0.5	
51	1	1340	100	12	2	6	1.2	10	0.5	No	0.5	mouth of stream confined by floodplain terrace bank
51	2	260	50	18	1.5	6	0.5	3	1	No	6	stream breaks out of ravine onto floodplain
51	3	1900	25	17	2	7	0.6	4	1.5	No	11	flow through ravine
51	4	1540	12	10	2	10	1	-1	-1	No	-1	begin long ditch with many drain tile outlets
51	5	1360	12	10	2	10	0.8	-1	-1	No	-1	reach extends indefinitely up through plateau
52	1	940	50	12	2.5	10	2	-1	-1	No	-1	location approximate (manually selected)
52	2	2240	30	12	2.5	9	2	-1	-1	No	-1	location approximate (manually selected)
52	3	1400	25	10	2	8	1.5	-1	-1	No	-1	location approximate (manually selected)
53	1	340	40	12	2	10	1.5	-1	-1	No	-1	location approximate (manually selected)
53	2	1880	25	10	2	8	1.5	-1	-1	No	-1	location approximate (manually selected)
53	3	2140	20	9	1.5	7	1	-1	-1	No	-1	location approximate (manually selected)
122	1	6000	100	85	6	50	2	12	3.5	No	2.5	reach drains into White River right
122	2	2320	250	80	4	50	1	10	2	No	1.5	
122	3	520	250	95	4	65	0.9	5	2	No	1	2 channels with floodplain island
122	4	4080	250	80	4.5	50	1.5	1	3.5	No	2.5	
122	5	1800	100	70	4	50	1.75	16	3	No	1.5	
122	6	8080	120	80	4.5	45	1.5	12	3	No	1.75	live coho lower reach
122	7	600	95	70	4.3	40	1.3	1.2	3	No	3	
122	8	2720	175	92	4.5	44	1.5	10	2	No	2	12 coho carcasses observed
186	1	2480	200	125	6	60	2	1.5	3.5	No	1.75	reach enters mainstem of the White River
186	2		700	150	7	50	2	18	3	No	2	move point 60 feet west southwest

Table F-4
Potential Fish Barriers

Map Reference	Stream Number	Reach Number	Blockage Type	Pool Depth	Drop at Outlet	Depth at Outlet	Drop at Inlet	Culvert Gradient	Culvert Length	Cascade Gradient (%)	Cascade Length	Notes
B1	0032	01	Culverts	2.2	0	2.2	0	0.5	90			Culvert under railroad tracks (CMP ~8' diam.) and culvert from ditch on left bank
B2	0032	01	Culverts	2	0	2	0	1	190			Culverts (CMP ~8' diam.) under Valley Freeway (Highway 167)
B3	0032	03N	Culvert	0	0	3	0	0	140			Single culvert under 32nd Street on-ramp to Valley Freeway (west side of hwy). Bottomless concrete box (30 ft wide and 10 ft high).
B4	0032	03S	Culvert	0	0	3	0	0	140			Single culvert under 32nd Street off-ramp to Valley Freeway (west side of hwy). Bottomless concrete box (30 ft wide and 10 ft high).
B5	0032	04	Culverts	0	0	1	0	1	140			Twin CMP culverts (~8' diam.) under Valley Freeway (near Tarp World). Left culvert only one receiving flow during survey.
B6	0032	05	Culvert	0	0	3	0	1	100			Bottomless concrete 2-barrel box culvert under Stewart Street. ~30 ft wide (total width) and 10 ft high.
B7	0033	01	Culvert	0	0	0.6	0	1	350			Single culvert (~8' wide) under Valley Freeway and on-off ramps.
B8	0033	02	Culverts	0	0	0.5	0					u/s end of 2 box culvs- 2ft deep u/s flow
B9	0033	02	Cascade	4	2	1	0	0	0	0	0	
B10	0033	03	Culvert	0.5	0	0.5	0	1	100	0	0	no pool or drop at outlet 5 foot corregated
B12	0033	04	Culvert	1.8	2.8	0.1	0	5	0			3ft diam
B14	0033	04	Culvert	1	0	1	0	1	70	0	0	2nd culvert 5 foot corregated
B13	0033	04	Culvert	0.5	0	0.5	0	1	100	0	0	5 foot corregated
B11	0033	04	Culvert	0.4	0	0.4	0.2	1	70	0	0	5 foot corregated
B16	0034	01	Culvert	0.5	0	0.5	0	0	0			18 in half buried rcp - cant see u/s side approx rch02 end
B15	0034	01	Culvert	0.6	0	0.6	0.1	1	80	0	0	114 street
B17	0035	01	Culvert	3	0.6	0.6	0.25					2 x 4 ft cmps data for N culv- 2 per slope- 30 ft long
B18	0035	03	Culvert	3.6	0.5	0.8	0.2					4.5 ft conc- 0 per slope- 16 ft long
B19	0035	10	Culvert	1.5	0	1.5	0	1	30			u/s trashrack 2ft drop across
B20	0035	14	Culvert	0	0	0.5	0	0	20			14inch deep at inlet no barrier
B21	0035	16	Culverts	0	0	0	0	0	0	0	30	3 culv - no barrier - 3ft diam + nutrient in /

Table F-4
Potential Fish Barriers

Map Reference	Stream Number	Reach Number	Blockage Type	Pool Depth	Drop at Outlet	Depth at Outlet	Drop at Inlet	Culvert Gradient	Culvert Length	Cascade Gradient (%)	Cascade Length	Notes
B22	0037	01	Culvert	0.1	0	0.1	0	3	40			Flow through the culvert less than an inch
B23	0038	01	Culvert	1	0	0.5	0.1	1	54			Two-piece single 48" diameter culvert
B24	0038	02	Culvert	0	1	1	0	1.5	60			Single 3' diameter concrete culvert under
B25	0038	03	Culvert			1.2	0	0	30			Single 2' diameter concrete culvert under
B26	0038	05	Culvert			1	1	1	80			Single 2' diameter concrete culvert under
B27	0038	06	Culvert						1200			No data for culvert. Location
B28	0039	01	Culvert		0		0		20			no flow to high flow between reaches suggest unvisible physical barrier or blockage
B29	0039	01	Culvert									Location approximate (manually selected).
B30	0040	01	Dam	0.3	0.5	0.3	0					weir or control structure that diverts 0040 into 0040.5 and 0040
B31	0051	01	Other							60	5	Steep slope barrier at mouth. Flow subsurface.
B32	0051	03	Culvert	2	0	2	0	0	40			
B33	0052	01	Other							60	5	Steep slope barrier at mouth. Flow subsurface.
B34	0053	01	Other							60	5	Steep slope barrier at mouth. Flow

Note: All measurements in feet

Table F-5
White River Basin Stream Surveys
Reach End Report

WRIA Stream #	Stream Reach	Reason for Break	Notes
31	1	Other	tailrace (downstream end of dewatered reach)
31	2	Physical Prm. Change	Stewart Street bridge
31	3	Physical Prm. Change	floodplain width narrows
31	4	Physical Prm. Change	floodplain width narrows
31	5	Physical Prm. Change	floodplain width narrows
31	6	Physical Prm. Change	floodplain width narrows
31	7	Barrier	buckley diversion dam (upstream end of dewatered reach)
32	1	Habitat Change	upstream end of culvert under highway
32	2	Habitat Change	drain ditch enters from right side
32	3	Habitat Change	riparian changes and at upstream end of 32 off ramp
32	4	Other	top of highway culvert
32	5	Tributary	Jovinta creek confluence; location approximate (manually selected)
32	6	Other	county line road; location approximate (manually selected)
33	1	Other	Hwy 167 culvert; location approximate (manually selected)
33	2	Habitat Change	reach looks manmade; location approximate (moved)
33	3	Physical Prm. Change	creek crosses road at downstream end of culvert; location approximate (moved)
33	4	Other	confluence with 0034; location approximate (moved)
33	5	Other	King County line
34	1	Barrier	114th Street culvert; location approximate (moved)
34	2	Physical Prm. Change	flood plain gets narrow - standing about 20/30 feet from stream south
34	3	Barrier	5 foot fall and pond
35	1	Barrier	culvert barrier
35	2	Habitat Change	
35	3	Barrier	culvert
35	4	Habitat Change	also tributary confluence
35	5	Other	manually moved to start of next reach
35	6	Habitat Change	start of bank trees
35	7	Tributary	channel change too
35	8	Habitat Change	end of tree canopy; manually moved to start of next reach
35	9	Habitat Change	banks become shrub dominated / dogwood
35	10	Other	culvert / road backwater pool
35	11	Habitat Change	culvert change from tree cover 2 shrub
35	12	Other	roadside ditch in + stream becoming roadside ditch
35	13	Other	culvert 3-foot diameter 40 feet long 0 gradient 1foot deep downstream 1.5 deep upstream
35	14	Habitat Change	mixed channel and culverts
35	15	Habitat Change	
35	16	Habitat Change	

Table F-5
White River Basin Stream Surveys
Reach End Report

WRIA Stream #	Stream Reach	Reason for Break	Notes
35	17	Barrier	long 2-foot diameter 1foot deep - no barrier + pic 2nd culvert; manually moved to start of next reach
35	18	Other	stream end - goes under and away
36	1	Physical Prm. Change	gradient sharply increases
36	2	Barrier	gradient sharply increases - velocity barrier - offset 15 feet north
37	1	Barrier	culvert at road
38	1	Barrier	habitat change also; location approximate (manually adjusted)
38	2	Barrier	culvert under railroad; location approximate (manually selected)
38	3	Habitat Change	location approximate (manually selected)
38	4	Physical Prm. Change	location approximate (manually selected)
38	5	Habitat Change	range in velocity stream enters wetland complex; location approximate (manually adjusted)
38	6	Barrier	culvert 3-foot diameter, .4 foot depth daylight other end; location approximate (manually adjusted)
39	1	Barrier	location approximate (manually adjusted)
39	2	Barrier	location approximate (manually adjusted)
39.5	1	Tributary	talirace drains to White River
40	1	Barrier	control structure; manually moved to start of next reach
40	2	Habitat Change	glide and shrubs to county line. Manually moved to start of next reach.
40	3	Other	county line; location approximate (manually selected)
40.5	1	Habitat Change	palustine to fp; manually moved to start of next reach
40.5	2	Other	beginning of created channel at control structure; manually moved to start of next reach
51	1	Physical Prm. Change	top of floodplain
51	2	Physical Prm. Change	mouth of ravine floodplain width increase less confinement
51	3	Other	culvert
51	4	Barrier	culvert
51	5	Other	channel extends further upstream, but no surface flow
52	1	Habitat Change	location approximate (manually selected)
52	2	Habitat Change	location approximate (manually selected)
52	3	Habitat Change	location approximate (manually selected)
53	1	Habitat Change	location approximate (manually selected)
53	2	Habitat Change	location approximate (manually selected)
53	3	Habitat Change	location approximate (manually selected)
122	1	Physical Prm. Change	river begins confinement by high banks
122	2	Habitat Change	return to mid and late seral stage
122	3	Habitat Change	riparian habitat changes to early seral stage
122	4	Other	start of day
122	5	Physical Prm. Change	more gravel riffles
122	6	Physical Prm. Change	

Table F-5
White River Basin Stream Surveys
Reach End Report

WRIA Stream #	Stream Reach	Reason for Break	Notes
122	7	Physical Prm. Change	channel narrows
122	8	Other	national forest boundary
186	1	Habitat Change	floodplain narrows somewhat and enters more conifer dominated floodplain
186	2	Other	f river mile 1.0

Appendix G

Tributary Stream Gauge Station Data and Tributary Water Quality Monitoring Data

THIS PAGE INTENTIONALLY LEFT BLANK.

Salmon Springs Creek at Sumner, WA

DISCHARGE (CFS), WATER YEAR 2005

MEAN DAILY VALUES (PROVISIONAL)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	---	---	---	---	---	---	---	---	---	5.0	5.1	6.0
2	---	---	---	---	---	---	---	---	---	5.0	4.8	6.0
3	---	---	---	---	---	---	---	---	---	4.9	5.0	6.1
4	---	---	---	---	---	---	---	---	---	4.9	4.9	6.1
5	---	---	---	---	---	---	---	---	---	5.0	4.7	4.8
6	---	---	---	---	---	---	---	---	---	6.7	4.7	4.7
7	---	---	---	---	---	---	---	---	---	5.3	4.9	4.7
8	---	---	---	---	---	---	---	---	---	6.2	4.7	4.7
9	---	---	---	---	---	---	---	---	5.6	6.2	4.7	5.0
10	---	---	---	---	---	---	---	---	5.7	5.5	4.7	6.0
11	---	---	---	---	---	---	---	---	5.9	5.3	4.8	5.0
12	---	---	---	---	---	---	---	---	5.9	5.1	5.0	4.8
13	---	---	---	---	---	---	---	---	5.8	4.8	4.7	4.8
14	---	---	---	---	---	---	---	---	5.7	4.7	4.7	4.8
15	---	---	---	---	---	---	---	---	5.5	5.0	4.9	4.7
16	---	---	---	---	---	---	---	---	5.6	5.4	5.5	4.9
17	---	---	---	---	---	---	---	---	8.0	4.9	6.1	4.8
18	---	---	---	---	---	---	---	---	5.9	5.0	5.5	4.7
19	---	---	---	---	---	---	---	---	5.5	5.0	6.1	4.8
20	---	---	---	---	---	---	---	---	5.2	4.5	6.6	4.9
21	---	---	---	---	---	---	---	---	5.2	4.9	6.5	4.6
22	---	---	---	---	---	---	---	---	5.7	5.6	6.0	4.7
23	---	---	---	---	---	---	---	---	5.4	5.1	6.0	4.6
24	---	---	---	---	---	---	---	---	5.1	4.9	5.6	4.5
25	---	---	---	---	---	---	---	---	5.2	4.9	5.5	4.6
26	---	---	---	---	---	---	---	---	5.1	4.8	5.5	4.7
27	---	---	---	---	---	---	---	---	5.8	4.9	5.8	4.7
28	---	---	---	---	---	---	---	---	5.6	4.9	5.9	4.7
29	---	---	---	---	---	---	---	---	5.3	4.9	6.4	5.4

30	---	---	---	---	---	---	---	---	5.1	4.9	6.3	6.9
31	---	---	---	---	---	---	---	---	---	4.7	6.0	---
TOTAL	0	0	0	0	0	0	0	0	123.8	158.9	167.6	151.7
MEAN	---	---	---	---	---	---	---	---	5.6	5.1	5.4	5.1
MAX	---	---	---	---	---	---	---	---	8.0	6.7	6.6	6.9
MIN	---	---	---	---	---	---	---	---	5.1	4.5	4.7	4.5
AC-FT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	246	315	332	301

CAL YEAR 2004
WTR YEAR 2005 TOTAL 602 MEAN 5.3 MAX 8.0 MIN 4.5 AC-FT 1194

Salmon Springs Creek at Sumner, WA

DISCHARGE (CFS), WATER YEAR 2006

MEAN DAILY VALUES (PROVISIONAL)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	5.6	16	8.6	11	---	---	---	---	---	---	---	---
2	5.5	8.3	11	10	---	---	---	---	---	---	---	---
3	5.0	7.4	9.7	9.1	---	---	---	---	---	---	---	---
4	5.3	8.1	8.2	8.7	---	---	---	---	---	---	---	---
5	5.2	10	7.9	17	---	---	---	---	---	---	---	---
6	5.9	9.8	7.6	19	---	---	---	---	---	---	---	---
7	6.4	7.8	7.4	21	---	---	---	---	---	---	---	---
8	5.7	7.0	7.0	12	---	---	---	---	---	---	---	---
9	5.7	6.8	6.7	16	---	---	---	---	---	---	---	---
10	5.7	6.9	6.7	54	---	---	---	---	---	---	---	---
11	5.6	8.2	6.7	39	---	---	---	---	---	---	---	---
12	5.5	8.0	6.9	20	---	---	---	---	---	---	---	---
13	6.0	9.7	7.1	---	---	---	---	---	---	---	---	---
14	5.8	7.6	6.7	---	---	---	---	---	---	---	---	---
15	6.4	7.1	6.6	---	---	---	---	---	---	---	---	---
16	5.9	6.9	6.2	---	---	---	---	---	---	---	---	---
17	5.9	6.9	6.2	---	---	---	---	---	---	---	---	---
18	5.7	6.5	6.2	---	---	---	---	---	---	---	---	---
19	6.0	6.4	6.5	---	---	---	---	---	---	---	---	---
20	5.9	6.5	7.3	---	---	---	---	---	---	---	---	---
21	5.7	6.3	9.3	---	---	---	---	---	---	---	---	---
22	5.8	6.4	11	---	---	---	---	---	---	---	---	---
23	6.1	6.3	15	---	---	---	---	---	---	---	---	---
24	6.0	7.1	29	---	---	---	---	---	---	---	---	---
25	6.0	19	16	---	---	---	---	---	---	---	---	---
26	6.0	12	13	---	---	---	---	---	---	---	---	---
27	5.8	8.2	13	---	---	---	---	---	---	---	---	---
28	6.1	7.6	14	---	---	---	---	---	---	---	---	---

29	6.3	12	11	---	---	---	---	---	---	---	---	---
30	6.1	9.3	15	---	---	---	---	---	---	---	---	---
31	11	---	17	---	---	---	---	---	---	---	---	---
TOTAL	185.6	256.1	310.5	236.8	0	0	0	0	0	0	0	0
MEAN	6.0	8.5	10.0	19.8	---	---	---	---	---	---	---	---
MAX	11	19	29	54	---	---	---	---	---	---	---	---
MIN	5.0	6.3	6.2	8.7	---	---	---	---	---	---	---	---
AC-FT	368	508	616	470	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CAL YEAR 2005	TOTAL	752	MEAN	8.2	MAX	29.0	MIN	5.0	AC-FT	1492
WTR YEAR 2006	TOTAL	989	MEAN	9.5	MAX	54.0	MIN	5.0	AC-FT	1962

Stream 051 near Bonney Lake, WA

DISCHARGE (CFS), WATER YEAR 2005

MEAN DAILY VALUES (PROVISIONAL)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	---	---	---	---	---	---	---	---	---	---	0.00	0.00
2	---	---	---	---	---	---	---	---	---	---	0.00	0.00
3	---	---	---	---	---	---	---	---	---	---	0.00	0.00
4	---	---	---	---	---	---	---	---	---	---	0.00	0.00
5	---	---	---	---	---	---	---	---	---	---	0.00	0.00
6	---	---	---	---	---	---	---	---	---	---	0.00	0.00
7	---	---	---	---	---	---	---	---	---	---	0.00	0.00
8	---	---	---	---	---	---	---	---	---	---	0.00	0.00
9	---	---	---	---	---	---	---	---	---	---	0.00	0.00
10	---	---	---	---	---	---	---	---	---	---	0.00	0.05
11	---	---	---	---	---	---	---	---	---	---	0.00	0.01
12	---	---	---	---	---	---	---	---	---	---	0.00	0.00
13	---	---	---	---	---	---	---	---	---	---	0.00	0.00
14	---	---	---	---	---	---	---	---	---	---	0.00	0.00
15	---	---	---	---	---	---	---	---	---	0.06	0.00	0.00
16	---	---	---	---	---	---	---	---	---	0.06	0.00	0.00
17	---	---	---	---	---	---	---	---	---	0.03	0.00	0.00
18	---	---	---	---	---	---	---	---	---	0.01	0.00	0.00
19	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
20	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
21	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
22	---	---	---	---	---	---	---	---	---	0.05	0.00	0.00
23	---	---	---	---	---	---	---	---	---	0.03	0.00	0.00
24	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
25	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00

26	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
27	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
28	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
29	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
30	---	---	---	---	---	---	---	---	---	0.00	0.00	0.65
31	---	---	---	---	---	---	---	---	---	0.00	0.00	---
TOTAL	0	0	0	0	0	0	0	0	0	0.24	0	0.71
MEAN	---	---	---	---	---	---	---	---	---	0.014	0.000	0.023
MAX	---	---	---	---	---	---	---	---	---	0.06	0.00	0.65
MIN	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
AC-FT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.5	0.00	1.4

CAL YEAR 2004
WTR YEAR 2005 TOTAL 1 MEAN 0.012 MAX 0.65 MIN 0.000 AC-FT 1.9

Stream 051 near Bonney Lake, WA

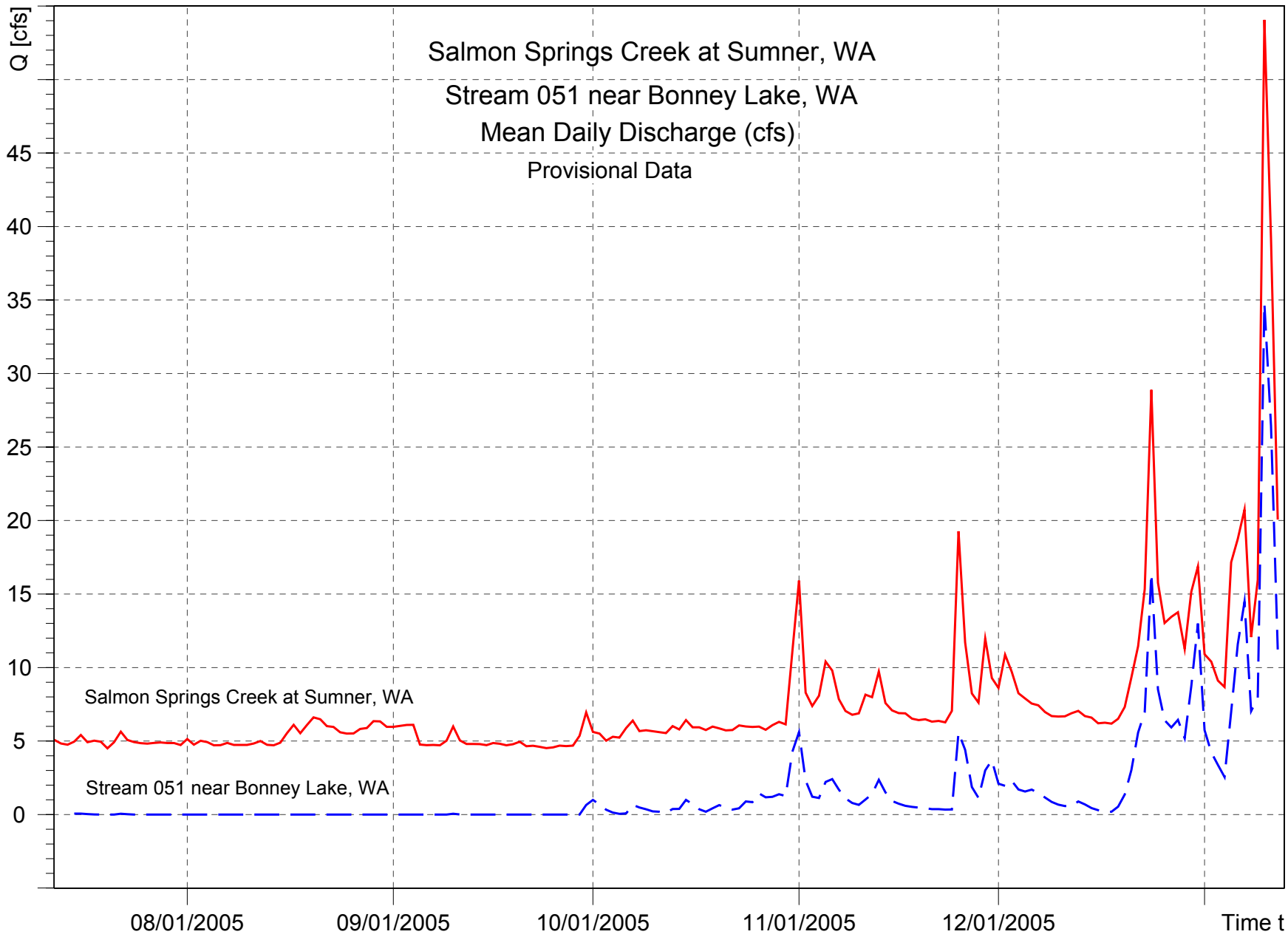
DISCHARGE (CFS), WATER YEAR 2006

MEAN DAILY VALUES (PROVISIONAL)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.00	5.6	2.1	5.7	---	---	---	---	---	---	---	---
2	0.68	2.3	2.0	4.2	---	---	---	---	---	---	---	---
3	0.33	1.2	2.3	3.4	---	---	---	---	---	---	---	---
4	0.13	1.1	1.7	2.6	---	---	---	---	---	---	---	---
5	0.05	2.2	1.6	7.0	---	---	---	---	---	---	---	---
6	0.08	2.4	1.7	12	---	---	---	---	---	---	---	---
7	0.66	1.7	1.5	14	---	---	---	---	---	---	---	---
8	0.48	1.1	1.2	7.0	---	---	---	---	---	---	---	---
9	0.36	0.79	0.86	7.9	---	---	---	---	---	---	---	---
10	0.22	0.66	0.67	35	---	---	---	---	---	---	---	---
11	0.19	1.0	0.58	26	---	---	---	---	---	---	---	---
12	0.12	1.4	0.58	11	---	---	---	---	---	---	---	---
13	0.38	2.4	0.89	---	---	---	---	---	---	---	---	---
14	0.39	1.5	0.69	---	---	---	---	---	---	---	---	---
15	1.00	0.93	0.44	---	---	---	---	---	---	---	---	---
16	0.71	0.73	0.29	---	---	---	---	---	---	---	---	---
17	0.36	0.59	0.19	---	---	---	---	---	---	---	---	---
18	0.19	0.52	0.19	---	---	---	---	---	---	---	---	---
19	0.43	0.47	0.53	---	---	---	---	---	---	---	---	---
20	0.64	0.43	1.4	---	---	---	---	---	---	---	---	---
21	0.47	0.37	3.0	---	---	---	---	---	---	---	---	---
22	0.34	0.37	5.6	---	---	---	---	---	---	---	---	---
23	0.42	0.34	7.0	---	---	---	---	---	---	---	---	---
24	0.89	0.34	16	---	---	---	---	---	---	---	---	---
25	0.84	5.6	8.5	---	---	---	---	---	---	---	---	---
26	1.4	4.4	6.4	---	---	---	---	---	---	---	---	---
27	1.2	1.9	5.9	---	---	---	---	---	---	---	---	---
28	1.2	1.1	6.4	---	---	---	---	---	---	---	---	---

29	1.4	3.0	5.2	---	---	---	---	---	---	---	---	---
30	1.3	3.7	8.7	---	---	---	---	---	---	---	---	---
31	4.3	---	13	---	---	---	---	---	---	---	---	---
TOTAL	22.16	50.14	107.11	135.8	0	0	0	0	0	0	0	0
MEAN	0.71	1.7	3.5	11.4	---	---	---	---	---	---	---	---
MAX	4.3	5.6	16	35	---	---	---	---	---	---	---	---
MIN	0.05	0.34	0.19	2.6	---	---	---	---	---	---	---	---
AC-FT	44	99	212	269	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CAL YEAR 2005	TOTAL	179	MEAN	2.0	MAX	16.0	MIN	0.050	AC-FT	356
WTR YEAR 2006	TOTAL	315	MEAN	3.0	MAX	35.0	MIN	0.050	AC-FT	625


Salmon Springs Creek at Sumner, WA
Stream 051 near Bonney Lake, WA
Mean Daily Discharge (cfs)
Provisional Data
Q [cfs]
45
40
35
30
25
20
15
10
5
0
Salmon Springs Creek at Sumner, WA
Stream 051 near Bonney Lake, WA
08/01/2005
09/01/2005
10/01/2005
11/01/2005
12/01/2005
Time t

DATE	SITE NUMBER	SITE DESCRIPTION	pH	Temp	Turbidity	Conductivity	Dissolved Oxygen	Fecals	T-Phos	O-Phos	Nitrate	Nitrogen (TKN)	TSS
05/03/05	MS037	Forest Canyon Road	6.89	12.8	2.78	118.0	n/a	10	ND	0.1	1.290		
05/24/05	MS037	Forest Canyon Road	7.10	12.9	3.71	115.0	n/a						
08/16/05	MS037	Forest Canyon Road	6.34	14.3	5.44	181.0	7.70	63	0.10	ND	0.647		
10/11/05	MS037	Forest Canyon Road	6.41	10.1	7.70	172.0	10.27	11	4.70	0.181	0.582		
12/15/05	MS037	Forest Canyon Road	6.40	6.5	6.56	223.0	12.60	25	ND	ND	1.400		
01/24/06	MS037	Forest Canyon Road	6.54	8.4	2.10	153.0	103.80	14	ND	ND	2.000		
02/09/06	MS037	Forest Canyon Road	7.11	7.3	1.30	135.0	106.10	11	ND	ND	1.800		
03/02/06	MS037	Forest Canyon Road	6.65	8.3	5.03	123.0	12.42	69					
03/22/06	MS037	Forest Canyon Road	7.70	9.6	1.79	138.6	9.93	180	0.03				
04/06/06	MS037	Forest Canyon Road	7.49	8.8	4.20	147.6	10.97	380	0.04				
04/25/06	MS037	Forest Canyon Road	7.10	10.0	3.32	161.0	11.43	43	0.08				
05/08/06	MS037	Forest Canyon Road	6.77	10.7	2.81	166.0	10.74	23	0.05				
07/20/06	MS037	Forest Canyon Road	7.25	12.6	1.95	164.0	10.10	24	0.02				
12/05/06	MS037	Forest Canyon Road	7.87	8.8	1.86	149.4	11.36	92	0.02				
03/22/07	MS037	Forest Canyon Road	6.93	8.8	6.37	103.5	7.78	16	0.03			0.13	5.000
06/20/07	MS037	Forest Canyon Road	6.74	11.0	3.67	61.6	6.60	55	0.04			0.1	9.000
10/24/07	MS037	Forest Canyon Road											
01/16/08	MS037	Forest Canyon Road	7.30	7.3	2.75	150.9		54	0.00			0.11	3.000
03/20/08	MS037	Forest Canyon Road	7.06	8.2	19.70	128.0	11.24	20	0.03			0.61	28.000
04/02/08	MS037	Forest Canyon Road	7.24	8.6	15.90	62.0	14.01	90	0.03			0.97	41.000
05/22/08	MS037	Forest Canyon Road											
06/03/08	MS037	Forest Canyon Road	6.45	10.6	3.30	97.0	11.23	90	0.08			0.05	70.000
05/03/05	MS039	Bowman Creek	6.53	15.4	0.53	116.0	n/a	10	ND	0.6	0.032		
05/24/05	MS039	Bowman Creek	6.46	14.5	1.03	151.0	n/a						
08/16/05	MS039	Bowman Creek	5.94	20.4	0.95	104.0	6.90	86	ND	0.092	ND		
10/11/05	MS039	Bowman Creek	5.96	13.6	0.60	120.9	7.97	49	0.22	0.088	ND		
12/15/05	MS039	Bowman Creek	6.13	2.9	1.61	133.0	12.67	110	ND	ND	0.038		
01/24/06	MS039	Bowman Creek	6.15	6.0	1.40	160.4	83.00	3	ND	ND	0.690		
01/06/00	MS039	Bowman Creek	6.11	4.7	0.70	162.1	86.80	0	ND	ND	0.490		
03/02/06	MS039	Bowman Creek	6.36	6.4	1.03	84.0	11.24	0					
03/22/06	MS039	Bowman Creek	7.60	9.9	0.14	74.0	10.15	160	0.02				
04/06/06	MS039	Bowman Creek	7.43	10.5	1.17	75.8	8.28	6	0.01				
04/25/06	MS039	Bowman Creek	6.46	14.4	1.26	125.0	7.78	7	0.03				
05/08/06	MS039	Bowman Creek	6.75	18.6	1.32	108.3	6.64	17	0.03				
06/19/06	MS039	Bowman Creek	7.72	17.8		75.4	8.16	60	0.00				
07/20/06	MS039	Bowman Creek	7.40	20.5	2.26	86.3	7.24	43	0.00				
12/05/06	MS039	Bowman Creek	7.55	4.8	0.16	81.7	10.05	5	0.02				
03/22/07	MS039	Bowman Creek	6.60	9.8	3.91	58.7	7.06	12	0.02			0.35	6.000
06/20/07	MS039	Bowman Creek	6.22	17.2	0.86	30.7	5.16	25	0.02			0.24	0.050
10/24/07	MS039	Bowman Creek	6.43	11.9	0.70	57.0	7.72	20	0.00			0.38	0.050
01/16/08	MS039	Bowman Creek	6.74	3.6	1.11	133.5		17	0.00			36	1.000
03/20/08	MS039	Bowman Creek	6.81	8.6	0.97	64.0	10.07	1	0.01			0.28	1.000
04/02/08	MS039	Bowman Creek	6.66	7.3	0.43	56.0	13.22	10	0.02			0.28	1.000
05/22/08	MS039	Bowman Creek	6.20	15.0	1.07	61.0	7.49	610	0.01			0.23	18.000
06/03/08	MS039	Bowman Creek	6.24	14.3	1.04	57.0	8.59	50	0.01			0.17	5.000
07/14/08	MS039	Bowman Creek	0.89	22.0	6.24	62.0	6.72	30	0.01			0.25	3.000
08/05/08	MS039	Bowman Creek	6.35	19.8	4.24	60.0	9.49	20	0.02			0.7	17.000
09/09/08	MS039	Bowman Creek	7.12	9.4	1.44	55.0	7.63	10	0.01			0.64	4.000
10/29/08	MS039	Bowman Creek	7.27	9.9	0.59	57.0	13.72	1	0.01			0.23	5.000

DATE	SITE NUMBER	SITE DESCRIPTION	pH	Temp	Turbidity	Conductivity	Dissolved Oxygen	Fecals	T-Phos	O-Phos	Nitrate	Nitrogen (TKN)	TSS
11/17/08	MS039	Bowman Creek	6.65	9.4	1.01	59.0	27.44	1	0.00			0.05	0.500
12/16/08	MS039	Bowman Creek	6.52	3.1	4.75	63.0	12.91	1	0.05			0.25	19.000
01/13/09	MS039	Bowman Creek	6.79	6.6	1.24	64.0	10.99	1	0.05			0.25	0.700
02/03/09	MS039	Bowman Creek	7.22	4.7	5.66	67.0	13.95	10	0.20			0.25	7.500
03/04/09	MS039	Bowman Creek	7.31	6.8	1.70	0.6	9.53	910	0.11			0.25	1.700
04/08/09	MS039	Bowman Creek	7.49	12.5	0.74	64.0	12.21	20	0.05			0.25	1.000
05/20/09	MS039	Bowman Creek	7.02	15.2	0.59	56.0	9.93	25	0.05			0.6	3.330
06/24/09	MS039	Bowman Creek	7.44	19.2	1.83	52.0	9.98	75	0.05			0.5	2.300
07/22/09	MS039	Bowman Creek	7.65	21.6	1.01	52.0	7.55	130	0.05			1.2	2.400
08/12/09	MS039	Bowman Creek	7.51	19.6	0.47	50.0	14.42	215	0.05			1.1	1.500
09/29/09	MS039	Bowman Creek	7.93	14.2	0.38	54.0	10.77	50	0.05			0.25	1.500
10/21/09	MS039	Bowman Creek	7.58	12.3	0.31	61.0	8.58	15	0.05			3.1	1.800
11/18/09	MS039	Bowman Creek	7.67	7.8	0.19	67.0	14.28	30	0.05			0.25	0.250
12/15/09	MS039	Bowman Creek	7.55	3.1	3.46	75.0	12.01	30	0.05			0.25	1.600
01/11/10	MS039	Bowman Creek	6.91	7.0	1.01	78.0	10.47	60	0.05			0.25	1.600
02/24/10	MS039	Bowman Creek	7.66	7.2	1.34	56.0	11.95	1	0.03			0.25	2.400
03/22/10	MS039	Bowman Creek	7.21	10.2	1.21	57.0	10.40	1	0.03			0.25	0.800
04/29/10	MS039	Bowman Creek	7.43	12.7	1.41	66.0	7.35	10	0.01			0.25	3.600
05/03/10	MS039	Bowman Creek	7.23	12.0	1.39	63.0	9.84	25	0.01			0.25	1.200
06/21/10	MS039	Bowman Creek	7.06	15.1	0.88	63.0	14.24	20	0.04			0.5	1.200
07/22/10	MS039	Bowman Creek	7.63	19.5	0.07	57.0	7.07	25	0.01			1.3	1.200
08/17/10	MS039	Bowman Creek	7.54	23.9	0.53	54.0	7.47	25	0.02			0.25	0.800
09/27/10	MS039	Bowman Creek	7.47	18.6	0.32	57.0	9.14	25	0.01			0.25	1.200
10/13/10	MS039	Bowman Creek	7.41	13.5	0.23	56.0	10.82	20	0.05			0.25	0.250
12/02/10	MS039	Bowman Creek	7.38	4.5	1.36	66.0	17.29	1	0.01			0.25	0.250
12/22/10	MS039	Bowman Creek	7.43	4.9	0.47	70.0	12.12	1	0.01			0.25	0.250
05/03/05	MS040	48th Street East Site	6.47	11.9	3.67	95.0	n/a	220	0.09	1.1	0.824		
05/24/05	MS040	48th Street East Site	7.10	11.5	3.82	133.0	n/a						
08/16/05	MS040	48th Street East Site	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry		
10/11/05	MS040	48th Street East Site	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry		
12/15/05	MS040	48th Street East Site	5.27	2.7	4.27	269.0	9.91	10	0.06	ND	2.700		
01/24/06	MS040	48th Street East Site	6.02	4.8	3.40	175.0	84.80	9	0.07	ND	1.100		
01/06/06	MS040	48th Street East Site	5.19	6.2	13.40	284.0	48.90	29	0.05	ND	0.730		
02/08/06	MS040	48th Street East Site	5.88	2.9	2.60	182.0	95.90	29	0.05				
03/02/06	MS040	48th Street East Site	7.07	6.3	4.10	184.0	10.88	30	0.05				0.088
03/22/06	MS040	48th Street East Site	7.33	8.4	2.62	119.0	10.34	3	0.07				
04/06/06	MS040	48th Street East Site	7.77	8.6	3.39	119.4	9.98	2	0.09				
04/25/06	MS040	48th Street East Site	6.79	1.8	3.80	150.0	10.90	1	0.15				
05/08/06	MS040	48th Street East Site											
12/05/06	MS040	48th Street East Site	7.38	5.6	1.54	122.1	10.15	4	0.05				
03/22/07	MS040	48th Street East Site	6.75	8.2	4.18	79.9	7.32	1	0.09			0.96	4.000
06/20/07	MS040	48th Street East Site											
01/16/08	MS040	48th Street East Site	6.99	2.8	5.23	190.7		1	0.03			1.7	1.000
03/20/08	MS040	48th Street East Site	7.00	6.6	4.36	93.6	11.41	1	0.09			0.88	2.500
04/02/08	MS040	48th Street East Site	6.79	5.9	3.70	100.0	14.78	10	0.05			1.3	1.000

