2010 Stormwater Needs Assessment Program

Little Washougal (Upper)/Little Washougal (Lower)/ Boulder Creek/Jackson Creek Subwatershed Needs Assessment Report

Clark County Department of Environmental Services

March 2011

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Acronyms and Abbreviations

B-IBI	Benthic Macroinvertebrate Index of Biological Integrity
BOCC	Board of County Commissioners
BMP	Best Management Practices
CCD	Clark Conservation District
CIP	Capital Improvement Program
CPU	Clark Public Utilities
CRFPO	Columbia River Fisheries Program Office
CWA	Clean Water Act
CWC	Clean Water Commission
CWP	Clean Water Program
DNR	Department of Natural Resources
EDT	Ecosystem Diagnostic and Treatment model
EIA	Effective Impervious Area
EIM	Environmental Information Management
EMAP	Environmental Mapping and Assessment
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FPIA	Focused Public Investment Area
FWS	Fall, Winter, Spring
GCEC	Gee Creek Watershed Enhancement Committee
GIS	Geographic Information System
GMA	Growth Management Act
GPS	Geographic Positioning System
HPA	Hydraulic Project Approval
IDDE	Illicit Discharge Detection and Elimination
LCFEG	Lower Columbia Fish Enhancement Group
LCFRB	Lower Columbia Fish Recovery Board
LID	Low-Impact Development
LiDAR	Light Detection and Ranging
LISP	Long-term Index Site Project
LWD	Large Woody Debris
MS4	Municipal Separate Storm Sewer System
MOP	Mitigation Opportunities Project
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit
NWIFC	Northwest Indian Fisheries Commission
ODEQ	Oregon Department of Environmental Quality

OWQI	Oregon Water Quality Index
PFC	Properly Functioning Condition
RM	River Mile
SCIP	Stormwater Capital Improvement Program
SCIPIT	Stormwater Capital Improvement Program Involvement Team
SCMP	Salmon Creek Monitoring Project
SCWC	Salmon Creek Watershed Council
SNAP	Stormwater Needs Assessment Program
SWMP	Stormwater Management Program
SWMMWW	Stormwater Management Manual for Western Washington
TIA	Total Impervious Area
TIP	Transportation Improvement Program
TIR	Technical Information Report
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
UGA	Urban Growth Area
UIC	Underground Injection Control
USFS	U.S. Forest Service
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VBLM	Vacant Buildable Lands Model
VLWP	Vancouver Lake Watershed Partnership
WAC	Washington Administrative Code
WCC	Washington Conservation Commission
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WSDOT	Washington Department of Transportation
WSU	Washington State University

Executive Summary

Study Area

This Stormwater Needs Assessment report includes the Little Washougal (Upper), Little Washougal (Lower), Boulder Creek, and Jackson Creek subwatersheds.

Intent

Stormwater Needs Assessment reports compile and provide summary information relevant to stormwater management, propose stormwater-related projects and activities to improve stream health, and assist with adaptive management of the county's Stormwater Management Program. Assessments are conducted at a subwatershed scale, providing a greater level of detail related to stormwater management than regional Water Resource Inventory Area (WRIA) or Endangered Species Act (ESA) plans. Stormwater Needs Assessments are not comprehensive watershed plans or stormwater basin plans.

Findings

Watershed Conditions

The table on the following page summarizes conditions in the four study area subwatersheds, including water quality, biological health, habitat, hydrology and the stormwater system.

Ongoing Projects and Involvement

The CWP actively coordinates with the Washington State Department of Ecology, Lower Columbia Fish Recovery Board, Clark County Legacy Lands and Vancouver-Clark Parks and Recreation in efforts to improve stream health. In the study area, there are no planned projects included in the Stormwater Capital Program or in the 2010-2015 Clark County Transportation Improvement Program.

Category	Status
Water Quality	
Overall	• Fair; Boulder Creek and Little Washougal (Lower), to good; Little Washougal (Upper); no data for Jackson Creek
Fecal coliform bacteria	• Meets state criteria
Temperature	• Little Washougal River exceeds target levels
pH	• Jones Creek is Category 2 listed (Waters of Concern)
Total phosphorus	• Meets EPA criterion (Jones Creek)
Biological	
Benthic macroinvertebrates	• Moderate to high biological integrity
Anadramous fish	• Coho, Chum, Fall Chinook and summer and winter steelhead
Habitat	
NOAA Fisheries criteria	• Forest cover Properly functioning for all subwatersheds except Little Washougal (Lower) • Road Density Non-functioning for all subwatersheds except Jackson Creek • Percent TIA is Properly functioning in the Jackson Creek subwatershed and between Properly Functioning and Non-Functioning for the remainder of the study area • Stream crossing density and estimated effective impervious area fall into the Properly Functioning category in all subwatersheds
Riparian	• Riparian conditions rated as Moderately Impaired • Large woody debris recruitment potential is low to moderate in the upper reaches and moderate to good in the lower reaches
Wetland	• Wetlands less than 2 percent of subwatershed area • Primarily limited to main channels including natural depressions and man-made impoundments
Hydrology and Geomorphology	
Overall hydrology	• Rated as good hydrologic health. No detailed hydrologic assessment but likely typical for a partly forested rural watershed
Future condition	• Projected impervious area should remain at levels that do not alter hydrology if forest cover is retained or expanded
Stormwater (unincorporated areas)	
System description	• Primarily road-side ditches; four private stormwater facilities
Inventory status	• Complete
System adequacy	• Adequate treatment is probably provided by vegetation in ditches • Minimal flow control other than infiltration in ditches
System condition	• No outfall screening was performed

Category	Status
	• Largely undocumented but presumed functional

Opportunities

Opportunities for stormwater-related projects are somewhat limited in this assessment area. Field work and review of existing information identified the following projects and actions that can improve stream conditions:

- Technical assistance visits to landowners and businesses with potential source control problems and water quality ordinance issues
- Focused stormwater outreach and education to streamside landowners
- Continue to expand efforts to design and build runoff reduction strategies in county right-of-way, such as ditch retrofits to provide water quality treatment
- Continue research and mapping new stormwater infrastructure with the goal of maintaining a complete stormwater infrastructure inventory

Non-project stormwater management recommendations address areas where CWP programs or activities could be modified to better address NPDES permit components or promote more effective mitigation of stormwater problems. Management recommendations relevant to the assessment area include:

- Continue to coordinate with Washington Department of Ecology, Lower Columbia Fish Recovery Board, Clark County Legacy Lands and Vancouver-Clark Parks and Recreation in efforts to improve stream health.
- Replace deteriorated stream name signs at road crossings
- Educate landowners to discourage disposal of trash and yard debris in streams or other receiving waters
- Develop a system to provide education about appropriate ditch maintenance practices to rural landowners
- Provide technical assistance to rural development projects required to implement stormwater controls
- Continue to encourage and support riparian planting efforts by private landowners
- Perform targeted technical assistance to ensure that timber harvest, land development and road BMPs are implemented
- Implement development regulations to minimize impacts, particularly from clearing and grading

Introduction

This Stormwater Needs Assessment includes the Little Washougal (Upper), Little Washougal (Lower), Boulder Creek, and Jackson Creek subwatersheds. The Clean Water Program (CWP) is gathering and assembling information to support capital improvement project (CIP) planning and other management actions related to protecting water bodies from stormwater runoff.

Purpose

The Stormwater Needs Assessment Program (SNAP), initiated in 2007, creates a system for the CWP to focus activities, coordinate efforts, pool resources and ensure the use of consistent methodologies. SNAP activities assess watershed resources, identify problems and opportunities, and recommend specific actions to help meet the CWP mission of protecting water quality through stormwater management.

The overall goals of SNAP are to:

- Analyze and recommend the best, most cost effective mix of actions to protect, restore or improve beneficial uses consistent with NPDES permit objectives and the goals identified by the state Growth Management Act (GMA), ESA recovery plan implementation, Total Maximum Daily Load (TMDLs), WRIA planning, floodplain management and other local or regional planning efforts
- Inform county efforts to address the following issues related to hydrology, hydraulics, habitat, and water quality:
    - Impacts from current or past development projects subject to lesser or non-existent stormwater treatment and flow control standards
    - Subwatershed-specific needs due to inherent sensitivities or the present condition of water quality or habitat
    - Potential impacts from future development

The CWP recognizes the need to translate assessment information into on-the-ground actions to improve water quality and habitat. Facilitating this process is a key requirement for the program's long-term success.