DATE	SITE NUMBER	SITE DESCRIPTION	pH	Temp	Turbidity	Conductivity	Dissolved Oxygen	Fecals	T-Phos	O-Phos	Nitrate	Nitrogen (TKN)	TSS
05/03/05	MS038	Salmon Springs Ck.	6.83	11.5	5.86	181.0	n/a	3200	0.06	0.17	0.775		
05/24/05	MS038	Salmon Springs Ck.	6.75	12.5	6.27	200.0	n/a						
08/16/05	MS038	Salmon Springs Ck.	6.45	12.1	14.70	267.0	9.02	470	0.18	ND	0.757		
10/11/05	MS038	Salmon Springs Ck.	6.51	11.4	2.40	233.0	9.78	49	0.83	ND	0.924		
12/15/05	MS038	Salmon Springs Ck.	6.24	6.9	4.40	298.0	11.20	980	ND	ND	1.000		
12/15/05	MS038-R	Salmon Springs Ck.						615	ND	ND	1.000		
01/06/06	MS038-R	Salmon Springs Ck.						670	0.05	ND	1.000		
01/24/06	MS038	Salmon Springs Ck.	6.59	8.7	8.50	281.0	83.50	960	0.20	ND	0.940		
01/24/06	MS038-R	Salmon Springs Ck.						670	0.09	ND	0.950		
02/08/06	MS038	Salmon Springs Ck.						480	0.11	ND	0.960		
02/09/06	MS038	Salmon Springs Ck.	6.43	7.7	6.20	274.0	90.60	700	0.06	ND	1.000		
03/02/06	MS038	Salmon Springs Ck.	6.03	9.2	7.25	207.0	10.87	3100					
03/22/06	MS038	Salmon Springs Ck.	7.45	10.6	5.35	242.0	8.20	175	0.02				
04/06/06	MS038	Salmon Springs Ck.	7.35	9.6	4.26	247.0	9.75	400	0.05				
04/25/06	MS038	Salmon Springs Ck.	7.26	10.8	2.86	252.0	10.35	31	0.04				
05/08/06	MS038	Salmon Springs Ck.	6.68	12.3	3.38	243.0	8.90	286	0.06				
06/19/06	MS038	Salmon Springs Ck.	7.88	13.5		260.0	9.05	230	0.05				
07/20/06	MS038	Salmon Springs Ck.	7.17	13.2	3.04	189.0	9.07	970	0.04				
12/05/06	MS038	Salmon Springs Ck.	7.51	9.1	2.14	205.0	9.60	3000	0.05				
03/22/07	MS038	Salmon Springs Ck.	6.85	9.6	7.37	183.0	7.41	70	0.09			0.1	10.000
05/03/05	MS042	Gov't. Canal Inlet	6.80	16.7	6.75	156.0	n/a	80	ND	0.67	0.426		0.426
05/24/05	MS042	Gov't. Canal Inlet	6.33	16.7	7.63	191.0	n/a						
08/16/05	MS042	Gov't. Canal Inlet	6.62	17.8	4.33	263.0	6.61	51	4.90	ND	ND		ND
10/11/05	MS042	Gov't. Canal Inlet	6.36	14.5	2.50	130.0	7.32	14	n/a	ND	ND		ND
10/11/05	MS042-R	Govt. Canal Inlt Replicate	6.36	14.5	2.50	130.0	7.32	9	0.22	ND	ND		ND
12/15/05	MS042	Gov't. Canal Inlet	4.16	3.0	11.30	364.0	8.53	20	ND	ND	NA		NA
01/24/06	MS042	Gov't. Canal Inlet	5.80	7.9	6.60	214.0	82.90	17	0.07	ND	0.630		0.630
02/09/06	MS042	Gov't. Canal Inlet	5.39	7.8	5.60	238.0	74.20	0	ND	ND	0.700		0.700
03/02/06	MS042	Gov't. Canal Inlet	6.82	9.9	5.11	208.0	7.83	140					
03/22/06	MS042	Gov't. Canal Inlet	7.25	11.1	3.02	236.0	8.60	80	0.01				
04/06/06	MS042	Gov't. Canal Inlet	6.91	11.4	4.41	240.0	9.03	46	0.03				
04/25/06	MS042	Gov't. Canal Inlet	6.40	14.5	4.57	227.0	10.80	120	0.03				
05/08/06	MS042	Gov't. Canal Inlet	6.71	10.4	161.00	113.9	11.63	83	0.37				
06/19/06	MS042	Gov't. Canal Inlet	7.35	17.3		246.0	8.33	85	0.02				
07/20/06	MS042	Gov't. Canal Inlet	6.95	19.6	4.53	198.0	9.08	270	0.02				
12/05/06	MS042	Gov't. Canal Inlet	7.25	9.3	6.76	201.0	6.65	20	0.04				
05/03/05	MS041	Gov't Canal Outlet	6.83	14.6	6.83	126.0	n/a	80	ND	0.64	0.273		0.273
05/24/05	MS041	Gov't Canal Outlet	6.60	16.7	7.00	171.0	n/a						
08/16/05	MS041	Gov't Canal Outlet	6.07	18.6	9.77	210.0	4.93	330	0.10	ND	ND		ND
10/11/05	MS041	Gov't Canal Outlet	6.07	12.7	11.00	192.0	7.57	31	3.20	ND	0.154		0.154
12/15/05	MS041	Gov't Canal Outlet	5.49	2.7	3.69	323.0	8.57	5	ND	0.16	0.240		0.240
01/24/06	MS041	Gov't Canal Outlet	6.40	6.8	5.70	186.0	76.50	20	ND	ND	0.450		0.450
02/09/06	MS041	Gov't Canal Outlet	5.19	6.2	13.40	284.0	48.90	6	0.05	NA	NA		NA
03/02/06	MS041	Gov't Canal Outlet	6.78	8.6	9.18	NA	6.79	63					
04/06/06	MS041	Gov't Canal Outlet	7.01	11.9	4.77	218.0	9.00	71	0.03				
04/25/06	MS041	Gov't Canal Outlet	6.29	15.3	4.49	183.0	7.53	1	0.02				
05/08/06	MS041	Gov't Canal Outlet	6.68	11.2	144.00	79.7	12.05	63	0.32				
06/19/06	MS041	Gov't Canal Outlet	7.37	18.1		226.0	6.41	120	0.07				

Appendix H

Pierce County Flood Risk Assessment – White River Basin

THIS PAGE INTENTIONALLY LEFT BLANK.

CHAPTER TWELVE
White River Basin

12.1 BASIN CHARACTERISTICS

The White River Basin includes the White River, Lower White River, and Mud Mountain surface water basins delineated by Pierce County. Thus, this flood risk assessment addresses three of the 26 surface water basins in unincorporated Pierce County. Since most of the White River Basin falls within National Forest lands or Mount Rainier National Park, the majority of this basin plan addresses surface water management in the Lower White River and Mud Mountain Basins. The Basin is also part of *Water Resource Inventory Area* (WRIA) 10, one of the 62 WRIAs that were established by the Washington State Department of Ecology in the 1970s.

The White River Basin originates at the glacial headwaters of Mount Rainier and terminates west of Lake Tapps at the confluence of the White, Carbon, and Puyallup Rivers. The Puyallup River flows generally northwest from the confluence, eventually discharging into Puget Sound in Tacoma, Washington. The White River Basin occupies approximately 496 square miles of Pierce and King Counties. The majority of the Basin area (75%) is located in Pierce County, whereas the smaller northern portion of the Basin (25%) is located in King County.

Climate in the Basin varies dramatically from east to west. The principal type of precipitation in the subbasin changes, based on the proximity to Mount Rainier and the steep rugged terrain in the eastern portion of the Basin. In the eastern part of the Basin, monthly average winter temperatures are below freezing whereas monthly average summer temperatures do not exceed 72°F. In the western portion of the sin, monthly average winter temperatures are just above freezing and monthly average summer temperatures have not historically exceeded about 76°F.

Precipitation recorded at three gauging stations within the White River Basin averaged 53 inches of rainfall (small variation in years recorded not averaged) and 34 inches of snowfall per year. About half of the Basin precipitation occurs from October through December. The eastern portion of the Basin—where elevations exceed 14,000 feet above mean sea level on Mount Rainier—experiences extended cooler winter weather, resulting in heavy snowfalls (76 inches per year). This differs from the western end of the Basin, where elevations range from 39 to 189 feet and snow accumulations are not persistent during the winter months.

Average air temperatures at the Greenwater gage (located in the eastern portion of the Basin) range from approximately 36°F to 55°F, whereas air temperatures further west at Buckley range from 41°F to 60°F. The temperature differences across the Basin also affect the dominant type of precipitation. Greenwater, the annual recorded rainfall is 57 inches and snowfall is 76 inches. Further east at Buckley, the averages change to 48 inches of rainfall and 11 inches of snowfall.

Steep-walled valleys dominate drainage patterns in the eastern portion of the Basin. In many places valley walls can rise more than 6,000 feet above the valley floor. Rivers in the eastern portion of the Basin are fast flowing, braided, and capable of transporting large volumes of suspended and bedload material. The Mud Mountain Dam, located east of Buckley, provides flood control for the Puyallup River.

Topography in the eastern half of the Basin consists of low rolling hills and valleys formed during the last period of glaciation. The exception to this is the relatively flat plateau east of Lake Tapps, which was covered by the Osceola mudflow. White River and its floodplain continue to modify the existing topography. Lake Tapps, originally four small lakes (developed as a reservoir), is the largest surface water body in the Basin.

The geology of the Basin is composed of volcanic and sedimentary rocks, a drift plain with glacial till and outwash material, alluvium, and mudflow deposits with various overlying soils (UPWC 2002). Although the entire Basin is underlain by bedrock consisting of volcanic and sedimentary rocks, outcrops of bedrock are evident only in the eastern portion of the Basin. The volcanic deposits of andesite and basalt are hard and cannot be eroded readily. However, pyroclastic rocks associated with eruptions of Mount Rainier are unstable and tend to erode. Areas where these materials have been deposited in the eastern subbasins are prone to landslides, potentially introducing large volumes of materials to the rivers.

The Pierce County (USDA SCS 1979) and King County (USDA SCS 1992) soils surveys provide mapping of soils in the western part of the White River Basin. Soils in the eastern mountainous portion of the Basin are derived from volcanic materials.

Soil associations present in the eastern portion of the Basin include the Kapowsin association, Alderwood-Everett association, Puyallup-Sultan association, and Buckley association. Much of the soil has poor draining characteristics and tends to retard infiltration of water. This condition, along with the presence of glacial till having low permeability, tends to increase ponding of water and runoff rather than deep infiltration and recharge of deep aquifers. The conditions also create a high potential for septic system failures.

Three sources of information were used in delineating subbasin planning units: 10-Meter Digital Elevation Models (DEMs) obtained from the Regional Ecosystem Office (REO 2006), river stream line coverage obtained from the WDFW, and basin boundary geographic information system (GIS) coverage obtained from Pierce County (Pierce County 2004).

Ten subbasins have been identified within the White River Basin. *Table 12-1* summarizes the geographic extent and size of each; general physical features in each are described below.

Currently, despite utilization of existing GIS data and input from Pierce County, in one area, drainage is uncertain. This flat area includes several marshes that drain north to the Duwamish/Green River Basin (via Mill Creek) or south in the White River Basin (via Tributary 0034 or Tributary 0040).

12.1.1 White River Basin

Lower White River Subbasin

The Lower White River Subbasin was established based on the transition from the Cascade foothills to the Puget Sound Lowlands. This subbasin drains 52 square miles of the plateau formed by the Osceola mudflow and landforms associated with the last glacial advance in the region. The White River flows for 22.5 miles in the subbasin, dropping in altitude from 620 to 39 feet at the confluence with the Puyallup River. In this subbasin, the White River and its tributaries are rainfall fed. Stream flow in the White River is affected by the Lake Tapps diversion near Buckley. Diverted water is stored in Lake Tapps and eventually returned to the White River via the Dieringer Canal at river mile (RM) 3.5.

Lake Tapps Subbasin

Delineation of the Lake Tapps Subbasin was based solely on the existing Pierce County basin coverage. The subbasin around the lake is very flat, and most drainage patterns are due to manmade conveyance or control features (i.e., ditches, berms, and storm drains). Available information is not sufficient to easily confirm the Lake Tapps Subbasin boundary, and detailed review of drainage facilities was outside the scope of this study.

TABLE 12-1
WHITE RIVER SUBBASINS

Subbasin	Area (sq. mi.)	Hydrology	Upstream and Downstream Extent
Clearwater River	37.7	Snowmelt	Clearwater River Watershed—Headwaters Clearwater River to confluence with White River
Greenwater River	76.1	Snowmelt	Greenwater River Watershed—Headwaters Greenwater River to confluence with White River
West Fork White River	66.8	Snowmelt/ springs	West Fork White River Watershed—Headwaters West Fork to confluence with White River
Huckleberry	37.3	Snowmelt	Huckleberry Creek Watershed—Headwaters Huckleberry Creek to confluence with White River
Frying Pan	61.7	Snowmelt	White River—Headwaters White River to Silver Creek tributary
Upper White River	47.0	Snowmelt	White River—Confluence with Silver Creek to West Fork tributary
Middle White River	45.5	Rainfall	White River—West Fork tributary to upstream end of Mud Mountain Dam Reservoir
Mud Mountain	55.0	Rainfall	White River—Upstream end of Mud Mountain Dam Reservoir to Boise Creek tributary
Lower White River	52.0	Rainfall	White River—Boise Creek tributary to confluence with Puyallup River
Lake Tapps	17.0	Rainfall	Lake Tapps Diversion Dam to Lake Tapps outlet
Total Basin	**496.1**		

The Lake Tapps Subbasin was divided into six distinct "Water Quality Management Units" (WQMUs) by Puget Sound Energy (PSE). URS developed WQMUs at specific locations in Lake Tapps based on consultation with PSE, the Cascade Water Alliance, and the Puyallup Tribe, all of whom have interest in the operation of Lake Tapps. The subdivisions were discussed during a September 2004 meeting with Pierce County, PSE, and the Puyallup Tribe. The WQMUs will be used to facilitate characterization and subsequent discussion of issues associated with Lake Tapps and the surrounding area.

Mud Mountain Subbasin

Mud Mountain Subbasin drains the portion of the Basin from Mud Mountain Dam to the Puget Sound Lowlands near Enumclaw. The subbasin encompasses an area of 55 square miles. This portion of the White River drops in altitude from 1,227 feet below Mud Mountain Dam to 620 feet at the western terminus of the subbasin, a length of 13.3 miles. In this subbasin, the White River and its tributaries are primarily rainfall fed.

Middle White River Subbasin

The Middle White River Subbasin drains an area of 45.5 square miles. It encompasses the topographically closed area that drains a reach of the White River bounded on the upstream end by the confluence of the White River and Greenwater River, and the White River and the West Fork of the White River. On the downstream end the subbasin terminates at the Mud Mountain Dam Reservoir. This section of the White River is 15 miles in length and drops in altitude from 1,693 feet at the confluence with Huckleberry Creek to approximately 1,227 feet where it joins the reservoir. The Upper White River and Middle White River Subbasins differ in that the Upper White River Subbasin tributaries are fed primarily by snowmelt, whereas tributaries of the Middle White River Subbasin are fed primarily by rainfall.

Greenwater River Subbasin

The Greenwater River Subbasin is defined by the closed topographic area drained by the Greenwater River and its tributaries. The subbasin occupies 76.1 square miles and is bounded by the Huckleberry Mountains on the north, the west slope of the Cascade Mountains on the east, and the Upper White River Subbasin to the south. Headwaters start at an approximate altitude of 5,804 feet, and the river drops to an altitude of 1,693 at the confluence with the White River, a length of 23 miles. The river is fed primarily by snowmelt.

Clearwater River Subbasin

The Clearwater River Subbasin, like the West Fork White River Subbasin, forms part of the western boundary of the subbasin. It drains an area of 37.7 square miles. The subbasin encompasses Clearwater River from its headwaters at an altitude of 5,403 feet to the point it enters the Mud Mountain Dam Reservoir at an altitude of about 1,227 feet, a distance of 11.6 miles. Clearwater River and its tributaries are fed primarily by snowmelt.

West Fork White River Subbasin

The West Fork White River Subbasin forms the western boundary of the eastern portion of the Basin. It starts on the flanks of Mount Rainier, but at a lower elevation than the Frying Pan Subbasin. Encompassing a land area of 66.8 square miles, it is defined as the closed area draining the West Fork of the White River, which originates in the upper part of the subbasin. From its headwaters to the confluence with the White River, the river is fed by snowmelt over a length of 20 miles. The river altitude drops from 6,394 feet at the headwater area to 1,837 feet at the confluence.

Huckleberry Subbasin

Huckleberry Creek drains an interior portion of the upper Basin between the Frying Pan and Upper White River Subbasins on the south and east and the West Fork White River Subbasin on the west. The subbasin drains a land area of 37.3 square miles. Huckleberry Creek is fed by snowmelt; from the headwaters to the confluence with the White River it is 13.9 miles long. From the headwater area the stream altitude drops from 6,539 to 2,077 feet.

Frying Pan and Upper White River Subbasins

The Frying Pan and Upper White River Subbasins include the upper reaches of the White River from its headwaters on the north flank of Mount Rainier downstream to the confluence with Huckleberry Creek. The division of the drainage area into two subbasins is based on the Frying Pan Subbasin draining headwater areas fed by glacial melt, whereas the Upper White River Subbasin primarily drains areas of snowmelt. Over 90% of the Frying Pan Subbasin lies within the Mount Rainier National Park boundary. The Frying Pan and Upper White River Subbasins encompass 61.7 and 47 square miles, respectively. The White River flows a distance of 16.7 miles in the Frying Pan Subbasin, dropping in altitude from 6,594 to 2,589 feet. The river flows a distance of 10.1 miles through the Upper White River Subbasin and drops in altitude from 2,589 to 1,837 feet.

12.2 LAND USE IN THE WHITE RIVER BASIN

To assess the hydrologic characteristics of a basin and to determine the potential for water quality/quantity problems requires an accurate understanding of a basin's existing and proposed land uses. This section will look at both the existing and future land use of this Basin.

Various land uses have different effects on the water quality and the hydrologic components of a watershed. Undeveloped forested land allows for maximum infiltration of rainwater and has the least potential for causing water pollution. Highly developed areas (characterized by large areas of impervious surfaces), whether residential, commercial, or industrial land uses, increase the surface runoff of stormwater, carrying pollutants picked up from the manmade surfaces into the streams and waterways. Increased stormwater discharges can erode drainage ditches and stream channels, increase turbidity of stream water, deposit sediment in habitats important to fish and aquatic life, and fill downstream flood storage areas. Poor agricultural practices, such as improperly applied irrigation methods and feeding or watering livestock too close to a stream, can also contribute to water quality problems when the practices increase erosion and disturb soils adjacent to streams. These areas can be significant sources of sediment, fecal coliform bacteria, and nutrients such as nitrate and phosphate. Excess nutrients in water reduce the dissolved oxygen content that fish and other aquatic organisms require.

12.2.1 Existing Land Use

The majority of the urban land development in the White River Basin has occurred west of Enumclaw. Development east of Buckley is limited to the town of Greenwater and residences along major roads, including Crystal Village. Dominant land uses in the eastern portion of the Basin are logging and recreational, especially on lands south of the Greenwater and White Rivers, which are parts of Mount Baker-Snoqualmie National Forest or Mount Rainier National Park. Unincorporated areas of Pierce County are present in both the western and eastern portions of the Basin. *Table 12-2* summarizes the existing land use for the Basin. The land use categories evaluated included the following (with examples of typical parcels in the White River Basin listed behind each category):

- Civic: schools, roads, religious centers, parks, libraries, fire stations, and post offices
- Commercial: shopping centers, restaurants, gas stations, banks, offices, marinas, and motels
- Industrial: furniture manufacturers, metal fabricators, and food product manufacturers
- Other: golf courses, cemeteries, resort camps, communications, and utilities/refuse
- Residential: single-family homes, duplexes, apartment buildings, and manufactured homes
- Resource use: agriculture, fishing activities, quarries, and timberland
- Vacant: vacant commercial, industrial, and residential land
- Water: lakes and saltwater tidelands
- Unknown: parcels with no GIS data provided

TABLE 12-2
CURRENT LAND USE IN THE WHITE RIVER BASIN BASED ON TAX PARCEL INFORMATION

Land Use Category	Lake Tapps	Lower White River	Mud Mountain	Middle White River	Greenwater River	Clearwater River	Upper White River	West Fork, Huckleberry, Frying Pan[a]	Total
Agricultural Land									
Total Area (acres)	1,542	9,615	1,742	0	0	0	0	0	**12,899**
Percent of Subbasin	12.1%	26.0%	3.5%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.1%**
Civic									
Total Area (acres)	530	667	0	0	0	0	0	0	**1,197**
Percent of Subbasin	4.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.4%**
College	253	0	0	0	0	0	0	0	**253**
Elementary Schools	51	24	0	0	0	0	0	0	**75**
Quasi Public	36	73	0	0	0	0	0	0	**109**
Religious Center	25	25	0	0	0	0	0	0	**49**
Roads	80	471	0	0	0	0	0	0	**551**
Roadways Major	5	0	0	0	0	0	0	0	**5**
Secondary Schools	81	74	0	0	0	0	0	0	**155**
Commercial									
Total Area (acres)	142	894	150	142	0	0	0	0	**1,328**
Percent of Subbasin:	1.1%	2.4%	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%	**0.4%**
Residential									
Total Area (acres)	4,163	6,557	2,105	28	7	0	4,324	0	**17,184**
Percent of Subbasin	32.7%	17.7%	4.2%	0.1%	0.0%	0.0%	29.0%	0.0%	**5.4%**
Group Home	4.8	7.1	0	0	0	0	0	0	**11.9**
High Density	8.4	15	0	0	0	0	0	0	**23.4**
Low Density	3587.8	4436.7	2095.7	27.7	6.7	0	4315.8	0	**14470.4**
Mobile Home	549.2	632.8	9.4	0.2	0	0	8.4	0	**1200**
Multifamily	12.9	1465	0	0.2	0	0	0	0	**1478.1**
Industrial									
Total Area (acres)	2	135	0	0	0	0	0	0	**137**
Percent of Subbasin	0.01%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.04%**
Open Space									
Total Area (acres)	4,261	4,473	2,176	62	5,403	0	103	0	**16,478**
Percent of Subbasin	33.5%	12.1%	4.4%	0.2%	16.7%	0.0%	0.7%	0.0%	**5.2%**
Resource Land									
Total Area (acres)	328	429	37,879	31,741	23,026	8,720	10,494	125,129	**237,745**
Percent of Subbasin	2.6%	1.2%	76.4%	85.6%	71.2%	100.0%	70.3%	100.0%	**74.9%**
Surface Water									
Total Area (acres)	1,743	48	0	1	0	0	0	0	**1,791**
Percent of Subbasin	13.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.6%**
Unknown Land Use									
Total Area (acres)	11	14,173	5,558	5,087	3,916	0	0	0	**28,745**
Percent of Subbasin	0.1%	38.3%	11.2%	13.7%	12.1%	0.0%	0.0%	0.0%	**9.1%**
Total Subbasin area[b]	**12,722**	**36,991**	**49,610**	**37,061**	**32,351**	**8,720**	**14,921**	**125,129**	**317,504**

a. Tax assessor use code information not available for the West Fork, Huckleberry, and Frying Pan Basins.

b. Estimates of current and future land uses are based on Pierce and King County tax assessor use codes and therefore the Basin areas vary slightly from actual Basin area.

The discussion of land use focuses mostly on the western portion of the Basin where most development has occurred, in particular in unincorporated Pierce County. The analysis of land use is based on an inventory of King and Pierce County tax parcel information supplemented by data from the *Pierce County Comprehensive Plan* (Pierce County 2006).

Cities and adjacent areas, communities, and towns in the Basin include the following:

- Upper White River Subbasin: Crystal Village
- Mud Mountain Subbasin: Enumclaw
- Middle White River Subbasin: Greenwater
- Lower White River Subbasin: Sumner, Auburn, Pacific, Edgewood, and Algona
- Lake Tapps Subbasin: Bonney Lake and Buckley

Eastern Portion of Basin

In the eastern portion of the Basin, the border of Pierce and King Counties is defined by the Greenwater and White Rivers. Although unincorporated areas of Pierce County are present, they lie within either Mount Baker National Forest or Mount Rainier National Park. Current zoning and land use reflect the mostly rugged terrain and recreational use of the lands. Zoning is predominantly forest and agriculture in both counties. Outside the National Forest and National Park boundaries, current land use is mostly resource use or vacant.

Crystal Village is the current development in the Upper White River Subbasin. It is located along the White River west of the area designated as vacant. The town of Greenwater is located along the White River in the upper part of the Middle White River Subbasin.

The majority of current land use is a combination of resource land and open space. Current residential development is limited to 29% of the Upper White River Subbasin.

Western Portion of the Basin

The majority of land development has occurred in the western portion of the Basin. East of Lake Tapps zoning is a combination of forest, agricultural, and residential, except for the cities of Enumclaw and Buckley. Most of the unincorporated land is currently zoned rural, except for smaller dispersed areas that are zoned either agricultural or Reserve 10. Land of the Muckleshoot Tribe of Indians is located east of the lake, adjacent to the north side of the White River. The main water feature east of the lake is the Lake Tapps diversion canal that starts near Buckley and flows west, entering the southeast corner of the lake. West of Lake Tapps most areas fall within the boundaries of Bonney Lake, Auburn, Sumner, Edgewood, and Pacific.

Current land use east of Lake Tapps (in Lower White River Subbasin) is a combination of resource use, residential, civic, vacant, and other. Most of this area falls within unincorporated Pierce County. North of the White River in King County, land use is mostly agricultural, except for tribal lands.

West of Lake Tapps, land use continues as a mixture of residential and vacant land in unincorporated Pierce County. Continuing west, however, land use changes, with commercial corridors and limited industrial use evident west of the White River around Sumner and Pacific. Industrial and commercial land use is mostly between the East and West Valley Highways. Current commercial land use in the Lower White River Subbasin is estimated to be 2.4% and industrial use 0.4%.

Lake Tapps and the surrounding area fall within the Lake Tapps Subbasin. Lake Tapps has long been a popular area for water recreation. Consequently the land use surrounding the lake is mostly residential or vacant. The cities of Auburn on the north and Bonney Lake on the south border the lake. Industrial and commercial use accounts for only 1.11% of the land use in the Lake Tapps Subbasin (a total of 144 acres).

Impervious Surface

Land use affects surface water hydrology by altering the landscape from its natural condition and changing water drainage, storage, and evaporation characteristics. The creation of impervious surfaces such as roads, buildings, and parking areas has a particularly important impact. Impervious surfaces block precipitation from soaking into the ground (infiltration) and reduce the amount of vegetated areas available to absorb precipitation, as occurs under natural conditions. Therefore, the effect of various land uses on surface water hydrology is taken into consideration by estimating the percentage of each subbasin area covered by impervious surfaces.

Impervious surface estimates for current land use in the subbasins range from 0 to 14% (*Table 12-3*). The highest percentages are in the Lake Tapps, Lower White River, and Upper White River Subbasins with 10, 14, and 8%, respectively. The remaining subbasins, where data was available, range from 0 to 4%.

TABLE 12-3
CURRENT AND PROJECTED PERCENT OF IMPERVIOUS SURFACE

Subbasin	Current % Average Impervious Surface	Projected Future % Average Impervious Surface
Lower White River	14.0%	20.0%
Lake Tapps	10.0%	13.0%
Mud Mountain	4.0%	4.0%
Middle White River	0.3%	0.4%
Greenwater River	0.4%	0.4%
Clearwater River	0.0%	0.0%
West Fork White	—	—
Huckleberry	—	—
Upper White River	8.0%	10.0%
Frying Pan	—	—

12.2.2 Future Land Use

The *Comprehensive Plan for Pierce County, Washington* (*County Comprehensive Pl an*) (Pierce County, March 1999) was developed and adopted in 1994 in response to the requirements of Washington's "Growth Management Act." The Plan seeks to obtain and balance 13 different planning goals. These goals include reducing sprawl while still encouraging development, providing public facilities and services to support development, protecting the environment while protecting property owners' rights, promoting economic development, preserving archeological and historical sites, artifacts and structures, and processing permits in a timely manner, while at the same time encouraging citizen participation in the planning process (Pierce County, March 1999). The *Pierce County Comprehensive Plan*, codified as *Title 19A, Pierce County Code*, divides the White River basin into rural areas and urban growth areas. *Table 12-4* summarizes future land use in the White River Basin.

TABLE 12-4
FUTURE LAND USE IN THE WHITE RIVER BASIN BASED ON TAX PARCEL INFORMATION

Land Use Category	Lake Tapps	Lower White River	Mud Mountain	Middle White River	Greenwater River	Clearwater River	Upper White River	West Fork, Huckleberry, Frying Pan[a]	Total
Agricultural Land									
Total Area (acres)	1542	9615	1742	0	0	0	0	0	**12899**
Percent of Subbasin	12.1%	26.0%	3.5%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.1%**
Civic									
Total Area (acres)	530	667	0	0	0	0	0	0	**1,197**
Percent of Subbasin	4.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.4%**
College	253.3	0	0	0	0	0	0	0	**253**
Elementary Schools	51	23.6	0	0	0	0	0	0	**75**
Quasi Public	35.9	73.1	0	0	0	0	0	0	**109**
Religious Center	24.5	24.8	0	0	0	0	0	0	**49**
Roads	79.5	471.4	0	0.4	0	0	0	0	**551**
Roadways Major	4.7	0	0	0	0	0	0	0	**5**
Secondary Schools	80.9	73.8	0	0	0	0	0	0	**155**
Commercial									
Total Area (acres)	521	1535	150	145	0	0	0	0	**2350**
Percent of Subbasin:	4.1%	4.1%	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%	**0.7%**
Residential									
Total Area (acres)	6,038	8,644	4,151	85	15	0	4,413	0	**23,347**
Percent of Subbasin	47.5%	23.4%	8.4%	0.2%	0.0%	0.0%	29.6%	0.0%	**7.4%**
Group Home	4.8	7.1	0	0	0	0	0	0	**11.9**
High Density	8.4	15	0	0	0	0	0	0	**23.4**
Low Density	5462.6	6524.2	4142	84.9	14.9	0	4404.6	0	**20633.2**
Mobile Home	549.2	632.8	9.4	0.2	0	0	8.4	0	**1200**
Multifamily	12.9	1465	0	0.2	0	0	0	0	**1478.1**
Industrial									
Total Area (acres)	2	811	0	0	0	0	0	0	**813**
Percent of Subbasin	0.01%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.26%**
Open Space									
Total Area (acres)	2007	1069	130	2	5395	0	14	0	**8616**
Percent of Subbasin	15.8%	2.9%	0.3%	0.0%	16.7%	0.0%	0.1%	0.0%	**2.7%**
Resource Land									
Total Area (acres)	328	429	37879	31741	23026	8720	10494	125129	**237745**
Percent of Subbasin	2.6%	1.2%	76.4%	85.6%	71.2%	100.0%	70.3%	100.0%	**74.9%**
Surface Water									
Total Area (acres)	1743	48	0	1	0	0	0	0	**1791**
Percent of Subbasin	13.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.6%**
Unknown Land Use									
Total Area (acres)	11	14173	5558	5087	3916	0	0	0	**28745**
Percent of Subbasin	0.1%	38.3%	11.2%	13.7%	12.1%	0.0%	0.0%	0.0%	**9.1%**
Total Subbasin area[b]	**12,722**	**36,991**	**49,610**	**37,061**	**32,351**	**8,720**	**14,921**	**125,129**	**317,504**

a. Tax assessor use code information not available for the West Fork, Huckleberry, and Frying Pan Basins.
b. Estimates of current and future land uses are based on Pierce and King County tax assessor use codes and therefore the basin areas vary slightly from actual basin area.

Eastern Portion of Basin

Future land use is projected to continue as resource use except in the Upper White River Subbasin, where vacant land is projected to develop as residential. Current residential development is limited to 29% of the Upper White River Subbasin. Projected future development does not indicate substantive changes in land use.

Western Portion of the Basin

Current commercial land use in the Lower White River Subbasin is estimated to be 2.4% and industrial use 0.4%. Commercial and industrial land use at full build out is projected to increase to 4.1% and 2.2%, respectively.

Industrial and commercial land use accounts for only 1.11% of the use in the Lake Tapps Subbasin (a total of 144 acres). Projected future land use at full build out shows residential use increasing 14.8% and commercial use increasing 3%

Future Percentage Impervious

Projected future land use indicates a conversion of open space to residential and some commercial uses, predominantly in the Lake Tapps and Lower White River Subbasins, and some increase of residential in the Mud Mountain Subbasin. *Table 12-3* lists the predicted future percent of impervious areas for the White River Basin. As shown in the table, the future projections of impervious surface range from 0% to 20%, with the greatest increases occurring in the most developed subbasin (the Lower White River Subbasin).

The projected increases in impervious surface estimates for the Lower White River, Lake Tapps, and Upper White River Subbasins are 6%, 3%, and 2%, respectively. The remaining subbasins had smaller increases, ranging from 0% to 0.1%. The predicted greatest change in land use is the increase in commercial development west of Lake Tapps, followed by the increase in conversion of agricultural and vacant land to residential development.

The eastern portion of the Basin did not have a significant increase in% impervious surface at build out. However, in the western portion of the Basin, the area west of Lake Tapps shows substantial projected increases in percent impervious surface at full build out. Based on tax parcel data, the current and projected future percent impervious surface in the western portion of the Basin have shown that there are significant increases and potential for surface water impacts to the prioritized rivers/tributaries from future development.

12.2.3 Population

The population is currently concentrated in the western portion of the Basin (both cities and nearby unincorporated Pierce County). A large portion of the eastern part of the Basin, including unincorporated Pierce County, is located within Mount Rainier National Park or Mount Baker-Snoqualmie National Forest. However, a small portion of the eastern basin along the White River includes Enumclaw and adjacent areas.

The State Office of Financial Management has prepared population estimates for Pierce County, which are presented in *Table 12-5* and *Table12-6*.

TABLE 12-5
EXISTING PIERCE COUNTY POPULATION—2005

Unit	Population
Unincorporated Pierce County	345,940
Incorporated Pierce County	409,960
Total Pierce County	755,900

Source: Washington State Office of Financial Management (2005)

TABLE 12-6
PROJECTED PIERCE COUNTY POPULATION—2025

Unit	Existing Population	Project Population
Pierce County (high series)	755,900	1,071,468
Pierce County (low series)	755,900	829,098

Source: Washington State Office of Financial Management (2002)

Future population growth is expected to be greater in the western portion of the Basin than the eastern portion because of the presence of unincorporated cities and their respective urban growth areas (UGAs). A substantial portion of the eastern basin is expected to remain rural and experience lower growth.

12.3 FLOOD CHARACTERISTICS

Flooding in the Lower White River Basin is a natural phenomenon that has been mitigated by means of engineered structures (dams and levees) and in some cases exacerbated by development and the increase in impervious surfaces. The discussion of flooding in this section addresses these two types of flooding: riverine and stormwater.

The months of November, December, and January have very high stream flows due to winter rainfall. The mountain snowpack plays a strong role in controlling summer flow conditions. The low-flow month generally is August because most of the snow has melted and, usually, very little rain falls in July and August. The White River Basin suffers from severe winter flooding and from low (often nonexistent) summer flows at certain locations.

Table 12-7 illustrates peak discharges for a given watercourse. *Table 12-8* illustrates the area within the 100-Year and 500-Year Flood Zones by subbasin. By understanding the potential flood condition for a specific area, it better enables Pierce County to identify mitigation alternatives appropriate for the level of risk for that stream or reach. Pierce County participates in the federal flood insurance program. FEMA has produced "Flood Insurance Rate Maps" (FIRMs) for many areas in the Basin, which delineate the 100-year and 500-year floodplains (the FIRMs are currently being revised).

TABLE 12-7
PEAK DISCHARGE—FREQUENCY ESTIMATES

Watercourse and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs)			
		10-Year	50-Year	100-Year	500-Year
White River at Mouth	494	16,400	18,300	19,100	21,600
White River at State Highway 410 in the city of Buckley	427	13,800	14,800	15,500	17,200
White River at confluence with Greenwater River	294	18,600	25,800	28,900	36,700
White River upstream of confluence with Greenwater River	217	13,500	18,700	12,200	13,600
White River upstream of confluence with West Fork of White River	145	8,940	12,200	13,600	17,000
White River upstream of confluence with West Fork of White River	145	8,940	12,200	13,600	17,000

TABLE 12-8
100- AND 500-YEAR FLOODPLAIN AREAS BY SUBBASIN

Subbasin	Area in 100-Year Flood Zone (acres)	Area in 500-Year Flood Zone Outside of 100-Year Zone (acres)
Lower White River	4,551	459
Lake Tapps	3,146	47
Mud Mountain	2,492	44
Middle White River	1,474	1
Greenwater River	226	0
Clearwater River	175	34
Upper White River	640	3
West Fork White River	1,337	0
Huckleberry	15	0
Frying Pan	658	0
Total	**14,714**	**588**

12.3.1 Known Flood Hazards

Figure 12-1 shows floodplains and wetlands in the White River Basin. The Mud Mountain Dam is the primary flood control structure on the White River, beginning operation in 1942. An informal agreement between the U.S. Army Corps of Engineers, the Muckleshoot Tribe, and Pierce and King Counties limits the rate of water release from the dam to 12,000 cfs, when feasible (USACE 2002).