Results and products of needs assessments promote more effective implementation of various programs and mandates. These include identifying mitigation opportunities and providing a better understanding of stream and watershed conditions for use in planning county road projects. Similar information also is needed by county programs implementing critical areas protection and salmon recovery planning under the state GMA and federal ESA.

Scope

This report summarizes and incorporates new information collected for SNAP, as well as pre-existing information. In many cases, it includes basic summary information or incorporates by reference longer reports which may be consulted for more detailed information.

SNAP reports produce information related to three general categories:

- Potential stormwater capital projects for county implementation or referral to other organizations
- Management and policy recommendations
- Natural resource information

Descriptions of potential projects and recommended program management actions are provided to county programs, including: Public Works CWP, Stormwater Capital Improvement Program (SCIP) and Development Engineering; Community Planning; Public Health; Legacy Lands; ESA. Potential project or leveraging opportunities also are referred to local agencies, groups and municipalities as appropriate.

Assessment Approach

Priorities for Needs Assessment in Little Washougal (Upper), Little Washougal (Lower), Boulder Creek, and Jackson Creek

Clark County subwatersheds were placed into a five year schedule for assessment using the procedures described in Prioritizing Areas for Stormwater Basin Planning (Swanson, July 2006).

For SNAP purposes, the Little Washougal (Lower) is categorized as Rural Residential Including City-Serviced Fringes of Urban Growth Area. The Little Washougal (Upper) is categorized as Rural Residential with No UGA, and Boulder Creek and Jackson Creek are categorized as Largely Forested Land.

Rural Residential Including City-Serviced Fringes of Urban Growth Area subwatersheds typically include rural areas bordering cities. These subwatersheds often score a high priority for stormwater management in general, but are a lower priority for Clark County due to the rural nature of unincorporated portions. Stormwater management needs tend to be limited in these areas. Urban development in this assessment area is controlled by the cities of Ridgefield and La Center.

Subwatersheds in the Rural Residential with No UGA category are generally not heavily forested but have limited stormwater management needs due to the lack of urbanization. Assessment efforts for these subwatersheds focus primarily on summarizing existing information to identify potential restoration projects."

Largely Forested Land subwatersheds contain significant amounts of private land zoned for industrial forestry and DNR forest lands. These areas have few county roads and stormwater management is limited to mapping and evaluating the area draining to county outfalls and possible habitat protection or restoration to mitigate for stormwater impacts to other parts of a watershed.

Assessment Tools Applied in Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek

SNAP uses a standardized set of tools for subwatershed assessment, including desktop mapping analyses, modeling, outreach activities and a variety of field data collection procedures. Tools follow standard protocols to provide a range of information for stormwater management. Though not every tool is applied in every subwatershed, the use of a standard toolbox ensures the consistent application of assessment activities countywide.

Table 1 lists the set of tools available for use in SNAP. Tools with an asterisk (*) are those for which new data was gathered or new analyses were conducted during this needs assessment. The remaining tools or chapters were completed based on pre-existing information.

Table 1: Stormwater Needs Assessment Tools

Outreach And Involvement *	Riparian Assessment *
Coordination with Other Programs *	Floodplain Assessment
Drainage System Inventory and Condition *	Wetland Assessment *
Review Of Existing Data *	Macroinvertebrate Assessment *
Illicit Discharge Screening	Fish Use And Distribution *
Broad Scale GIS Characterization *	Water Quality Assessment *
Rapid Stream Reconnaissance	Hydrologic and Hydraulic Modeling
Physical Habitat Assessment *	Source Control *
Geomorphology And Hydrology Assessment	

Assessment Actions

Outreach Activities

Outreach activities were limited and focused primarily on raising awareness about the SNAP effort. The following activities were completed:

- Press release to local media
- April 2010 – article in Clean Water Program E-Newsletter
- August 2010 – information on SNAP distributed at 10-day Clark County Fair
- Clean Water Program web pages updated as needed; 135 visitors to SNAP web page since June 2010 (Note: these figures are under-reported as tracking software only records top 20 pages and documents monthly)
- A description of SNAP is included in Clark County's annual stormwater management program plan submitted to Ecology

Clark County Clean Water Commission members were updated periodically on SNAP progress.

Actions available to educate in response to identified problem areas include the following:

- Site visits by CWP technical assistance staff
- Letters detailing specific problems and solutions to individual landowners
- General educational mailings to selected groups of property owners
- Workshops on best management practices, including septic maintenance and mud, manure and streamside property management
- Referral to other agencies, such as Clark Conservation District or WSU Extension, for educational follow-up

Review of Existing Data

Data and information review is incorporated throughout this report in pertinent sections. A standardized list of typical data sources created for the overall SNAP effort is supplemented by subwatershed-specific sources as they are discovered. Data sources consulted for this report include, but are not limited to those listed below:

- LCFRB Habitat Characterization (2004)
- LCFRB 6-Year Habitat Work Plan
- Ecology 303(d) list
- WRIA 27/28 Plan
- Ecology EIM data
- Clark County 2004 Subwatershed summary

- Clark County 2006 Stormwater Basin Planning
- Clark County 2010 Stream Health Report
- Clark County LISP/SCMP/ Project data
- Clark County 6-Year TIP

Broad-Scale GIS Characterization and Metrics

The broad-scale characterization is a GIS-based exercise providing an overview of the biophysical setting for each subwatershed, background information for use in implementing other SNAP tools, and identification of potential acquisition or project sites. GIS data describe subwatershed characteristics such as topography, geology, soils, hydrology, land cover, land use and GMA critical areas. A standard GIS workspace, including shape files for more than 65 characteristics, forms the basis for the characterization.

GIS data are generally used as a tool to complete the report and not presented in the report itself. Summary metrics are taken from existing reports and data. For example, Wierenga (2005) summarized many GIS characteristics for Clark County subwatersheds. Some of these characteristics are described in greater detail in later sections.

The characterization includes three components:

- A set of four standard map products, as paper maps for SNAP use
- A summary table of selected subwatershed-scale metrics
- A brief narrative including comparison of metrics to literature values and conclusions about general subwatershed condition and potential future changes

Map Products

The four standard SNAP map products are: 1) Stormwater Infrastructure and Hydrologic Soil Groups; 2) Critical Areas information; 3) Vacant Buildable Lands within UGAs; 4) Orthophoto. These maps are printed out for tabletop evaluations.

General Conditions and Subwatershed Metrics

General Geography

The study area comprises four subwatersheds in the Washougal River basin: Little Washougal (Upper), Little Washougal (Lower), Boulder Creek, and Jackson Creek subwatersheds. The Little Washougal (Upper) and Boulder Creek subwatersheds group a number of forested streams draining to the Little Washougal River, including East Fork Little Washougal River, Jones Creek, Boulder Creek and several small unnamed creeks that drain steep canyons (Figure 1).

Land use in these subwatersheds is primarily forested and contains significant amounts of private land zoned for industrial forestry and DNR forest lands.

The Little Washougal (Lower) subwatershed encompasses the Little Washougal River from the confluence of Boulder creek and East Fork Little Washougal River to the Washougal River. This subwatershed also has several small unnamed creeks that have their headwaters at the base of

steep canyons. Land use is rural residential in lower elevations and forested on steeper hills and higher elevations in the northeastern part of the study area. The entire area is rural with the southern portion of the subwatershed just inside the urban growth area.

The Jackson Creek subwatershed drainage area drains water eastward to the West Fork Washougal River in Skamania County. Land use in this subwatershed is primarily forested and contains significant amounts of private land zoned for industrial forestry and DNR forest lands.

Topography

In the study area, Little Washougal (Upper), Boulder Creek and Jackson Creek subwatersheds are generally mountainous terrain in the Western Cascade Mountains foothills near the eastern boundary of Clark County. The ridge elevation is roughly 1,400 to 2,000 feet with a high point of 3,500 feet at Larch Mountain.

The Little Washougal (Lower) subwatershed is generally about 400 to 800 feet above sea level between mountain ridges that reach about 900 feet elevation to the west and about 1,000 feet on the east. The Little Washougal River's confluence with Washougal Creek drops to about 100 feet above sea level.

Geology and Soils

The study area is underlain by two principal geologic units. Oligocene volcanic andesite lava underlies most of the basin above 400 to 500 feet elevation. Consolidated gravel deposited by an ancestral Columbia River forms ridges up to about 500 feet elevation. Ice Age sediments are present in the lower Little Washougal terraces and alluvial deposits are found along channels having flood plains.

Soils formed on the volcanic andesite lavas and glacial deposits are generally well-drained mountain soils belonging to the Kinney Series and Olympic Series.

Hydrology

Geology and topography play the main role in determining the study area hydrologic framework. Mountain streams are generally higher gradient and have little or no floodplain. Much of the precipitation leaves the area as rainfall runoff or shallow interflow, leaving streams with low flows in summer months.

All tributary streams in the study area drain mostly forested and rural areas. Consequently, stream hydrology is not altered considerably from a natural forested condition.

Clark County operates stream gauges on Jones Creek, Little Washougal (Upper) and Little Washougal (Lower). Stream flow data in this study area indicate that streams maintain a "natural" flow pattern during wet and dry months.

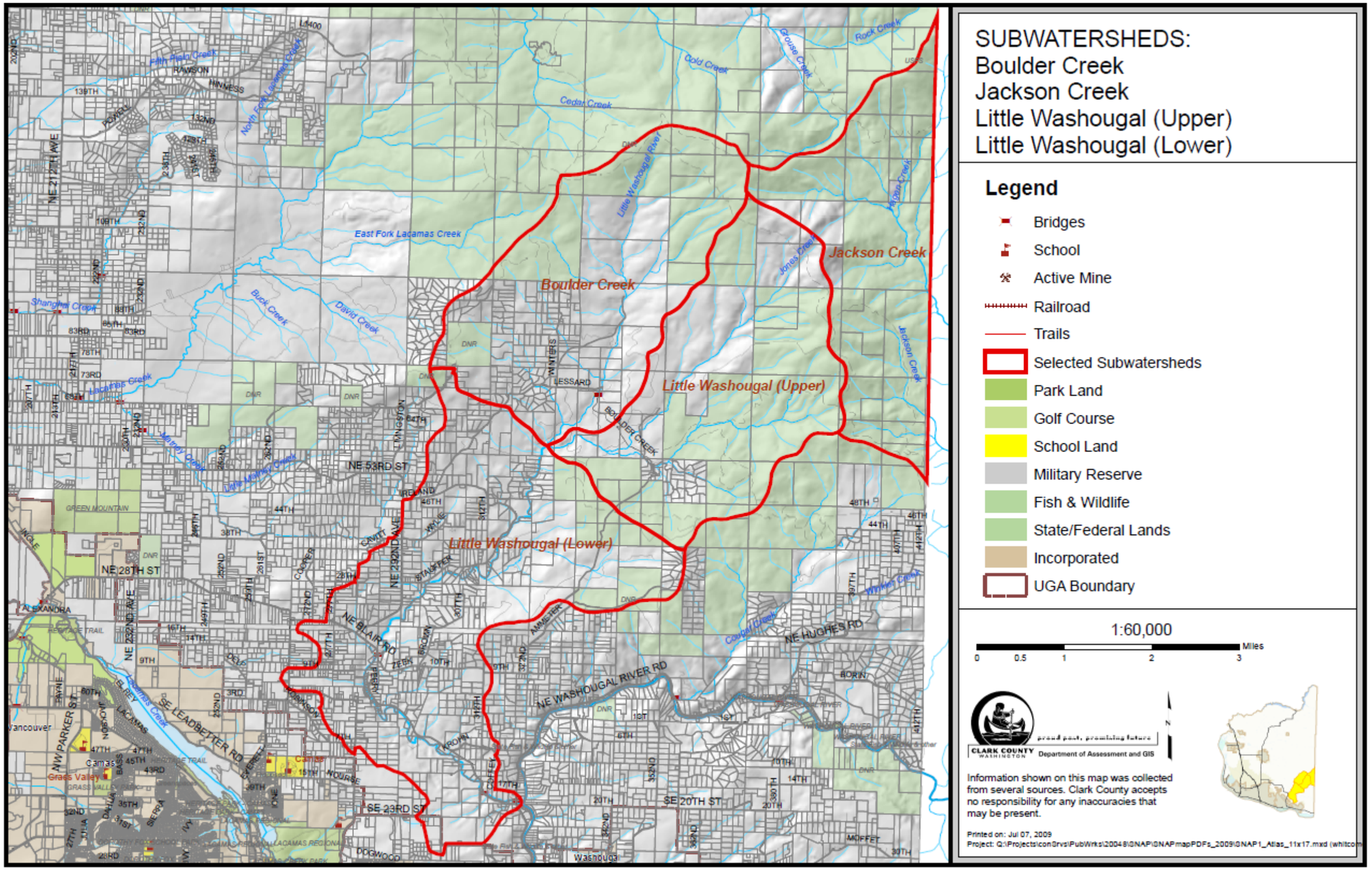

Figure 1: Subwatershed Map: Boulder Creek, Jackson Creek, Little Washougal (Upper), and Little Washougal (Lower) Subwatersheds

Subwatershed Metrics

Subwatershed scale metrics provide a simple way to summarize overall conditions. Metrics are calculated from Landsat land cover analysis and current GIS data. Benchmarks for properly functioning and not properly functioning are based on NOAA fisheries standards for salmon protection and restoration (1996 and 2003).

Overall, these metrics suggest that the Boulder Creek, Jackson Creek, and Little Washougal (Upper) subwatersheds have functioning stream habitat (Table 2). Little Washougal (Lower) subwatershed does not completely meet standards due to lost forest and the amount of roads present.

Table 2: Watershed Scale Metrics

Metric	Boulder Creek	Jackson Creek	Little Washougal (Upper)	Little Washougal (Lower)	Functioning	Non-functioning
Percent Forested (2000 Landsat)	80.2	87.9	91.4	48.2	> 65 %	< 50 %
Percent TIA (2000 Landsat)	6.8	4.6	5.1	13.4	< 5 %	> 15 %
Road Density 2007 data (miles/mile2)	4.3	1.4	4.4	6.2	< 2	> 3
Stream Crossing Density (crossings per stream mile)	1.0	0.4	0.9	1.7	< 3.2/mile	> 6.4/mile
Percent EIA estimated from the Comprehensive Plan	0.9	0	0	3.4	< 10 %	> 10 %

Forest Cover

The proportion of a watershed in forest cover is known to have a profound influence on watershed processes. Forest cover estimates are taken from a report summarizing land cover for Clark County (Hill and Bidwell, January 2003). Research in the Pacific Northwest has shown that when forest cover declines below approximately 65 percent, watershed forming processes become degraded (Booth and Jackson, 1997). These include reducing riparian shade, less wood debris delivery to streams, increased stormwater runoff, and increased fine sediment delivery due to mass wasting.

Boulder Creek, Jackson Creek and Little Washougal (Upper) are largely forest tracts in various stages of growth that range from recently cleared to mature forest. Little area is cleared for pasture or residential use. Percent forested values place for these subwatersheds place them well into the functioning habitat.

The Little Washougal (Lower) subwatershed contains large amounts of agricultural clearing, rural residential use and pasture in the lower portions of the subwatershed. This is reflected in the much lower percentage of remaining forested area in comparison to the Boulder Creek, Jackson Creek and Little Washougal (Upper) subwatersheds.

TIA (Total Impervious Area)
Total impervious area is one of the most widely used indicators of urbanization and coincident watershed degradation (Center for Watershed Protection, March 2003). Total impervious areas are estimated from land cover data in Hill and Bidwell (January 2003). While various organizations and publications categorize stream condition based on TIA, the NOAA fisheries standard is less than five percent as fully functional and greater than 15 percent as non-functioning. The TIA estimate is within the functioning habitat value (< 5 %) in Jackson Creek subwatershed and currently between functioning and non-functioning habitat in the remainder of the study area.