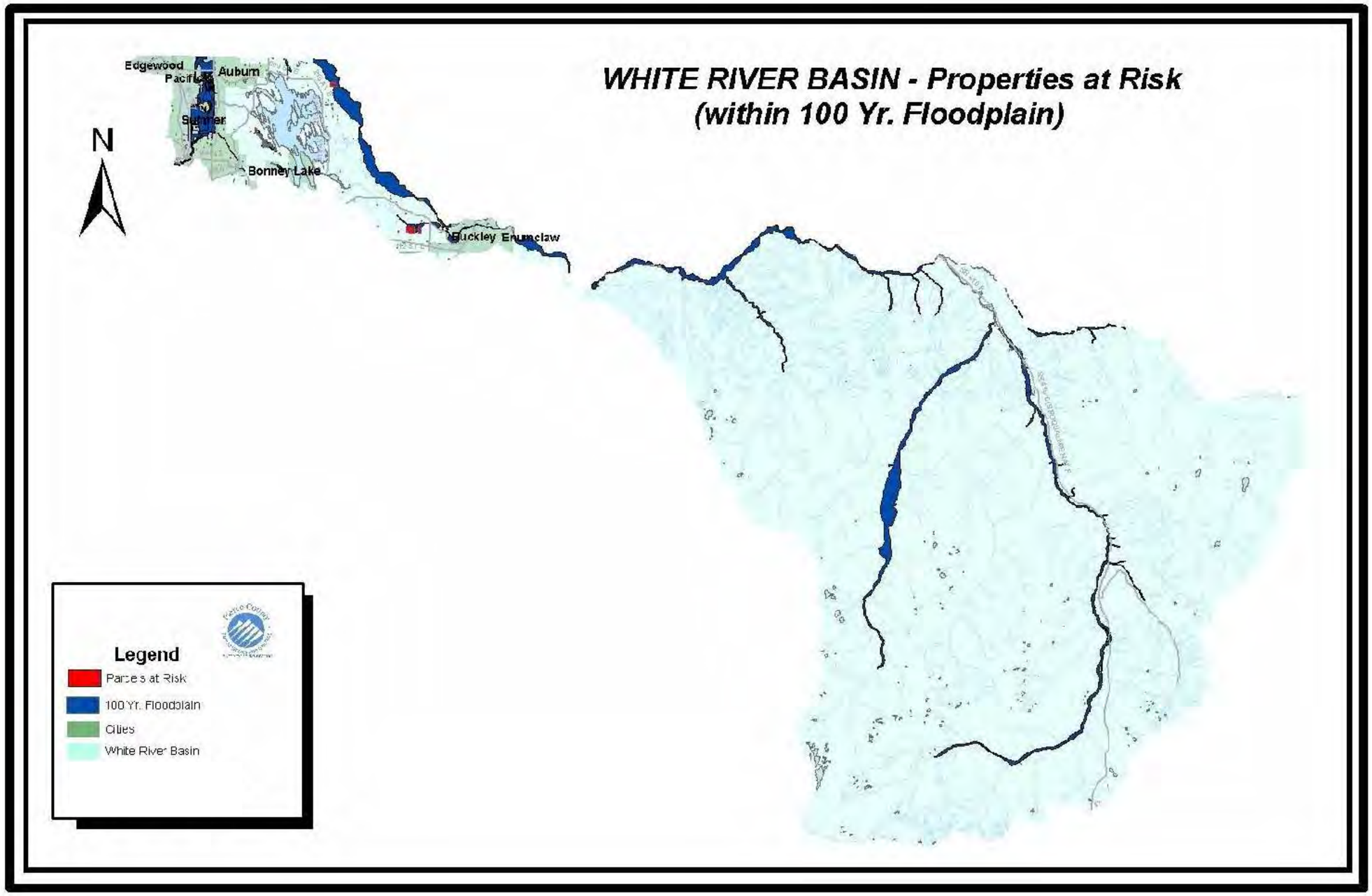


Figure 12-1
Floodplain extent and location
White River Basin

Due to curtailment of maintenance at Mud Mountain Dam and due to development along the White River below the dam, flood damage in some areas might be expected at flows as low as 6,000 cfs (USACE 2002). However, a pool evacuation occasioned by the flood of February 1996 resulted in a release from the dam of 13,500 cfs, which caused no "major damage in the reach above the mouth of the White." Release up to the legal limit of 18,000 cfs (the 100-year flood, estimated by the U.S. Army Corps of Engineers (USACE) taking into account the operating rules of the dam (USGS 1988)), if necessary to prevent damage to the dam or catastrophic failure of the dam, could result in severe flooding below the dam.

The USACE (2002) listed the following locations as specific areas threatened by discharges of 12,000 cfs from the Mud Mountain Dam:

- Residences in the Red Creek area just downstream from the dam
- Muckleshoot Tribe fish hatchery
- Buckley Meadows subdivision
- Sumner golf course
- Residences near intersection of 8th Street East and 138th Avenue East
- Sumner sewage treatment plant

No complete account of historical flood losses is available. It has been estimated (USACE 2002) that the total damage from floods of December 1917 and January 1919 was $400,000. Although some channel capacity has been lost over the operational history of the dam and some flood damage is likely at flows below 17,600 cfs, flood damage has been significantly reduced.

Pierce County (River Improvement Division) maintains a system of flood control levees along the White River. According to the 2005 Capital Improvement Program (CIP), prepared by Water Programs, 6% (1,840 of 29,209 linear feet of levee) on the White River levee system is currently "adequate" (i.e., provides 100-year protection).

The following levee segments on the White River have been identified for inclusion in the levee setback project and have been assigned priority values (list provided by Pierce County, priority value in parentheses; none of these potential projects appear as yet in the CIP plan):

- County Line Site (55)
- Pacific Avenue setback (53)
- 24th Street East Pointbar (47)
- Pacific Pointbar (45)
- Interurban-White Site (43)
- 8th Street East Setback (29)

Historically, there have been numerous flooding-related complaints in the Lake Tapps area, all but two of which have been addressed and are closed files.

12.3.2 Causes of Flooding

According to the Federal Emergency Management Agency's (FEMA) *1987 Flood Insurance Study,* floods typically occur between October and March as a result of rainstorms, sometimes augmented by melting snow. According to the *Pierce County Natural Hazard Mitigation Plan* (2005), the potential for severe flooding is greatest during warm, wet periods when a mid to low level snow pack is combined with long duration rainfall, saturated soils and an elevated water table.

The *Natural Hazard Mitigation Plan* suggests that there is an increasing potential for urban flooding in Pierce County due to continued population growth and land development. Human alteration of the landscape–including clearing, grading, paving, building construction, and landscaping–has an impact on the hydrologic process. Increasing impervious area decreases infiltration, while clearing of natural vegetation decreases interception storage and allows runoff to flow into streams faster. These effects lead to higher peak flows in streams and greater runoff volumes.

Types of flooding observed in the White River Basin are riverine and stormwater flooding. Stormwater flooding refers to the flooding resulting from the changed hydrology of a river or stream due to changes in the stream or in land use and impervious area in a basin . It can also refer to "nuisance flooding" that occurs when elements of the storm drainage system are blocked or have reduced capacity temporarily due to debris or inadequate maintenance, or when conveyance capacity is no longer adequate.

Nuisance flooding is addressed through routine maintenance, response to citizen complaints, and, if necessary, capital projects to provide increased conveyance capacity (e.g., culvert replacement) or enhanced detention storage.

Many of the priority tributaries in the Basin are likely to experience flashy hydrology where there has been extensive use of culverts and ditching to straighten channel reaches. Such tributaries have often lost associated wetlands and lost their capacity to temporarily store stormwater runoff. Remaining wetlands east of Lake Tapps may provide continued flow attenuation in Tributary 0051 as defined in the BCR, but west of Lake Tapps development has substantially reduced the presence of wetlands.

The tributaries that appear to most threatened from potential new development are 0032, 0037, and 0038 as defined in the BCR. Many of these tributaries have already experienced habitat degradation due to channel straightening, wetland loss, and changed hydrology. Pierce County manages this flood potential in its "Site Development Standards," which specify that peak discharges from new developments must match predeveloped discharge rates. Pierce County may also provide regional stormwater detention for flood control storage on a broader scale.

Field observations made in the 1970s indicated that flooding in the White River downstream of the Mud Mountain Dam was occurring with dam discharges as low as 12,000 cfs. The reduced flood capacity of the river was attributed to multiple factors including encroachment of development along the channel, accretion of sediments in the channel, and limitations on channel dredging (USACE 2002).

12.4 FLOOD HAZARD IMPACTS

Flooding in the White River Basin can have numerous impacts on the on the way of life within this basin, and Pierce County in general. Under this section, we will assess the vulnerability of the basins, improved property, critical facilities, and assess the impact a flooding on the basin's population and economy.

12.4.1 Public Safety and Health

There are no reported losses of life due to flooding within this basin, but damage and disruption cased by flooding is a severe has been a recurrent problem.

Pierce County has experienced substantial growth in previous years and is expected to support more growth over the next 30 years. According to the U.S. Census, the population of Pierce County in 2000 was 586,203. According to the Puget Sound Regional Council's (PSRC) long-range population forecasts

for the forecast analysis zones within Pierce County, the County is expected increase 16% to 812,859, by the year 2010 (PSRC, 2002).

According to the *2001 Population and Employment Forecasts* report for the central Puget Sound region, Pierce County is expected to reach the following populations (PSRC, October 2001):

- 812,859 in 2010
- 892,314 in 2020
- 951,747 in 2030

Pierce County population projections help predict future populations in the White River Basin. The estimated 2000 population in the White River Basin planning area was 12,881, which is 1.8% of the county's total population 700,820 in 2000. Assuming that the planning area will continue to capture at least 2% of the county's growth, it is predicted that in 2010, the population residing in the White River Basin planning area will be approximately 16,300 and 18,000 people will reside within the Basin in 2020.

Based on these projections the assumptions for the potential impacts of flooding are as follows:

- There may become increase pressures to develop floodplains within this Basin as land uses change to accommodate the increasing population.
- It should be noted that the current/existing regulatory environment within Pierce County is very focused on not allowing and increase in flood risk exposure due to new development. As long as this regulatory environment remains in tact, the assumption would be that development in responses to this new growth would be directed away from the known flood hazard areas within this Basin.
- There is currently little or no flood warning capability within this Basin. As the population increases within this Basin, the need to increase the County's flood warning and response capability may increase as well.

There is real-time flood warning capability within the White River Basin. USGS real-time gauges are located at:

- The Greenwater River at Greenwater
- Mud Mountain Lake near Buckley
- The White River near Buckley
- The White River Canal at Buckley
- The White River at Boise Creek near Buckley
- Lake Tapps near Sumner
- Lake Tapps Diversion

There is one additional stream flow gauge within this Basin available for flood threat recognition located on the White River near the confluence with the Clearwater River near Buckley. This is not a real time gauge. The approximate lead time for flood warning provided within this Basin is 24 to 48 hours based on the flood threat recognition capability within the Basin. Flood prediction is not an exact science. Although gauge readings and historical data are excellent forecasting tools, rivers can continually change. There are also local factors that can contribute to flooding such as stream and creek discharge into a river, snowmelt and damming caused by fallen trees and other debris. Therefore, during flood situations floodplain residents should not rely solely on gauge readings and historical flood levels, but should keep an eye on the river and stay tuned to local media reports.

Water quality degradation requiring action can result from local pollution (stormwater non-point pollution and septic systems) and basin-level conditions. The current overall water quality in the White River is generally good (WCC 1999), except for pH and temperature. Water quality in the tributaries is variable and marginal for parameters such as temperature, turbidity, and dissolved oxygen, according to recent measurement and samples analysis Pierce County did on selected tributaries.

12.4.2 Critical Facilities

Using the parameters to define "Critical Facilities" discussed in Chapter 1 of this risk assessment, Pierce County Water Programs, coordinating with Pierce County Emergency Management has identified that there are no critical facilities that could be impacted by flooding within this Basin. The basis for this determination is: physical location within a mapped or known floodplain, known history of flooding, and the lack flood protection to the facility.

Two components of the County's infrastructure in this Basin are worth noting. Their role in the County's ability to provide flood protection and services within this Basin are vital to the county's ability to respond to flooding events within this Basin. These critical facilities described below.

Mud Mountain Dam

Mud Mountain Dam is located on the boundary between King and Pierce Counties (RM 29.6). This is a single-purpose dam providing flood control for the Lower White and Puyallup River valleys. As a single-purpose flood control dam, it passes all inflow, except during times of flood or maintenance, and does not store water during low flow periods. Minimum in-stream flow releases have not been set for the dam.

The dam has a flood control capacity of 106,275 acre-feet (USACE 2004). Normally, during non-flood stages the reservoir is empty. Debris transported into the reservoir consists of both drift (trees, logs, and other forest trash) and river bedload or sediment. Wood debris is either salvaged for booms, firewood, habitat logs, and other projects or it is ricked into piles and burned. An estimated 8,000 to 10,000 cords of wood are captured annually behind the dam (WCC 1999). River bedload or sediment deposited while the pool is high is eroded and passed through the outlets by river flow when the pool is evacuated.

Lake Tapps, Power Plant and Associated Infrastructure

Lake Tapps is the only significant lacustrine water body in the White River Basin. Lake Tapps was built to create storage for the PSE White River hydroelectric project, which came on line in 1912 and suspended operations in January 2004. Approximately 2.5 miles of earthen dikes and embankments were built around four small natural lakes to create the current Lake Tapps. The dikes are maintained to control flooding of water.

A diversion dam on the White River (RM 24.3) is used to fill the lake. The diversion dam is an 11-foot-high structure consisting of a concrete- and rock-filled crib structure 352 feet long and 4 feet high. The structure is topped with 7-foot-high flash boards. The 21-mile stretch of White River between the diversion dam and the return canal is referred to as the bypass reach. Although several minor drainages also feed Lake Tapps, the White River diversion dam is responsible for the vast majority of water supply to the lake.

The White River Basin planning area is primarily rural and does not have many constructed drainage facilities aside from ditches and pipes associated with roads. Culverts and bridges have been constructed throughout the basin at driveway, road, and highway crossings. There are no known stormwater capital improvement projects under construction or in design in the planning area. There are no drainage districts in the planning area.

A list of critical facilities was obtained from the Pierce County *Natural Hazard Mitigation Plan (2005)*. Three critical facilities are located within the basin planning area; two of these facilities are dams and one is a County Sheriff detachment. According to the Plan, the County Sheriff detachment and one of the dams is located in an area that is outside of a floodplain or flood prone area. The other dam facility has a flood vulnerability classification of "low: the facility is in a floodplain or flood prone area but has no prior history of flood damage."

12.4.3 Structures impacted

Table 12-9 shows an estimate of the number of structures on parcels in the floodplain within the White River Basin. These estimates were generated using planimetric data available for this basin. To identify the potential dollar/loss exposure for the basin, assessed values for improvements to each of the parcels shown to have structures within the 100-year floodplain were accumulated by subbasin. This value is representative of the exposure. To truly gauge vulnerability, one would need to identify depth of flooding to apply FEMA's depth/damage functions to this exposure. This detail of information was not available at the time of the preparation of this assessment. However, total exposure values can be a good gage of potential flood impact for planning purposes and for identifying potential project benefits when prioritizing mitigation actions.

12.4.4 Repetitive Loss Areas

Utilizing the FEMA definition of "Repetitive Loss" defined under the Community Rating System, there are no identified repetitive loss properties within this Basin.

12.4.5 Insurance Analysis

Flood insurance statistics can help identify vulnerability by regionally isolating areas where claim activity is high and a high rate of flood insurance is in force. *Table 12-10* summarizes vital insurance statistics that can be used to help identify vulnerability within the White River Basin. The locations of these policies are identified in *Figure 1-2*.

TABLE 12-9
STRUCTURES WITHIN THE 100-YEAR FLOODPLAIN WHITE RIVER BASIN

	Structure Type				
Subbasin	Commercial	Dwelling	Other	Total	Market Improvement Value (in Millions)
Lower White River	13	26	2	41	$41.6
Lake Tapps	9	18	1	28	$28.7
Mud Mountain	7	14	1	22	$22.8
Middle White River	4	8	1	13	$12.9
Greenwater River	1	1	0	2	$3.0
Clearwater River	0	1	0	1	$0.2
Upper White River	2	4	0	6	$6.3
West Fork White River	4	7	1	12	$12.7
Huckleberry	0	0	0	0	$0
Frying Pan	2	4	0	6	$6.0
Total	**42**	**83**	**6**	**131**	**$134.2**

TABLE 12-10
FLOOD INSURANCE STATISTICS FOR THE WHITE RIVER BASIN

Number of flood insurance policies in force within the Basin (as of May 1, 2007)	81
Number of Policies within a mapped floodplain (FIRM)	9
Number of Policies outside of a mapped floodplain	72
Number of Claims filed within the Basin	6
Number of claims filed for losses outside the 100-year floodplain	3
Estimated number of insurable, primary Structures in mapped floodplains	125
Estimated % of at risk structures with flood insurance coverage	4.6%
% of current flood insurance coverage outside of a mapped floodplain	89%

Based on a review of this data, the following observations can be made:

- Based on the approximate number of primary, insurable structures in the floodplain and the insurance coverage in force within the floodplain, insurance coverage as a form of mitigation appears to be well below the national average. According to a study being conducted for the NFIP by the Rand Corporation, nationwide about 49% of single-family homes in special flood hazard areas (SFHAs) are covered by flood insurance.
- With 89% of the current policies in force located outside of a mapped floodplain, there appears to be some flooding issues within this Basin not addressed via the existing mapping. These could be drainage related flood issues that the Pierce County Water Programs' "Basin Planning Program" seeks out, that typically are not captured through standardized floodplain mapping techniques.
- The majority of historical claims filed within this Basin have been outside of a mapped floodplain. This once again, suggests that there are flooding issues within this Basin not addressed through flood hazard mapping.
- The small policy base within this Basin makes it very difficult to establish trends or correlations to identify risk exposure within this Basin.
- The low policy counts within this Basin suggest that there has been wise land use within this Basin, and that new development has been directed away from known flood hazard areas. The continuance of this policy will help to keep the level of risk exposure in balance as this Basin continues to grow.

Appendix I

Lake Water Quality Management Plan (White River Basin Plan)

THIS PAGE INTENTIONALLY LEFT BLANK.

BROWN AND CALDWELL

DRAFT Technical Memorandum

701 Pike St Suite 1200
Seattle, WA, 98101
Tel: 206-624-0100
Fax: 206-749-2200

Prepared for: Pierce County, Washington

Project Title: White River Basin Plan

Technical Memorandum No. 10

Subject: Lake Water Quality Management Plan (White River Basin Plan)

Date: May 8, 2008

To: Janine Redmond, Pierce County Water Programs

From: Jennifer Belknap Williamson, Brown and Caldwell

Mike Milne, Brown and Caldwell

Table of Contents

1. Introduction 2
2. Pierce County Goals for Lake Management 2
3. Beneficial Uses and Economic Importance of Lakes 2
4. Lake Water Quality Concerns 4
5. Lake Tapps Water Quality 5
6. Current Organizational Roles and Responsibilities for Lake Management in Pierce County 6
   6.1 Water Programs 6
   6.2 Tacoma-Pierce County Health Department 7
   6.3 Pierce Conservation District 8
   6.4 Washington State Department of Ecology 9
   6.5 Washington State Department of Fish and Wildlife 11
   6.6 Assessment Summary of Current Organization Roles and Responsibilities 11
7. Lake Management Gaps/Needs 12
8. Recommended Program for the White River Basin 21
References 23

Limitations:

This is a draft memorandum and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon; consult the final report.

This document was prepared solely for Pierce County Water Programs in accordance with professional standards at the time the services were performed and in accordance with the contract between Pierce County Water Programs and Brown and Caldwell. This document is governed by the specific scope of work authorized by Pierce County Water Programs; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Pierce County Water Programs and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

1. Introduction

Pierce County is responsible for addressing surface water management issues in unincorporated areas within the County. These issues include drainage, flood hazard reduction, water quality, and fish and wildlife habitat in the floodplain. Pierce County does not currently have a formal program for addressing the unique water quality issues often found in lakes. The purpose of this memorandum is to evaluate lake water quality concerns, existing management activities related to lake water quality, and lake management gaps/needs. Based on the results of the gap analysis, a recommended lake program is provided. In addition, relevant policy questions are provided for Pierce County to consider as it evaluates the role it will play in lake management in the County.

2. Pierce County Goals for Lake Management

Pierce County Public Works and Utilities, Water Programs Division (PCWP) has identified the need to provide a fully functioning lake management program. The goals for the lake management program are the same goals as for the Basin Plans, which are to:

- Reduce flood hazards
- Improve fish habitat
- Improve water quality

This document focuses on Pierce County's goals for improving and maintaining lake water quality, which in turn also supports goals related to improving habitat and reducing flood hazards.

3. Beneficial Uses and Economic Importance of Lakes

There are approximately 57 lakes in unincorporated Pierce County. These lakes provide valuable functions including:

- Recreational opportunities such as swimming, motorized and non-motorized boating, and fishing
- Aesthetic qualities which contribute to property values
- Fish and wildlife habitat, surface water and groundwater flow regulation, and sediment and nutrient sinks
- Water supply

Several relevant studies have been conducted on the economic importance of lakes and the potential negative impacts of lake water quality problems. These studies indicate that recreational usage of lakes, which is often correlated with the quality of lakes, contributes to the local economies of areas around lakes. These studies also describe how the value of lakeside properties can depend on the

quality of lakes, particularly if problems such as algae blooms or invasive aquatic plants significantly degrade the usability of a lake.

A study of Lake Delavan, a 2,000-acre lake in Wisconsin with extensive lakeshore development and recreational use, evaluated the economic value of water quality management activities based on property owner and recreational user surveys, input-output analysis, and a hedonic analysis of property values (University of Wisconsin-Whitewater 2005). The study was conducted in 2005, approximately 12 years after a $7 million rehabilitation program was completed to enhance wetlands, eliminate carp, restock game fish, and reduce algae and phosphorus in the lake. The study evaluated the positive economic effects of the rehabilitative lake management activities as well as the potential negative effects of the lake water quality returning to the pre-rehabilitation conditions if future deterioration occurs.

The Lake Delavan study determined that households located near the lake due to the presence of the lake amenities (i.e., views and recreation) spend $52.6 million/year in the local area (about $24,000 per household). Visitors to the lake spend an additional $9.4 million/year. Indirect spending as a result of the lake also contributed $15 million/year, resulting in total direct and indirect spending related to the lake of approximately $77 million annually. The study estimated that 812 jobs are generated from these expenditures. The study also found that the lake water quality improvements implemented resulted in the average lakeshore property appreciating in value by $177,000 over a 16 period (beyond additional appreciation not related to the quality of the lake), an aggregate increase in valuation of over $99 million for the 565 homes considered.

The Lake Delavan study found that degradation of water quality to pre-rehabilitation levels would reduce the amount of time property owners and visitors spend around the lake, resulting in a reduction of regional economic activity by 8% to 13% ($5 to $6 million/year). Conversely, the study found that maintaining existing water quality while providing additional improvements in the management of Eurasian water milfoil could increase economic activity by 8% to 11%.

Several studies have also recently been completed on the economic value of lakes in Maine (State of Maine DEP 2007, and EPA 2000). At a state-wide level, the studies found that lake-based expenditures by all users support over 50,000 jobs in Maine and generate an estimated $1.8 billion in total direct expenditures for recreation. Recreation generates $1.1 billion each year, other uses of lake water (such as drinking water, youth camps, and commercial uses) generate $400 million each year, and lake front property owners contribute over $300 million in investments in properties and taxes.

The Maine studies found that a 1 meter reduction of summertime minimum clarity (Secchi transparency) resulted in a reduction of 3 to 5% in the expected market price of a typical lakefront property. The State of Maine estimated that the net benefit of avoiding measurable water quality degradation in lakes exceeds $2 billion annually. The studies also evaluated the willingness of day access users to pay for water quality, and found users are estimated to be willing to pay $2 to $6 million annually to support water quality efforts.

The Maine studies also reported that water clarity, quality of swimming, and scenic beauty are important to most people when they choose which lake to visit or where to buy property. A noticeable gain in water quality could increase statewide lake use in Maine by up to 13% (1.6 million user days) each year, which would result in approximately a $107 million increase in economic

activity in the state. Conversely, the Maine studies found that a visible decrease in water quality would likely result in equivalent or greater losses in economic benefit from the lakes.

The studies on the economic value of lakes in Wisconsin and Maine indicate that lake water quality management activities can benefit regions surrounding lakes through increased economic activity associated with recreation and through increased property values. These studies also indicate that degradation of lake water quality can adversely affect the local economies.

4. General Lake Water Quality Concerns

Lake water quality is important to the public for many reasons, including recreational usage, aesthetics, and habitat quality for fish and wildlife. Common lake water quality problems include:

- Excessive and/or invasive aquatic plant growth
- Excessive algal growth (typically due to elevated phosphorus inputs to the lake) and toxic algae (cyanobacteria) blooms
- Poor water clarity due to algal growth and/or soil eroded from the lake's watershed
- Pathogens from human and animal waste, which can increase health risks for people swimming or wading in the lake
- Low dissolved oxygen levels caused by excessive aquatic plant growth and/or discharges of oxygen-demanding materials into the lake
- Trash, oil and gasoline spills, and lake disturbance resulting from recreational activities.

Many lake water quality problems can be linked to excessive nutrient input, which accelerates eutrophication in lakes resulting in increased aquatic plant and algae growth and degraded water quality. Potential nutrient sources include land use activities (such as removal of native vegetation along lakeshores and tributary streams), point source discharges (such as wastewater treatment plant and industrial discharges), and non-point discharges (such as agricultural runoff, stormwater, and septic systems). River management controls like dams can affect lake parameters such as temperature and suspended sediment.

Although recreational usage and aesthetic values of lakes can be impaired by excessive aquatic plant and algae growth, healthy lakes typically require some level of algae and aquatic plants. Algae are primary producers and serve as the food base for many lake organisms, including fish and benthic invertebrates. Aquatic plant communities provide oxygen for aquatic life; habitat and food for waterfowl, fish, amphibians, invertebrates, and insects; protection of the shoreline from erosive waves; and stabilization of bottom sediments from re-suspension (Cooke et al. 2005).

However, excessive algal and aquatic plant growth and its effects on water quality are the most common problems addressed in the management of shallow, eutrophic lakes (Cooke et al. 2005). Excessive algal blooms hinder lake recreation, are unsightly, and deplete lake oxygen levels during decomposition. Certain strains of blue-green algae (also known as cyanobacteria) can be toxic to people and animals if ingested; thus, algae-dominated lakes require close surveillance to ensure public safety. Aquatic plants, especially invasive species, can grow out of control in nutrient-rich

lakes. Excessive aquatic plant growth similarly hinders lake recreation, is unsightly, and can negatively alter lake food webs.

The factors typically affecting the abundance and distribution of plants within lakes are nutrients, light availability, sediment characteristics, wind, and wave energy (Nichols, 2001). Algal growth is often limited by nutrient concentrations in the water column. The cycling of nutrients in lakes is complex and dependent upon a variety of physical, chemical, and biological factors. In aquatic systems, phosphorus (P) and nitrogen (N) are the most limiting nutrients for algal growth; generally, the addition of these nutrients to a lake will increase the rate and amount of algae production (Bachmann, 2001). However, lake size and depth control how nutrients affect algal growth. In deeper lakes, there is generally a continual loss of nutrients from the epilimnion to the hypolimnion as algae and particulate matter die and sink to the bottom of the lake. In contrast, the frequent mixing of shallow lakes typically results in a relatively rapid return of nutrients from most settled material into the water column.

Controlling nutrient inputs to lakes is a key component in maintaining or improving lake water quality. Septic systems and runoff from agricultural land are two potential sources for high nutrient inputs to lakes and contributing streams. Stormwater runoff can also contribute nutrients to lakes from fertilizers and eroded soil. In Piece County, the Tacoma-Pierce County Health Department is responsible for septic system design, inspection, and repair. Pierce Conservation District addresses runoff from agricultural land through voluntary landowner participation in its conservation planning program. Water Programs addresses stormwater quality through its NPDES MS4 permit program and basin planning. The Washington State Department of Ecology (Ecology) also supports programs to address invasive aquatic weeds and toxic algae in lakes. The control measures implemented by these agencies are described in greater detail in Section 6 below.

Once lake sediments are enriched with nutrients, addressing invasive or excessive aquatic vegetation generally requires controlling plant growth through physical, mechanical, chemical, or biological control methods. Examples of physical and mechanical control methods include hand pulling and harvesting with machines. Examples of chemical control methods include herbicides that target certain types of aquatic vegetation and alum to reduce concentrations of plant-available forms of P. Examples of biological control methods include herbivorous fish (such as sterilized grass carp), weevils that feed on target aquatic plants, and restoration of native aquatic plant communities. Ecology recommends that lake management groups and local governments collaborate in the development of integrated aquatic vegetation management (IAVM) plans for lakes with aquatic plant management issues. An IAVM plan evaluates the available control methods and selects the most appropriate methods for the lake conditions and management goals. Ecology generally will not issue permits for application of certain aquatic herbicides and other control techniques unless the applicant has completed an IAVM.

5. Lake Tapps Water Quality

The White River Basin Characterization Report identified Lake Tapps as the only major water quality concern in the planning area. The report noted that although current lake water quality is good, water quality could decline in the future due to changes in the lake operations and/or pollutant inputs from the area around the lake. Pierce County Water Programs does not own the lake and does not have authority over its operation. However, Water Programs can perform water

quality management activities, such as non-point pollution source control, water quality monitoring, and implementation of stormwater quality Best Management Practices.

Lake Tapps is heavily used for boating, water skiing, swimming, and other recreational activities. Many of the shoreline residences have private docks. Two public parks, one at the north end and one at the south end allows for public access to the water. Eight other private parks located around the lake provide access for resident members.

Potential sources of pollutants to the lake include White River inflows as well as stormwater runoff and septic system effluent from lake shore areas. Settling basins on the diversion canal remove some of the potential pollutants from the White River before they can enter the lake.

PSE ceased hydropower operations at Lake Tapps in 2004. In 2006, PSE agreed to sell the Lake Tapps facilities to the Cascade Water Alliance (CWA), contingent on PSE obtaining a municipal water right for the project, among other things (Ecology 2006a). Conversion of Lake Tapps from hydropower and recreational uses to municipal water supply and recreational uses will likely result in lower flow rates through the lake.

Additional monitoring of Lake Tapps would help Water Programs gain a better understanding of its existing water quality and the potential effects of changes in lake operations. Monitoring would also help Water Programs identify source control needs and evaluate water quality trends over time. A recommended long term monitoring program for Lake Tapps is described in TIM 8 and a recommended source identification program for Lake Tapps is described in TIM 9.

6. Current Organizational Roles and Responsibilities for Lake Management in Pierce County

Pierce County addresses issues associated with lake management through Water Programs (PCWP) and Tacoma-Pierce County Health Department (TPCHD).

6.1 Water Programs

Water Programs (PCWP) is currently developing an Invasive Vegetation and Lakes Management project. The Invasive Vegetation project includes field surveys of 21 lakes in unincorporated Pierce County to obtain information on invasive aquatic plants (i.e., aquatic weeds). Invasive aquatic plants reduce recreational and aesthetic qualities of lakes and put lakes at risk for shifts in ecological functions and decreased habitat quality. The Invasive Vegetation project will provide baseline information on lakes and recommendations to address invasive plant issues in lakes. In addition, the results of this technical information memorandum describing existing lake management activities and gaps in a fully functioning lake management program are intended to be included in the overall Lakes Management Plan developed through the Invasive Vegetation project.

PCWP addresses water quality through its National Pollutant Discharge Elimination System (NPDES) stormwater permit and Stormwater Management Program as well as through the development and implementation of Basin Plans, Watershed Action Plans (focused on non-point source pollution), and the Salmon Recovery Plan. As a part of the Watershed Action Plans, Pierce County works collaboratively with local watershed councils and other groups to improve water quality.

The Stormwater Management Program describes actions taken by the County to comply with its stormwater NPDES permit and improve water quality. These actions include:

- Water quality monitoring
- Public education and outreach
- Operation and maintenance practices for roads and stormwater structures
- Illicit discharges detection and elimination
- Stormwater management and site development manual
- Inspection of businesses and industries
- Use of Best Management Practices to prevent stormwater pollution
- Capital Improvement Programs to build regional stormwater facilities

6.2 Tacoma-Pierce County Health Department

Tacoma-Pierce County Health Department (TPCHD) has 0.5 FTE performing lake water quality monitoring and limited public outreach. The work is often nearly full-time in the summer and then part-time the rest of the year. TPCHD also implements a septic system program that affects lake management. TPCHD has a new position (1 FTE) working on Green Landscaping issues such as composting and yard care. This position could provide assistance in the future related to lakefront property landscaping and nutrient reduction.

TPCHD monitors water quality at seven freshwater swimming beaches each summer. Water samples are collected from each swimming area at least once every other week and tested for E. coli bacteria. E. coli bacteria are found in the intestines of humans and warm-blooded wildlife species. High concentrations of E. coli in a surface water sample indicate that the water body is contaminated with fecal matter and may therefore pose a health risk for people swimming or wading in the water. If E. coli levels are high, an advisory sign is posted at the beach. TPCHD does some data management to track the monitoring information; however they lack staff time to do extensive data management and dissemination. The beaches monitored are:

- American Lake: North Park, Harry Todd Park
- Spanaway Lake: Main Beach, North Beach
- Lake Tapps: North Park, Allan York Park
- Wapato Lake: Main Beach

Funding for the freshwater swimming beach monitoring comes from the general "Health Pool" funding provided to TPCHD by the City of Tacoma and Pierce County. This funding source has been declining in recent years.

In addition to the beach monitoring program, TPCHD also monitors for toxic algae in lakes from public access points, identifies algae species in the lab and field, and posts caution signs at lakes with

toxic algae levels of concern. Currently, they focus on taking samples where scum layers are observed near public access points. However, they may be missing some areas with algae problems that would only be accessible by boat and sites with algae dispersed through the water column by boat activity. Some algae problems are reported by volunteers involved in PCD's monitoring program, and when invited by those volunteers to investigate further TPCHD field staff have the opportunity to go on private property and access other parts of lakes.

TPCHD received a Freshwater Algae Program grant from the Dept. of Ecology for about $48,000. The grant will help fund an increased toxic algae project that will include additional public education and outreach (including mailings, workshops, and newspaper articles), purchase of additional sampling equipment to sample the density of algae blooms to better find dispersed algae problems, creating an Algae Watch Program using community volunteers to help identify algae problem areas, creating a database to better track algae program data and activities, making the database available to the public via the web, and enhancing the toxic algae public warning system.

In addition to monitoring and the planned Algae Program, TPCHD does some education and outreach when contacted by lakeside property owners with questions about lake water quality, including distributing flyers and brochures. TPCHD has done targeted mailings to waterfront property owners as well. TPCHD does some informal coordination with other agencies, primarily with Pierce Conservation District (PCD), but inter-agency coordination is limited.

The TPCHD Septic System Program addresses the permitting of new septic systems and assists homeowners with maintenance and repair of existing septic systems. The TPCHD Septic System Program, along with the Operation and Maintenance Program, works to ensure that septic systems are located and installed correctly and kept in good working condition. TPCHD does some limited education regarding septic systems, primarily in response to questions and for properties that are going through sale or transfer. TPCHD provides guidance to homeowners regarding how to keep septic systems in good condition; the guidance includes determining the location of the systems, inspecting the systems periodically (every three years), and maintaining the systems (pumping systems every three to five years). TPCHD provides as-built drawings to landowners when requested to assist landowners in determining the location of septic systems. TPCHD also provides homeowners with contact information for contractors who can assist with septic system inspection and maintenance.

6.3 Pierce Conservation District

PCD implements a volunteer monitoring program for water quality in streams called the Pierce Stream Team. There are 3.0 FTE staff in the Stream Team program who provide watershed health education as well as monitoring, data management, training and equipment loan, and aquatic weed management advice. The Stream Team program is primarily focused on volunteer monitoring in streams and several lakes in and around incorporated cities. PCD estimates that program management for the lake-oriented aspects of Stream Team work currently requires approximately 0.3 FTE.

PCD coordinates volunteer lake monitoring for the cities of Lakewood (since 2000), Bonney Lake (since 2004), and previously for Tacoma (ending in 2005). The lakes monitored for these programs include American, Gravelly, Louise, Steilacoom and Carp (for Lakewood); and Bonney and Debrajane (for Bonney Lake). PCD coordination for the Lakewood and Bonney Lake monitoring

programs includes training volunteers, picking up samples collected by volunteers, conducting lab testing of water samples and providing data management. Lab fees and lake kits for the Lakewood and Bonney Lake programs are paid for by the cities. Lakewood spends approximately $11,000 per year monitoring five lakes and Bonney Lakes spends approximately $4,500 per year monitoring two lakes.

To assist with volunteer monitoring in unincorporated Pierce County, PCD owns three lake kits for loan to individuals to conduct lake water quality monitoring of physical parameters. Each kit cost about $1,770 and includes a dissolved oxygen and temperature meter and secchi disks for measuring water clarity. There are several lakeshore residents on Ohop Lake who regularly monitor the physical parameters of the lake using the PCD kits. Occasionally, residents on Harts Lake and Tule Lake also collect physical data on lakes. PCD has no funding available to collect and analyze water quality samples from volunteers monitoring these lakes.

PCD compiles lake water quality data and shares it with city staff and volunteer participants in the Lakewood and Bonney Lake programs. PCD also manages the data reported from individual lake homeowners monitoring their lakes. PCD shares data with TPCHD and communicates with Ecology regarding lake health issues and lake conditions.

PCD has a lake health brochure available for download at their website: piercecountycd.org. PCD provides support to lake homeowner groups for aquatic weed management in Lake Bonney and Lake Ohop, and answers questions on aquatic weeds from the public when contacted. PCD served on the Ohop Lake Improvement Club plant control advisory committee and assisted the Ohop Lake homeowners group with submitting an Integrated Aquatic Vegetation Management (IAVM) plan development grant application to Ecology. PCD served as the fiduciary agent for the implementation of the Ohop Lake IAVM plan grant.

6.4 Washington State Department of Ecology

Ecology has several programs and policies that affect lake management, including the Aquatic Plant Management Program, Freshwater Aquatic Weeds Account, NPDES permitting for aquatic herbicide application, and the Algae Control Program. Ecology also provides educational materials to citizens addressing lake management topics. Ecology has 7 employees whose work includes some aspects of lake management; however most of these employees work on other non-lake issues as well. It is estimated that Ecology has 3 to 4 FTE implementing lake management programs and policies.

From 1989-1999, Ecology ran a statewide lake water quality monitoring program. The statewide program was discontinued in 2000 due to lack of funds. However, Ecology still conducts water quality monitoring studies in lakes where needed to support development of Total Maximum Daily Loads (TMDLs).

Aquatic Plant Management Program

Ecology strongly encourages development of long-term, integrated aquatic vegetation management (IAVM) plans to address nuisance aquatic plants in lakes. IAVM plans may be required before certain aquatic plant control activities may be initiated or before permits are issued for the use of herbicides. Ecology follows federal court guidance by requiring National Pollutant Discharge Elimination System (NPDES) permits for the use of aquatic pesticides.

In 1991, the legislature established the Freshwater Aquatic Weeds Account to provide financial and technical support for addressing invasive aquatic plants at a statewide level. This Account provides funding for technical assistance, public education and grants to help prevent and/or control invasive, non-native aquatic plants. The budget for the Freshwater Aquatic Weeds Account program is approximately $600,000 per year. Revenue for the Account comes from a $3 contribution from annual license fees for boat trailers. The types of activities funded include planning, education, monitoring, implementation, pilot or demonstration projects, surveillance and mapping projects. The Account calls for completion of an IAVM Plan before projects can be considered for implementation grants.

Cities, counties, state agencies, tribes, and special purpose districts (excluding lake management districts) are eligible to receive grants. Lakes groups and other private organizations must work in conjunction with their local governments to receive funding for projects. For example, PCD received $30,000 from the Account in 2005 to develop an IAVM plan for Ohop Lake. PCD applied for $75,000 from the fund for an Ohop Lake submerged aquatic weed eradication project in 2006 and 2007, but did not receive funding. The Lake Ohop project proposes removing Brazilian elodea using a fluridone treatment combined with hand removal of weeds in problem areas.