Road Density
Road density, including all public and private roads, is an easily calculated development measure. Based on criteria set by NOAA Fisheries to protect salmon habitat, road densities are within the functioning criteria (< 2) in Jackson Creek subwatershed and approximately two to three times as dense as the threshold for non-functioning (>3 road miles/mi^2) in the remainder of the study area.

Stream Crossing Density
Stream crossing densities are easily measured using available road and stream channel data. The salmon protection standard considers larger fills more than 60 feet wide, which would be approximately five- to 10-foot high road fill. The study area subwatersheds all have stream crossing densities within the functioning category (<3.2 crossings/stream mile NOAA Fisheries criteria).

Future Effective Impervious Area
Effective impervious area is the amount of impervious area that actually drains to a water body. Depending on factors such as soil types and level of development, effective impervious area is about half (lower intensity development) to almost equal (high intensity development) the TIA value.

The Comprehensive Plan guides development for the next few years and when used to estimate effective impervious area, it can provide a metric for potential hydrologic impacts due to expected development. Expected EIA in the study area ranges from zero to approximately 3 percent, which is well within the 10 percent EIA NOAA Fisheries standard for functioning salmon habitat.

Estimated Channel Stability Based on Forest and EIA

In a recent publication by Booth, Hartley, and Jackson (June 2002), a relationship between forest and percent EIA was presented as a graphic (Figure 2). According to this figure, streams in Boulder Creek, Jackson Creek and Little Washougal (Upper) subwatersheds would be expected to have stable channels.

The Little Washougal (Lower) subwatershed falls into the 'zone of uncertain channel stability' category. This indicates that through protection and restoration activities, it may be possible to increase forest cover and reduce the EIA as approaches to improve stream habitat. Conversely, increased land clearing could result in less stable channel conditions. Based on subwatershed scale conditions, the Little Washougal (Lower) is a good candidate for improving forest functions that could have a measurable impact on channel stability.

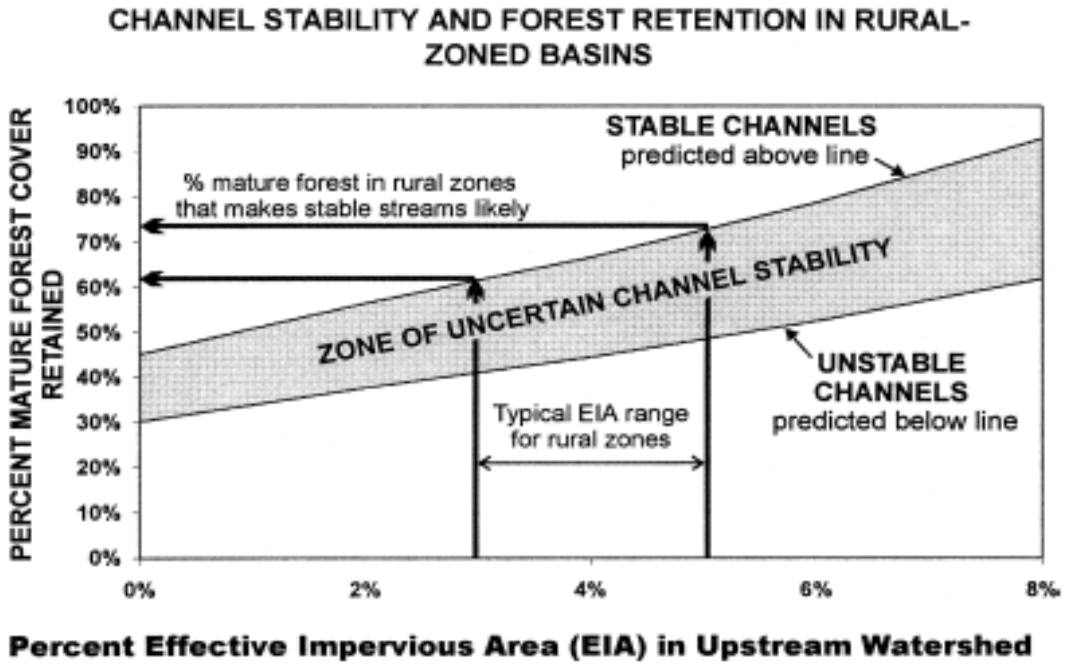

Figure 2: Channel stability in rural areas (Booth, Hartley, and Jackson, June 2002)

Water Quality Assessment

This section briefly summarizes and references available water quality data from the Little Washougal (Upper and Lower), Boulder Creek, and Jackson Creek subwatersheds. A description of applicable water quality criteria is included, along with discussions of beneficial use impacts, likely pollution sources and possible implications for stormwater management planning.

Water Quality Criteria

For a full explanation of current water quality standards see the Ecology website at: http://www.ecy.wa.gov/programs/wq/swqs/index.html

Under Washington state water quality standards, the Washougal River from Section 7 T1N R4E, including tributaries, is to be protected for the designated uses of: "Core Summer Salmonid Habitat; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values" (WAC 173-201A-600, Table 602).

Table 3 summarizes currently applicable water quality criteria for the assessment area.

Table 3: Applicable Water Quality Criteria for Little Washougal, Boulder and Jackson Creek Subwatersheds

Characteristic	Ecology criteria
Temperature	≤ 16° C (60.8° F)
Dissolved Oxygen	≥ 9.5 mg/L
Turbidity	Shall not exceed 5 NTU over background when background is 50 NTU or less
pH	6.5 – 8.5 units
Fecal coliform bacteria	Geometric mean fecal coliform concentration not to exceed 100 colonies/100mL, and not more than 10% of samples exceeding 200 colonies/100mL.
Aesthetics	Aesthetic values must not be impaired by the presence of materials or their effects… which offend the senses of sight, smell, touch, or taste
Toxics	Toxic substances shall not be introduced… which have the potential…to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health

Source: Washington Department of Ecology (http://www.ecy.wa.gov/programs/wq/swqs/index.html)

303(d) Listed Impairments

The 2008 303(d) list of impaired waters is on the Ecology website at: http://www.ecy.wa.gov/programs/wq/303d/index.html

Jones Creek (a tributary to the Upper Little Washougal River) is Category 2 listed (Waters of Concern) for pH. There are no listings for Jackson Creek or the Little Washougal River.

Clark County Stream Health Report

In 2010, the CWP compiled available data and produced a countywide assessment of general stream health.

Based on the available dataset including water quality, biological health and stream flow patterns, overall stream health in the Little Washougal (Upper) subwatershed scored in the good range, while Boulder Creek and the Little Washougal (Lower) subwatershed scored fair. Sufficient data were not available to score the Jackson Creek subwatershed.

The 2010 Stream Health Report may be viewed on the county website at: http://www.clark.wa.gov/water-resources/stream.html.

Available Data

A considerable water quality dataset is available for Jones Creek in the Little Washougal (Upper) subwatershed. Data from the remaining subwatersheds in this study area are limited to summertime temperature records from 2004.

A full review and summary of available data and studies are beyond the scope of this document. This summary focuses on recent water quality data collected by the CWP, including monthly water quality data from Jones Creek (2002 through 2009) and temperature data collected during the summer of 2004 for the Lower Columbia Fish Recovery Board. Associated reports may be viewed on the CWP website at: http://www.clark.wa.gov/water-resources/documents-monitoring.html#strmac

Data and information sources reviewed or summarized as part of this water quality characterization are listed in Table 4.

Table 4: Data Sources

Source	Data and/or Report
Clark County Clean Water Program	2002-2009 Long-term Index Site Project 2010 Stream Health Report Benthic Macroinvertebrate and Water Temperature Monitoring for Clark County Watershed Assessments in 2004

Water Quality Summary

Long-term monthly data and summer temperature data are collected at Station JNS060 (Jones Creek upstream of Camas water intake).

Stream temperature was recorded continuously during summer 2004 at the following stations:

- LWG015 (Little Washougal River at Blair Road)
- LWG040 (Little Washougal R at Blair Rd Br 252)

- LWG050 (Little Washougal R at 40th Circle)
- LWG080 (Little Washougal R at 324th Ave)

Oregon Water Quality Index (OWQI) Scores
The OWQI was developed by the Oregon Department of Environmental Quality (ODEQ) as a way to improve understanding of water quality issues by integrating multiple characteristics and generating a score that describes water quality status (Cude, 2001). It is intended to provide a simple and concise method for expressing ambient water quality.

The OWQI integrates eight water quality variables: temperature; dissolved oxygen; biochemical oxygen demand; pH; ammonia + nitrate nitrogen; total phosphorus; total solids; and fecal coliform. For each sampling event, individual sub-index scores and an overall index score are calculated. Overall index scores are aggregated into low flow (June through September) and high flow (October through May) seasons, and a seasonal mean value is calculated.

Index scores are categorized as follows:
very poor = 0 to 59; poor = 60 to 79; fair = 80 to 84; good = 85 to 89; excellent = 90 to 100.

Since 2003, annual OWQI scores for JNS060 have ranged from 92 to 97, remaining in the excellent category in all seven years. The most recent dataset in WY2009 fell in the middle of this range with an OWQI score of 94. Among 15 long-term monitoring stations countywide between 2002 and 2006, Station JNS060 ranked first in overall water quality (Hutton and Hoxeng, 2007).

Eleven monthly samples were collected in WY2009 (no sample in December 2008). Monthly OWQI values in WY2009 were excellent every month. Monthly sub-index scores for fecal coliform, temperature, dissolved oxygen and total solids were consistently excellent. Total phosphorus scores were typically excellent but fell to the good category in two months. Nitrogen scores were excellent except for a single month with a poor score. Scores for pH ranged from poor to excellent, with eight of eleven scores in the excellent category.

Trends Over Time
An analysis of potential statistical trends in OWQI scores based on the 2002-2006 dataset found no significant trends in water quality at Station JNS060.

Nutrients
Nutrient criteria are not established for Washington streams. EPA suggests a total phosphorus criterion of 0.100 mg/L for most streams and 0.050 mg/L for streams which enter lakes (EPA, 1986). EPA nitrate criteria are focused on drinking water standards and are not generally applicable to aquatic life issues.

Phosphorus and nitrogen in excess may contribute to elevated levels of algal or plant growth, especially in slower moving, low gradient streams or in downstream water bodies.

Total phosphorus samples from station JNS060 during WY2009 ranged from 0.010 mg/L to 0.047 mg/L. No samples exceeded the EPA criterion.

Turbidity
It is difficult to establish an exact background turbidity level for the assessment area because no data exist from a time when it was not impacted by human activities. However, based on data from the least-impacted streams monitored by CWP, we estimate that natural background turbidity in most Clark County streams would have been in the range of 0.5 to 2 NTU. Based on this estimate, the turbidity criterion is likely between 5.5 and 7 NTU.

The median of 11 samples collected in WY2009 was 1.4 NTU, with a range of 0.3 to 2.2 NTU.

Fecal Coliform Bacteria
Based on 11 monthly samples collected in WY2009, fecal coliform levels met both parts of the state criteria. Geometric mean concentration at station JNS060 was 2 cfu/100mL and the 90th percentile value was 6 cfu/100mL. No samples exceeded 100 cfu/100mL.

Stream Temperature
One summer of continuous temperature monitoring (2004) at Stations LWG015, LWG040, LWG050 and LWG080 indicated that water temperature in the Little Washougal River exceeded target levels. The maximum of the 7-day moving average of daily maximum temperatures (7-DAD Max) at the time of the study was not to exceed 64º F. As of 2006, the temperature criterion changed to 60.8º F for all of these stream segments. Table 5 summarizes results from all four stations.

Table 5: Little Washougal River water temperature summary, summer 2004. Adapted from Wierenga, November 2005)

Station	Date	7-DADMax temperature	Duration >64 deg F
LWG015	8/12/04	73.2	54
LWG040	8/12/04	69.7	42
LWG050	8/12/04	67.9	37
LWG080	8/12/04	65.9	20

Due to the negative effects of chronic high temperatures on salmonids and other cold-water biota, the amount of time spent with elevated temperatures also is of interest. Table 5 indicates the number of days on which the *daily* maximum temperature exceeded 64º F at each station. Sixty-four degrees was the Class A criterion prior to November 2006 and is a threshold above which salmonids are known to suffer deleterious effects. At the Little Washougal River stations, daily temperatures exceeded 64º F between 20 and 54 days during July and August. Temperatures and time exceeding 64º F increased consistently from upstream to downstream stations.

Impacts to Beneficial Uses and Potential Sources
General water quality in Jones Creek is excellent, according to the overall OWQI and other measures discussed above. Observed water temperatures in the Little Washougal River may have negative impacts on the listed beneficial uses of core summer salmonid habitat. Table 6 at the

conclusion of this section summarizes the primary water quality impacts to beneficial uses in the study area and probable sources of the observed impact.

Implications for Stormwater Management

Table 6 lists the primary known water quality concerns and potential solutions for each. Solutions listed in bold indicate areas where CWP activities can have a positive impact. It should be noted that CWP activities, though important, are not likely to achieve water quality improvement goals on their own. Other county departments, local agencies and, not least of all, the public must all contribute to water quality improvement.

Table 6: Known Water Quality Concerns, Sources, and Solutions for Little Washougal River

Characteristic	Beneficial Use Affected	Potential Sources	Mechanism	Solutions (bold indicates direct Clean Water Program involvement)
Water temperature (mainstem Little Washougal River)	Core summer salmonid habitat	vegetation removal	direct solar radiation	**Streamside planting/vegetation enhancement/riparian preservation through acquisition** **Education programs** Pond removal or limitation
		low summer flows	decreased resistance to thermal inputs	

Drainage System Inventory and Condition

Inventory

Clark County's drainage system inventory resides in the StormwaterClk GIS database and is available to users through the county's GIS.

Drainage system inventory is an ongoing CWP work effort focused on updating the StormwaterClk database to include all existing stormwater drainage infrastructure. In 2008-2009, the inventory was a significant priority for the CWP, with a major work effort focused on identifying and mapping previously unmapped infrastructure and reviewing existing records for completeness and accuracy.

Table 7 indicates the number of features currently inventoried in StormwaterClk. Of the four stormwater facilities, none are publicly owned and operated.

Table 7: Drainage System Inventory Results Boulder Creek/Jackson Creek/Little Washougal (Upper and Lower)

Database Feature Category	Inventoried prior to 2007	Added during 2007-2009	Total Features
Inlet	0	12	12
Discharge Point (outfall)	1	345	346
Flow Control	1	1	2
Storage/Treatment	3	7	10
Manhole	0	1	1
Filter System	0	0	0
Channel	26	1183	1209
Gravity Main	118	520	638
Facilities	2	2	4

Condition

Stormwater system condition is assessed based on three components:

- An evaluation of retrofit opportunities at public stormwater facilities
- An inspection and maintenance evaluation at public stormwater facilities
- An off-site assessment to check for outfall-related problems in downstream receiving waters

Component 1: Retrofit Evaluation

Purpose

The purpose of this component is to identify existing public stormwater facilities that may be retrofitted to provide additional storage or treatment beyond the level intended during original construction.

Methods

The evaluation is conducted at all public stormwater facilities that contain detention ponds, treatment wetlands, wet ponds, pre-settling cells, open filters or bioswales and discharge to surface waters or stormwater drainage infrastructure that eventually discharges to surface waters.

The retrofit evaluation includes a review of the drainage area, stormwater infrastructure condition, facility lot size, ownership of adjacent parcels, and the functionality of the facility objects listed above. Facilities or parcels with the potential to provide additional storage and/or treatment of stormwater are referred as "potential retrofit" opportunities for further evaluation as Capital Improvement Projects.

Results

Based on the county's StormwaterClk database, as of August 2010, there were no mapped public stormwater facilities in the Boulder Creek, Jackson Creek or Little Washougal (Upper and Lower) subwatersheds.

Component 2: Inspection and Maintenance Evaluation

Purpose

The inspection and maintenance evaluation verifies that maintenance activities are implemented and facilities are properly functioning.

Methods

The inspection and maintenance evaluation is conducted at public stormwater facilities in conjunction with retrofit evaluations. Public stormwater facilities are evaluated if they contain detention ponds, treatment wetlands, wet ponds, pre-settling cells, open filters or bioswales and discharge to surface waters or stormwater drainage infrastructure that eventually discharges to surface waters.