Algae Control Program

In 2005, the legislature established funding for an algae control program and requested Ecology to develop the program. Ecology recognizes that reducing nutrient input to lakes is the only long-term solution to prevent algae blooms. However the amount of money available for this program (about $250,000 per year) is not enough to fund comprehensive lake-wide and watershed-wide nutrient reduction projects. Instead the program focuses on providing local governments with the tools they need to manage algae problems. The program targets blue-green algae (also known as cyanobacteria) because these algae pose a health risk to humans, pets, and livestock. Ecology's algae program provides for:

- Algae identification
- Toxicity testing
- An on-line database to post the laboratory results
- Small grants ($25,000 to $50,000) for algae or nutrient management projects

Ecology began funding small grants to local governments in the fall of 2007. TPCHD received a grant from the Freshwater Algae Control program for approximately $48,000 in 2007. For more information, see the Ecology website on the Algae Control Program at: http://www.ecy.wa.gov/Programs/wq/plants/algae/index.html

Educational Resources

Ecology provides educational resources for landowners on lake functions and lake management at the following website: http://www.ecy.wa.gov/Programs/wq/links/plants.html#management

Information on the website includes the "Washington Lakes Book," information about lake landscaping practices and forming a lake association, and "A Citizen's Guide to Understanding and Monitoring Lakes and Streams."

Statewide Lake Monitoring Program

Ecology has monitored rivers and streams since the 1950s. With the assistance of federal grants Ecology was able to implement an extensive statewide lake monitoring program from 1989 through 1999. During that period, Ecology typically monitored about 60 lakes annually with help from about 250 volunteers. Ecology staff visited each lake in the spring or early summer and again in late summer while volunteers collected data every two weeks. Ecology collected data from more than 180 lakes during the statewide lake monitoring program. Parameters sampled included temperature, pH, conductivity, and dissolved oxygen profiles, chlorophyll, total nitrogen and total phosphorus. At selected lakes Ecology also monitored hardness, turbidity, total suspended solids, and fecal coliform bacteria. Volunteers monitored surface temperature and Secchi disk depth and provided general information and observations about their lake including noting where Eurasian milfoil and zebra mussels were observed.

In 2000, Ecology was unable to obtain sufficient funding and had to discontinue the statewide lake monitoring program. Ecology still files data from volunteers who have chosen to continue monitoring lakes, but they no longer recruit new volunteers or meet with current volunteers, nor are they able to assess the data submitted. At present, there is no state-wide monitoring or assessment of lake water quality.

6.5 Washington State Department of Fish and Wildlife

The Washington State Department of Fish and Wildlife (WDFW) stocks certain lakes with fish and responds to fisheries issues in lakes. Nearly 4.1 million trout, 7 inches or larger, were scheduled to be stocked in 356 Washington lowland lakes in 2007. WDFW stocks some of the lakes in Pierce County. For example, the following lakes in the Nisqually Basin were stocked with trout by WDFW: Clear Lake, Harts Lake, Ohop Lake, Rapjohn Lake, Tanwax Lake, and Whitman Lake. When recreational fisheries are degraded by an imbalance of predator fish or other issues, WDFW may propose rehabilitative actions such as treating a lake with rotenone to remove existing fish and restocking with a balanced population of game fish. WDFW also provides public education and outreach about fish and wildlife issues, such as a guidance video for boaters to avoid spreading zebra mussels.

6.6 Assessment Summary of Current Organization Roles and Responsibilities

Numerous local and state organizations play different roles in the management of lakes in Pierce County. Many of these roles and activities are focused on water quality in general at the local level. Projects that specifically address lake issues are typically added duties to other priorities. At the state level there are programs focused on lake management, however resources are spread throughout the state for these programs and they are not extensively funded. All sharing of information between governmental entities occurs as a result of informal arrangements. Data collection and information sharing with the public is generally reactive rather than preventive focused on water quality problems in lakes. Financial and technical assistance to property owners is sparse. There is no specific unifying local legislative framework in place.

7. Lake Management Gaps/Needs

The components of a fully functional lake management program have been identified through research into similar programs and through stakeholder meetings and interviews. A fully functional lake management program includes the following components:

1. Monitoring and Source Identification
2. Volunteer Monitoring
3. Data Management and Dissemination
4. Education and Outreach
5. Community Technical Assistance
6. Inter-Agency Coordination and Information Sharing
7. Phased Implementation of the Aquatic Invasive Plant Program
8. Funding for Lake Projects
    a. Lake Projects: Detailed lake studies
    b. Lake Projects: In-lake control and management strategies
    c. Lake Projects: Watershed strategies
    d. Lake Projects: Provide funding for private projects
9. Enforcement
10. Legal Authority

Table 1 summarizes the gaps in current activities related to these lake management program components and identifies resources that would be required to fill these gaps County-wide. Each of the lake management program components is also discussed below.

As discussed in Section 6, Water Programs is currently developing an Invasive Vegetation and Lakes Management Program. The results of this technical information memorandum describing existing lake management activities and gaps in a fully functioning lake management program are intended to be included in the overall Lakes Management Plan developed through the Invasive Vegetation project.

The gap analysis identified the need for approximately 6.0 FTE and an additional $2,245,000 in supporting budget to implement a fully functional lake management program throughout unincorporated Pierce County. Specific lake projects are projected to require $2,125,000 per year in funding and supporting program costs are projected to require $120,000 per year in funding. Table 2 provides an overview of the gap analysis.

In addition to these County-wide estimates for lake management, planning level cost estimates for specific long term monitoring and source identification recommendations were developed for Lake Tapps and are described in TIMs 8 and 9. The planning-level cost estimates for the County-wide

lake management program described in this section are for costs in addition to those costs estimated for Lake Tapps monitoring and source identification.

7.1 Detailed Gap Analysis

1. Monitoring and Source Identification

Program Gaps

Monitoring and source identification is needed to identify water quality problems (including aquatic weeds and toxic algae) and their sources or causes as well as to track changes in water quality over time. Monitoring results are also required to determine which lakes need further study or improvement.

Water quality monitoring is currently performed by TPCHD to address human health concerns. TPCHD has 0.5 FTE to monitor 7 beaches at 4 lakes for fecal bacteria, and to respond to algae concerns on all lakes. There is significant travel time involved in reaching the lakes for monitoring. The 0.5 FTE is not adequate to meet the lake monitoring needs to monitor all lakes in Pierce County or to organize a volunteer monitoring program. The Department of Ecology is no longer running the volunteer lake monitoring program.

There is limited water quality data available for many lakes in Pierce County. Additional monitoring and source identification data is needed to organize lake management activities and determine which lakes need projects proposed for additional study and water quality improvement activities. There is a need to use a boat to conduct lake water quality monitoring at multiple sites in lakes to capture trends and conditions throughout lakes, not just at public access points. Data management and dissemination is a critical complementary component to the monitoring and source identification component. The volunteer monitoring program component will also provide complementary resources for monitoring lake conditions.

The recommended monitoring program component includes assessing lakes for water quality risks and sorting lakes into management level tiers. 1st Tier lakes would be at high risk for water quality problems and would require more frequent and extensive monitoring. 2nd and 3rd Tier lakes would be at moderate and lower risk for water quality problems, respectively, and would require less frequent monitoring. It is recommended that all lakes be monitored by County staff periodically, with additional monitoring data collected by volunteers in conjunction with the volunteer monitoring program component.

To develop a monitoring program component like the former Ecology lake monitoring program, County staff would visit each lake at least as frequently as once in the spring or early summer and once again in late summer while volunteers collect data every two weeks. If volunteers are not available and additional information is needed, staff would be required to visit lakes more frequently. Staff would collect data on parameters such as temperature, pH, conductivity, and dissolved oxygen profiles, chlorophyll, total nitrogen, total phosphorus and dissolved phosphorus. At selected lakes staff would also monitor hardness, turbidity, total suspended solids, fecal coliform bacteria, invasive aquatic weeds, and toxic algae. Volunteers would monitor surface temperature and Secchi disk depth and provided general information and observations about their lake including noting where algae and invasive aquatic weeds were observed. More highly trained volunteers could assist by

collecting lake water samples, which would be picked up and analyzed by County staff as in the King County lake monitoring program.

Pollutant source identification monitoring work may also be required on lakes with observed water quality problems. The level of this work will be dependent upon future results from the monitoring program component, however for the purpose of estimating the current gap it is assumed that preliminary source identification monitoring would be performed through this program component and more detailed studies would be conducted under program component 8, funding for lake projects (detailed lake studies).

Estimated Need

A fully functioning program is estimated to require an additional 2.0 FTE to monitor lakes throughout Pierce County in addition to the 0.5 FTE currently monitoring lakes for TPCHD. This estimate includes 0.5 FTE for data management and dissemination, discussed below in program component 3. However, this estimate does not include the 1.0 FTE for volunteer monitoring described below in program component 2.

It is recommended that these staff positions be added to PCWP. The monitoring program staff will need to coordinate closely with the staff involved in the volunteer monitoring program at PCD and staff involved in water quality monitoring for TPCHD. It may increase efficiency to use laboratory facilities at TPCHD.

An additional $50,000 per year in funding for the monitoring program will also be required to provide field equipment, travel costs, laboratory sample analysis, and other program components.

2. Volunteer Monitoring

Volunteer monitoring provides an opportunity for residents to take an active part in monitoring lake health, and provides economic and useful background data on lake functions and water quality. Volunteers can collect data at more frequent intervals and more locations than County staff. As noted above, the Department of Ecology is no longer running a volunteer lake monitoring program. Pierce Conservation District runs a volunteer stream monitoring program, but the program has a limited lake monitoring element in unincorporated Pierce County. PCD currently coordinates volunteer lake monitoring programs for the cities of Bonney Lake and Lakewood. PCD has three lake kits available to loan out to individual landowners interested in monitoring lakes in unincorporated Pierce County, however these kits only measure physical parameters such as temperature, dissolved oxygen, and water clarity. PCD does not currently have funding available to collect and test water samples from volunteers in unincorporated Pierce County. There may be an opportunity to coordinate volunteer monitoring activities with Tribes in the area, which occasionally also support volunteer monitoring.

The lake management program in King County relies heavily on volunteer monitoring for water quality samples. King County staff are willing to provide Pierce County with program development information and volunteer training information to assist in the development of this program component.

There is a need to expand the volunteer monitoring of lakes performed in Pierce County. There is a need to recruit additional volunteers, train additional volunteers in lake monitoring techniques,

collect and organize additional data from volunteers, collect samples from volunteers when appropriate, perform testing on samples, and work in conjunction with the staff in the monitoring program component to distribute the data to the public through a website. In addition, planning and implementation of volunteer outreach and volunteer appreciation activities will be needed.

Estimated Need

A fully functioning program is estimated to require an additional 1.0 FTE to plan and implement the volunteer monitoring component of the lake management program. It is recommended that this staff position be added to PCD, increasing program efficiency by adding to the existing volunteer monitoring program at PCD. An increase in PCD funds will be necessary to complete this work. The staff for the volunteer monitoring program will work closely with the staff added for program component 1, monitoring and source identification.

An additional $35,000 per year in funding for the volunteer monitoring program will also be required to provide field equipment, travel costs, laboratory sample analysis, volunteer recruiting, volunteer appreciation, and other program elements. An increase in PCD funding for volunteer monitoring will be required to provide these supporting program costs.

3. Data Management and Dissemination

Monitoring data needs to be organized and made accessible to other organizations and to the public. If additional monitoring is conducted through program components 1 and 2, data management and dissemination will be required as well.

There is a need to organize and make monitoring data and other program information accessible to other organizations and to the public, preferably through the web similar to the King County program. TPCHD will use a portion of the grant from Ecology for the toxic algae program to provide algae data on the web, but otherwise there are no current resources available for organizing and disseminating lake water quality monitoring data.

Estimated Need

A fully functioning program is estimated to require an additional 0.5 FTE to provide data management and dissemination as a part of the monitoring and source identification program component. This staff need is included in the 2.0 FTE described for program component 1, monitoring and source identification.

An additional $2,000 per year in funding for the data management and dissemination program component will be required to make monitoring data and other program information available to the public and other organizations, primarily through electronic sources such as the web.

4. Education and Outreach

Outreach and education are needed to inform the public about lake issues and motivate changes to improve lake health. Lakes are affected significantly by the activities occurring in the lake watershed, and addressing lake water quality problems and preventing future problems requires extensive public involvement and education. Education of lakeshore property owners and lake users could help encourage lake-friendly landscaping, pet waste disposal, care and maintenance of septic systems, sewage and trash disposal for recreational users, and other behaviors that would help reduce

pollutant inputs to lakes. In addition, education programs could improve local support for lake management fees or assessments, and/or restrictions on shoreline land use.

TPCHD provides limited outreach and education regarding lake water quality issues including distribution of flyers and other information. TPCHD recently added 1.0 FTE to implement a Green Landscaping program. This position could provide assistance in the future related to lakefront property landscaping and nutrient reduction, however it is not currently focused in that area. PCD provides outreach and education on nutrient management to County residents however this outreach is not lake specific. PCD provides outreach and education primarily regarding general watershed health issues, with some focus on lake water quality issues including distribution of brochures on protecting lake water quality. WDFW provides public education and outreach about fish and wildlife issues, such as a guidance video for boaters to avoid spreading zebra mussels, however WDFW conducts these activities statewide with limited budget available.

There is a need to perform additional outreach and education regarding lake-friendly landscaping, on-site sewage treatment system maintenance, proper boat maintenance to prevent lake pollution, invasive aquatic plants, lake health, and other issues. An outreach and education staff person could also provide community technical assistance and inter-agency coordination and information sharing to fulfill program components 5 and 6, respectively.

Estimated Need

A fully functioning program is estimated to require an additional 1.0 FTE to provide lake-focused education and outreach. This estimate includes 0.3 FTE for community technical assistance, discussed below in program component 5, and 0.1 FTE for inter-agency coordination and information sharing, discussed below in program component 6. This staff position should be added to PCWP.

An additional $10,000 per year in funding for the education and outreach program component will be required to provide resources to the public through printed materials, outreach events, educational activities, and other program elements.

5. Community Technical Assistance

Lakeshore property owners and lake recreational users often want to know more about lake health and want to address problems on lakes. TPCHD and PCD currently provide limited technical assistance related to lakes, answering questions when possible and directing landowners to additional resources if available. PCD provides aquatic weed management advice when requested. However, additional assistance for these stakeholders is needed.

There is a need to provide a County staff person to answer questions on lake health and functions from property owners and recreational users. There is also a need to provide technical assistance to help lakeshore owners obtain grants for lake management activities, form lake management districts, and determine appropriate fees or rates. There are a number of complaints each year to various County departments regarding beaver activity around lakes and streams. There is a need to provide information to landowners about beaver management options available. In addition, if lake management projects are being implemented by lakeshore landowners, there is a need to provide technical guidance on these projects to protect aquatic habitat and human health.

Estimated Need

A fully functioning program is estimated to require an additional 0.3 FTE to provide community technical assistance. This staff need is included in the 1.0 FTE described for program component 4, education and outreach.

An additional $2,000 per year in funding for the community technical assistance program component will be required to provide resources to the public through printed materials, technical assistance events, and other program components.

6. Inter-Agency Coordination and Information Sharing

There is a need to share information on lake management activities performed by PCWP with other local and state agencies (e.g., TPCHD, PCD, and Ecology). There is currently very limited inter-agency coordination, and what occurs is performed informally. PCD shares lake water quality data with TPCHD, and communicates with Ecology about lake conditions. Additional inter-agency coordination is needed to improve the efficiency and effectiveness of lake management activities. There is a need to form a lake management task force or inter-agency committee to provide a regularly scheduled opportunity for stakeholders to meet and discuss lake management issues.

Estimated Need

A fully functioning program is estimated to require an additional 0.1 FTE to provide inter-agency coordination and information sharing. This staff need is included in the 1.0 FTE described for program component 4, education and outreach.

An additional $1,000 per year in funding for the inter-agency coordination and information sharing program component will be required to provide resources fulfill the program component.

7. Aquatic Invasive Species Management

PCWP is currently implementing an Invasive Vegetation and Lakes Management Plan project. The Invasive Vegetation project includes field surveys of 21 lakes in unincorporated Pierce County to obtain information on invasive aquatic plants (i.e., aquatic weeds). Invasive aquatic plants reduce recreational and aesthetic qualities of lakes and put lakes at risk for shifts in ecological functions and decreased habitat quality. The Invasive Vegetation project will provide baseline information on invasive plants in lakes and recommendations to address these issues.

There is a need to provide resources to implement baseline activities recommended by Invasive Vegetation project such as lake monitoring and management activities focused on aquatic invasive plants and education and outreach focused on preventing the further dispersal of aquatic invasive species. More complex or extensive lake management projects recommended by the Invasive Vegetation project will require additional lake project funding under program component 8, funding for lake projects.

Estimated Need

A fully functioning program is estimated to require an additional 1.0 FTE to plan and implement the aquatic invasive plant component of the lake management program. This staff position should be added to PCWP.

It is estimated that an additional $20,000 per year in funding for the aquatic invasive species program component will be required to provide resources fulfill the baseline program component such as field equipment, travel costs, laboratory sampling, education and outreach materials and other program elements specific to aquatic invasive species. The recommendations in the Invasive Vegetation project may call for more complex or extensive lake management projects to address aquatic invasive species. These projects would require additional funding under program component 8, funding for lake projects.

8. Funding for Lake Projects

The need for detailed lake studies and specific capital projects to address problems in lakes is not yet known. These needs will be identified as the Lake Management Program is implemented, monitoring data results are analyzed, and community requests for action are received. However, once these needs are identified there is limited funding available for conducting detailed lake studies and implementing capital projects or programmatic actions to address problems in lakes. TPCHD was able to obtain lake study grants from the U.S. Environmental Protection Agency (EPA) in the early 1990's to study American Lake and Steilacoom Lake. The Nisqually Tribe also conducted a detailed study of Ohop Lake in 1997. The costs for these lake studies and the estimates of project costs developed in these studies can be used to develop a range of potential funding needs for lake projects.

There are a variety of types of lake projects that could be needed in Pierce County. These types of projects include:

- Detailed lake studies of lake characteristics, functions, problems and proposed projects to address problems.
- In-lake control and management strategies such as aquatic plant harvesting and chemical control implemented by County staff.
- Watershed strategies such as stormwater treatment, agricultural runoff management, forestry runoff management, and water treatment to reduce inputs of nutrients, bacteria and other pollutants to lakes.
- Funding for private projects such as retrofitting septic systems and funding in-lake treatment or management implemented by private landowners.

The scale of lake projects could vary dramatically, depending on what problems are identified and how complex the functions are in lakes that are identified as needing improvement. The Ohop Lake study completed by the Tribe in 1997 cost roughly $150,000. Costs could be substantially higher for studies involving larger or more complex lakes. Studies of American Lake and Steilacoom Lake in the early 1990's cost $330,000 and $350,000, respectively. Therefore, costs are estimated to range from $150,000 to $400,000 or more per lake studied.

As discussed in program component 1, monitoring and source identification, Pierce County could organize lakes into management level tiers. 1st Tier lakes would be at high risk for water quality problems and would require more frequent and extensive monitoring, and would likely be candidates for additional detailed lake studies. 2nd and 3rd Tier lakes would be at moderate and lower risk for water quality problems, respectively, and would require less frequent monitoring and likely

would not require additional detailed lake studies. In the White River Basin, Lake Tapps is a potential 1st Tier lake.

The projects that are developed as proposed solutions to lake problems can also vary significantly in scale and cost. For instance, the results of the Ohop Lake study conducted by the Nisqually Tribe found that the lake functions are controlled primarily by natural system conditions. Thus, the recommended actions from that study focused on educating landowners about the natural conditions and functions of the lake. In contrast, the Steilacoom Lake Phase I Restoration Study recommended alum treatment of inflow to the lake, with an approximate capital cost of roughly $4 to $8 million and annual costs of roughly $300,000 (KCM 1996). The American Lake study recommended watershed strategies to improve water quality in the lake requiring over $20 million in capital costs.

As a result of these uncertainties, the costs for funding lake restoration projects cannot not be accurately predicted in this early phase of planning the Lakes Management Program. However, funding will be required and a budget need can be developed based on the costs of other lake studies and projects. There is a need for a staff person to plan and implement the lake project funding component of the lake management plan. This staff person would work closely with monitoring and education staff to identify lakes with problems, determine the studies or capital projects needed for lakes, manage funding and project budgets for lake projects, and oversee lake studies.

Estimated Need

A fully functioning program is estimated to require an additional 1.0 FTE to plan and implement the lake project funding component of the lake management program. This staff position should be added to PCWP.

The recommended Lake Management Program includes annual budget requests identified in the lake management program. It is estimated that the need for additional funds to implement lake projects is $2,125,000 per year County-wide. The recommended lake management program includes annual budget requests to implement specific projects once the needs for the projects are known. It is estimated that the cost of specific lakes projects could range from $200,000 to $1,000,000.

9. Enforcement

Enforcement options may be needed to address sources of water quality problems. TPCHD has ability to obtain a search warrant if they have evidence that a property is discharging untreated wastewater, but this option is rarely used. The need for additional enforcement options will be evaluated as the lake management program is implemented. No FTE staff need is currently identified.

Estimated Need

No FTE staff need or additional resources required are currently identified. Additional FTE staff or resources may be required in the future as the lake management program is implemented and needs are identified.

10. Legal Authority

Pierce County is responsible for addressing surface water quality under the NPDES MS4 program and the TMDL program. As a public agency, Pierce County requires legal authority to implement programs such as the lake management program. To facilitate a County-wide lake management program, and ordinance may be desirable to clarify the program and the lake management function in PCWP.

Estimated Need

A fully functioning program may require an initial investment of time by existing County staff to develop a County-wide ordinance to facilitate the lake management program and clarify the lake management function in Water Programs.

7.2 Lake Management Program Summary

Current Conditions

At this time, in total between them, PCWP, PCD, and TPCHD have approximately 0.8 FTE and $48,000 (grant-funded) dedicated to lake management activities. TPCHD has 0.5 FTE to monitor 7 beaches at 4 lakes for fecal bacteria and to respond to algae concerns on all lakes, and a $48,000 grant from the state Freshwater Algae Program to provide additional services addressing toxic algae. PCD dedicates approximately 0.3 FTE to volunteer monitoring and other activities which affect lake management.

Program Gaps

The analysis has identified program gaps related to monitoring, data management, education and outreach, community technical assistance, inter-agency coordination, phased implementation of the aquatic invasive plant program, funding for lake projects, enforcement and legal authority. These gaps are described in Table 1 and summarized in Table 2. In total, there is a need for an additional 6.0 FTE and $2,245,000 annually to support a fully functioning lake management program. To be effective over time, resources for lake management need a long term, stable commitment that is funded out of each agency's respective budget.

To begin the implementation of the lake management program, Pierce County will conduct a phased implementation of lake management activities. The lake management program was recommended as a part of the Nisqually Basin Plan. A tiering process is recommended to identify high priority lakes for further study and management. The tiering process is described in Section 8.0. In the White River Basin, Lake Tapps is the only lake. Due to the potential for changes in lake water quality in Lake Tapps, it is a tier 1 lake.

Based on a tiering system, Pierce County Public Works and Utilities Water Programs Division will move into a lake management program. Rough (stand alone) monetary estimates will be developed to address the management of the highest tiered lakes. In addition, staff will be assigned to each of the high tiered lakes to work on management issues.

Estimated Needs – Fully Funded Program Costs

The estimated needs for a fully functioning lake management program are described in detail in Table 1 and summarized in Table 2. Pierce County Public Works and Utilities Water Programs Division will require an additional 5.0 FTE and $2,210,000 in supporting program budget per year. Pierce Conservation District will require an additional 1.0 FTE and $35,000 in supporting budget per year. When combined, the total annual FTE and supporting program budget for Pierce County Public Works and Utilities Water Programs Division will be $2,710,000. Over 10 years (without inflation), the total lake management program cost for Pierce County is projected to be $27,100,000. The total annual FTE and supporting program budget for Pierce Conservation District will be $135,000. Over 10 years (without inflation), the total lake management program cost for Pierce Conservation District is projected to be $1,350,000.

8. Recommended Program for the White River Basin

As discussed in Section 6, Pierce County Water Programs is currently implementing an Invasive Vegetation and Lakes Management Program. The results of this technical information memorandum describing existing lake management activities and gaps in a fully functioning lake management program are intended to be included in the overall lake management program developed through the Invasive Vegetation project. This section describes the recommended phased implementation of the lake management program for the White River Basin specifically.

The gap analysis identified the need for approximately 6.0 FTE and an additional $120,000 in supporting funding (aside from specific lake project funding needs) to implement a fully functional lake management program throughout unincorporated Pierce County. Specific lake projects are projected to require an additional $2,125,000 per year in funding. These resources would be required to implement the full range of program components described in Table 1.

To implement these program components in just the White River Basin, fewer resources would be required than for the County-wide program. A recommended long term monitoring program for Lake Tapps is described in TIM 8 and a recommended source identification program for Lake Tapps is described in TIM 9. The recommended elements of these two programs for Lake Tapps include elements listed in Tables 1 and 2 such as monitoring and source identification, volunteer monitoring, data management and dissemination, education and outreach, and lake projects. As a result of this overlap, the elements of the recommended long term monitoring program and source identification program for Lake Tapps could be funded as a part of the County-wide recommended lake management program.

The recommended program elements and costs for lake management in Lake Tapps are summarized below. For more information, see TIM 8 and TIM 9.

Long Term Water Quality Monitoring

The recommended elements of long term water quality monitoring program for Lake Tapps described in TIM 8 include trophic state monitoring and fecal contamination monitoring. The annual planning level cost estimate (in 2008 dollars) for the water quality monitoring program for Lake Tapps ranges from $300,000 for Year 1 to $221,000 for Years 2 through 10. The 10-year planning level cost estimate (in 2008 dollars) for the water quality monitoring program for Lake

Tapps is $2,325,000. The estimate assumes that all of the work except for laboratory analysis would be performed by County staff. It may be possible to use volunteer labor to reduce costs and promote public education.

Source Identification

The recommended program components for the source identification program for Lake Tapps described in TIM 9 includes color infrared aerial photography, indicator testing, and optical brightener monitoring traps. The 10 year cost for implementation of the source monitoring program is estimated to be 0.25 FTE per year and a total of $86,500 in supporting program costs over 10 years. Combining the approximate cost for FTE support with the supporting program costs, the 10-year cost for implementing the pollutant source identification and monitoring program is estimated to be $336,500.

References

Bachmann, R.W. 2001. The limiting factor concept: what stops growth? Lakeline (North American Lake Management Society). v. 21, no. 1, p. 26-28.

Cooke, G.D., E.B. Welch, S.A. Peterson and S.A. Nichols. 2005. Restoration and Management of Lakes and Reservoirs (third ed.) New York, CRC Press Taylor & Francis Group.

EPA. 2000. Costs and Benefits of Water Quality Protection, Chapter 8 of 2000 National Water Quality Inventory. Accessed online on 7/18/07 at: http://www.epa.gov/305b/2000report/chp8.pdf

Nichols, S.A., 2001. Macrophytes: where they grow and why. Lakeline (North American Lake Management Society), v. 21, no. 1, p. 38-41.

State of Maine DEP. 2007. The Economics of Lakes - Dollars and $ense. Accessed online on 7/17/07 at: http://www.maine.gov/dep/blwq/doclake/research.htm

University of Wisconsin-Whitewater. 2005. What Is the Value of a Clean and Healthy

Lake to a Local Community? Accessed online on 7/16/07 at: http://www.wisconsinlakes.org/AboutLakes/PDFs/DelavanLakeStudy.pdf

THIS PAGE INTENTIONALLY LEFT BLANK.

Table 1: Detailed Gap Analysis for Pierce County Lake Management Program

					Annual County-Wide Program Implementation Cost Estimates	
	Lake Management Component	**Function**	**Current work**	**Gap/Need**	**FTE Resources**	**Additional supporting budget**
1	**Monitoring and Source Identification**	Identify water quality problems (including aquatic weeds and toxic algae) and their sources or causes, track changes in water quality over time. Determine which lakes need further study or improvement.	TPCHD has 0.5 FTE to monitor 7 beaches at 4 lakes for fecal bacteria, and to respond to algae concerns on all lakes.	Limited water quality data is available for many lakes. TPCHD only reports lake water quality concerns, does not propose how to address concerns. Need additional info to organize lake management activities and determine which lakes need proposed projects for additional study and water quality improvement activities. Need to use a boat to conduct lake water quality monitoring at multiple sites in lakes (not just public access points).	**2.0 FTE PCWP** (includes 0.5 FTE for Data Management)	$ 50,000
2	**Volunteer Monitoring**	Train volunteers in lake monitoring techniques, collect samples from volunteers, perform testing on samples, distribute data to public via website.	PCD Stream Team provides equipment loan of 3 lake kits to landowners.	Volunteer monitoring provides an opportunity for residents to take an active part in monitoring lake health, and provides economic and useful background data on lake functions and health. Volunteers can collect data at more frequent intervals than County staff.	**1.0 FTE PCD**	$35,000 PCD
3	**Data Management and Dissemination**	Make monitoring data and other program information accessible to other organizations and to the public.	TPCHD grant will be used to provide algae data on the web. PCD shares data with TPCHD.	Monitoring data needs to be accessible to other organizations and to the public. If additional monitoring is conducted, data management and dissemination will be required as well.	*0.5 FTE* (included in 2.0 FTE for Monitoring)	$ 2,000
4	**Education and Outreach**	Perform outreach and education regarding lake-friendly landscaping, on-site sewage treatment, lake health, etc.	TPCHD, PCD, WDFW, and Ecology perform limited outreach and education. PCD provides outreach and education on watershed health and nutrient management. PCD and TPCHD distribute lake management brochures.	Additional outreach and education activities are needed to inform the public about lake issues and motivate changes to improve lake health	**1.0 FTE PCWP** (includes 0.3 FTE for Community Assistance, and 0.1 FTE for Inter-Agency Coord)	$ 10,000
5	**Community Technical Assistance**	Answer questions on lake health and functions. Help lakeshore owners obtain grants, form lake management districts, and determine appropriate fees or rates. Provide technical guidance on lake projects.	TPCHD and PCD provide limited technical assistance related to lakes. PCD provides aquatic weed management advice when requested.	Lakeshore property owners and recreational users often want to know more about lake health and address problems on lakes. Assistance for these stakeholders is needed.	*0.3 FTE* (included in 1.0 FTE for Education)	$ 2,000

Table 1: Detailed Gap Analysis for Pierce County Lake Management Program

					Annual County-Wide Program Implementation Cost Estimates	
	Lake Management Component	**Function**	**Current work**	**Gap/Need**	**FTE Resources**	**Additional supporting budget**
6	**Inter-Agency Coordination and Information Sharing**	Share information on lake management activities with other local and state agencies (e.g., TPCHD, PCD, Ecology).	Limited inter-agency coordination occurs. PCD shares data with TPCHD and communicates with Ecology.	Inter-agency coordination is needed to improve the efficiency and effectiveness of lake management activities.	*0.1 FTE* (included in 1.0 FTE for Education)	$ 1,000
7	**Aquatic Invasive Species Management**	Implement activities recommended by PCWP Invasive Vegetation project such as education, lake monitoring and management activities.	PCWP is currently conducting an Invasive Vegetation project.	Invasive aquatic species reduce recreational and aesthetic qualities of lakes and put lakes at risk for shifts in ecological functions and decreased habitat quality.	**1.0 FTE PCWP**	$ 20,000
8	**Funding for lake projects**	Provide funding to implement projects to improve lake health.	None.	As a result of the Aquatic Invasive Plant Program, monitoring information, public requests, and detailed lake studies, various capital lake projects are likely to be proposed. Funding to implement these projects will be needed.	**1.0 FTE PCWP**	$ 2,125,000
	Lake Projects: Detailed lake studies	Perform detailed analysis of lake characteristics, functions, problems, and proposed projects to address problems.	None.	Costs could range from $150,000 to $400,000 or more per lake studied. There is one 1st Tier Lake in the White River Basin and five 1st Tier Lakes in the Nisqually Basin that could require detailed studies. Funding will be needed.		*varies*
	Lake Projects: In-lake control and management strategies	As a result of the Invasive Vegetation project and detailed lake studies, in-lake control and management strategies are likely to be proposed including aquatic plant harvesting or chemical control.	Ecology provides small grants for aquatic weed and algae management.	Costs could range from $10,000 to $8 million or more per lake studied and managed. Funding will be needed.		*varies*
	Lake Projects: Watershed strategies	As a result of the Invasive Vegetation project and detailed lake studies, watershed strategies such as stormwater treatment, agricultural runoff management, and forestry runoff management to reduce inputs of nutrients, bacteria, and other pollutants to lakes that receive stormwater runoff.	PCWP and PCD implement watershed improvements for stormwater and water quality enhacement.	Costs could range from $10,000 to $20 million or more per lake studied and managed. Funding will be needed.		*varies*
	Lake Projects: Funding for private projects	As a result of education, outreach, and monitoring, lakeshore owners may request assistance in retrofitting septic systems, funding in-lake treatment or management, etc.	Ecology provides small grants for aquatic weed and algae management.	Costs could range from $10,000 to $1 million or more per requested project. Funding will be needed.		*varies*

Table 1: Detailed Gap Analysis for Pierce County Lake Management Program

					Annual County-Wide Program Implementation Cost Estimates	
	Lake Management Component	**Function**	**Current work**	**Gap/Need**	**FTE Resources**	**Additional supporting budget**
9	**Enforcement**	Enforcement options may be needed to address sources of water quality problems.	Limited to none. TPCHD has ability to obtain search warrant if they have evidence that a property is discharging untreated wastewater, but this option is rarely used.	The need for additional enforcement options will be evaluated as the lake management program is implemented. No FTE staff need is currently identified.		
10	**Legal Authority**	As a public agency, Pierce County requires legal authority to implement programs such as the lake management program.	Pierce County is responsible for addressing surface water quality under the NPDES MS4 program and the TMDL program.	To implement a lake management program, a County-wide ordinance may be needed to establish the program and the lake management function in Water Programs. This will not require on-going FTE support, however an initial investment of time by County staff may be needed.		

Table 2: Pierce County Lake Management Program Gap Analysis Summary

Program Elements	GAP-SWM		GAP-Others	
	FTEs	$	FTEs	$
Monitoring and Source Identification				
Water Programs	1.5	$50,000		
TPCHD			1.0	(no cost)
PCD				
Volunteer Monitoring				
Water Programs				
TPCHD				
PCD			1.0	$35,000
Data Management and Dissemination				
Water Programs	0.5	$2,000		
TPCHD				
PCD				
Education and Outreach				
Water Programs	0.6	$10,000		
TPCHD				
PCD				
Community Technical Assistance				
Water Programs	0.3	$2,000		
TPCHD				
PCD				
Inter-Agency Coordination and Information Sharing				
Water Programs	0.1	$1,000		
TPCHD				
PCD				
Aquatic Invasive Species Management				
Water Programs	1.0	$20,000		
TPCHD				
PCD				
Funding for lake projects				
Water Programs	1.0	$2,125,000		
TPCHD				
PCD				
Enforcement				
Water Programs				
TPCHD			1.0	(no cost)
PCD				
Legal Authority				
Water Programs				
TPCHD				
PCD				
Summary				
Water Programs	5.0	$2,210,000		
TPCHD			2.0	(no cost)
PCD			1.0	$35,000
TOTAL	5.0	$2,210,000	3.0	$35,000

Appendix J

Lake Tapps Water Quality Monitoring Plan

THIS PAGE INTENTIONALLY LEFT BLANK.

BROWN AND CALDWELL

Technical Memorandum

701 Pike St Suite 1200
Seattle, WA, 98101
Tel: 206-624-0100
Fax: 206-749-2200

Prepared for: Pierce County, Washington

Project Title: White River Basin Plan

Technical Memorandum No. 8

Subject: Lake Tapps Water Quality Monitoring Plan Recommendations

Date: May 8, 2008

To: Heather Kibbey, Project Manager

From: Mike Milne

Prepared by: Liz Korb
Mike Milne

Limitations:

This is a draft memorandum and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon; consult the final report.

This document was prepared solely for Pierce County Water Programs in accordance with professional standards at the time the services were performed and in accordance with the contract between Pierce County Water Programs and Brown and Caldwell. This document is governed by the specific scope of work authorized by Pierce County Water Programs; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Pierce County Water Programs and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

1. INTRODUCTION

This Technical Information Memorandum 8 (TIM 8) describes the existing water quality information and recommendations for a future monitoring plan for Lake Tapps as a part of the White River Basin Plan.

1.1 Scope of Work and Purpose

The White River Basin Characterization Report identified Lake Tapps as the only major water quality concern in the planning area. The report noted that although current lake water quality is good, water quality could decline in the future due to changes in the lake operations and/or pollutant inputs from the area around the lake. Pierce County Water Programs does not own the lake and does not have authority over its operation. However, Water Programs can perform water quality management activities, such as non-point pollution source control, water quality monitoring, and implementation of stormwater quality Best Management Practices.

Additional monitoring of Lake Tapps would help Water Programs gain a better understanding of its existing water quality and the potential effects of changes in lake operations. Monitoring would also help Water Programs identify source control needs and evaluate water quality trends over time.

To help address this issue, Task 4 in Brown and Caldwell's (BC's) scope of work for the White River Basin Plan includes development of recommendations for long-term water quality monitoring to help discern water quality trends and possibly identify correlations between "indicator" parameters (e.g., turbidity, chlorophyll-a) and water quality conditions in the lake. If the monitoring indicates that lake water quality is declining, the monitoring results would support development of appropriate lake management measures and track their effectiveness over time.

Brown and Caldwell (BC) compiled and reviewed the water quality data that have been collected from Lake Tapps by Pierce County Water Programs (Water Programs), Puget Sound Energy (PSE), Washington State Department of Ecology (Ecology), and the Muckleshoot Indian Tribe Fisheries Division (MITFD) from the past three years. Reviewing the data will help BC decide some of the key questions that the Lake Tapps long-term monitoring plan will want to try to answer.

2. BACKGROUND

Lake Tapps was built by Puget Power Electric in 1911 for hydroelectric power generation. The lake covers 2,566 acres and has a maximum depth of 88.5 feet (27 m) and a mean depth of 25 feet (7.6 m). The lake can store up to 46,655 acre-feet of water. Water is diverted from the White River and conveyed in a canal to Lake Tapps. The lake discharges through a tailrace that enters the White River near Dieringer, just upstream from the confluence with the Puyallup River.

At the time of the original diversion and impoundment, the region around the lake was sparsely populated and hydroelectric power generation was the sole use of diverted water. In 1954 much of the land around the lake was purchased by Lake Tapps Development Company from Puget Sound Power and Light Company. The original intention of the development company was to provide summertime recreational home sites. As part of this development, a number of local parks were created for the use of property owners within the various projects. Pierce County was given 70 acres, with nearly a mile of shoreline, and the City of Bonney Lake was given two acres of waterfront property for public use.

The south shore of Lake Tapps is in the City of Bonney Lake. The rest of the lake lies within unincorporated Pierce County. Residential land uses dominate the shorelines and islands. The shoreline area encompasses numerous stormwater outfalls and septic systems.