Public stormwater facilities that contain filter systems, buried detention or retention vaults, and facilities that infiltrate stormwater are typically not included in this evaluation. They may be inspected on a case-by-case basis as resources allow.

The evaluation is conducted using county and state standards equivalent to maintenance standards specified in Chapter 4, Volume V, of the 2005 Stormwater Management Manual for Western Washington. The standards list the part or component of the facility, condition when repair or maintenance is needed and expected results. Individual components of a facility are referred to as "facility objects."

The inspection and maintenance evaluation process involves inspecting all facility objects to determine if maintenance complies with the standards. If any facility object fails to meet the maintenance standards, the entire facility is not in compliance. Noncompliant stormwater facilities are referred to the appropriate department for repairs or maintenance.

Results

Based on the county's StormwaterClk database, as of August 2010, there were no mapped public stormwater facilities in the Boulder Creek, Jackson Creek or Little Washougal (Upper and Lower) subwatersheds.

Component 3: Offsite Assessment

Purpose

Discharges from stormwater outfalls can cause moderate to severe erosion as stormwater moves through the riparian zone and to the receiving water. Erosion creates a source of sediment to the stream due to incision and slope failures. It also can increase slope instability problems.

The Offsite Assessment looks for offsite or downstream problems associated with the county's storm sewer system, particularly from facility outfalls that discharge to critical areas.

Methods

County-owned and operated stormwater outfalls meeting one or more of the following criteria are included in the offsite assessment:

- Within 200 feet of a critical area (e.g. riparian, wellhead protection, landslide hazard, etc)
- Within 300 feet of a headwater stream
- Located on public land
- Originates from a public-dedicated facility currently under the two-year maintenance warranty bond

Stormwater outfalls are prioritized into three categories:

- Priority 1 outfalls are stormwater outfalls that discharge to landslide hazard areas outside of county road rights-of-way.
- Priority 2 outfalls are stormwater outfalls that discharge to all other critical areas outside of county road rights-of-way
- Priority 3 outfalls are stormwater outfalls that discharge to critical areas within county road rights-of-way

At a minimum, all Priority 1 outfalls are inspected. As resources allow, Priority 2 and Priority 3 outfalls may be inspected. If an outfall fails to meet the general outfall design criteria or is contributing to a downstream erosion problem, the outfall is not in compliance. Non-compliant outfalls are referred to the appropriate Public Works program for maintenance or repair or, in some cases, referred as potential Capital Projects.

Results

Based on the county's StormwaterClk database, as of August 2010, there were 175 mapped outfalls in the Little Washougal (Lower) subwatershed, 12 mapped outfalls in the Little Washougal (Upper) subwatershed, and 34 mapped outfalls in Boulder Creek subwatershed discharging to critical areas. There were no mapped outfalls discharging to critical areas in the Jackson Creek subwatershed.

In the Little Washougal (Lower) subwatershed, there were no mapped Priority 1 or Priority 2 outfalls, and 175 Priority 3 outfalls.

In the Little Washougal (Upper) subwatershed, there were no mapped Priority 1 or Priority 2 outfalls, and 12 Priority 3 outfalls.

In the Little Boulder Creek subwatershed, there were no mapped Priority 1 or Priority 2 outfalls, and 34 Priority 3 outfalls.

Table 8, Table 9, and
Table 10 summarize results Boulder Creek and Little Washougal (Upper and Lower) subwatersheds. There were 221 mapped outfalls discharging to critical areas. There were no mapped Priority 1 or Priority 2 outfalls. No Priority 3 outfalls were assessed.

Table 8: 2010 Off-site Assessment Project Activity Summary for Little Washougal (Lower) subwatershed

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	0	0	175
# of outfalls assessed	n/a	n/a	0
# of outfalls compliant	n/a	n/a	n/a
# of noncompliant outfalls	n/a	n/a	n/a
# of referrals initiated	n/a	n/a	n/a
# of referrals ongoing	n/a	n/a	n/a
# of outfalls fixed	n/a	n/a	n/a

Table 9: 2010 Off-site Assessment Project Activity Summary for Little Washougal (Upper) subwatershed

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	0	0	12
# of outfalls assessed	n/a	n/a	0
# of outfalls compliant	n/a	n/a	n/a
# of noncompliant outfalls	n/a	n/a	n/a
# of referrals initiated	n/a	n/a	n/a
# of referrals ongoing	n/a	n/a	n/a
# of outfalls fixed	n/a	n/a	n/a

Table 10: 2010 Off-site Assessment Project Activity Summary for Boulder Creek subwatershed

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	0	0	34
# of outfalls assessed	n/a	n/a	0
# of outfalls compliant	n/a	n/a	n/a
# of noncompliant outfalls	n/a	n/a	n/a
# of referrals initiated	n/a	n/a	n/a
# of referrals ongoing	n/a	n/a	n/a
# of outfalls fixed	n/a	n/a	n/a

Potential Projects

The offsite assessment project yielded no potential project opportunities.

Management Recommendations

Drainage system inventory is an ongoing CWP work effort focused on updating the StormwaterClk database to include all existing stormwater drainage infrastructure. Prior to 2007, stormwater drainage infrastructure in the Boulder Creek, Jackson Creek and the Little Washougal (Lower and Upper) subwatersheds included 151 objects. In 2007-2009, an additional 2,071 previously unmapped objects were added to the StormwaterClk database.

Since there were no mapped public stormwater facilities found in the study area, retrofit evaluations and inspection and maintenance evaluations were not conducted. However, education and public outreach efforts regarding Clark County's Stormwater Facility Maintenance Manual focused on private stormwater facility owners would help maintain private stormwater facilities to county maintenance standards.

Outfall assessments were not conducted in the study area. Future efforts should be made to assess Priority 3 outfalls, which make up all of the outfalls discharging to critical areas in these subwatersheds. Maintaining the frequency of offsite assessment activities may reduce downstream erosion problems by discovering potential issues before they become more serious erosion problems.

Illicit Discharge Detection and Elimination Screening

Illicit discharge screening was not conducted.

Source Control

Purpose

Source control visits to Clark County businesses provide both an educational and technical assistance purpose. An initial site visit allows staff to educate owners and employees by providing basic information about nearby water resources and Clark County's Water Quality Ordinance (13.26A). The initial site visit also provides information on how Clark County's storm sewer system works, how the site is connected to this storm system, and how the activities performed by the business may impact their subwatershed.

Most importantly, the source control visit can find, then eliminate or change, business activities that negatively impact stormwater runoff.

Methods

Under the County's 2007 NPDES municipal stormwater permit, each year staff is required to visit 20 percent of businesses that perform one of many potential pollution-generating activities listed in the permit. Additionally, the permit requires visits to any business with a paved parking area. To simplify project planning and tracking, the CWP plans to visit 20 percent of all county businesses each year.

To determine which specific businesses will be inspected each year, SNAP prioritizes a list of subwatersheds where source control visits will be performed. Once those subwatersheds are determined, GIS maps are developed to highlight all parcels paying the Type 4 (commercial and industrial property) and Type 3 (Multi-Family property) Clean Water Fee. Each highlighted parcel is labeled with the parcel number (Property Account Number).

At each site, staff asks the business manager or owner to lead a tour of the business, inside and out. By closely observing business activities and asking questions, staff gains information about site-specific conditions and current stormwater best management practices (BMPs).

If any business related activities allow contaminants to enter stormwater runoff, specific BMPs are suggested to the business manager or owner. Following the tour, BMP sheets explaining the issue and required fixes are left with the manager or owner. If the BMP will take some time to implement, a follow up visit date is agreed upon. Letters are sent to businesses when multiple activities require BMPs and/or when a specific BMP may take some time to implement. Letters usually give a deadline for completion of BMP implementation.

Following the deadline date, a follow up visit is made to the business to confirm BMP implementation. As long as some corrective effort has been made, the source control staff will continue working with the business until it is in compliance. However, if the business fails to take any corrective action despite repeated visits, a referral to Clark County Code Enforcement, and possibly the Washington State Department of Ecology, is made to assist with compliance through enforcement.

During or immediately after each site visit, a Business Site Visit Report Form is completed for entry into the Tidemark database.