Lake Tapps is heavily used for boating, water skiing, swimming, and other recreational activities. Many of the shoreline residences have private docks. Two public parks, one at the north end and one at the south end allows for public access to the water. Eight other private parks located around the lake provide access for resident members.

Potential sources of pollutants to the lake include White River inflows as well as stormwater runoff and septic system effluent from lake shore areas. Settling basins on the diversion canal remove some of the potential pollutants from the White River before they can enter the lake.

When the lake was used for hydropower generation, PSE tried to maintain high lake water levels during the summer recreation season and draw down the lake during the winter. The winter draw down facilitated inspection and maintenance of berms and other structures around the lake and may also have helped reduce the growth of aquatic weeds by exposing them to desiccation and cold temperatures.

PSE ceased hydropower operations at Lake Tapps in 2004. In 2006, PSE agreed to sell the Lake Tapps facilities to the Cascade Water Alliance (CWA), contingent on PSE obtaining a municipal water right for the project, among other things (Ecology 2006a). The CWA is a coalition that includes Bellevue, Issaquah, Kirkland, Redmond, Tukwila, Covington, the Sammamish Plateau and Skyway Water Districts. CWA would use Lake Tapps as a source of potable water while continuing to support recreation uses of the lake. CWA plans to construct a water treatment plant and delivery systems to transport the treated water to CWA members.

Conversion of Lake Tapps from hydropower and recreational uses to municipal water supply and recreational uses will likely result in lower flow rates through the lake. According to Ecology (2006a), lower flows could improve lake water quality by:

- Reducing phosphorus loads from the White River, which would reduce algal growth, improve water clarity, and increase dissolved oxygen levels in the deeper lake waters.
- Reducing sediment loads from the White River, thereby improving water clarity.
- Increasing water residence times, resulting in warmer water near the lake surface where most recreation occurs.

Ecology also noted that lower flows could degrade water quality by:

- Decreasing dissolved oxygen levels in the warmer surface layer of the lake (because warm water can hold less dissolved oxygen than cold water).
- Increasing light penetration, which could increase algae and aquatic plant growth.
- Decreasing dilution of any phosphorus that enters the lake from lake-side sources, which could cause increased algae levels, more turbid water, and lower levels of dissolved oxygen in the deeper lake waters.

A long-term monitoring program would help identify potential changes in lake water quality caused by the new flow regime. If the monitoring indicates that lake water quality is declining, the monitoring results may help support development of appropriate management measures.

3. SUMMARY OF RECENT WATER QUALITY DATA

3.1 Overview of Recent Studies

Pierce County Water Programs, Ecology, and the MITFD have performed recent water quality monitoring in Lake Tapps. The Pierce County and Ecology monitoring occurred during 2004-2005, while MITFD monitored the lake during 2004, 2005, 2006, and 2007. All of these monitoring efforts began after PSE had ceased hydropower operations at the lake. Diversion rates during these water quality studies were low compared to the diversion rates during hydropower operation.

To facilitate lake characterization, Pierce County Water Programs divided the lake into six water quality management units (WQMUs). WQMU 1 is located near the area where the diversion canal from the White River enters the lake. Depths are generally shallow (10 to 20 feet) and reach depths up to 30 feet when the lake is full (~543 ft. above mean sea level). WQMU 2 encompasses the deeper, main basin of the lake and reaches depths of up to 90 feet. WQMU 3 is the North Embayment near the outlet and reaches depths up 60 feet. WQMU 4 is also located in the North Embayment and is generally between 20 and 30 feet with depths up to 50 feet. WQMU 5 falls in the Mid Embayment and is generally 30 to 40 feet deep. WQMU 6 is shallow (10 to 20 feet).

Figure 1 shows the WQMUs and the 11 locations where the lake was monitored during 2004-2007. Table 1 summarizes the sampling locations included in the Pierce County, Ecology, and MITFD monitoring efforts. The sampling sites used in 2004-2007 are numbered Locations 1-9, Diversion, Inlet, and Outlet. As noted in Table 1, samples were collected from near the water surface at all locations. In addition, Ecology performed water quality profiling at several locations to characterize water quality conditions at various depths in the water column.

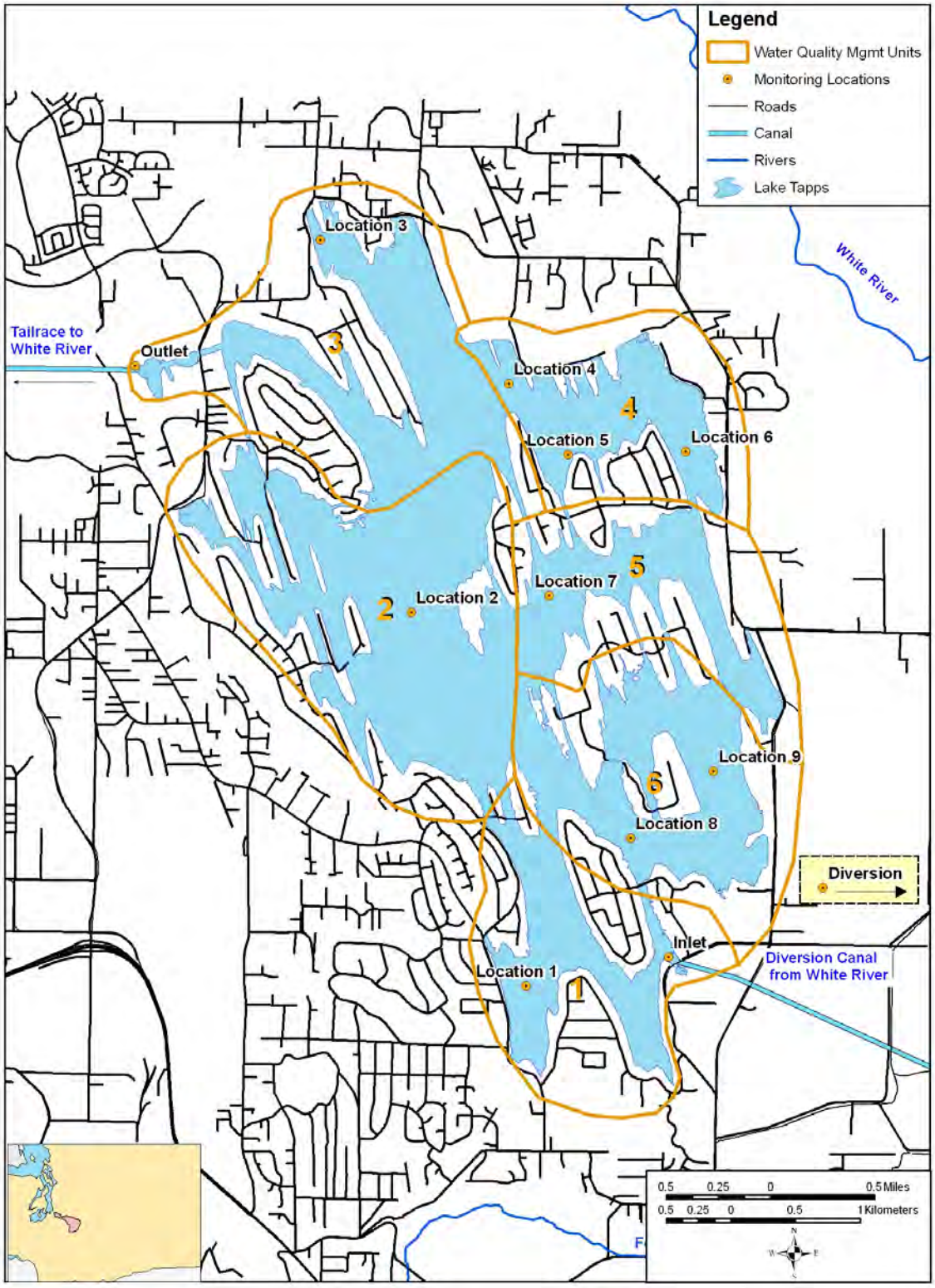


Figure 1. Monitoring Locations, 2004-2007

Table 1. Locations Sampled							
Location Names	Previous Names	WQMU	Depth Sampled	Location Description	Study		
					Ecology	PC	MITFB
Diversion	Diversion	NA*	Epilimnion	Near upstream end of diversion canal	2004-05	2004-05	2004-07
Inlet	URS 1, Ecology 7	1	Epilimnion	Inlet (218th Street Bridge)	2004-05	2004-05	2004-07
Location 1	URS 2	1	Epilimnion	Inlet		2004-05	
Location 2	URS 3, Ecology 1	2	Epilimnion	Main Basin- 90 ft deep	2004-05	2004-05	2004-07
Location 3	URS 9	3	Epilimnion	Outlet & N Arm		2004-05	
Outlet	URS 6, Ecology 9	3	Epilimnion	Outlet & N Arm (East Valley Highway Bridge)	2004-05	2004-05	2004
Location 4	URS 4	4	Epilimnion	N. embayment		2004-05	
Location 5	Ecology 4	4	Epilimnion	N. embayment- 50 feet deep	2004-05		
Location 6	URS 5	4	Epilimnion	N. embayment		2004-05	2004
Location 7	URS 8, Ecology 5	5	Epilimnion	Mid embayment- 40 feet deep	2004-05	2004-05	
Location 8	Ecology 6	6	Epilimnion	S. embayment- 20 feet deep	2004-05		
Location 9	URS 7	6	Epilimnion	S. embayment		2004-05	

**Not Applicable*

Table 2 lists the parameters included in each study. All three studies included total phosphorus and chlorophyll-a. Phosphorus was included because algal growth in freshwater lakes is often limited by phosphorus concentrations. If phosphorus concentrations in the lake become too high, the lake could experience nuisance algal blooms, reduced dissolved oxygen levels, and reduced water clarity. Such conditions could impair current recreation and aesthetic uses of the lake and could also interfere with potable water treatment in the future. Chlorophyll-a was measured because it is a good indicator of algal populations. Total phosphorus and chlorophyll-a concentrations are commonly used indicators of trophic status.

Table 2. Parameters Sampled			
Parameter	Entity		
	Ecology	PC	MITFD
Temperature	X	X	
DO	X	X	
pH	X	X	
Total Phosphorous	X	X	X
Soluble Reactive Phosphorus	X		
Ammonia Nitrogen	X	X	
Nitrate + Nitrite Nitrogen	X		
Total Nitrogen	X	X	
Fecal Coliform		X	
Chlorophyll-a	X	X	X
Secchi Depth	X	X	X
TSS	X		
Total VSS	X		
Turbidity	X		

Another widely used indicator of trophic status, Secchi depth, was included in the Ecology, Pierce County and MITFD studies. Secchi depth is a measure of the clarity or transparency of the water. In many lakes, algal blooms are the main cause of reduced clarity. However, glacial silt as well as algae could affect water clarity in Lake Tapps (Ecology 2006b).

In addition to parameters relevant to lake eutrophication, the Pierce County monitoring program included fecal coliform bacteria. Fecal contamination is a concern because Lake Tapps is heavily used for water–based recreation and there are numerous septic systems and other potential sources of fecal contamination around the lake. Fecal matter can contain a wide variety of pathogenic bacteria, viruses, and parasites. The State of Washington water quality standards use fecal coliform as the indicator organism for pathogens.

3.2 Existing Monitoring Results

3.2.1 Summary

This section summarizes the combined results for Pierce County, Ecology, and MITFD studies. Table 3 lists the minimum, median, and maximum values for each parameter for all samples collected from the surface during 2004-2007. Tables 4, 5, 6, and 7 summarize the results by year.

Table 3. Surface Parameter Value Summary

Parameter	Number of Samples	Minimum	Median	Maximum
Temperature (C)	147	5.6	17.8	24.8
DO (mg/L)	139	7.33	9.21	13.1
pH	135	6.1	7.5	8.9
Phosphorous (ug/L)	212	1.0	10.0	290.0
Ammonia (mg/L)	174	< 0.04	0.04	0.29
Total Kjeldahl Nitrogen (mg/L)	130	0.3	0.5	2.9
Fecal Coliform (col/100mL)	124	<2	2	420
Chlorophyll- a (ug/L)	173	0.5	2.7	11
Secchi Depth (m)	144	0.1	2.6	5.8
TSS (mg/L)	47	0.67	2.0	127.0

Table 4. 2004 Surface Parameter Value Summary

Parameter	Number of Samples	Minimum	Median	Maximum
Temperature (C)	63	8.9	18.4	24.8
DO (mg/L)	60	7.33	8.84	12.1
pH	56	6.1	7.165	8.39
Phosphorous (ug/L)	99	3.1	9	124
Ammonia (mg/L)	83	< 0.04	< 0.04	0.16
Total Kjeldahl Nitrogen (mg/L)	63	0.3	0.5	2.8
Fecal Coliform (col/100mL)	57	<2	3	340
Chlorophyll- a (ug/L)	80	0.5	1.9	11
Secchi Depth (m)	59	0.1	2.0	4.2
TSS (mg/L)	16	1	2	8

Table 5. 2005 Surface Parameter Value Summary				
Parameter	Number of Samples	Minimum	Median	Maximum
Temperature (C)	84	5.6	17.3	24.6
DO (mg/L)	79	7.4	9.31	13.1
pH	79	7.2	7.6	8.9
Phosphorous (ug/L)	100	1.0	11	258
Ammonia (mg/L)	91	< 0.04	< 0.04	0.29
Total Kjeldahl Nitrogen (mg/L)	67	0.3	0.6	2.9
Fecal Coliform (col/100mL)	67	<2	2	420
Chlorophyll- a (ug/L)	80	0.8	3.5	10.1
Secchi Depth (m)	73	0.6	3.3	5.8
TSS (mg/L)	13	1	2	9

Table 6. 2006 Surface Parameter Value Summary				
Parameter	Number of Samples	Minimum	Median	Maximum
Temperature (C)	0	N/A	N/A	N/A
DO (mg/L)	0	N/A	N/A	N/A
pH	0	N/A	N/A	N/A
Phosphorous (ug/L)	8	7.0	42	290
Ammonia (mg/L)	0	N/A	N/A	N/A
Total Kjeldahl Nitrogen (mg/L)	0	N/A	N/A	N/A
Fecal Coliform (col/100mL)	0	N/A	N/A	N/A
Chlorophyll- a (ug/L)	7	1.2	2.3	5.3
Secchi Depth (m)	6	2.9	3.6	4.4
TSS (mg/L)	14	0.7	1.9	127.0

Table 7. 2007 Surface Parameter Value Summary				
Parameter	Number of Samples	Minimum	Median	Maximum
Temperature (C)	0	N/A	N/A	N/A
DO (mg/L)	0	N/A	N/A	N/A
pH	0	N/A	N/A	N/A
Phosphorous (ug/L)	6	9.0	24	30
Ammonia (mg/L)	0	N/A	N/A	N/A
Total Kjeldahl Nitrogen (mg/L)	0	N/A	N/A	N/A
Fecal Coliform (col/100mL)	0	N/A	N/A	N/A
Chlorophyll- a (ug/L)	6	1.6	2.25	3.2
Secchi Depth (m)	6	1.7	2.9	3.3
TSS (mg/L)	11	0.8	2.0	16.0

Tables 8, 9, and 10 summarize the minimum, median, and maximum values for samples collected from various depths in the lake. The sampling depths are divided into three categories: surface: 0-2 meters, middle: 3-12 meters, and deep: 13-25 meters.

Table 8.Temperature Profile Summary				
Parameter		Minimum	Median	Maximum
2004 Temperature (C)	Surface	5.6	18.1	24.8
	Middle	11.7	16.3	22.4
	Deep	7.3	7.8	11.8
2005 Temperature (C)	Surface	5.6	13.8	17.0
	Middle	4.2	9.9	16.9
	Deep	4.4	7.4	8.1

Table 9.Phosphorus Profile Summary				
Parameter		Minimum	Median	Maximum
2006 Phosphorous (ug/L)	Surface	1	10	290
	Middle	6	9	30
	Deep	7	10	43
2007 Phosphorous (ug/L)	Surface	9	24	30
	Middle	7	11	45
	Deep	8	14	52

Table 10. DO Profile Summary				
Parameter		Minimum	Median	Maximum
2004 DO (mg/L)	Surface	7.6	8.8	10.6
	Middle	3.4	8.4	9.0
	Deep	0.6	4.3	6.5

DO concentrations were always above the state water quality standard (6.5 mg/L) near the water surface, but dropped below 1 mg/L near the lake bottom during the summer months. Figures 2, 3, and 4 show DO profiles for the four lake locations monitored by Ecology during 2004. Figure 2 shows that the shallow embayments (Locations 5 and 7) exhibited hypolimnetic anoxia in early July, while hypolimnetic DO concentrations at the main basin (Location 2) and the south basin (Location 8) remained relatively high. Figures 3 and 4 show that Locations 5 and 7 remained anoxic during August and September, while the hypolimnion in the main basin (Location 2) gradually became more anoxic during August and September. Ecology (2006b) suggested that the anoxia in the embayments was due to their relatively thin hypolimnion layers; the amount of oxygen available to be consumed by decomposition was small compared to the main basin (Location 2) with its far deeper hypolimnion.

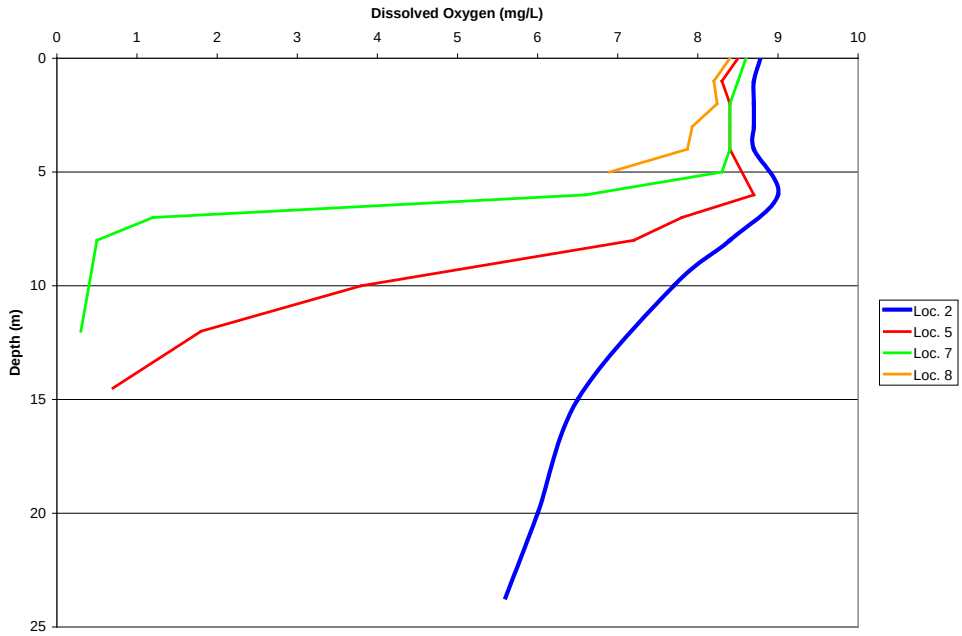


Figure 2. Dissolved Oxygen Profile on July 7, 2004 in Lake Tapps

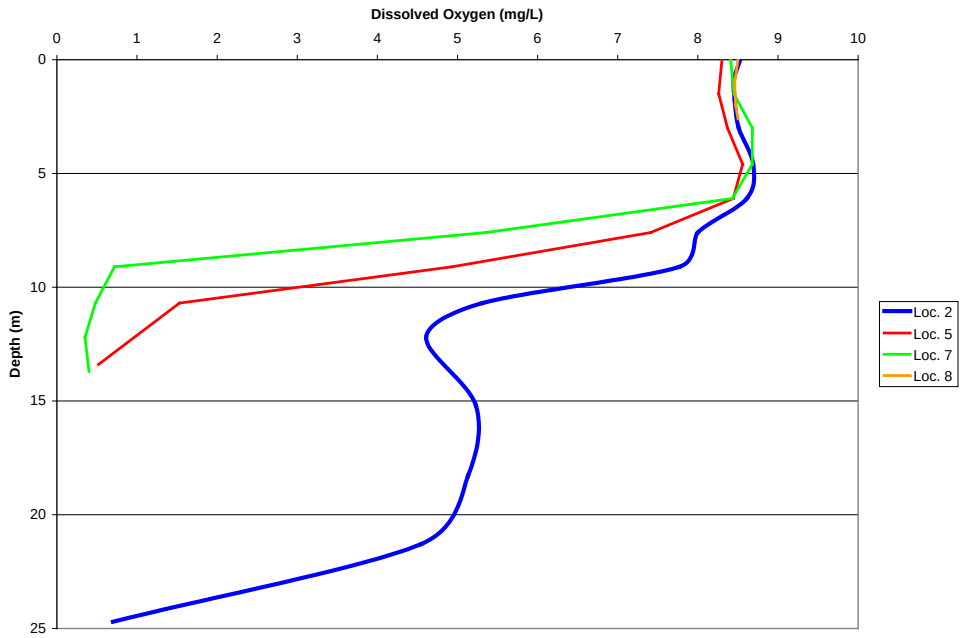


Figure 3. Dissolved Oxygen Profile on August 11, 2004 in Lake Tapps

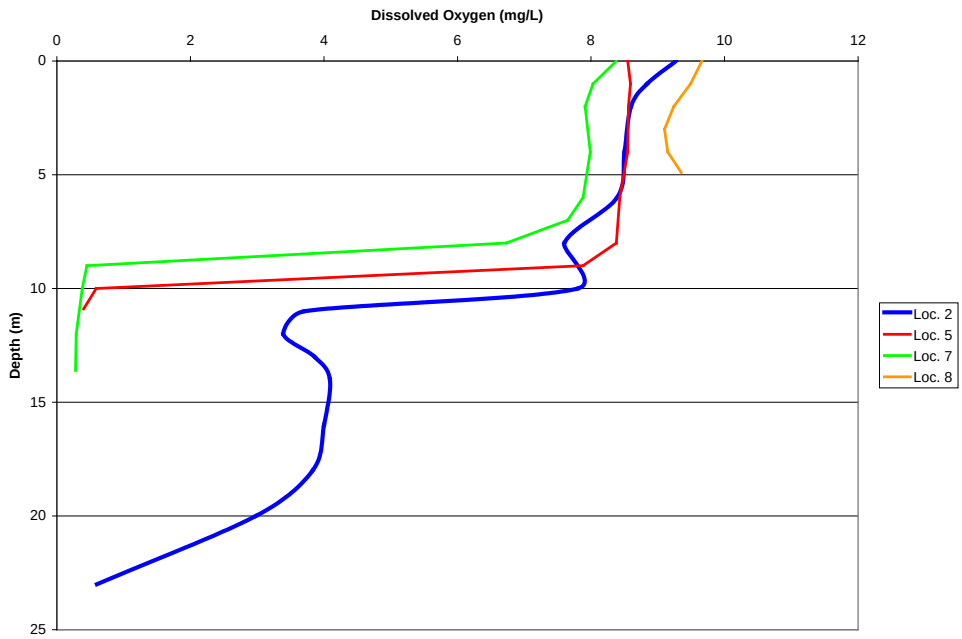


Figure 4. Dissolved Oxygen Profile on September 16,, 2004 in Lake Tapps

3.2.2 Temporal Trends

PSE ceased hydropower operations at Lake Tapps early in 2004. Since then, flows through the lake have been considerably lower than they were during hydropower operations. Changes in flow could affect lake water quality in a number of ways, as discussed in Section 2 above.

BC evaluated the 2004-2007 water quality data at each location to identify potential changes from year to year. The evaluation used Trophic State Index (TSI) values calculated based on chlorophyll-a, total phosphorus, and Secchi depth.

The "trophic state" of a lake reflects its biological productivity, as indicated by algal biomass. Oligotrophic lakes have low biological productivity. Mesotrophic, eutrophic, and hypereutrophic lakes have moderate, high, and very high algal biomass, respectively. The probability of hypolimnetic anoxia (i.e., depletion of dissolved oxygen in the deeper portion of the lake) tends to increase as algal biomass increases (Carlson and Simpson 1996). The TSIs for Lake Tapps were calculated using the equations developed by Carlson (1977):

$$TSI = 60 - 14.41 * (\ln \text{Secchi disk [meters]})$$
$$TSI = 9.81 * (\ln \text{chlorophyll-a [ug/L]}) + 30.6$$
$$TSI = 14.42 * (\ln \text{TP [ug/L]}) + 4.15$$

Table 11 lists the chlorophyll-a, total phosphorus, and Secchi values characteristic of each trophic state.

Table 11. Trophic State Index Descriptions (Carslon, 1977)				
Category	TSI	Chlorophyll-a	Total Phosphorus	Secchi
		(ug/L)	(ug/L)	(meters)
Oligotrophic	<30-40	0-2.6	0-12	>8-4
Mesotrophic	40-50	2.6-7.3	12- 24	4-2
Eutrophic	50-70	7.3-56	24-96	2-0.5
Hypereutrophic	70-100+	56-155+	96-384+	0.5-<0.25

Chlorophyll-*a* is a more direct measure of algal biomass and therefore a better predictor of trophic state than either total phosphorus concentrations or Secchi depth. Therefore, TSIs based on chlorophyll-*a* will generally provide a better indication of trophic state than TSIs based on total phosphorus concentrations and/or Secchi depth. For this reason, TSIs calculated based on chlorophyll-a should not be averaged with TSIs calculated based on TP and/or Secchi depth (Carlson and Simpson 1996). However, in lakes with naturally turbid water, chlorophyll concentrations may increase relative to algal biomass (Carlson 1991).

Figures 5, 6, and 7 below show the TSIs for Lake Tapps based on chlorophyll-*a*, total phosphorus, and Secchi depth, respectively. As shown in Figure 5, TSIs based on chlorophyll-*a* were mostly in the oligotrophic range during 2004 and in the mesotrophic range during 2005. Ecology (2006b) noted that the ratio of chlorophyll-a to algal biomass in Lake Tapps may be higher than normal due to turbidity caused by glacial flour; consequently, the TSI may indicate a higher biomass that actually exists (Ecology 2006b). This could help explain why the TSIs based on chlorophyll-*a* (Figure 5) are higher than the TSIs based on total phosphorus (Figure 6).

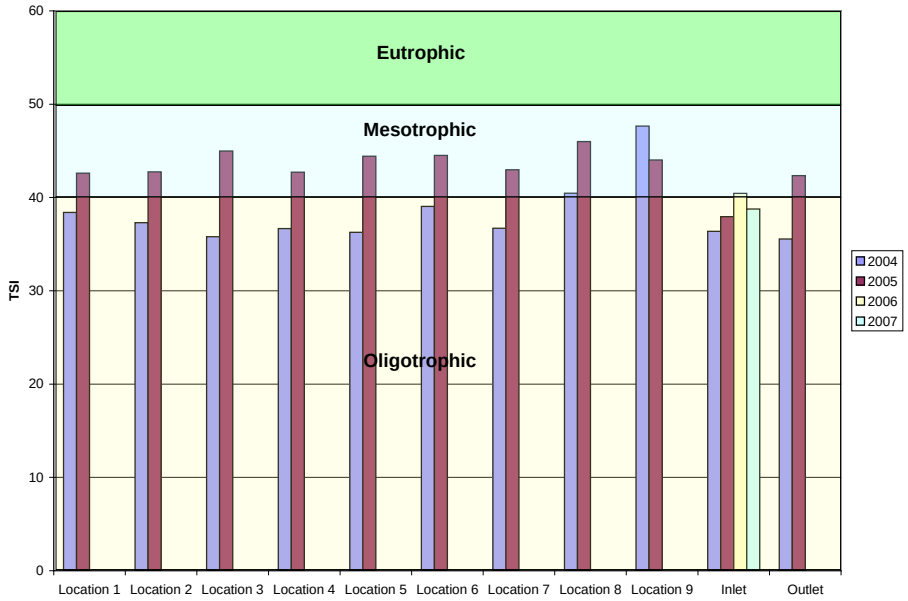


Figure 5. Trophic State Index based on Chlorophyll-a

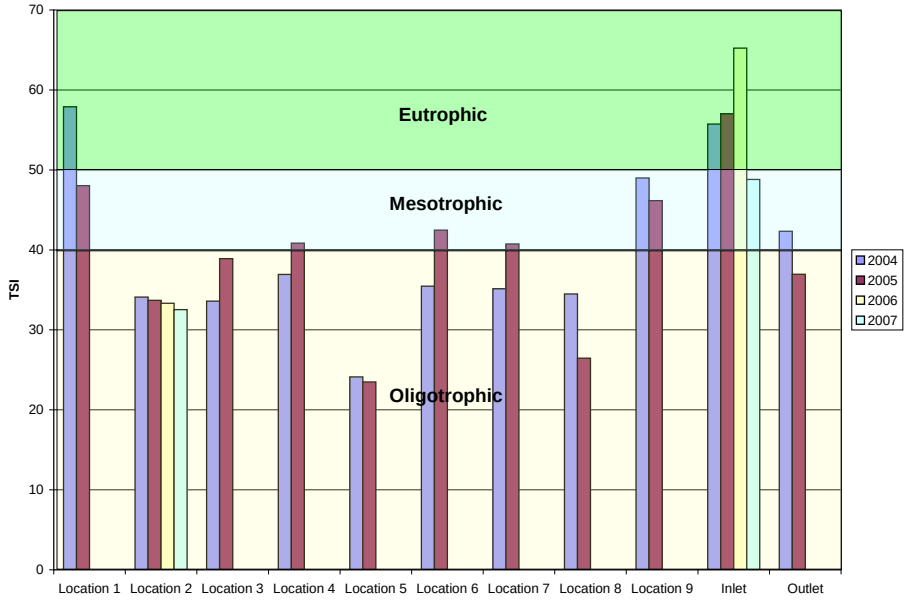


Figure 6. Trophic State Index based on Total Phosphorus

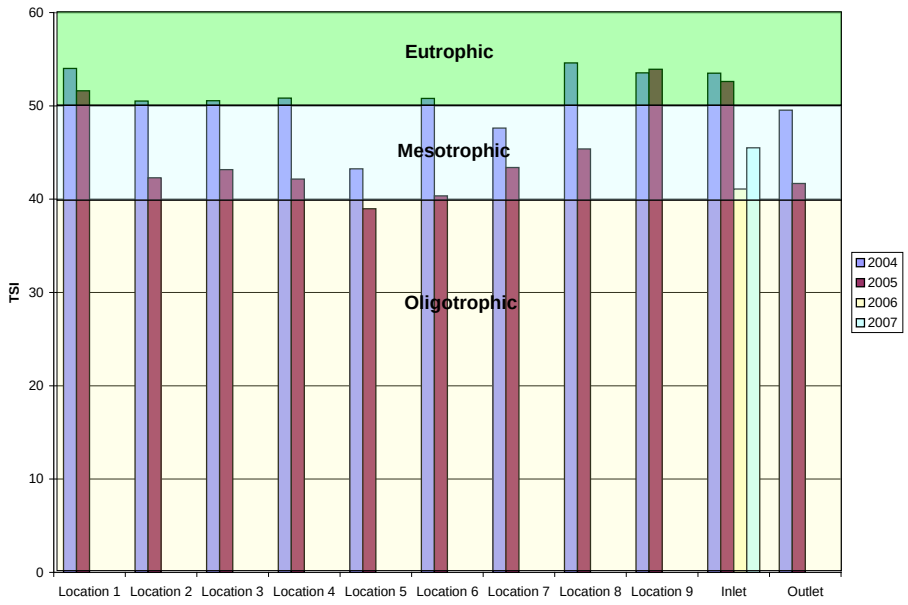


Figure 7. Trophic State Index based on Secchi Depth

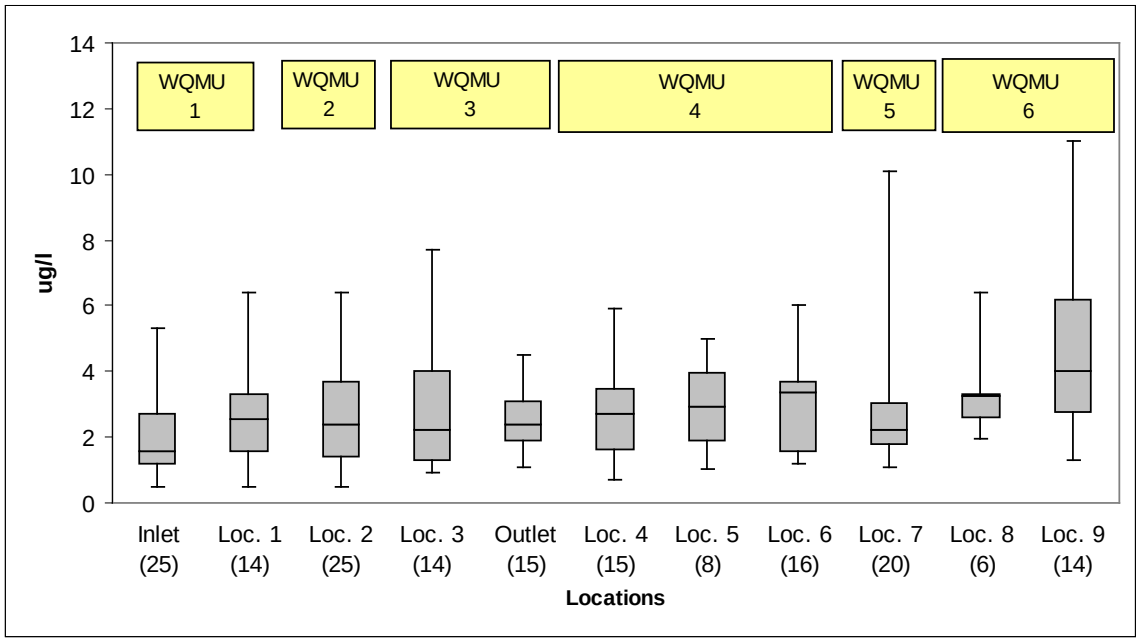
It is important to note that the TSI is based on algal biomass so it may underestimate the trophic state of macrophyte-dominated lakes (Carlson and Simpson 1996). Lake Tapps has had problems with the macrophyte Eurasian milfoil for a number of years. TSIs based on Secchi depth, shown in Figure 7, indicated

a near eutrophic condition in 2004 and a mesotrophic condition in 2005. However, in the case of Lake Tapps, turbidity caused by glacial flour introduced from the White River likely causes lower Secchi depth readings (resulting in a higher TSI score). With this in mind, the TSI based on Secchi depth may not be the best trophic state indicator for Lake Tapps, but could still be useful in tracking trends in lake water quality.

3.2.2 Spatial Trends

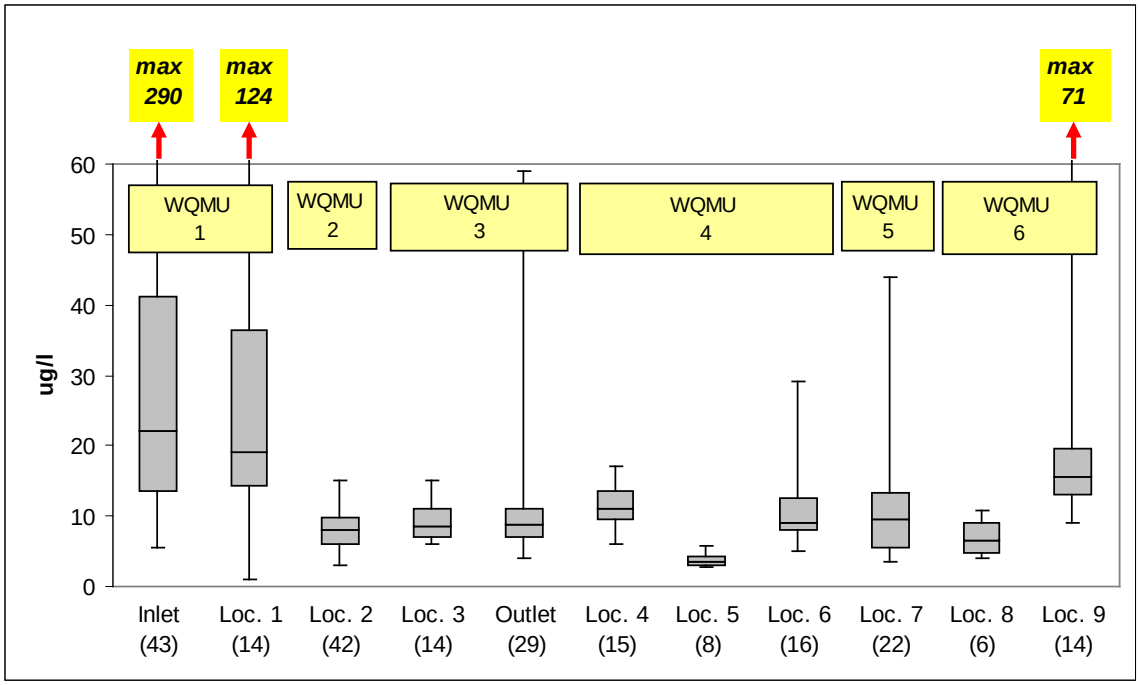
BC compared the data collected at each station during 2004-07 to help identify stations that could be dropped or monitored at a lower intensity because they are similar to other stations within the WQMU. The evaluation used box and whisker plots to show the chlorophyll-a, total phosphorus, and Secchi depth measurements at each location. Figures 8-10 show the results. In the box plots the horizontal line represents the median, the box limits correspond to the 25th and 75th percentile, and the whiskers show the maximum and the minimum values sampled.

Comparison of Figures 1 and 8 indicates that all of the monitoring locations within a WQMU had similar chlorophyll-a concentrations. Total phosphorus concentrations were more variable, as shown in Figure 9. In WQMU 6, total phosphorus concentrations appeared to be lower at Location 8 than Location 9.



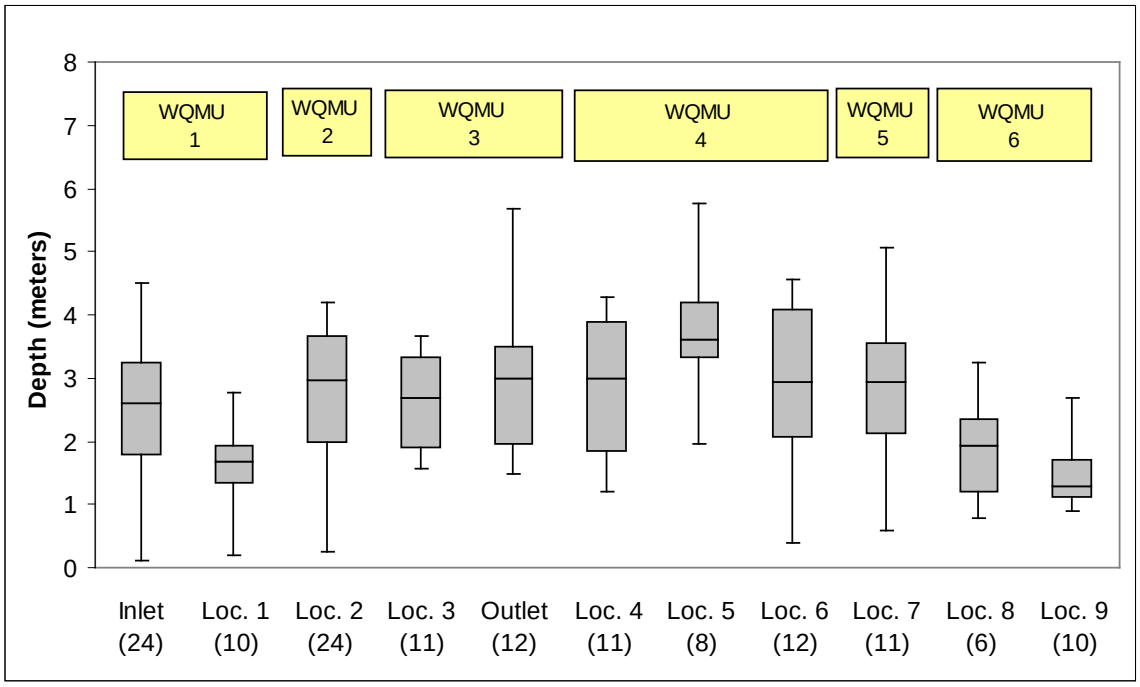
Parenthesis contain the number of data points

Figure 8. Chlorophyll-a Concentrations at Lake Tapps (2004-07)



Parenthesis contain the number of data points

Figure 9. Total Phosphorus Concentrations at Lake Tapps 2004-07



Parenthesis contain the number of data points

Figure 10. Secchi Depths at Lake Tapps WQMUs

Comparison of Figure 10 and Figure 1 suggests that Secchi depths were generally similar within each WQMU. WQMUs 1 and 6 exhibited more spatial variability than the other WQMUs.

3.2.3 Turbidity as an Indicator of Total Phosphorus

Algal growth in Lake Tapps appears to be controlled by total phosphorus concentrations (Ecology 2006b; Welch 2006). Measurement of total phosphorus requires sample collection and laboratory analysis. Ecology's 2004-05 study found that total phosphorus concentrations at the diversion canal and lake inlet were highly correlated with turbidity (Ecology 2006b). Turbidity can be measured "in situ" using water quality datasondes, which can automatically measure and record turbidity at short time intervals (e.g., 15 minutes) over extended time periods (e.g., 4-6 weeks). Datasondes can show how water quality changes during high flow events. If turbidity is strongly correlated with total phosphorus, it may be possible to use datasondes to estimate total phosphorus concentrations.

BC performed regression analyses on the existing turbidity and total phosphorus data for the diversion canal, lake inlet, and lake outlet stations. As shown in Figures 11, 12, and 13, the regression analysis found good relationships between turbidity and total phosphorus concentrations at all three locations.

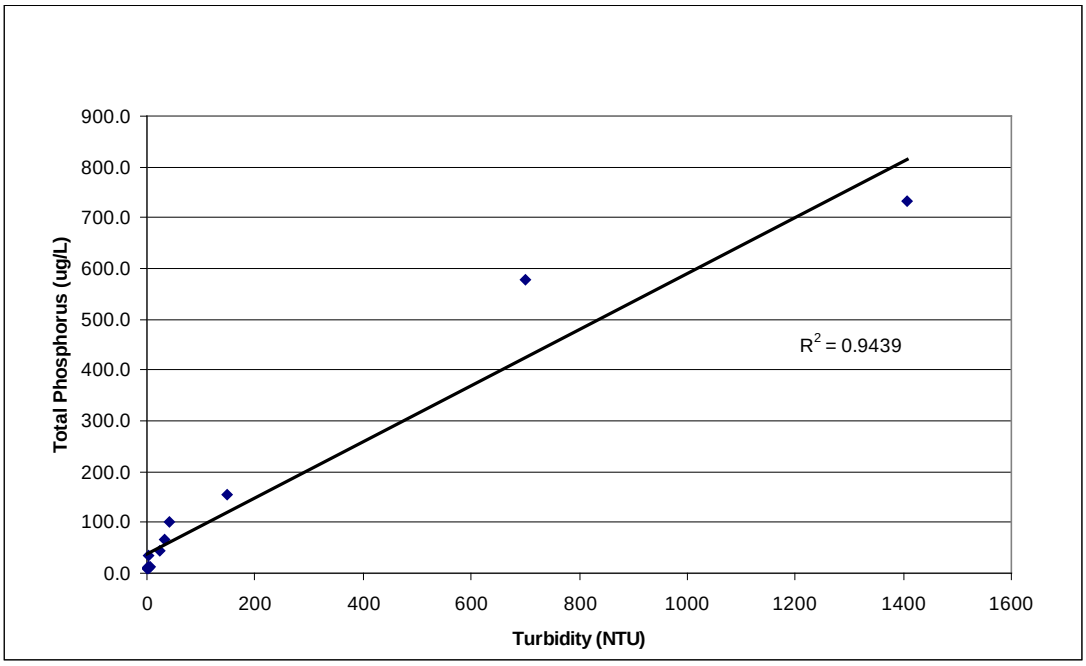


Figure 11. Relationship between Turbidity and Total Phosphorus Concentrations at Diversion Canal, 2004-05

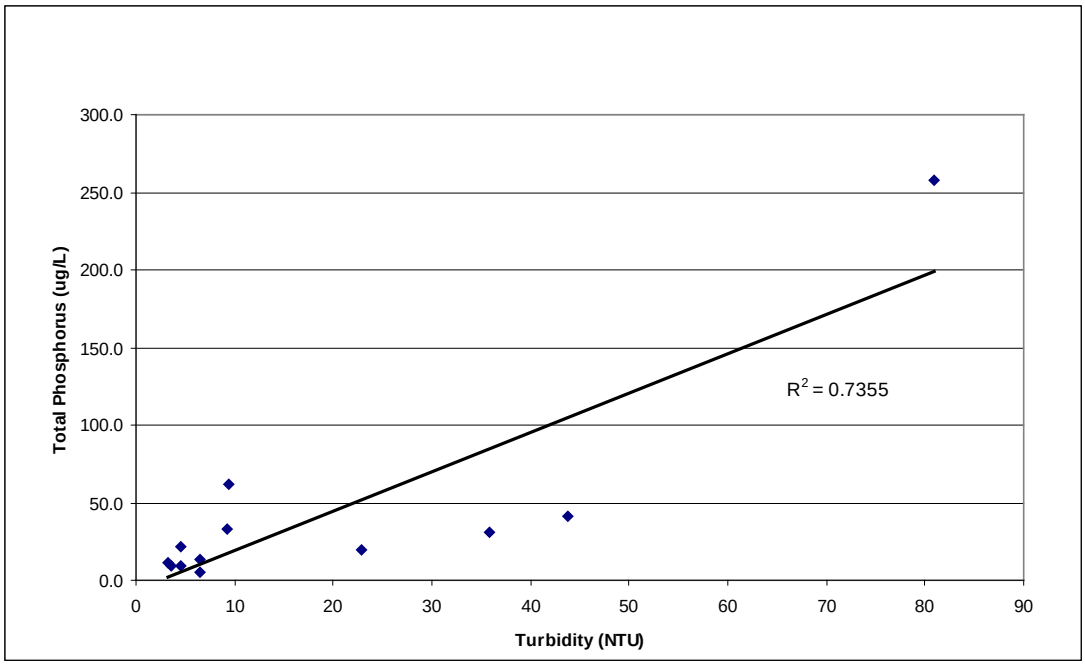


Figure 12. Relationship between Turbidity and Total Phosphorus Concentrations at Lake Inlet Monitoring Location, 2004-05

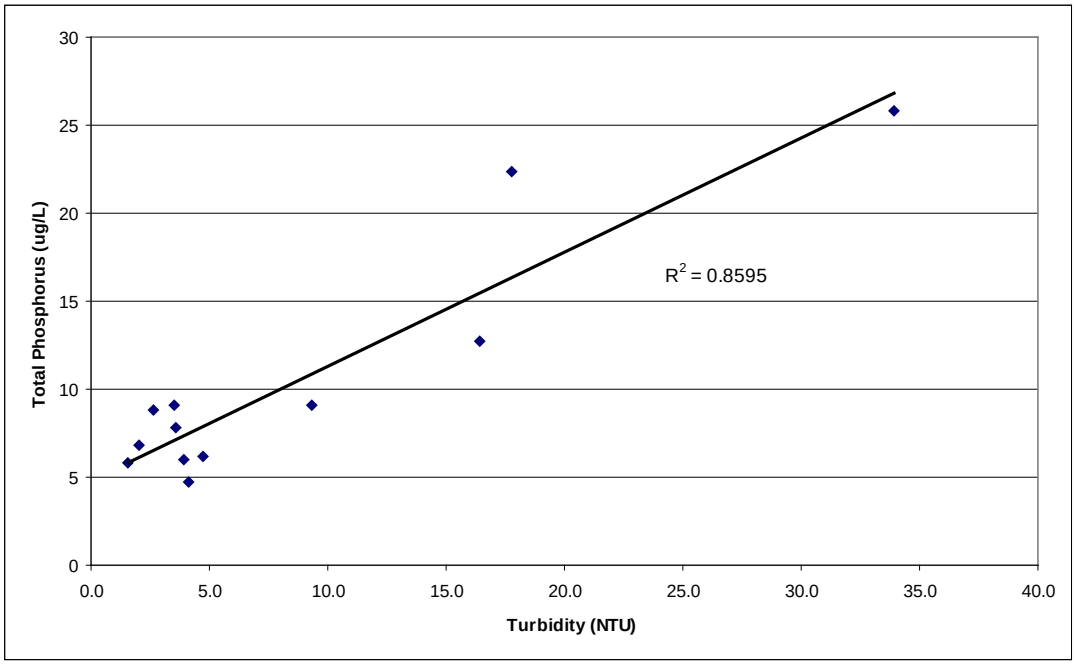


Figure 13. Relationship between Turbidity and Total Phosphorus Concentrations at Lake Outlet Monitoring Location, 2004-05

The relationship between turbidity and total phosphorus was strongest at the diversion canal location ($R^2 = 0.94$). Thus, continuous turbidity measurements may be a reliable surrogate or indicator of total phosphorus concentrations at the upstream end of the diversion canal. Continuous monitoring of turbidity could help estimate total phosphorus concentrations in the water entering the diversion canal. The concentrations could then be combined with flow data collected at the USGS gage on the diversion canal to estimate total phosphorus loads.

Although the relationships between turbidity and phosphorus at the inlet and outlet locations were not quite as strong, continuous turbidity monitoring at those locations could provide useful estimates of phosphorus concentrations. Additional monitoring for total phosphorus and turbidity could help refine the regression equations at the inlet and outlet locations.

4. RECOMMENDATIONS

4.1 Monitoring Objectives

As discussed above, water quality in Lake Tapps could change in the future due to changes in the lake operating rules, pollutant loads from the White River, pollutant loads from shoreline areas, or other factors. Early detection of adverse water quality trends could provide an opportunity for corrective measures to be implemented before the beneficial uses of the lake are compromised. Information on the likely causes of water quality degradation would help ensure that the corrective measures are focused and effective.

Lake eutrophication is the primary concern for Lake Tapps. Ecology's 2004-05 study found generally oligotrophic conditions in the main basin, but hypolimnetic anoxia and other evidence of mesotrophic conditions in the embayments. Eutrophication could impair the recreation, aesthetic, supply uses of the lake. Therefore, the long-term monitoring program should be designed to answer the following question:

- Is the lake's trophic state changing over time?

Fecal contamination is a secondary concern for Lake Tapps. Although recent monitoring by Pierce County Water Programs found low levels of fecal coliform bacteria in the lake, the shoreline area encompasses more than 2,000 septic systems as well as numerous stormwater outfalls. Stormwater runoff and septic system effluent can contain elevated concentrations of fecal bacteria. Fecal contamination could impair swimming and other recreational uses of the lake. Source control is generally the best way to control fecal contamination. Thus, the long-term monitoring program should be designed to answer the following questions:

- Is fecal contamination impairing beneficial uses of the lake? If so, what are the sources?

Lake Tapps has not had any documented toxicity problems to date. Toxicity could become an issue in the future, considering the numerous stormwater outfalls and septic systems around the lake. Stormwater runoff can contain pesticides, metals, and other potential toxicants. Inadequately treated septic system effluent can contain a variety of potentially toxic organic compounds. If toxic substances arise in the future, the long-term monitoring program could be expanded to answer the following questions:

- Is the lake water toxic to aquatic life? If so, which substances appear to be causing the toxicity?

Sections 4.2, 4.3, and 4.4 discuss the recommended approach for monitoring to evaluate the lake's trophic state; monitoring to identify potential fecal contamination problems; and monitoring to identify potential toxicity problems.

4.2 Monitoring to Assess Trophic State Trends

Potential changes in the trophic state of Lake Tapps should be addressed by monitoring key indicator parameters at the same locations over time. To maximize the benefit of the existing data, previously monitored locations should be used where possible. However, to help differentiate past monitoring locations from proposed future monitoring locations, the proposed sites will be labeled "LT-1" through "LT-9", "LT- Inlet", "LT-Div", and "LT-Out" instead of by "Location". The monitoring results should be used to calculate trophic state index values and hypolimnetic oxygen deficit rates. Statistical analyses should be conducted to help identify changes over time. Ideally, the statistical analyses should include five or more years of data so that longer-term trends can be distinguished from year-to-year variations.

The monitoring program should also collect information that may help explain observed trends (if any) in trophic state. To that end, the monitoring program should include collecting information on lake inflow, outflow, and water surface elevation, and nutrient loads from the White River. The flow and stage data should be obtained from the lake owner and USGS. Nutrient loads should be estimated by installing datasondes to monitor turbidity and depth at the upstream end of the diversion canal (LT-Div) and the lake inlet (LT-Inlet), combined with periodic sampling and analysis for nutrients, total suspended solids (TSS), settleable solids, and total organic carbon (TOC). Regression analyses should then be performed to re-confirm the validity of turbidity as an indicator of total phosphorus. Phosphorus loads entering the diversion canal and the lake could then be estimated using diversion flow data (obtained from the USGS gage on the diversion canal). Comparison of the phosphorus concentrations at the upstream end of the diversion canal and the lake inlet could be used to estimate phosphorus removal in the settling ponds along the canal.

Ecology (2006b) suggested that phosphorus from the White River may be accumulating in the lake sediments. To help address this hypothesis, the lake outlet should be monitored in the same fashion as the lake inlet. If the data continue to show good correlation between total phosphorus and turbidity, the inlet and outlet data could be compared to estimate phosphorus build-up in the lake.

Nutrient loads from shoreline areas could also contribute to changes in trophic state. If changes in trophic state are observed in specific portions of the lake, the results of the pollutant source monitoring program described in TIM #9 should be reviewed to identify potential local sources. Moreover, the source identification monitoring could be adjusted to focus on the shoreline areas near the observed problems.

The trophic status indicators described above are focused on algal biomass, not macrophytes like Eurasian milfoil, which has been present in Lake Tapps for a number of years. The current operating rules for the lake include an annual drawdown in the winter to help retard the growth of milfoil. Future flows through the lake are likely to be lower than historic rates. Lower flows would entail lower sediment loads and more time for settling, which would increase water clarity. Increased light penetration could allow macrophytes to colonize deeper areas of the lake. Annual mapping of the areas covered by milfoil could help discern potential trends and provide useful information on the effectiveness of the annual drawdown as a milfoil control measure.

The following sections describe the recommended locations, parameters, and methods for trophic state monitoring.

4.2.1 Trophic State Monitoring Locations

Lake Tapps encompasses a number of distinct basins where water quality could vary due to differences in depth, circulation, shoreline land uses, or other factors. Therefore, the lake should be monitored at locations that represent water quality in each of the basins that comprise the lake. Pierce County divided the lake into six WQMUs as shown in Figure 1. Four of the WQMUs contain more than one monitoring location. BC evaluated the 2004-2007 chlorophyll-a, total phosphorus, and Secchi depth data for the locations within each WQMU. Chlorophyll-*a* concentrations appeared to be similar within each WQMU, but total phosphorus and

Secchi depths appeared to vary among the locations monitored within WQMU #4 and WQMU #6. This suggests that it may be prudent to monitor multiple locations within WQMUs 4 and 6. Moreover, Ecology (2006b) observed that hypolimnetic DO concentrations in the embayments (WQMU 4, 5, and 6) were lower than the main basin.

Given the complexity of the lake and the observed spatial variability in water quality, the trend monitoring should initially include all of the previously monitored locations. At the end of each year, the water quality data should be reviewed to identify potential spatial trends, especially locations that appear to have similar water quality. If two locations appear to exhibit similar water quality, statistical analyses (e.g., cluster analysis, regression) should be conducted to determine whether one of the locations can be dropped.

Table 12 lists the recommended monitoring locations and type of monitoring. All of the previously monitored locations would be included although some locations would be monitored less intensively (e.g., WQMUs with multiple locations). The recommended program includes continuous monitoring of turbidity and stage at the diversion canal, lake inlet, and lake outlet locations. Figure 14 shows the types of monitoring recommended for each location.

Table 12. Recommended Monitoring Locations

Location ID	Previous IDs	WQMU	Location Description	Surface Grab	Depth Comp: Epilim.	Depth Comp: Hypolim.	Profile (Sonde)	Contin. (Sonde)
LT-Div	Diversion	NA	Diversion canal at end of River Road	X				X
LT-Inlet	URS 1, Ecology 7	1	Inlet (218th Street Bridge)	X				X
LT-1	URS 2	1	Basin SW of inlet		X	X	X	
LT-2	URS 3, Ecology 1	2	Main western basin		X	X	X	
LT-3	URS 9	3	North Arm		X	X	X	
LT-Out	URS 6, Ecology 9	3	Outlet to tailrace		X	X	X	X
LT-4	URS 4	4	North embayment, NW portion		X	X	X	
LT-5	Ecology 4	4	North embayment, SW portion		X	X	X	
LT-6	URS 5	4	North embayment, SE portion		X	X	X	
LT-7	URS 8, Ecology 5	5	Mid embayment		X	X	X	
LT-8	Ecology 6	6	South embayment, north-east		X	X	X	
LT- 9	URS 7	6	South embayment, south-west		X	X	X	

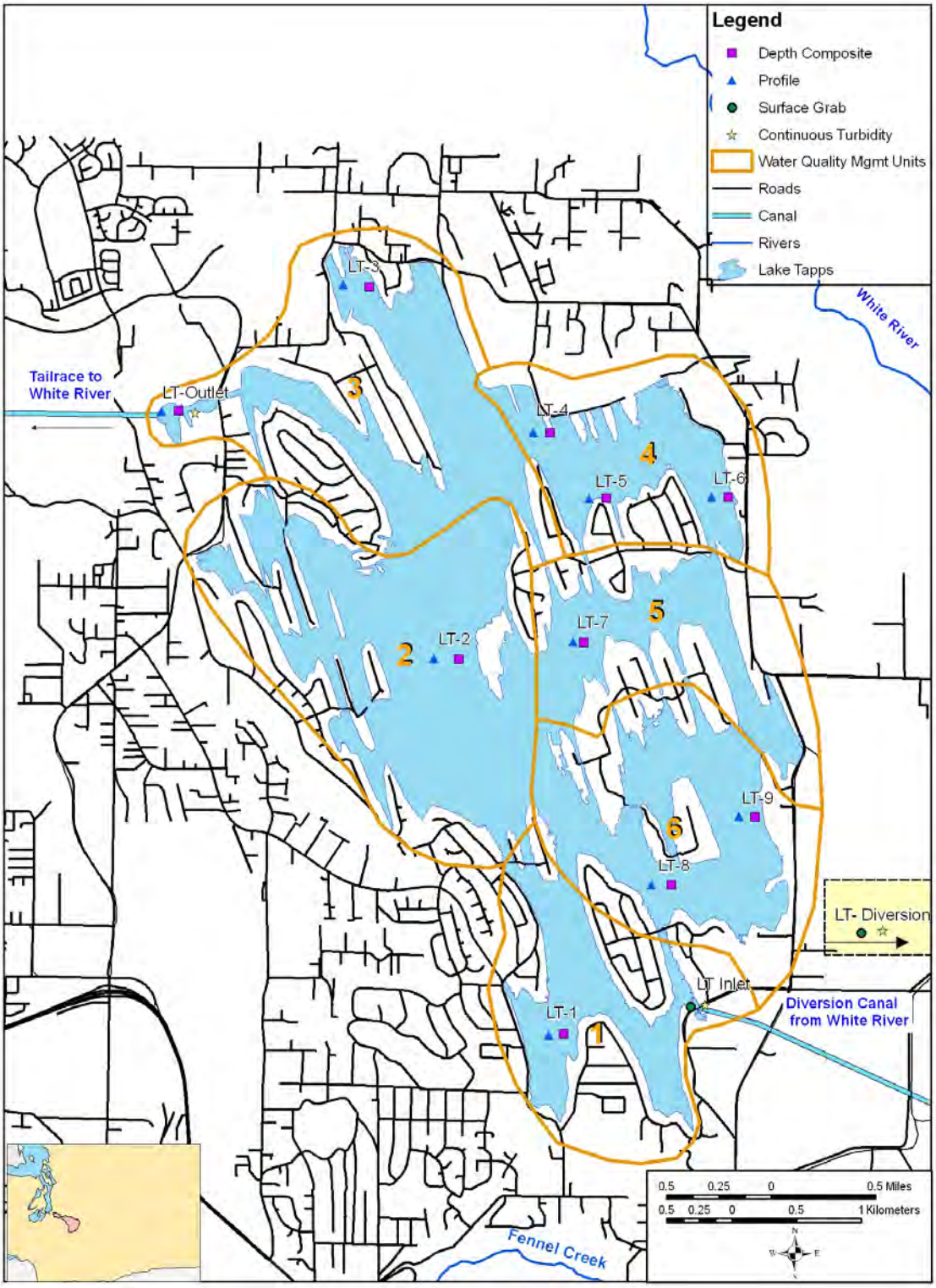


Figure 14. Recommended Trophic State Monitoring Locations

4.2.2 Trophic State Monitoring Parameters

The trophic state monitoring would involve a combination of field and laboratory parameters. Table 13 lists the recommended laboratory parameters. Samples collected from the locations shown on Figure 14 should be analyzed for the water quality parameters listed in Table 13 below.

Table 13. Laboratory Parameters for Trophic State Monitoring

Parameter	Lake Stations - Epilimnion	Lake Stations - Hypolimnion	Inlet Grab	Diversion Canal Grab
Chlorophyll-*a*	X			
Total phosphorus	X	X	X	X
Soluble reactive phosphorus	X	X	X	X
Total Kjeldahl nitrogen	X	X	X	X
Ammonia-N	X	X	X	X
Nitrate + nitrite-N	X	X	X	X
Settleable solids			X	X
Total suspended solids	X	X	X	X
Turbidity	X	X	X	X
Total organic carbon			X	X

Table 14 lists the recommended field parameters, which would be measured by monitoring personnel at each monitoring location immediately before collecting samples for laboratory analyses. Secchi depths should be measured at each monitoring location. Water quality profiles should be measured at each location using a hand-held datasonde equipped with sensors for DO, conductivity, pH, temperature, and turbidity. If possible, the datasonde should also include a sensor to measure chlorophyll-a. All of the parameters except chlorophyll-a should be measured at 1 meter intervals from the water surface in the epilimnion and metalimnion, and at intervals of 2-5 meters in the hypolimnion. Chlorophyll-a should be measured in the epilimnion only.

Table 14. Field Parameters for Trophic State Monitoring

Parameter	Lake Stations - Epilimnion	Lake Stations - Hypolimnion	Inlet	Diversion Canal
Secchi depth	X			
DO	X	X	X	X
Temperature	X	X	X	X
Conductivity	X	X	X	X
Turbidity	X	X	X	X
Chlorophyll-a	X			

In addition to the field and laboratory parameters listed above, the recommended program includes installation of datasondes at the diversion canal, lake inlet, and lake outlet stations to allow near-continuous measurements of turbidity, temperature, and stage. The primary objective is to use the turbidity data to estimate total phosphorus concentrations and loads entering and leaving the lake.

Water quality at the lake outlet location may be indicative of the quality of discharges from the lake to the White River. Therefore, the datasonde installed at the lake outlet should be equipped with pH, DO, and conductivity sensors, in addition to turbidity, temperature, and stage.

Inflow and outflow rates and lake elevation data should be obtained from existing gages operated by the lake owner and USGS.

4.2.3 Trophic State Monitoring Methods

The recommended program for characterizing the trophic state includes near-surface grab sampling; Secchi disc measurements; depth-integrated composite sampling; in-situ water quality profiling; and continuous monitoring using datasondes. The methods associated with each program element are summarized below. For additional details regarding monitoring procedures, please refer to *Survey of the Nation's Lakes Field Operations Manual for Ponds, Lakes, Reservoirs* (EPA 2007) and *The Lake Monitoring Field Manual* (USGS, undated).

- Secchi depths should be measured at each lake location following standard protocols (e.g., EPA 2007).
- Field parameters will be measured at all sampling locations using a hand-held multi-parameter datasonde with depth increments marked on the cable. At a minimum, the datasonde should include sensors for temperature, DO, conductivity, and pH. Chlorophyll-*a* and turbidity sensors should also be included if possible.
- At the diversion and inlet locations, the field parameters should be measured about 1 meter below the water surface. At the lake locations, the datasonde should be used to measure each parameter at frequent depth intervals between the water surface and the lake bottom. Measurements should be taken starting at 0.5 meter below the water surface and at 1-meter intervals through the metalimnion. In the hypolimnion, the interval between readings may be increased from 2 to 5 meters depending on the observed variability. The depth intervals for the epilimnion and hypolimnion should be noted at each location.
- One composite sample should be collected from the epilimnion and one from the hypolimnion at each lake location. The field data described above should first be reviewed to identify the approximate depth intervals for the epilimnion and hypolimnion at the time of sampling. The composite samples should be prepared by collecting discrete samples from two to three equidistant depths in the epilimnion and two to three equidistant depths in the hypolimnion, and combining the samples to form one epilimnion composite and one hypolimnion composite for laboratory analysis.
- The laboratory results should be reviewed soon after they are received to identify and assign qualifier codes to sample results that do not meet the fully meet the data quality objectives (e.g., accuracy, precision, blank contamination) for the project.
- Datasondes should be installed near the upstream end of the diversion canal and at the lake inlet and outlet stations. As noted above, the datasondes installed in the diversion canal and lake inlet should be equipped with turbidity, temperature, and depth (stage) sensors. The datasonde installed at the lake outlet should be equipped with turbidity, temperature, conductivity, stage, pH, and DO sensors. The datasonde records should be graphed and reviewed immediately after downloading to identify potential anomalies.

- Periodic mapping of macrophytes could help identify trends (e.g., change in extent of lake area covered by milfoil) and evaluate the effectiveness of the annual drawdown as a control measure. Given the extensive shoreline of Lake Tapps, periodic field surveys may be impractical. It may be possible to use aerial photographs as the basis for mapping if the photographs are taken during the annual drawdown and/or when the lake water is relatively clear. The source identification and tracking program outlined in TIM #9 recommends aerial photography of the lake shore area to help identify failing septic systems. If the County decides that macrophyte mapping is warranted, the mapping should use the aerial photography developed for the source identification and tracking program if possible.

4.2.4 Trophic State Monitoring Frequency

Grab and composite samples and profile measurements should be collected twice a month during the late spring and summer (i.e., spring refill until drawdown begins in the fall) and once a month during the rest of the year. Some locations may not be accessible during the winter drawdown period.

The datasondes installed at the upstream end of the diversion canal, the lake inlet, and the lake outlet should be programmed to take measurements at hourly intervals. The datasondes should be downloaded and recalibrated in accordance with the manufacturer's recommendations.

4.2.5 Trophic State Data Evaluation

The data collected for trophic state evaluation should be evaluated annually. TSI values should be calculated based on the chlorophyll-a, total phosphorus, and Secchi depth. Charts showing TSI values for each year may be especially useful for public education and outreach efforts.

At the end of each year, the water quality data should be charted to help identify potential spatial trends, especially locations that appear to have similar water quality. If two locations within a WQMU appear to exhibit similar water quality, statistical analyses (e.g., cluster analysis, regression) should be conducted to determine whether water quality at both locations is sufficiently similar that one of the locations can be dropped from further monitoring.

To help identify potential trends over time, charts should be prepared to display the trophic status indicator data (chlorophyll-a, total phosphorus, Secchi depth, turbidity, DO) for each monitoring location for the period of record. Charts should be prepared to show the parameter values for each sampling event during each year as well as average or median annual values. If the charts indicate potential trends over time, appropriate statistical analyses (e.g., Mann Kendall test) should be conducted to determine whether the differences between years are statistically significant. If significant trends are found, additional statistical analyses, such as Sen's slope may be used to estimate the magnitude of change in the parameter.

Regression analyses should be conducted using the diversion canal, lake inlet, and lake outlet datasonde turbidity data and lab sample results for total phosphorus, TSS, and TOC. If the regression analyses confirm that turbidity continues to be strongly correlated with total phosphorus, the continuous turbidity data should be combined with flow gage data (obtained from the lake owner and USGS) to estimate phosphorus loads. If the regression analyses show that turbidity is also a good indicator of TSS and/or TOC, then loads should be estimated for these parameters as well. The loads estimates could aid in the interpretation of the trophic state data.

4.3 Monitoring for Fecal Contamination

Pathogen contamination is a potential concern because Lake Tapps is heavily used for recreation and there are numerous potential sources of fecal contamination (e.g., septic systems, pet waste) around the lake and

the diversion canal. In addition, the White River may convey fecal contaminants from sources, such as dairy cows or other livestock, in the upper basin.

4.3.1 Fecal Contamination Monitoring Locations

Initially, fecal contamination should be addressed by collecting grab samples at the locations shown in Figure 15. The samples would be analyzed for fecal indicator bacteria. In addition, Microbial Source Tracking (MST) analyses would be conducted to identify the sources of the fecal bacteria. If the annual review of the sample results indicates fecal contamination at a monitoring location, or if the Source Identification and Tracking investigations (described in TIM#9) identify potential problems in a specific shoreline area, Water Programs should consider expanding the monitoring program to include collection of composite samples along the shorelines near the affected locations. Composite sampling would help compensate for spatial variability in the lake. Each composite would consist of grab samples collected from multiple locations (e.g., 10) along the shoreline. If the composite samples indicate elevated bacteria concentrations, additional discrete sampling would be conducted to help identify the source areas. The MST results would also be used to help identify the sources.

4.3.2 Fecal Contamination Parameters

The samples should be analyzed for fecal coliform and E. coli using standard methods. The samples should also be submitted for microbial source tracking (MST) analysis to identify the specific sources of the fecal contamination.

A wide variety of MST methods are available. At this point in time, the Pulsed-Field Gel Electrophoresis (PFGE) DNA "fingerprinting" method appears to be the best choice. The PFGE method separates the DNA from the fecal bacteria and creates DNA "fingerprints," which are then compared to a library of DNA fingerprints from known sources. The PFGE method has been widely used in epidemiological studies throughout the U.S. The Institute for Environmental Health in Seattle has a library containing more than 120,000 sources.

The Bacteroides method may also be appropriate. Up to a third of fecal bacteria are in the Bacteroides group. Because these bacteria are restricted to gut habitats, their presence in water always indicates fecal pollution. Researchers have identified Bacteroides genetic markers that can distinguish between human and other sources of fecal pollution in water (Fields et al. 2002). Since this method is based on genetic markers in the bacteria itself, it does not require a library. However, genetic markers have not yet been identified for some species. Both the PFGE and Bacteroides analyses can be performed by local laboratories.

4.3.3 Fecal Contamination Monitoring Methods

Grab samples should be collected from just below the water surface at each monitoring location. If Water Programs decides that composite sampling is warranted, each subsample should be collected in a sterile 100-mL poly bottle and poured into a sterile 1-L bottle for laboratory analysis. To minimize the potential for cross-contamination, a separate 100-mL poly bottle should be used at each site.

4.3.4 Fecal Contamination Data Evaluation

At the end of each year, the geometric mean and 90th percentile bacteria concentrations for each location should be calculated to allow comparison to state and federal criteria. Box plots should be prepared to show the results for each location by year. If the box plots show potential trends over time, an appropriate non-parametric statistical test, such as the Wilcoxon Ranked Sum test, should be used to determine whether the bacteria concentrations observed in the current year are significantly different from those observed in a previous year.

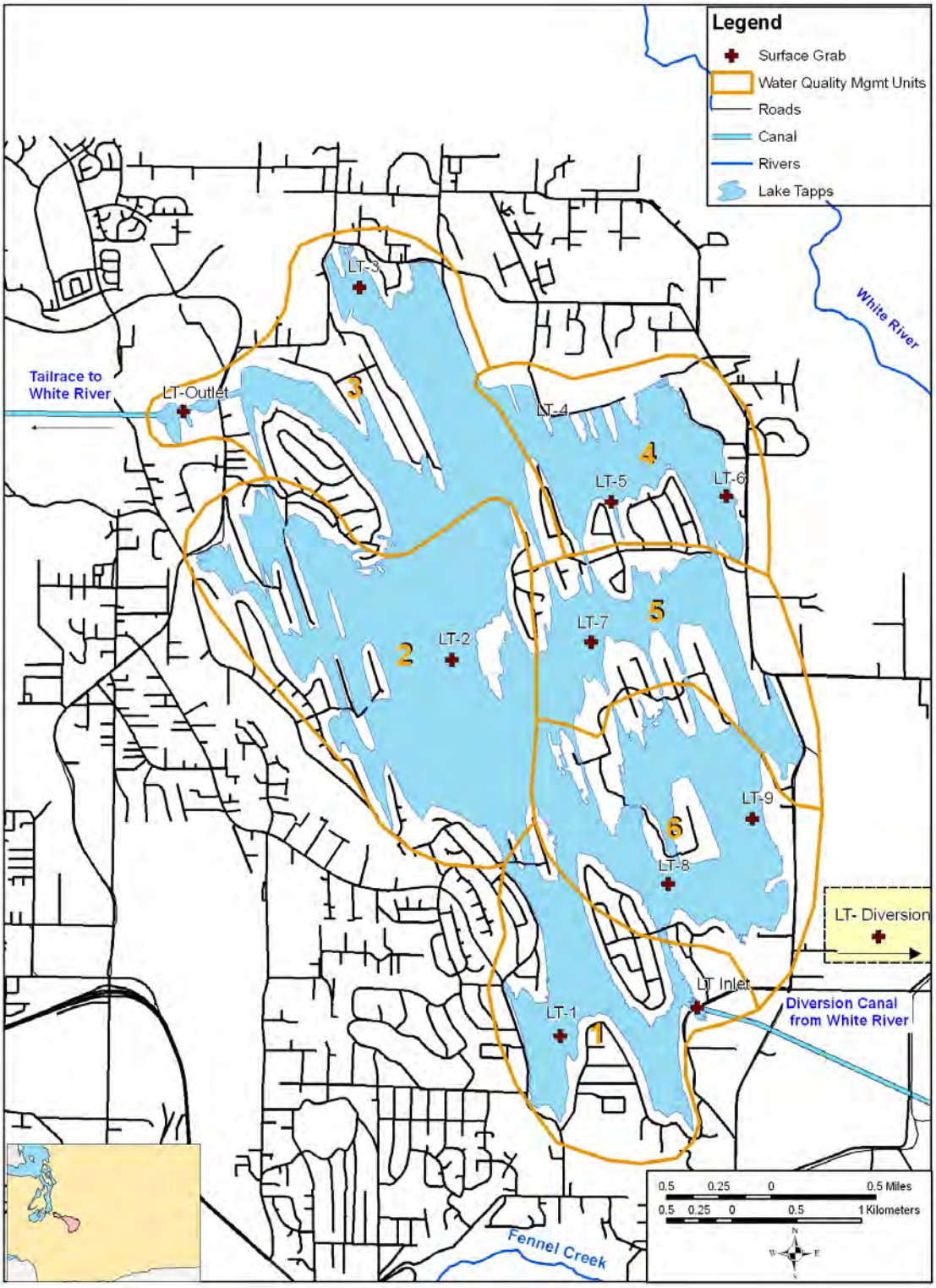


Figure 15. Fecal Contamination Monitoring Locations

The MST results should be evaluated to determine the percentages of samples from the identified sources at each location, and identify the sources for samples that exceeded state or federal criteria. The MST data should be evaluated together with information obtained from the Source Identification and Tracking program to help identify the most likely sources for the observed contamination. In addition, the MST data may be used to refine the Source Identification and Tracking program so that it focuses on the most likely sources (e.g., human, dog, etc.) for the fecal contamination observed at that location.

4.4 Monitoring for Potential Toxicity

Lake Tapps' shoreline area encompasses numerous septic systems, stormwater outfalls, and landscaped areas that have the potential to contribute toxic substances, such as pesticides, endocrine disrupters, or metals, to the lake. Toxic pollutants could impair the current recreational uses and future potable water use of the lake.

Lake Tapps does not have any known or suspected problems associated with pesticides, metals, or other toxic pollutants from human sources. Therefore, testing for toxic pollutants does not appear to be warranted at this time.

If future conditions (e.g., fish kills) raise concerns about toxic compounds in the lake, the Early Life Stages (ELS) in-situ bioassay could be used to screen for aquatic toxicity problems in the lake. The ELS tests characterize salmonid (e.g., rainbow trout) embryo development over periods of up to about 60 to 90 days (depending on temperature) and have been used successfully in British Columbia Canada (Bailey et al. 2005). Because this test employs salmonids, the method provides a direct measure of existing support and potential impacts on beneficial uses.

The following sections provide general recommendations for design of ELS monitoring program, should toxicity concerns arise in the future. The Pierce County County-Wide Monitoring Plan (Pierce County Water Programs 2007) contains a detailed description of the ELS method. Water Programs is currently conducting a pilot test of the ELS at several stream locations.

4.4.1 Toxicity Monitoring Locations

The ELS involves deploying hatch boxes containing rainbow trout embryos for extended periods. In Lake Tapps, the hatch boxes would need to be deployed in locations where they are in the epilimnion throughout the test period, can be easily retrieved, and are unlikely to be damaged by water craft or vandalism. Thus, the hatch boxes may need to be secured. If possible, the hatch boxes should be deployed near the trophic state monitoring locations so that the water quality data obtained from the latter can be used to characterize water quality conditions for the hatch boxes.

4.4.2 Toxicity Monitoring Methods

Appendix B of the Pierce County County-Wide Water Quality Monitoring Plan describes the proposed standard operating procedures for the ELS in streams. The methods in Appendix B will likely be refined based on the ELS pilot testing that Water Programs plans to conduct in 2008. The methods would need to be adjusted slightly for use in a lake setting. The hatch boxes would need to be deployed in the late spring or early summer when the lake is near its full pool elevation.

4.4.3 Toxicity Data Evaluation

If toxicity is observed, the data collected for the trophic state monitoring program (e.g., DO, pH, conductivity, temperature, turbidity, lake elevation, inflow/ outflow) should be reviewed to identify potential causes or factors. Appropriate statistical analyses should be performed to evaluate potential trends over time (e.g., frequency of abnormalities or mortality).