Results
In 2010, staff visited 100% of the businesses required under the NPDES permit in the Little Washougal (Upper)/Little Washougal (Lower)/Boulder Creek/Jackson Creek subwatershed. Table 11 summarizes source control activities.

Table 11: Source Control Project Summary, Little Washougal (Upper)/ Little Washougal (Lower)/ Boulder Creek/Jackson Creek subwatershed

Metric	Number
Number of sites visited	1
Number of sites with source control issues	0
Number of repeat visits	0
Number of sites with issues successfully resolved	0
Number of sites referred to other agencies	0

Overview
The Little Washougal (Upper)/ Little Washougal (Lower)/ Boulder Creek/Jackson Creek subwatershed is located in southeastern Clark County. The creeks in this subwatershed flow out of the heavily forested Yacolt Burn State Forest. Once the creeks flow together, the Little Washougal River subwatershed is dominated by large rural properties with farms, dairies and residences. There are only a few Type 4 parcels, with only one requiring a source control visit. This site did not have any source control issues.

Stream Reconnaissance and Feature Inventory

A stream reconnaissance and feature inventory was not conducted.

Physical Habitat Assessment

Purpose
Physical habitat assessments provide direct measurements of stream channel morphology, habitat conditions, and riparian conditions for specific stream reaches. This information can be used for planning projects and interpreting hydrologic, macroinvertebrate, and geomorphologic information at reach and subwatershed scales.

Methods
Physical habitat measurements were made for multiple reaches of the Little Washougal River (LW1 extends from the confluence with the Washougal River to RM 2.7, LW1c, RM 3.25 to RM 5.3, LW2b RM 5.8 to RM 6.7) and for one reach of Boulder Creek (B1 extends from the confluence with the Little Washougal River to RM 1.0) by R2 Resource Consultants, Inc.

(December 2004) for the Lower Columbia Fish Recovery Board. The project followed modified USFS Level II protocols.

Results

The R2 Resource Consultants, Inc. (R2) report includes a good narrative summary of the habitat survey results, including figures and tables, some of which are presented here. The full report may be found on the CWP website at:
http://www.clark.wa.gov/water-resources/documents-monitoring.html#strmac

The LW 1 survey reach has a moderate gradient. The channel transitions from a moderate gradient contained type in the canyon to a moderate gradient mixed control type for the remainder of the reach. For most of the reach, the river is alluvial to semi alluvial with abundant in-channel gravel and cobble deposits. The reach has a map gradient of 1.1 percent. Habitat consists primarily of pools, which represents 44 percent of the survey reach habitat by length followed by large cobble riffle (37 percent), glide (11 percent) and small cobble riffle (8 percent). The maximum depth of pools averages greater than 0.9 meters.

R2 noted that the dominate and subdominant substrate classes of streambed riffles are comprised of gravel (34 percent) and cobble (28 percent). Embeddedness is rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75%, 75-100%). The overall mean embeddedness level is 39 percent. Table 12 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

Table 12: Summary of Habitat Evaluations of Lower Washougal River from the confluence with the Washougal River to RM 2.7 (LW 1 Survey Reach) Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards

Parameter	WCC[1]	PFC[2]
% Pool by Surface Area	Fair	
Pool Frequency		Not properly functioning
Pool Quality	Fair	At Risk
LWD	Poor	Not properly functioning
Substrate	Poor	Not properly functioning
Streambank Stability	Good	Properly functioning
Water temperature	Poor	Not properly functioning
[1] Available Ratings: Good; Fair; Poor		
[2] Available Ratings: Properly Functioning; At Risk; Not Properly Functioning		

The LW1c survey reach has a map gradient of 1.6 percent. The channel transitions from a moderate gradient contained type to a moderate gradient mixed control. For most of the reach, the river is alluvial. Habitat consists primarily of large and small cobble riffle (65 percent) by length followed by pool (23 percent), and cascade (12 percent) habitat. The maximum depth of pools averaged 1.0 meters.

R2 noted that the dominate and subdominant substrate classes of streambed riffles are comprised of boulder (24 percent) and bedrock (23 percent). The overall mean embeddedness level is 28 percent. Table 14 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

Table 13: Summary of Habitat Evaluations of Lower Washougal River from RM 3.25 to RM 5.3 (LW1c Survey Reach). Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards

Parameter	WCC[1]	PFC[2]
% Pool by Surface Area	Poor	
Pool Frequency		Not properly functioning
Pool Quality	Fair	Properly functioning
LWD	Poor	Not properly functioning
Substrate	Fair	At Risk
Streambank Stability	Good	Properly functioning
Water temperature	Poor	Not properly functioning
[1] Available Ratings: Good; Fair; Poor		
[2] Available Ratings: Properly Functioning; At Risk; Not Properly Functioning		

The LW2b survey reach is classified as a moderate gradient mixed channel type. For most of the reach, the channel is semi alluvial. The reach has a map gradient of 2.0 percent. Habitat consists primarily of large and small cobble riffle (72 percent), followed by pool (25 percent) and glide (3 percent). The maximum depth of pools averages 1.1 meter.

R2 noted that the dominate and subdominant substrate classes of streambed riffles are comprised of boulder (28 percent) and gravel (24 percent). The overall mean embeddedness level is 35 percent. Table 14 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

Table 14: Summary of Habitat Evaluations of Lower Washougal River from RM 5.8 to RM 6.7 (LW2b Survey Reach). Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards

Parameter	WCC[1]	PFC[2]
% Pool by Surface Area	Poor	
Pool Frequency		Not properly functioning
Pool Quality	Fair	At Risk
LWD	Poor	Not properly functioning
Substrate	Fair	Not properly functioning
Streambank Stability	Fair	At Risk
Water temperature	Poor	Not properly functioning

[1] Available Ratings: Good; Fair; Poor
[2] Available Ratings: Properly Functioning; At Risk; Not Properly Functioning

The B1 survey reach is classified as a moderate gradient mixed control type. For most of the reach, the channel is semi alluvial. The reach has a map gradient of 3.0 percent. Habitat consists primarily of small cobble riffle (71 percent), followed by pool (24 percent), cascade (3 percent) and glide (2 percent). The maximum depth of pools averages 0.8 meter.

R2 noted that the dominate and subdominant substrate classes of streambed riffles are comprised of cobble (39 percent) and boulder (29 percent). The overall mean embeddedness level is 24 percent.

Table 15 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

Table 15: Summary of Habitat Evaluations of Boulder Creek from the confluence with the Little Washougal to RM1 (B1 Survey Reach) Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards

Parameter	WCC[1]	PFC[2]
% Pool by Surface Area	Poor	
Pool Frequency		Not properly functioning
Pool Quality	Fair	At Risk
LWD	Fair	At Risk
Substrate	Good	Properly functioning
Streambank Stability	Fair	At Risk
Water temperature		
[1] Available Ratings: Good; Fair; Poor		
[2] Available Ratings: Properly Functioning; At Risk; Not Properly Functioning		

Geomorphology Assessment

A geomorphology assessment was not conducted.

Riparian Assessment

Purpose

The riparian assessment characterizes existing conditions, based on available data, to identify general riparian needs and potential areas for rehabilitation projects. Riparian enhancement projects, such as installation or protection of native plantings within riparian areas, can provide for increased future shading and woody debris recruitment, which can further provide an opportunity for stormwater-related watershed improvement.

The need for riparian rehabilitation tends to be widespread and exceeds the scope and resources of the CWP mission of stormwater management. Therefore, potential riparian projects are usually referred to agencies such as the LCFRB, Lower Columbia Fish Enhancement Group (LCFEG), Clark Public Utilities, Fish First, Washington State University (WSU) Watershed Stewards Program and Clark Conservation District for possible implementation.

This section focuses on opportunities located on publicly owned lands within high priority salmon-bearing stream reaches, as defined by LCFRB salmon recovery priorities.

Method

Where possible, the assessment is based on GIS data from existing reports prepared for the Lower Columbia Fish Recovery Board. These include the Habitat Assessment reports (R2 Resource Consultants, Inc., 2004) and the 2010 Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Both can be found at http://www.lcfrb.gen.wa.us/default1.htm

These reports apply primarily to salmon-bearing stream reaches and therefore do not provide information for many smaller streams. Results are based on aerial photo interpretation using Washington Forest Practices Board methods for LWD delivery and channel shade estimates.