5. PLANNING LEVEL COST ESTIMATES

5.1 Trophic State Monitoring

Table 15 lists the 10-year planning-level cost estimate (2008 dollars) for the trophic state monitoring program described in Section 4.2 above. The estimate assumes that all of the work except for laboratory analysis would be performed by County staff. The planning-level estimate includes:

- Preparation of a Quality Assurance Project Plan (QAPP) in Year 1.
- Annual revisions to the QAPP based on the previous year's results.
- Purchase (in Year 1) of a multi-parameter datasonde for water quality profiling.
- Monitoring the diversion canal, lake inlet, and 10 lake stations during Years 1 and 2.
- Monitoring the diversion canal, lake inlet, and 6 lake stations during Years 3-10.
- Monitoring twice per month from June through September, and once per month from October through May for a total of 16 monitoring events per year.
- Laboratory analysis for nutrients, chlorophyll-a, suspended solids, settleable solids, turbidity, and organic carbon.
- Purchase and installation (in Year 1) of 3 datasondes for continuous water quality monitoring in the diversion canal, lake inlet, and lake outlet.
- Datasonde downloading, calibration, and maintenance (monthly) at same time as trophic monitoring events.
- Data quality review after each monitoring round.
- Statistical analyses to detect trends over time.
- Annual reports.
- Project management.

Table 15. Planning-level Cost Estimate for Trophic State Monitoring				
Year	# Sites	County Labor	Other Costs (Lab, Equip, etc.)	Total
1	12	$ 108,000	$ 108,000	$ 216,000
2	12	$ 95,000	$ 80,000	$ 175,000
3	8	$ 81,000	$ 58,000	$ 139,000
4	8	$ 81,000	$ 58,000	$ 139,000
5	8	$ 81,000	$ 58,000	$ 139,000
6	8	$ 81,000	$ 58,000	$ 139,000
7	8	$ 81,000	$ 58,000	$ 139,000
8	8	$ 81,000	$ 58,000	$ 139,000
9	8	$ 81,000	$ 58,000	$ 139,000
10	8	$ 81,000	$ 58,000	$ 139,000
	Total	$ 851,000	$ 652,000	$ 1,503,000

The cost estimate in Table 15 does not include periodic mapping of macrophytes. If the County decides that macrophyte mapping is warranted, the mapping should be coordinated with the aerial photography recommended for the source identification and tracking program (TIM #9). If the same aerial photos can be used, the cost for macrophyte mapping would be based on the time required for interpretation and preparation of a GIS layer to portray the results.

5.2 Fecal Contamination Monitoring

Table 16 lists the 10-year planning-level cost estimate (2008 dollars) for the fecal contamination monitoring program described in Section 4.3 above. The estimate assumes that all of the work except for laboratory analysis would be performed by County staff. The planning-level estimate includes:

- Preparation of a Quality Assurance Project Plan (QAPP) in Year 1.
- Annual revisions to the QAPP based on the previous year's results.
- Monitoring the near-surface water at the diversion canal, lake inlet, and 10 lake stations during Years 1-10, at the same time as the trophic state monitoring.
- Monitoring twice per month from June through September, and once per month from October through May for a total of 16 monitoring events per year.
- Collection of one grab sample at each location during each sampling round.
- Laboratory analyses for fecal coliform and E. coli bacteria.
- Microbial Source Tracking using the PFGE method to identify sources of E. coli. Two subsamples will be analyzed from each E. coli sample.
- Data quality review after each monitoring round.

- Statistical analyses to detect trends over time.
- Annual reports.
- Project management.

Table 16. Planning-Level Cost Estimate for Fecal Contamination Monitoring

Year	# Sites	County Labor	Other Costs (Lab, Equip, etc.)	Total
1	12	$ 30,000	$ 54,000	$ 84,000
2	12	$ 28,000	$ 54,000	$ 82,000
3	12	$ 28,000	$ 54,000	$ 82,000
4	12	$ 28,000	$ 54,000	$ 82,000
5	12	$ 28,000	$ 54,000	$ 82,000
6	12	$ 28,000	$ 54,000	$ 82,000
7	12	$ 28,000	$ 54,000	$ 82,000
8	12	$ 28,000	$ 54,000	$ 82,000
9	12	$ 28,000	$ 54,000	$ 82,000
10	12	$ 28,000	$ 54,000	$ 82,000
	Total	$ 282,000	$ 540,000	$ 822,000

The cost estimate in Table 16 assumes collection of one grab sample per location per round at the same time as the trophic monitoring is conducted. As discussed in Section 4.3, if significant fecal contamination is found at some point in the future, Water Programs may decide to expand the monitoring program to include collection of composite samples along the shorelines near the affected locations. Table 16 does not include costs for composite sampling at additional locations. The costs for composite sampling would depend on the number of locations and monitoring rounds.

5.3 Toxicity Monitoring

Toxicity testing does not appear to be warranted at this time because Lake Tapps does not have any known or suspected problems associated with pesticides, metals, or other toxic pollutants from human sources. Therefore, no cost estimate was prepared for toxicity testing. If at some point in the future Water Programs determines that toxicity testing is needed, the ELS method described in Section 4.4 may be appropriate. The costs would depend on the number of locations and the duration of the tests. Based on recent costs estimates for ELS testing in creeks, the ELS cost per site may be on the order of $4,000, assuming County labor. It may be possible to use volunteer labor to reduce costs and promote public education.

References

Bailey, H., J. Elphick, and B. Chalmers, 2005. Use of In Situ Hatchbox Studies to Evaluate Water Quality Effects. SETAC North America 26th Annual Meeting, Baltimore, Maryland, 13 – 17 November 2005.

Carlson, R. E., 1977. A Trophic Status Index for Lakes. Limnology and Oceanography. 22:361-369.

Carlson, R.E., 1991. Expanding the Trophic State Concept to Identify Non-nutrient Limited lakes and Reservoirs. Proceedings from Enhancing the States' Lake Management Programs, 1991.

Carlson, R. E., and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society.

Field, K. T.J. Brodeur, L.K. Dick, M. Simonich, T.E. Jones, Jr. and C. Bracken. 2002. Who's Responsible: Fecal Source Tracking with *Bacteroides*. Research & Extension Regional Water Quality Conference 2002

Pierce County Water Programs, 2007. County-wide Water Quality Monitoring Plan.

U.S. EPA, 2007. *Survey of the Nation's Lakes Field Operations Manual for Ponds, Lakes, Reservoirs*. EPA 841-B-07-004.

USGS, undated. *The Lake Monitoring Field Manual*. Lake Michigan Ecological Research Station. Porter, IN.

Washington State Department of Ecology, 2006a. Report of Examination, Lake Tapps Reservoir Water Supply Project Application 4 S2-29934.

Washington State Department of Ecology, 2006b. Lake Tapps (Pierce County) Monitoring Final Data Report. Publication No. 06-03-006.

Welch, E. 2006. Draft Summary of Conclusions Regarding Water Quality in Lake Tapps. Prepared for Muckleshoot Indian Tribe.

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix K

Capital Improvement Project Cost Estimate and Site Map

THIS PAGE INTENTIONALLY LEFT BLANK.

Project Name: 185th Avenue East Drainage Improvements

Project Number: CIP15-TAP-C01

Project Type: Culvert replacement, drainage improvements

Sub-Basin: Lake Tapps

Existing Conditions: A residential questionnaire reported road flooding due to moderate rain events at the cul-de-sac near 4468 185th Ave. E. The cul-de-sac is relatively flat, and at the time of the site visit, there was ponded water in the northeast corner. Two culverts were observed along the perimeter of the cul-de-sac. Both culverts are located under driveways; however, the downstream outlet could not be located for one of the culverts. This culvert may lead directly to the lake; however, the cul-de-sac's surface does not appear to slope toward this culvert. This culvert may also have capacity problems because it appeared to be one-half to three-quarters full of sediment at the time of the site visit.

Analysis: The rational method was used to calculate a conservative estimate of the peak design discharge to the storm drainage system, which is an appropriate method considering the runoff catchment area is small (approximately 1 acre). Uniform Flow Analysis Method (i.e., Manning's Equation) was used to verify the conveyance capacity of the existing swale and culvert, using conservative assumptions for dimensions, slopes, and roughness coefficients.

Proposed Solution/ Project Description Remove vegetation and deposited sediments from the cobble swale along 185th Avenue East; the swale should be excavated and expanded as necessary to ensure a minimum bottom width of 1 foot, a minimum of 2:1 side slopes, and a minimum channel depth of 18 inches (includes 6 inches of freeboard as required by the SWM Manual). Remove sediments and expose the culvert inlet at the 185th Avenue East cul-de-sac. Check the condition of the culvert, and verify that the culvert outlet is free from obstruction (the outlet could not be found during the site visit). For cost estimating purposes, it is assumed that the culvert must be replaced with 70 linear feet of new 12-inch storm drainage pipe. Install a Type 1 catch basin at the end of the new 12-inch storm drainage pipe to replace what would have been the old culvert outlet. This catch basin will help to capture runoff from the cul-de-sac. Install an additional 120 linear feet of 12-inch tightline should be added downstream from the new catch basin. This will reduce the potential for erosion caused by discharging concentrated runoff onto the steep slope near the lake shore. Because the 120 feet of tightline will need to cross private properties, a drainage easement will need to be established. Install an energy dissipater structure at the outfall to prevent shoreline erosion. Re-grade and re-surface the cul-de-sac as necessary to divert runoff into the swale and catch basin along the northeast side of 185th Avenue East.

Design Assumptions: Cost estimates are based on a review of Pierce County bid tabs and WSDOT historical unit bid costs. Project will require the County to purchase drainage easement between 185th Ave. E. and Lake Tapps (assume 120-ft length and 30-ft width). One day of survey will be required before project construction to improve/verify design. A Spill Prevention, Control, and Countermeasures (SPCC) plan is required before any construction activities begin. Miscellaneous site restoration includes items as signing and stripping, hydroseeding, removal of excess materials, fine grading, etc. and is assumed for a length of 100 feet. Installation of a Type 1 catch basin assumed to be a lump sum of $2,000. Energy dissipator assumed to be lump sum of $300.

Land Costs[1]

Item	Unit	Unit Cost	Quantity	Cost
Drainage Easement	SF	$ 2,000	0.08	$ 165
				$ -
				$ -
				$ -
				$ -
				$ -
			Total	$ 165
			Contingency (20%)	$ 33
			Total Land Costs	**$ 198**

Construction Costs[1]

Item	Unit	Unit Cost	Quantity	Cost
Mobilization (min $5,000)	10%	-	-	$ 8,644
Erosion and sediment control	LS	$ 1,000	1	$ 1,000
SPCC Plan	LS	$ 1,000	1	$ 1,000
Traffic control	LS	$ 1,000	1	$ 1,000
Survey	LS	$ 500	1	$ 500
Excavate swale (1' bottom, 18" depth)	CY	$ 35	33	$ 1,141
12" Concrete Installed	LF	$ 50	70	$ 3,500
12" SDR 17 HDPE Installed	LF	$ 300	120	$ 36,000
Type 1 Catch Basin	Each	$ 2,000	1	$ 2,000
Energy dissipator	Each	$ 300	1	$ 300
Misc. Site Restoration (residential road)	LF	$ 400	100	$ 40,000
			Total	$ 95,085
			Contingency (*%)	$ 33,280
			Taxes (8.9%)	$ 11,424
			Sub-Total	$ 139,789
			Engineering and Administration (**%)	$ 48,926
			Total Land Costs	$ 198
			Cost Escalation to 2010 dollars (0.6%)	$ 1,133
			Project Cost	**$ 190,000**

Project Prioritization Summary

Flood Hazard Reduction	53
Water Quality Improvement	7
Natural Resource Protection	8
Other Factors	0
Total Score	**68**

Cost/Benefit Ratio: 2794
(Cost/Priority Score)

* 45% habitat projects
35% all other projects

** 35% for construction costs up to $100,000
25% for construction cost between $100,000 - $250,000
20% for construction cost above $250,000

1. The estimated costs are based on year 2007 dollars and are escalated to year 2010 dollars based on ENR cost indices for Seattle.

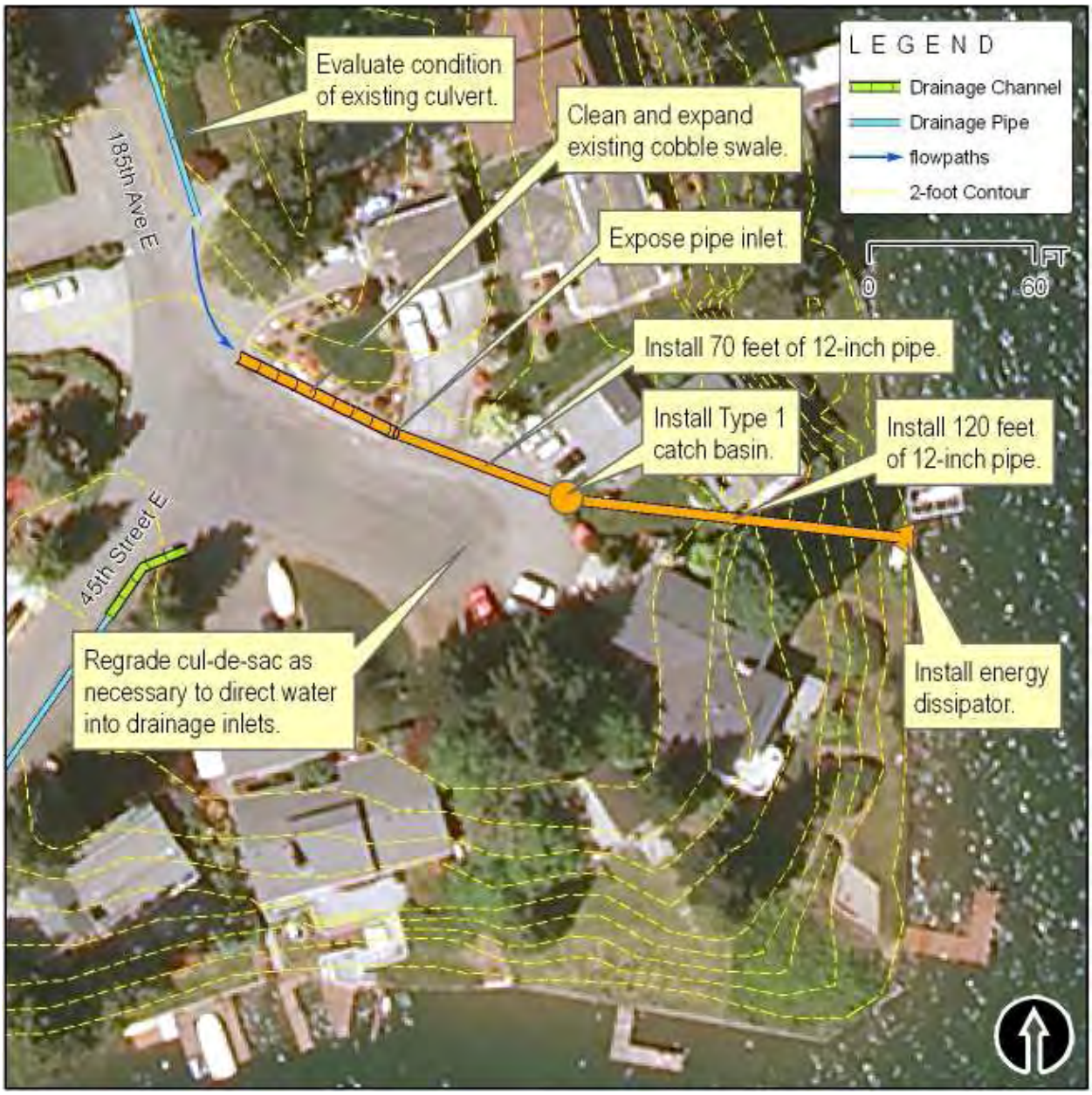


Figure K-1. Recommended drainage improvements CIP15-TAP-C01

Project Name: Acquire Property Adjacent to White River for Floodplain Preservation and Water Quality Protection

Project Number: CIP15-LWR-AC01

Project Type: Property Acquisition

Sub-Basin: Lower White River

Existing Conditions: Sections of the lower White River, from the Lake Tapps diversion to its confluence with the Puyallup River, are on Ecology's 303(d) list for temperature, pH, and fecal coliform. Stream-survey observations resulted in ratings of "fair" for aquatic habitat and riparian corridor. Channel conveyance capacity downstream of Mud Mountain Dam is decreasing. Reduced capacity could increase flooding occurrences.

Analysis: SWM acquires and manages properties for floodplain, water quality, and habitat protection. Analysis indicates there are opportunities to acquire properties in the White River floodplain.

Proposed Solution/ Project Description Purchase properties along the White River mainstem, within the 100-year floodplain, to preserve riparian function and maintain flood storage. Properties that are acquired shall not have existing levees or planned levee setbacks. Acquisitions should be focused between the Lake Tapps diversion and the county line, in areas with reduced channel conveyance capacity or frequent channel migration.

Design Assumptions: Purchase properties as they become available with available funding. Existing County-owned levees in the basin require ongoing maintenance, and there is currently no funding available for land acquisition.

Land Costs

Item	Unit	Unit Cost	Quantity	Cost
Land Acquisition	LS	$ 1,900,000	1.00	$ 1,900,000
Stewardship plan	LS	$ 100,000	1	$ 100,000
				$ -
				$ -
				$ -
				$ -
			Total	$ 2,000,000
			Total Land Costs	**$ 2,000,000**

Construction Costs

Item	Unit	Unit Cost	Quantity	Cost
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
			Total	$ -
			Contingency (*%)	$ -
			Taxes (8.9%)	$ -
			Sub-Total	$ -
			Engineering and Administration (**%)	$ -
			Total Land Costs	$ 2,000,000
			Cost Escalation to 2010 dollars (0.6%)	
			Project Cost	**$ 2,000,000**

Project Prioritization Summary	
Flood Hazard Reduction	50
Water Quality Improvement	55
Natural Resource Protection	62
Other Factors	40
Total Score	**207**

Cost/Benefit Ratio: 9662
(Cost/Priority Score)

* 45% habitat projects
35% all other projects

** 35% for construction costs up to $100,000
25% for construction cost between $100,000 - $250,000
20% for construction cost above $250,000

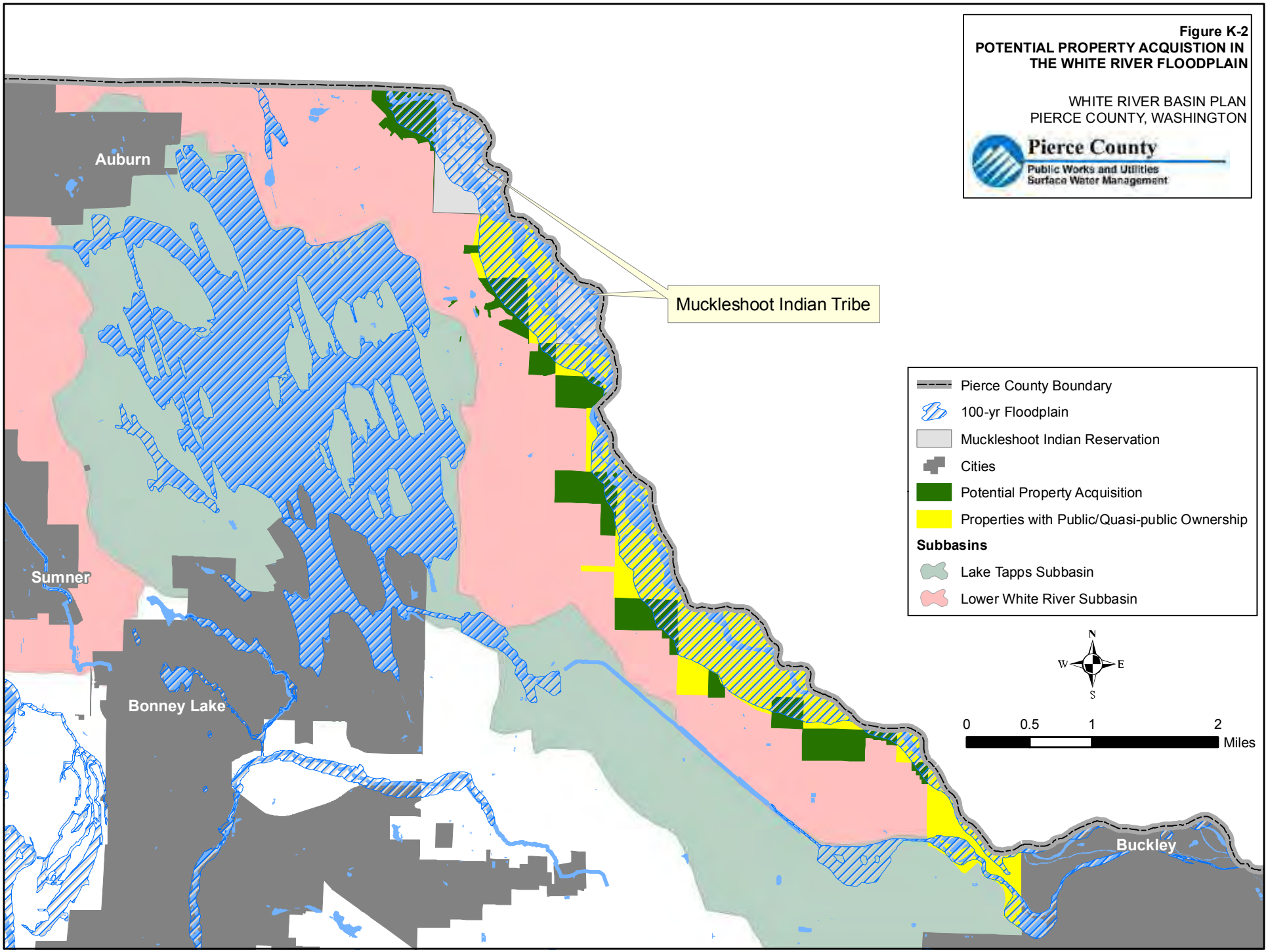


Figure K-2
POTENTIAL PROPERTY ACQUISTION IN THE WHITE RIVER FLOODPLAIN
WHITE RIVER BASIN PLAN
PIERCE COUNTY, WASHINGTON
Pierce County
Public Works and Utilities
Surface Water Management
Auburn
Sumner
Bonney Lake
Buckley
Muckleshoot Indian Tribe
Pierce County Boundary
100-yr Floodplain
Muckleshoot Indian Reservation
Cities
Potential Property Acquisition
Properties with Public/Quasi-public Ownership
Subbasins
Lake Tapps Subbasin
Lower White River Subbasin
N
W
E
S
0
0.5
1
2
Miles

Project Name: Crystal River Ranch Estates Drainage Improvements

Project Number: CIP21-UWR-C01

Project Type: Culvert replacement, drainage improvements

Sub-Basin: Upper White River

Existing Conditions: This problem area is relatively flat, but surrounded by a large, steep drainage basin. There are a series of 18" to 24" culvert under private driveways on Mountain Side Drive East. The maintenance history shows that the ditches along Mountain Side Drive East undersized for larger, infrequent flow events. Most of the culverts in the area do not have sufficient capacity to convey the runoff. Capacity is also restricted when runoff events are combined with snow that blocks the culverts.

Analysis: The drainage basin was delineated with GIS contour data. Total acreage is approximated at 162 acres. Land use was estimated as forested using aerial photography and tax parcel information.

Proposed Solution/ Project Description The proposed solution for the drainage problem is to upsize the culverts to pass the required flows and be fish passable. In order to closely match the existing ditch section, a 72" equivalent arch pipe is proposed. The pipe will be countersunk at a zero slope in order to be fish passable. The existing triple culvert under Birch Way East may be a larger culvert. Additional engineering is required.

Design Assumptions: Box culverts are proposed due to limited ground cover. Steel pipe is proposed for cost reasons. The culverts have been approved by Gina at WDFW to be countersunk at zero slope.

Land Costs

Item	Unit	Unit Cost	Quantity	Cost
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
			Total	$ -
			Contingency (20%)	
			Total Land Costs	**$ -**

Construction Costs

Item	Unit	Unit Cost	Quantity	Cost
Aluminized Steel Arch Pipe 72" equivalent	LF	$ 150	425	$ 63,750
Removal of existing Driveway	EA	$ 250	18	$ 4,500
Spill Prevention Plan	L.S.	$ 500	1	$ 500
ESC Lead	Day	$ 25	150	$ 3,750
Erosion Water Pollution Control	Dol.	$ 5,000	1	$ 5,000
Survey	L.S.	$ 2,000	1	$ 2,000
Structure Excavation	CY	$ 8	1,000	$ 8,000
Shoring	S.F.	$ 0.25	2,268	$ 567
Mobilization	L.S.	$ 30,000	1	$ 30,000
Select Backfill	CY	$ 25	370	$ 9,238
Streambed Gravel	CY	$ 65	250	$ 16,250
Concrete Approach	EA	$ 2,250	18	$ 40,500
72" Flared end section	EA	$ 350	18	$ 6,300
			Total	$ 190,355
			Mitigation (*%)	$ 57,106
			Taxes (8.9%)	$ 16,942
			Sub-Total	$ 264,402
			Engineering and Administration (30%)	$ 79,321
			Total Land Costs	$ -
			Contingency (25%)	$ 85,931
			Project Cost	**$ 429,700**

Project Prioritization Summary	
Flood Hazard Reduction	117
Water Quality Improvement	7
Natural Resource Protection	26
Other Factors	9
Total Score	**159**

Cost/Benefit Ratio: 2703
(Cost/Priority Score)

* 0% mitigation is project is self-mitigating
15% mitigation for 1 acre or less impact
30% mitigation for greater than 1 acre impact

1. This CIP was a late addition to the basin plan as Pierce County received a service request to address flooding in January 2011 when the plan was nearing completion. The basis for the cost estimate differs from the other CIP in the plan as it was developed by Pierce County. The cost estimate for the other CIP was developed by Brown and Caldwell using the same methodology as the Nisqually River Basin Plan.

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix L

Capital Improvement Project and Programmatic Measures Ranking Score Sheets

THIS PAGE INTENTIONALLY LEFT BLANK.

Basin Plan Prioritization Worksheet

Project ID: PRG00-01	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Low Impact Development Program	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	3
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	5
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	3
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	7
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	7
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	10
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	5
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	8
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**53**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	13
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	7
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	13
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	13
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	20
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	20
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**122**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	10
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	10
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	10
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**68**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	7
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	10
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	7
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**34**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**277**

Basin Plan Prioritization Worksheet

Project ID: PRG00-02	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Update Stormwater Management Manual	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1	5
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8	25
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7	20
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5	15
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3	10
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	13
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	20
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	20
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	15
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	15
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	25
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**188**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	13
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	7
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	7
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	7
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	10
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	0
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	5
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**75**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	7
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	10
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	5
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**109**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	0
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	0
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	3
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**13**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**385**

Project ID: PRG00-03	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Increase Inspections for Compliance with Stormwater Requirements and NPDES Permit	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	1
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	8
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	1
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	13
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	13
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	10
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	5
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	8
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**59**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	20
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	20
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	20
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	20
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	20
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	30
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	10
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**195**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	13
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	0
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	7
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**103**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	0
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	3
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**23**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**380**

Project ID: PRG00-04	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Land Management Program for Flood Hazard Reduction, Water Quality, and Habitat Impact Mitigation	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	5
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	3
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	3
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	20
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	15
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	10
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	17
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**78**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	13
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	13
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	13
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	13
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	20
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	20
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	12
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**137**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	20
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	7
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	10
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	7
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**112**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	10
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	10
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**40**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**367**

Project ID: PRG00-05	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Program to Enhance Degraded Riparian Habitat and Water Quality	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	7
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. ***Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later -*** *High = 15, Medium = 10, Low = 5*	10
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**17**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	13
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	13
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	13
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	13
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	20
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	30
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	7
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**140**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	30
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	13
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	10
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	7
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**115**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	10
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	10
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	7
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**37**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**309**

Basin Plan Prioritization Worksheet

Project ID: PRG00-06	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Education, Outreach, and Technical Assistance Program	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	3
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	8
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	10
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	10
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	13
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	15
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	10
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	17
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**91**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	13
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	7
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	20
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	13
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	30
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	20
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**171**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	13
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	7
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	3
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**106**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	7
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	7
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**34**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**402**

Project ID: PRG00-07	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Surface Water Monitoring Program	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	0
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**0**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	13
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	13
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	13
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	13
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	20
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	20
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**147**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	10
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	3
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	0
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	1
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**68**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	0
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	0
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**20**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**235**

Basin Plan Prioritization Worksheet

Project ID: PRG00-08	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: BMP Manual for Pierce County Surface Water Management Maintenance Activities	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	1
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	8
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	7
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	5
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	3
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	7
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	7
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	7
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) (*high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	10
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	5
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	8
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**73**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	20
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	13
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	13
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	20
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	20
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	20
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**174**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	30
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	13
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	10
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	10
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	5
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**120**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	7
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	7
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**34**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**401**

Basin Plan Prioritization Worksheet

Project ID: PRG00-09	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Invasive Species Management Program	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	1
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	3
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	7
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	7
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	13
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	15
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	5
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	17
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**68**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	7
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	0
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	13
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	13
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	0
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	0
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	20
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**108**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	30
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	20
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	10
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	3
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	5
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**128**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	7
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	10
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	7
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**34**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**338**

Basin Plan Prioritization Worksheet

Project ID: PRG00-10	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Beaver Management Policy	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	3
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	17
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	5
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	3
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	13
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	10
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	10
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	17
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**78**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	0
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	0
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	0
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	0
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	0
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	0
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	0
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	5
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**18**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	10
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	0
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	3
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	8
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**58**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	3
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	3
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	7
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	7
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**20**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**174**

Project ID: PRG00-11	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Enhance Cooperation with Cities and Other Agencies	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	3
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	3
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	10
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	15
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	10
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	17
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**63**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	7
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	7
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	7
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	7
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	7
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	10
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	10
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**87**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	10
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	3
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	3
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	1
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**52**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	3
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	0
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	3
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	3
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**9**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**211**

Project ID: PRG00-12	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Lakes Water Quality Management Program	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	0
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**0**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	20
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	20
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	20
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	20
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	20
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	30
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	10
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	25
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**195**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	30
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	10
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	3
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**100**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	10
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	10
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**40**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**335**

Project ID: PRG00-13	**Subbasin: All**
Location: White River Basin (portion of countywide program)	
Description: Habitat Monitoring Program	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	7
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	5
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	5
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**17**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	7
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	0
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	7
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	7
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	0
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	10
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	20
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	5
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**69**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	30
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	20
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	7
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	3
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**100**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	0
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	3
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	7
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	7
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**17**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**203**

Project ID: PRG00-14	**Subbasin: All**
Location: Riparian corridors throughout basin	
Description: Vegetation Management Program	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	1
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	3
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	7
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	15
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	5
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	8
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**39**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	20
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	7
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	20
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	20
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	7
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	7
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	30
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**149**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	30
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	20
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	10
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	7
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	5
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**115**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	10
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	10
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**40**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**343**

Project ID: PRG15-01	**Subbasin: Lake Tapps**
Location: Lower White River Basin	
Description: Coordinate with the Cascade Water Alliance on Develop a Lake Tapps Water Quality Monitoring Plan	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) (*high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	0
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**0**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	13
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	13
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	13
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	13
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	13
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	20
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	10
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	5
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**125**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	0
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	0
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	0
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	5
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**52**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	7
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	0
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**27**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**204**

Project ID: PRG15-02	**Subbasin: Lake Tapps**
Location: Lower White River Basin	
Description: Lake Tapps Pollutant Source Identification and Monitoring Program	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	0
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**0**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	20
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	13
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	20
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	20
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	20
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	30
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	10
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	5
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**163**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	0
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	0
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	0
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	5
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	5
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**52**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	3
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	0
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**23**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**238**

Project ID: PRG15-03	**Subbasin: All**
Location: Various locations throughout Lower White River Basin	
Description: Coordinate with Tacoma-Pierce County Health Department to Address Reported On-site Sewer System Problems	
1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) (*high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	0
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**0**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	0
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	0
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	20
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	20
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	7
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	30
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	0
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	17
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	10
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**114**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	7
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	0
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	0
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	0
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	10
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	8
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	15
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**65**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	7
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	3
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	7
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**27**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**206**

Basin Plan Prioritization Worksheet

Project ID: PRG15-04	**Subbasin: All**
Location: White River Basin	
Description: Enhance Puyallup River Watershed Council's Capacity	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	0
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	0
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	0
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**0**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	20
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	20
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	20
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	20
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	20
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	30
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	30
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	10
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	10
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**195**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	13
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	7
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	7
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	3
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	15
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	10
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	10
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**90**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	0
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	0
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	0
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	0
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**0**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**285**

Project ID: CIP15-TAP-C01	**Subbasin: Lake Tapps**
Location: Cul-de-sac near 4468 185th Avenue East	
Description: Check existing infrastructure; clean out swale; install new catch basin/manhole; establish drainage easement; install energy dissipator at outfall.	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	5
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	8
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	10
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	20
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	0
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	0
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	5
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**53**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	7
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	0
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	0
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	0
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	0
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	0
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	0
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	0
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	0
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	0
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**7**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	0
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	0
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	0
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	3
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	5
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	0
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	0
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	0
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	0
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**8**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	0
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	0
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	0
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	0
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**0**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**68**

Basin Plan Prioritization Worksheet

Project ID: CIP15-LWR-AC01	**Subbasin: Lower White River**
Location: Lower White River (100-year floodplain, between the County Line and the Lake Tapps diversion)	
Description: Acquire Property Adjacent to White River for Floodplain Preservation and Water Quality Protection	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	0
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	0
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	7
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	10
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	0
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	13
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	0
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later - *High = 15, Medium = 10, Low = 5*	15
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**50**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	7
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	7
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	7
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	7
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	7
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	10
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	10
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	0
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	0
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	0
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**55**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	20
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	20
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	7
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	10
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	0
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	5
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	0
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	0
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	0
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**62**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	10
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	10
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	10
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	10
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**40**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**207**

Basin Plan Prioritization Worksheet

Project ID: CIP21-UWR-C01	**Subbasin: Upper White River**
Location: Crystal River Ranch Estates	
Description: Install new cross culverts and replace driveway culverts along Mountain Side Drive East to alleviate local flooding	

1. FLOOD REDUCTION	**SCORE**
a. Level of Flooding *(score all that apply)*	
Prevents/reduces inconvenience flooding (high = 5, medium = 3, low = 1)	5
Prevents/reduces hazard to public safety (high = 25, medium = 17, low = 8)	17
Prevents/reduces risk to critical facilities (hospitals, etc.) (high = 20, medium = 13, low = 7)	0
Prevents/reduces severe property damage (> $100,000/year) (high = 15, medium = 10, low = 5)	0
Prevents/reduces minor property damage (< $100,000/year) (high = 10, medium = 7, low = 3)	7
b. Frequency of Flooding – solves an existing problem *(select & score* ***one*** *only)*	
Prevents/reduces annual flooding *(high = 20, medium = 13, low = 7)*	0
Prevents/reduces flooding every 1 to 5 years *(high = 15, medium = 10, low = 5)*	20
Prevents/reduces flooding every 5 to 25 years *(high = 10, medium = 7, low = 3)*	0
Prevents/reduces flooding less than one in 25 years *(high = 5, medium = 3, low = 1)*	0
c. Required due to flooding liability *(high = 20, medium = 13, low = 7)*	13
d. Increases capacity of floodplain *(high = 20, medium = 13, low = 7)*	20
e. Corrects non-compliance with County design standard (H/D ratio < 1.5) *(high = 20, medium = 13, low = 7)*	20
f. Future Flooding: level of increase in peak discharge that is expected due to land use changes within the project area - *High = 15, Medium = 10, Low = 5*	5
g. ***Estimated benefit to doing the project now (in feasibility and cost benefit) versus waiting and doing project later -*** *High = 15, Medium = 10, Low = 5*	10
h. Provides basin-wide flood reduction benefit *(For programmatic recommendations only)*	0
i. Provides county-wide flood reduction benefit *(For programmatic recommendations only)*	0
TOTAL FLOODING SCORE (Maximum Score is 185 for CIP or 225 for programmatic)	**117**
2. WATER QUALITY IMPROVEMENT	
a. Reduces sources of or impacts from emission of fine sediments *(high = 20, medium = 13, low = 7)*	7
b. Reduces sources of or impacts from emission of heavy metals *(high = 20, medium = 13, low = 7)*	0
c. Reduces sources of or impacts from emission of excess nutrients *(high = 20, medium = 13, low = 7)*	0
d. Reduces sources of or impacts from excess oxygen demanding conditions *(high = 20, medium = 13, low = 7)*	0
e. Reduces sources of or impacts from emission of oil and grease *(high = 20, medium = 13, low = 7)*	0
f. Reduces sources of emission of pathogens such as fecal coliform *(high = 30, medium = 20, low = 10)*	0
g. Lowers water temperature, provides more shade *(high = 30, medium = 20, low = 10)*	0
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	0
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	0
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	0
TOTAL WATER QUALITY SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**7**
3. NATURAL RESOURCE IMPROVEMENT & PROTECTION	
a. Improves and/or protects habitat for aquatic species *(high = 30, medium = 20, low = 10)*	10
b. Improves and/or protects habitat for terrestrial species *(high = 20, medium = 13, low = 7)*	0
c. Increases proportion of native plant species *(high = 10, medium = 7, low = 3)*	0
d. Improves flow regime and/or natural hydrology *(high = 10, medium = 7, low = 3)*	10
e. Increases channel stability/reduces erosion *(high = 5, medium = 3, low = 1)*	5
f. Increases extent of salmonid spawning habitat *(Q = [Good(ft) + Fair(ft)] / [Total (ft)])*	0
Opens passage to long reach of habitat (>4000 ft) Q*80	
Opens passage to medium reach of habitat (1000 - 4000 ft) Q*65	
Opens passage to short reach of habitat (<1000 ft) Q*50	
g. Salmonids other than cutthroat trout present *(high = 5, medium = 3, low = 1)*	1
h. Provides basin-wide water quality benefits *(For programmatic recommendations only)*	0
i. Provides county-wide water quality benefits *(For programmatic recommendations only)*	0
j. Solves or substantially reduces an existing problem *(For programmatic recommendations only)*	0
TOTAL NATURAL RESOURCE IMPROVEMENT SCORE (Maximum Score is 160 for CIP or 215 for programmatic)	**26**
4. OTHER FACTORS	
a. Provides recreational or multiple use opportunities *(high = 10, medium = 7, low = 3)*	0
b. Enhances visual aesthetic of area *(high = 10, medium = 7, low = 3)*	3
c. Provides public education opportunities *(high = 10, medium = 7, low = 3)*	3
d. Is a highly visible project or has been on the CIP needs list multiple years. *(high = 10, medium = 7, low = 3)*	3
TOTAL OTHER FACTORS SCORE (Maximum Score 40)	**9**
TOTAL SCORE (Maximum Score is 545 for CIP or 695 for programmatic)	**159**

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix M

Pollutant Source Identification and Monitoring Program

THIS PAGE INTENTIONALLY LEFT BLANK.

701 Pike Street, Suite 1200
Seattle, WA 98101
Tel: 206-624-0100
Fax: 206-749-2200

Prepared for: Pierce County, Washington

Project Title: White River Basin Plan

Technical Memorandum No. 9

Subject: Pollutant Source Identification and Monitoring Program Technical Memorandum #9 (TIM#9)

Date: March 31, 2008

To: Heather Kibbey, Project Manager

From: Mike Milne

Prepared by: Laura Porter and Jennifer Belknap Williamson

Table of Contents

1. Introduction 2
2. Existing Data 2
    2.1 Land Use 2
    2.2 Septic Systems 3
    2.3 Water Quality 4
3. Potential Source Identification Methods 5
    3.1 Visual Inspections of the Shoreline 5
    3.2 Periodic Monitoring of Outfalls and Near Shore Areas 5
    3.3 Remote Sensing 9
4. Recommended Pollutant Source Identification and Monitoring Program for Lake Tapps 11
    4.1 Recommended Program Components 11
5. References 14

Pollutant Source Identification and Monitoring Program

1. Introduction

This Technical Memorandum (TIM #9) describes a pollutant source identification and monitoring program for the Lake Tapps subbasin in the White River basin. The source monitoring program described in this TIM is an important component of a fully functional water quality management program for Lake Tapps. Pollution source monitoring is designed to enable the early detection and control of pollution sources that could degrade water quality in Lake Tapps. The source monitoring program is designed to complement the long-term water quality trend monitoring program described in TIM #8, "Lake Tapps Water Quality Monitoring Plan Recommendations."

This TIM identifies potential sources of pollution to Lake Tapps based on existing data, describes methods available to detect pollution, recommends elements of a pollutant source monitoring program, and describes implementation methods and expected costs associated with the pollutant source monitoring program.

Lake Tapps is a man-made reservoir originally constructed for hydropower generation. Water is diverted from the White River and conveyed in a canal to Lake Tapps. It is the only sizable lake in the White River Basin planning area, with more than 46 miles of shoreline. There are approximately 3,000 homes around the lake.

Puget Sound Energy ceased hydropower operations in 2004 and has announced its intention to sell the lake to Cascade Water Alliance (CWA) for use as a potable water source. The Washington State Department of Ecology (Ecology) is now reviewing the proposed transaction. Use of the lake for potable water supply rather than hydropower will require changes in the lake's diversion and discharge rates, which in turn could affect lake water quality. The lake is heavily used for boating, water skiing, swimming, and other recreational activities.

2. Existing Data

2.1 Land Use

The Lake Tapps Subbasin encompasses 12,722 acres. Residential land uses dominate the shorelines and islands (Figure 1, end of memo). The south shore of Lake Tapps is in the City of Bonney Lake. The rest of the lake and shoreline lies within unincorporated Pierce County.

Approximately 33% of existing land use in the Lake Tapps subbasin is residential. This is estimated to grow to 48% in the future, as shown in Table 1. There are more than 3,000 houses located near the lake. Agricultural land use is 12%, commercial and civic land uses combined range from 5% (current) to 8% (future), and industrial land use is less than 1%. The agricultural land uses are found along the diversion canal. Brown and Caldwell completed field work in the summer of 2007 and noted at that time that agricultural land uses include hobby farms, small animal operations and small vegetable farms. Single-family residences with septic systems cover most of the shoreline.

Table 1. Lake Tapps Land Use

Land Use Category	Current Land Use, %	Future Land Use, %
Agriculture	12.1	12.1
Civic: schools, roads, religious centers, parks, libraries, fire stations, and post offices	4.2	4.2
Commercial: shopping centers, restaurants, gas stations, banks, offices, marinas, and motels	1.1	4.1
Residential: single family homes, duplexes, apartment buildings, and manufactured homes	32.7	47.5
Industrial: furniture manufacturers, metal fabricators, and food product manufacturers	0.01	0.01
Open Space	33.5	15.8
Resource Land: fishing activities, quarries, and timberland	2.6	2.6
Surface Water	13.7	13.7
Unknown	0.1	0.1

Source: Pierce County (2007), Table 4-4 and 4-5.

According to the Pierce County Geographic Information System (GIS) "Drainage Pipes" shape file, there are more than 150 stormwater pipes that discharge into the lake[1]. Stormwater runoff from residential areas can contain a variety of pollutants, such as sediment, metals, nutrients, bacteria, oils, detergents, and oxygen demanding substances.

Impervious surface area is generally a good indicator of urbanization. The current average impervious surface for the Lake Tapps subbasin is approximately 10% based on land use. Projected future average impervious surface is 13% (Pierce County, 2007, page 4-26).

2.2 Septic Systems

There are approximately 3,000 homes served by septic systems around Lake Tapps. Septic system effluent typically contains high concentrations of phosphorus and bacteria. Septic system drainfields tend to clog over time. Severe clogging can result in surface failures and allow inadequately treated effluent to flow overland into the lake, with little contaminant removal en route. The risk of failure tends to be greater for older systems. Failing septic systems are a concern for Lake Tapps because of the large number and age of the systems near the lake. Septic system failures could result in pathogens and nutrients entering the lake via overland flow.

[1] Pierce County Geographic Information System (GIS) data was used to determine the number of stormwater pipes that discharge to the lake, by querying the "DISCHRG_DE" field for the term "LAKE" in the "Drainage Pipes" shapefile.

Septic systems can also contribute phosphorus and pathogens to the lake via groundwater. Phosphorus usually moves very slowly in soil and groundwater because it adsorbs on soil particles and forms chemical complexes with low solubilities. It is possible that phosphorus plumes from shoreline drainfields exist but have not reached the lake yet. If these septic systems remain in use, phosphorus plumes could eventually reach the lake via groundwater. Bacteria in septic system effluent typically does not travel very far in the subsurface, so drainfields more than 150 feet from the lake are unlikely to be significant sources of bacteria to the lake.

The northwest and west shores of Lake Tapps, from north of Tacoma Point to Jenks Park, contain the oldest development where construction occurred prior to current septic system design and setback regulations. As noted above, drainfields tend to clog over time and eventually need to be replaced. Soils along this section of shoreline are dominated by Alderwood gravelly sandy loams that contain shallow, moderately well-draining soils over a weakly cemented glacial till. Water infiltrates to the till layer, them moves horizontally downslope and discharges as seeps along the shoreline.

2.3 Water Quality

Brown and Caldwell obtained Lake Tapps water quality data collected during 2004-2007 by Pierce County Public Works and Utilities Water Programs Division (PCWP), Ecology, and the Muckleshoot Indian Tribe Fisheries Division (MITFD). These monitoring activities were conducted after hydropower operations on the lake had ended. Detailed analysis of the water quality data is provided in TIM #8, Lake Tapps Water Quality Monitoring Plan Recommendations. The monitoring found that Lake Tapps had good water quality. Total phosphorus (TP) and chlorophyll *a* concentrations were generally in the oligotrophic range (Ecology 2006; Welch 2006).

Algal growth in Lake Tapps appears to be limited by phosphorus concentrations rather than by nitrogen concentrations or light transparency (Welch 2006). Thus, if phosphorus concentrations in the lake become too high, the lake could experience nuisance algal blooms, reduced dissolved oxygen levels, and reduced clarity. Such conditions would impair current recreation and aesthetic uses of the lake and could also interfere with potable water treatment in the future. As noted above, Lake Tapps had low algal concentrations during 2004-05 because TP concentrations were low (Welch 2006).

Potential sources of phosphorus include the White River, stormwater runoff, and septic systems. Ecology's 2004-2005 monitoring indicated that the sediment traps on the diversion canal substantially reduced the phosphorus loads from the White River. Diversion rates during 2004-05 were considerably lower than historic diversion rates during hydropower operations. Lower diversion rates are expected to reduce phosphorus loads from the White River and allow more time for phosphorus to settle to the lake bottom (Welch 2006). Stormwater runoff from residential land uses (such as those near Lake Tapps) often contains elevated phosphorus concentrations due to fertilizer use, plant debris, and soil erosion. Septic system drainfields near the lake are also potential sources of phosphorus.

Pathogens are also a potential concern for Lake Tapps. The lake is heavily used for swimming, water skiing, and other water–based recreational activities where people could be exposed to pathogens (if present) in the water. There are approximately 3,000 homes served by septic systems around the lake, and septic system effluent typically contains high concentrations of fecal bacteria (e.g., approximately 1 million fecal coliforms per 100 mL immediately below the drainfield). Stormwater runoff often contains elevated concentrations of fecal bacteria, which may be indicative of pathogens. In the residential areas around Lake Tapps, potential sources of fecal bacteria include pets, wildlife (e.g., birds, rodents), and failing septic systems. Livestock could contribute bacteria and other pathogens to the lake via discharges to the White River and the diversion canal.

The 2004-05 monitoring found low dissolved oxygen (DO) concentrations in the hypolimnion during the summer. The DO depletion appears to be due to organic matter from White River inflow rather than in-lake algal production (Welch 2006).

URS conducted a shoreline survey of Lake Tapps on March 25, 2005. The pollutant source survey covered 11 miles of shoreline on the northwest and west portions of Lake Tapps, from north of Tacoma Point to Jenks Park. The survey focused on this section of the lake because it contains the oldest development and septic systems. Septic system drainfield performance usually declines over time due to clogging; thus, the risk of incomplete treatment or failure tends to increase with age. Moreover, some of the drainfields may be closer to the lake than current regulations would allow. These properties have septic systems that are reaching or have exceeded their estimated life spans. The survey discovered very few problems and did not discover any illicit discharges (Pierce County, 2007).

3. Potential Source Identification Methods

The potential pollutants of greatest concern for Lake Tapps are phosphorus and pathogens. Based on the local land uses, the most likely potential sources for phosphorus and pathogens are septic systems, landscaped areas, and construction sites along the lake shore. Methods appropriate for identifying pollution from these sources are described in this section.

The White River diversion appears to be an important conveyance for phosphorus and oxygen-demanding materials to the lake (Welch 2006). White River pollutant loads will be addressed through the lake trend monitoring program described in TIM #8. If the trend monitoring identifies phosphorus or fecal contamination in the lake, the source identification and monitoring program may be revised to focus on areas that could contribute to the observed contamination.

Techniques for identifying potential sources of pollution include visual inspections of the shoreline during the winter drawdown period; periodic monitoring of outfalls and near-shore areas; and remote sensing. These techniques are discussed in more detail in the following sections. Most of the techniques described in the following sections are derived from *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments* (IDDE Manual) (Center for Watershed Protection and Pitt, 2004).

3.1 Visual Inspections of the Shoreline

The current operating rules for Lake Tapps call for the lake to be drawn down 10-15 feet each winter to help control milfoil. Visual inspections of the shoreline during the winter drawdown period could help identify potential problems that require additional inspection and analysis, including potential discharges from failing septic systems around the lake.

Conditions to look for include dry weather discharges; foul odors; algal blooms or excessive weed growth in adjacent ditches, ponds, and stream; sediment runoff from construction sites; or other unusual discharges. If a potential problem is found, the visual inspector should note the outfall location and record basic characteristics of the flow. The reports should be tracked by the County for additional follow-up and analysis. For more information on conducting visual inspections, see Chapter 7 and 11 of the IDDE Manual (2004).

3.2 Monitoring of Outfalls and Near Shore Areas

Contributing areas that have been identified as potential sources of pollutants could degrade in-lake water quality. Water quality monitoring of outfalls and near-shore areas can be used to evaluate pollutant levels in water bodies and potential sources of pollutants based on the types of parameters observed. Since failing

septic systems have been identified as a potential concern, the monitoring methods described below are focused on identifying untreated wastewater discharges into Lake Tapps. Methods to identify potential problems include indicator monitoring and optical brightener monitoring traps. Caulk dams can sometimes be used to collect water from intermittent flows. If dry weather flows are observed at outfalls, outfall monitoring to characterize the discharge may also be appropriate.

3.2.1 Indicator Monitoring

Indicator monitoring is often used to provide clues about the source of a suspect discharge and can be used in an outfall or in open water. In addition, indicator monitoring can be used to measure improvements in water quality during dry weather flow as a result of the local water quality program. Indicator parameters used to detect untreated wastewater discharges include ammonia, detergents, *E. coli*, fluorescence, and potassium. These parameters are summarized in Table 2 and discussed further in Chapter 12 and Appendix F of the IDDE Manual (2004).

Research by Lalor (1994) suggests that detergent is the best single parameter to detect the presence or absence of sewage and washwater (i.e. laundry discharges from homes). Presence of detergents in flow is usually measured as surfactants or fluorescence. Surfactants are the main component of commercial detergents.

Ammonia is another parameter that has been used as an indicator for potential sewage contamination. An ammonia concentration greater than 1 mg/L is generally considered to be a positive indicator of sewage contamination. Ammonia concentration can be analyzed in the field using a portable spectrophotometer, which means crews can get fast results and immediately proceed to track down the source of the discharge. However, if the flow is diluted with non-sewage discharge testing for ammonia only may not fully identify sewage discharges. Supplementing ammonia testing with potassium testing and evaluating the ammonia/potassium ratio helps to further and more accurately characterize the discharge. Ratios of ammonia/potassium greater than one indicate a sewage source, while ratios less than or equal to one indicate washwater source. Potassium is easily analyzed using a probe.

A typical per sample contract lab cost for detergents is $17 to $35 and for ammonia is $12-$25 (in 2004). Additional costs include initial sampling equipment, and staff preparation time, field work, and analysis. Additional information can be found in Chapter 12 of the IDDE Manual (2004).

Table 2. Indicator Parameters Used to Detect Illicit Discharges

Table 39: Indicator Parameters Used to Detect Illicit Discharges					
Parameter	Discharge Types It Can Detect				
	Sewage	Washwater	Tap Water	Industrial or Commercial Liquid Wastes	Laboratory/Analytical Challenges
Ammonia	●	⦿	○	⦿	Can change into other nitrogen forms as the flow travels to the outfall
Boron	⦿	⦿	○	N/A	
Chlorine	○	○	○	⦿	High chlorine demand in natural waters limits utility to flows with very high chlorine concentrations
Color	⦿	⦿	○	⦿	
Conductivity	⦿	⦿	○	⦿	Ineffective in saline waters
Detergents – Surfactants	●	●	○	⦿	Reagent is a hazardous waste
E. coli Enterococci Total Coliform	⦿	○	○	○	24-hour wait for results Need to modify standard monitoring protocols to measure high bacteria concentrations
Fluoride*	○	○	●	⦿	Reagent is a hazardous waste Exception for communities that do not fluoridate their tap water
Hardness	⦿	⦿	⦿	⦿	
pH	○	⦿	○	⦿	
Potassium	⦿	○	○	●	May need to use two separate analytical techniques, depending on the concentration
Turbidity	⦿	⦿	○	⦿	

● Can almost always (>80% of samples) distinguish this discharge from clean flow types (e.g., tap water or natural water). For tap water, can distinguish from natural water.
⦿ Can sometimes (>50% of samples) distinguish this discharge from clean flow types depending on regional characteristics, or can be helpful in combination with another parameter
○ Poor indicator. Cannot reliably detect illicit discharges, or cannot detect tap water
N/A: Data are not available to assess the utility of this parameter for this purpose.
Data sources: Pitt (this study)
*Fluoride is a poor indicator when used as a single parameter, but when combined with additional parameters (such as detergents, ammonia and potassium), it can almost always distinguish between sewage and washwater.

Source: Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments (IDDE Manual), page 122.

3.2.2 Optical Brightener Monitoring Traps

Optical brightener monitoring (OBM) traps indicate the presence of detergents, which are often present in residential wastewater. OBM traps involve an absorbent unbleached cotton pad or fabric swatch and a holding or anchoring device such as a wire mesh trap or a section of small diameter PVC pipe. Traps are anchored to the inside of outfalls at the invert using wire or monofilament that is secured to the pipe itself or rocks used as temporary weights.

Field crews retrieve the OBM traps after they have been deployed for several days of dry weather, and place them under a fluorescent light that will indicate if they have been exposed to detergents. OBM traps tend to identify most discharges of untreated wastewater; the detergent level needed to produce a "hit" is roughly similar to washwater from a washing machine. OBM traps need to be retrieved before surface runoff enters the outfalls, which will contaminate the trap or wash it away. OBM traps are a simple indicator of the presence of intermittent washwater flows but, due to the ease with which the sample can be diluted, OBM traps are not well suited to confirm the absence of washwater flows. The Tacoma-Pierce County Health Department (TPCHD) recommends making sure that the cotton used in an OBM trap does not have

brightener already in it and that the OBM trap is placed close to the source, has low flows, and little to no dilution.[2]

OBM traps are inexpensive and easy to implement. If materials are bought in bulk, each monitoring trap is expected to cost around $10. Additional costs include staff time to build, install, and retrieve the traps. The UV light needed to "read" the OBM trap costs approximately $240. For more detailed guidance on how to use OBM traps and interpret the results, consult the guidance manuals found at http://www.naturecompass.org/8tb/sampling/index.html, http://www.novaregion.org/obm.htm , and pages 139-140 and 157-158 of the IDDE Manual (2004).

3.2.3 Caulk Dams

Caulk dams are another tool that can be used to gain insight into the "history" of an outfall without being physically present. The caulk dam technique uses caulk, plumber's putty, or a similar substance to make a dam about 2 inches high within the bottom of a storm drain pipe to capture any dry weather flow that occurs between field observations. Any water that has pooled behind the dam is then sampled using a hand-pump sampler, and analyzed in the lab for appropriate indicator parameters. Caulk dams cost as much as the caulk and the caulking gun which should be under $10 per site plus staff time. More information can be found on page 140 of IDDE Manual (2004).

3.2.4 Microbial Source Tracking

Microbial source tracking (MST) methods can help identify the sources of fecal contamination in surface waters, such as humans, wildlife, pets, or livestock. Source identification can be very helpful in targeting control measures. There are many MST methods available.

MST methods can be grouped into library dependent methods (LDMs) and library independent methods (LIMs) (USEPA, 2005). LDMs require databases of genotypic or phenotypic fingerprints for bacterial strains isolated from suspected fecal sources, i.e., cows, birds, dogs, cats and humans. Fingerprints of isolates from contaminated water are compared with these libraries for classification. Bacterial indicators of fecal contamination (e.g., *E. coli* and enterococci) are commonly used for LDM development. LIMs do not depend on the isolation of a targeted source identifier because detection is performed via the amplification of a genetic marker by a Polymerase Chain Reaction (PCR) step. Some LIMs target the 16S rDNA (which is vital for protein synthesis and therefore present in all bacteria), while others target function-specific genes (which are present in a particular bacterial group) for PCR primer development. A schematic representation of MST methods is included as Figure 2.

The effectiveness, efficiency, and cost of source tracking methods varies (Field and Samadpour, 2007). Methods based on isolating indicator organisms are slow and labor-intensive, most have unacceptable levels of accuracy and false positives, and genetic evidence has shown that the population makeup of indicator organisms in the environment does not match fecal sources. The best evidence supports taking a multi-tiered approach, moving from general to specific and from less to more expensive testing. After each step, progress

[2] Personal communication with Ray Hanowell from the Tacoma Pierce County Health Department, January 2008.

can be assessed before deciding to move to the next one. For example, the first step could simply involve visual inspection followed by sampling and analysis of *E. coli* upstream and downstream of a potential source. If the results are inconclusive, additional MST analysis could be performed. Bacteriodes might be a good choice if the goal is to quickly ascertain whether human sources are present. Ribotyping or PFGE might be more appropriate if the specific sources (waterfowl, dog, rodent, cow, horse) need to determined. MST costs may be on the order of $100-150 per sample, depending on the method. For more information, please see Field and Samadpour (2007) or USEPA (2005).

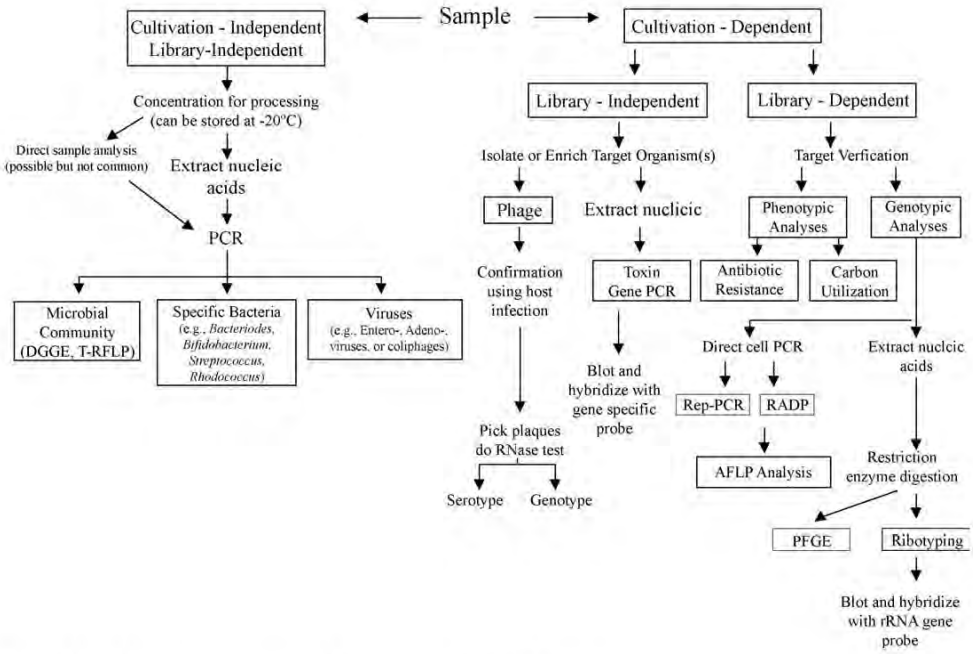


Figure 2. Available MST Methods (from USEPA (2007), p. 16).

3.3 Remote Sensing

Infrared imagery is a special type of remote sensing photography with gray or color scales that represent differences in emissivity of objects in the image. The following discussion highlights two remote sensing imagery techniques: aerial infrared thermography and color infrared aerial photography. Remote sensing can cover a large area quickly and can be a good way to find outfalls with untreated wastewater discharges and failing septic systems.

3.3.1 Infrared Thermography

Infrared thermography is increasingly being used to detect illicit discharges and failing septic systems. Thermography is the use of an infrared imaging and measurement camera to "see" and "measure" thermal energy emitted from an object. The technique uses the temperature difference of sewage as a marker to locate these illicit discharges. Some aerial photography companies provide infrared thermography services. Equipment needed includes an aircraft (plane or helicopter); a high-resolution, large format, infrared camera; GPS unit; and digital recording equipment. Data are analyzed after the flight by trained analysts to locate

suspected discharges, and field crews then inspect the ground-truthed sites to confirm the presence of a failing septic system.

Late fall, winter, and early spring are typically the best times of year to conduct these investigations in most regions of the country. This allows for a bigger difference between receiving water and discharge temperatures, and interferences from vegetation is minimized (Stockton, 2004). In addition, flights should take place at night to minimize reflected and direct daylight solar radiation that may adversely affect the imagery (Stockton, 2004).

3.3.2 Color Infrared Aerial Photography

Color infrared aerial photography can sometimes identify septic failures through rapidly growing or damaged vegetation, unusual soil moisture, and surface effluent. Color infrared photography records near or reflective infrared imagery, not thermal emissions or temperature. The Tennessee Valley Authority (TVA) uses color infrared aerial photography to detect failing septic systems in reservoir watersheds. Local health departments conduct follow-up ground-truthing surveys to determine if a system is actually failing. Similar to thermography, it is recommended that flights take place at night, during leaf-off conditions, or when the water table is at a seasonal high (which is when most failures typically occur (U.S. EPA, 1999).

Color infrared relies on the fluctuations in the color of vegetation (color signatures) to detect leaking septic tanks. Accuracy is affected by season, distance between trees, canopy density, soil type, and moisture. The survey can be significantly affected if there are evergreen trees which obscure the land (Jiang and Worthington, 2005). TVA considers color infrared aerial photography, "a cost-effective tool that watershed planners can utilize for developing and implementing NPS pollution corrective actions" (Holcombe and Malone, 2005). TVA uses color infrared aerial photography for identifying the condition of on-site septic systems, as shown in Table 3 below.

Table 3. Color Infrared Aerial Photography Indicators of On-Site Septic Systems (from Holcome and Malone, 2005)

Condition	Indicator Description
Distinctive Moisture Pattern	Effluent plume from visible fieldline pattern.
Suspicious Moisture Pattern	Visible plume pattern but no fieldlines visible; condition may be straight pipe from septic system, gray water disposal, system breakout with no fieldlines showing, roof drainage, or natural seepage/spring.
Distinctive Drainfield Area	Fieldline pattern but no plume visible; may indicate slow leaching of a seasonally or hydraulically stressed system or evapotranspiration characteristic of a functioning system or newly installed system.
Suspect Location	No plume or fieldlines; home sites on very steep slopes, small lots, visible rock outcrops, in close proximity to stream or reservoirs, and/or heavily wooded lots.

3.3.2 Cost of Aerial Imaging

Private contractors provide infrared imaging services. The cost depends on the length of flight; how difficult it will be to fly the route; the number of heat anomalies expected to be encountered; the expected post-flight processing time (typically, four to five hours of analysis for every hour flown); and the distance of the site from the plane's "home." In 2004, the cost range for infrared thermography was typically $150 to $400 per mile of stream or river flown, which includes the flight and post-flight analyses. The cost for color infrared aerial photography is expected to be in the same range. Infrared thermography cameras can also be purchased and range in cost from $250,000 to $500,000. As an alternative, local police departments may already own an infrared imaging system that may be used. The disadvantage is that the equipment may not be available at optimal times to conduct the investigation and the equipment may not be sensitive enough to detect the narrow range of temperature differences (only a few degrees) often expected for sewage flows.

4. Recommended Pollutant Source Identification and Monitoring Program for Lake Tapps

Lake Tapps is an important aesthetic amenity for the more than 3,000 property owners along its shores. The lake is also very important as a recreational resources; it is heavily used for swimming, boating, water skiing, and fishing. In the near future, Lake Tapps will likely also serve as a source of potable water for thousands of people. Recent monitoring studies indicate that the water quality of the lake is sufficient to support all of these beneficial uses. However, the lake's drainage area encompasses numerous septic systems, landscaped areas, and other potential pollutant sources that could degrade water quality in the future. In order to maintain these beneficial uses, Brown and Caldwell recommends that the County implement a pollutant source identification and monitoring program for Lake Tapps.

Ecology and TPCHD provided input for developing a pollutant source identification and monitoring program in the Lake Tapps subbasin[3]. TPCHD currently monitors in-lake water quality at North Park and Allan York Park for temperature, pH, conductivity and bacteria as a part of its freshwater beach monitoring. TPCHD recommends monitoring for nutrients and bacteria and determining sources from residential and agricultural uses, such as fertilizers or septic discharge. Ecology recommends tracking bacteria and nutrients; evaluating waterfowl contributions to fecal bacteria concentrations; considering impacts of reduced flows from the White River; and coordinating with other agencies on the monitoring program. Some of the monitoring recommended by Ecology and TPCHD is addressed in TIM #8, "Lake Tapps Water Quality Monitoring Plan Recommendations."

4.1 Recommended Program Components

During the first year of program implementation, the County should survey the entire shoreline using color infrared aerial photography. This will provide a baseline of information for the County to work from and will also provide a measure of cost savings to complete the full shoreline all at once. The Tennessee Valley Authority (TVA) and Gwinnett County, Georgia have had success using color infrared aerial photography to locate failing septic systems affecting water quality (Holcombe et al., 2005 and Jiang et al., 2005).

After the remote sensing data has been analyzed and potential problems identified, the County should enlist and train volunteers to complete annual physical shoreline surveys during the late fall or early winter when the lake water elevations are low. The homeowner associations around Lake Tapps should be engaged to help identify volunteers interested in performing shoreline surveys. Each volunteer could sign up for surveying 1 to 2 miles of the lakeshore. With 20 to 40 volunteers, the entire lake edge could be visually monitored during annual draw down. During this survey volunteers can ground truth the remote sensing information and document potential problems such as discolored or malodorous flows, stained areas, sediment deposition, landscaping debris, etc. The volunteers would be asked to report any anomalies to County staff, who would then investigate potential problems using the most appropriate technique for each situation (e.g., indicator testing, optical brightener monitoring traps, caulk dams, and microbial source tracking). The County would

[3] Personal communication with Maggie Bell-McKinnon and Kathy Hamel from the Department of Ecology and Ray Hanowell from the Tacoma Pierce County Health Department, January 2008.

need to budget staff time for developing the volunteer program and implementing volunteer training sessions 1-2 times per year, depending on volunteer turnover.

The County should conduct visual inspections and indicator testing as needed to investigate potential pollution sources identified by the volunteers. For example, if sewage contamination is suspected, sampling and analysis for surfactants and ammonia may be appropriate. If the indicator results suggest sewage MST analysis using the PFGE method may be used to help confirm whether e. coli from human sources is present in the sample.

For this planning level cost estimate, program implementation for Year 1 is estimated to require 0.25 FTE and $37,960 in supporting program costs as shown in Table 4. Staff time will be dedicated to initiating a remote sensing program; developing and executing a volunteer program; collecting and analyzing water quality samples based on volunteer concerns; collaborating with Pierce Conservation District and other agencies; and coordinating with the in-lake monitoring program and TPCHD monitoring efforts. Equipment may need to be purchased to conduct sampling. For this planning level cost estimate, it was assumed that the field work would involve approximately 10 indicator tests and 25 optical brightener monitoring traps.

Table 4. Source Monitoring Program Cost Estimate – Year 1

(Based on costs from IDDE Manual, 2004)

Item	Unit	Unit Cost	Quantity	Annual Cost
Color Infrared Aerial Photography	Mile	$400	46	$18,400
Post-flight Image Review of Aerial Photography	Mile	$400	46	$18,400
Indicator Testing	Test	$99	10	$990
OBM Traps[1]	Test	$20	25	$500
			TOTAL	$38,290
Staff Time (Volunteer Program Coordination, Monitoring, & Analysis)	FTE	$100,000	0.25	$25,000

[1] Cost of UV light ($240) included in the cost of 25 tests. Once the UV light is purchased, each OBM trap is expected to cost approximately $10.

For the next four years of program implementation, the County should continue to implement the volunteer monitoring program as well as conduct indicator tests and deploy optical brightener monitoring traps as needed to monitor potential sources of pollutants. If hot spots are identified, the County may decide to perform more concentrated monitoring in those areas. For this planning level cost estimate, it was assumed that monitoring would include approximately 10 indicator tests and 25 optical brightener monitoring traps.

Table 5. Source Monitoring Program Cost Estimate – Years 2-5

(Based on costs from IDDE Manual, 2004)

Item	Unit	Unit Cost	Quantity	Annual Cost
Indicator Testing	Test	$99	10	$990
OBM Traps	Test	$10	25	$250
			TOTAL	$1,240
Staff Time (Volunteer Program Coordination, Monitoring, & Analysis)	FTE	$100,000	0.25	0.25 FTE

During years 2-5 of the source monitoring program implementation, the annual cost of implementing the program is estimated to be 0.25 FTE and $1,240 per year as shown in Table 5. Staff time will continue to be dedicated to executing a volunteer program; collecting and analyzing water quality samples based on volunteer concerns; collaborating with Pierce Conservation District and other agencies; and coordinating with the in-lake monitoring program and TPCHD monitoring efforts. If MST studies are performed, additional funding will be required as budget has not been included for MST in this planning level cost estimate.

Following the first five years of the source monitoring program implementation, it is recommended that the County revisit the program goals and objectives to determine if they are being met and adjust the monitoring program accordingly. It may be appropriate to re-evaluate the program components and consider adding new component or shifting resources to better address emerging issues. To estimate costs for the 10-year CIP budget however, it is assumed that the cost of implementing the program during years 6-10 will be similar to the costs during years 1-5 including the cost of a second round of remote sensing surveying of the shoreline. If the first remote sensing survey documented significant issues that have been remedied during the 5 years of monitoring, another aerial remote sensing survey could document improvements and potentially uncover additional problem areas.

The 10 year cost for implementation of the source monitoring program is estimated to be 0.25 FTE per year and a total of $86,500 in supporting program costs over 10 years. Combining the approximate cost for FTE support with the supporting program costs, the 10-year cost for implementing the pollutant source identification and monitoring program is estimated to be $336,500.

5. References

[Ecology] Washington Department of Ecology. 2001. Stream Sampling Protocols for the Environmental Monitoring and Trends Section. Publication No. 01-03-036.

[Ecology] Washington Department of Ecology. 2006. Lake Tapps (Pierce County) Monitoring Final Data Report. Publication no. 06-03-006.

Field, K. and M. Samadpour. 2007. Fecal source tracking, the indicator paradigm, and managing water quality. Water Research, Volume 41, Issue 16, August 2007, pages 3517-3538.

Holcombe, J. and D. Malone. 2005. The Tennessee Valley Authority's Watershed-Based Approach to Integrated Pollutant Source Inventory. Available online at http://gis.esri.com/library/userconf/proc05/papers/pap1350.pdf. Accessed on 03-18-2008.

[IDDE Manual] Center for Watershed Protection and R. Pitt. 2004. Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments.

Jiang, F. and A. Worthington. 2005. Recommendations for Improving Fecal Coliform Pollution Control in Gwinnett County, Georgia. Available online at http://www.rivercenter.uga.edu/education/upper_altamaha/pdf/gwinnet_f_c_control_2006.pdf. Accessed 03-18-2008.

Lalor, M. 1994. Assessment of Non-Stormwater Discharges to Storm Drainage Systems in Residential and Commercial Land Use Areas. Ph.D. Thesis. Vanderbilt University Department of Environmental and Water Resources Engineering. Nashville, TN.

McDonald, J.L, P.G. Hartel, L.C. Gentit, C.N. Belcher, K.W. Gates, K. Rodgers, J.A. Fisher, K.A. Smith, and K.A. Payne. 2006. Identifying Sources of Fecal Contamination Inexpensively with Targeted Sampling and Bacterial Source Tracking. Journal of Environmental Quality. 35:889-897.

Pierce County, Washington. 2007. White River Basin Plan, Characterization Report. Public Works and Utilities, Water Programs. "Lake Tapps Pollutant Source Survey," p4-95 through 4-98.

Pitt, R. *et al.* 1993. A User's Guide for the Assessment of Non-Stormwater Dischargers Into Separate Storm Drainage Systems. EPA/600-R-92-238. Risk Reduction Engineering Laboratory, USEPA. Cincinnati, OH.

Stockton, G. R. 2004. Advances in Applications and Methodology for Aerial Infrared Thermography. Proceedings: IR/INFO 2004.

USEPA (U.S. Environmental Protection Agendy). 1999. Aerial Photography Helps Assess Septic Systems. Available online at http://www.epa.gov/nerlesd1/land-sci/epic/pdf/fs-septic.pdf. Accessed 01/21/2008.

USEPA. 2003. Elements of a State Water Monitoring and Assessment Program. EPA/841-B-03-003. Available online at http://www.epa.gov/owow/monitoring/elements/. Accessed 01/29/2008.

USEPA. 2005. Microbial Source Tracking Guide Document. Office of Research and Development, Washington, DC EPA-600/R-05/064. 131 pp.

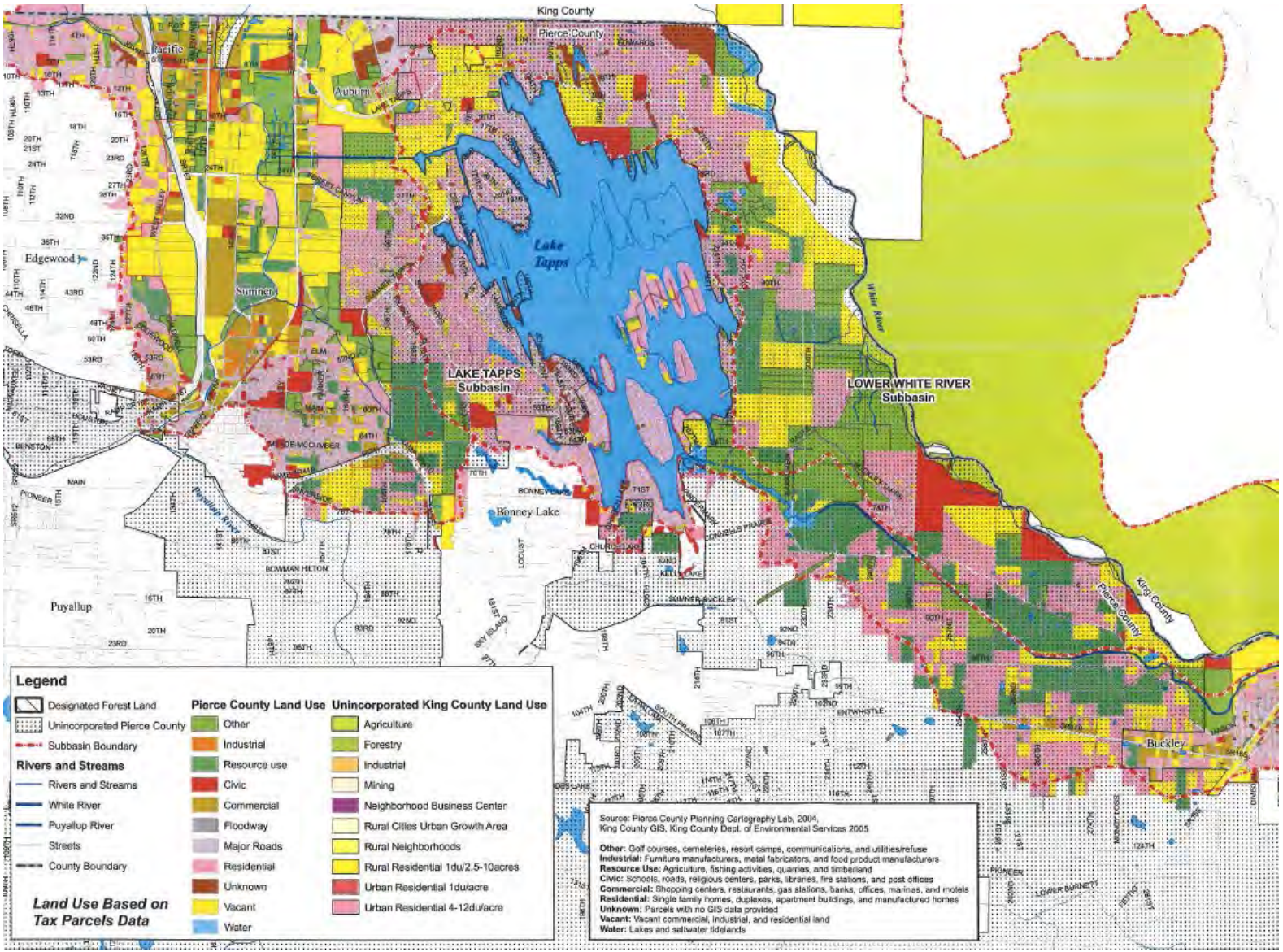


Figure 1: Land Use in the Lake Tapps and Lower White River Subbasins