In streams where no data exists from the LCFRB characterization, an examination of current orthophotographs is used to make a general assessment of riparian condition and identify areas where restoration or preservation projects may be appropriate.

Many riparian project opportunities are discovered through other SNAP activities, including Rapid Stream Reconnaissance feature inventories and geomorphological assessments. Potential projects discovered through these activities are discussed in their respective sections and most are included on a final list for referral to outside agencies.

The 2004 LCFRB Habitat Assessment report and 2010 Subbasin Plan also were reviewed for specific project opportunities in each subwatershed. Potential project sites have been reviewed and verified through field reconnaissance and are detailed in the results.

Results

Results are based primarily on the 2004 LCFRB Habitat Assessment for the Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek subwatersheds. The full characterization report is available on the Clark County website at:
http://www.clark.wa.gov/water-resources/documents.html#mon

For areas in the subwatersheds not included in the habitat assessment (several tributaries to Boulder Creek, Jones Creek, Little Washougal River and the East Fork Little Washougal River, and the entire Jackson Creek subwatershed), LWD recruitment potential and shade rating analyses were based on a qualitative review of 2010 orthophotographs available through Google Earth.

At the subwatershed scale, the LCFRB rated the riparian conditions in the Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek subwatersheds as "Moderately Impaired."

Riparian (Large Woody Debris (LWD) Delivery)
Figure 3 shows the Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek subwatersheds LWD delivery potential. The Jackson Creek subwatershed was not included in the LCFRB survey. In the Little Washougal (Upper) subwatershed, the survey includes the mainstems of Jones Creek and the East Fork Little Washougal River. The mainstem of Jones Creek is shown as having Medium LWD recruitment potential closer to its confluence with the East Fork Little Washougal and Low LWD recruitment potential further upstream. Review of survey data shows "Poor" recruitment potential for 54 percent of the length surveyed and "Fair" potential for 46 percent of the length surveyed (EDT reaches "Jones Creek" and "Jones Creek 1b").

In the Little Washougal (Upper) watershed, the mainstem of the East Fork Little Washougal is shown as having Medium LWD recruitment potential further downstream and Low LWD recruitment potential further upstream. Review of survey data shows "Fair" recruitment potential for 50 percent of the length surveyed and "Poor" potential for 50 percent of the length surveyed (EDT reaches "Little Washougal 3" and "4").

In the Boulder Creek subwatershed, the survey includes the mainstem of Boulder Creek from its confluence with the Little Washougal River, upstream approximately 1.6 miles. The mainstem of Boulder Creek is shown as having primarily low LWD recruitment potential. Review of survey data shows "Fair" recruitment potential for 34 percent of the length surveyed and "Poor" potential for 66 percent of the length surveyed (EDT reaches "Boulder Creek," "Boulder Creek 1b" and "Boulder Creek 1c").

In the Little Washougal (Lower) subwatershed, the survey includes the mainstem of the Little Washougal River and one tributary entering the Little Washougal River from the east. The mainstem of the Little Washougal River is shown as having primarily Moderate LWD recruitment potential, with some areas of high potential. Review of survey data shows "Good" recruitment potential for 10 percent, "Fair" for 78 percent and "Poor" for 12 percent of length surveyed (EDT reaches "Little Washougal 1," "1b," "2," "2b," "2c," "2d," and "2e"). The tributary entering the Little Washougal from the east is shown as having Low LWD recruitment potential along the entire length surveyed (EDT reach "LBtrib A (28.0211)").

The Jackson Creek subwatershed was not surveyed. Review of aerial photographs indicates likely Moderate to High levels of LWD recruitment potential, with the lower values in areas that have

been cleared of forest vegetation through timber harvest practices. Such areas are likely to be replanted and would be expected to regain their LWD recruitment potential over time as the replanted vegetation matures.

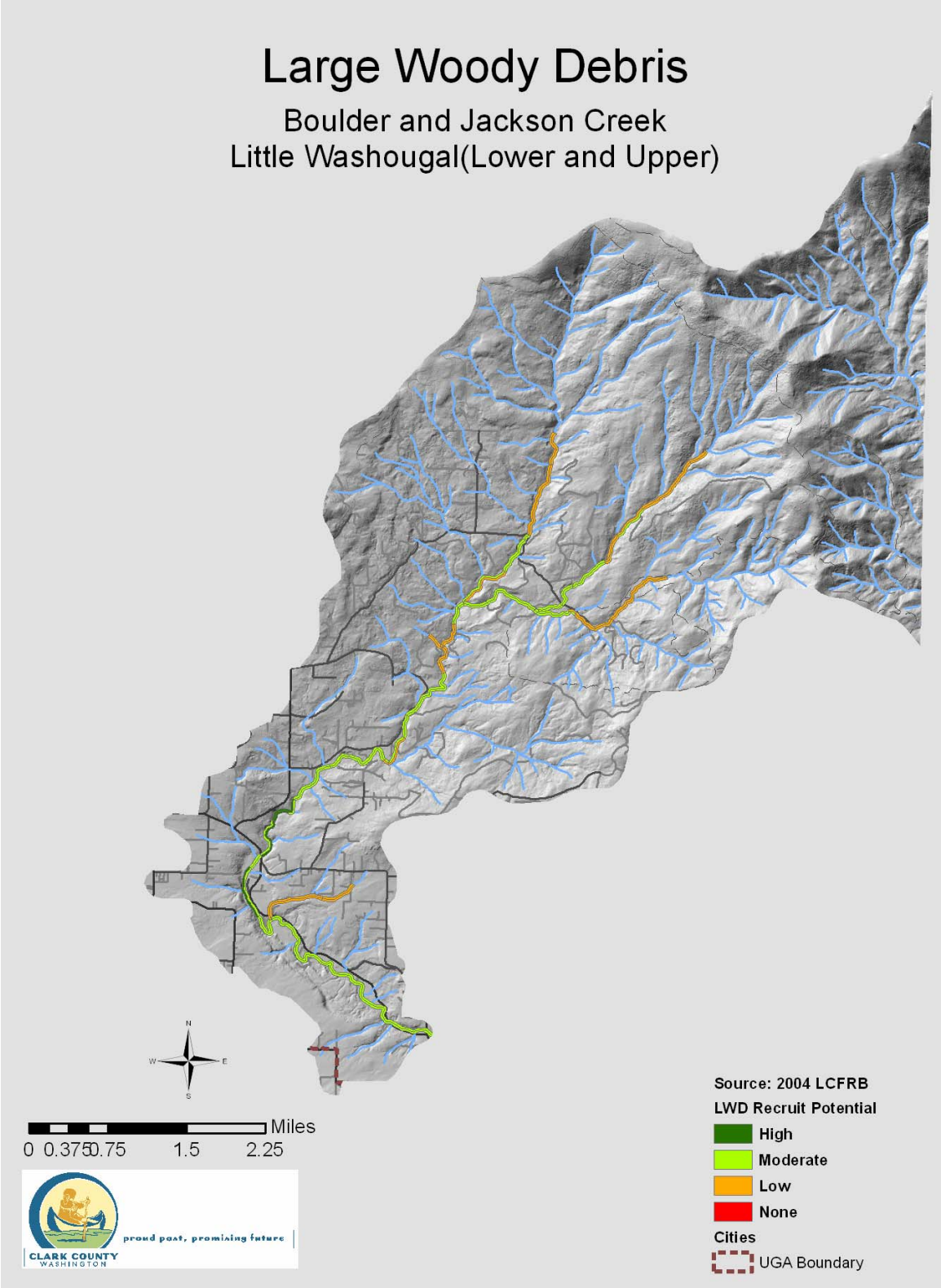

Figure 3: Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek LWD Recruitment Potential (adapted from R2 Resource Consultants, Inc., 2004)

Shade

The Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek subwatersheds shade ratings from the 2004 LCFRB Habitat Assessment are illustrated on Figure 4. The Jackson Creek subwatershed was not included in the LCFRB survey. In the Little Washougal (Upper) subwatershed, the survey includes the mainstems of Jones Creek and the East Fork Little Washougal River.

The mainstem of Jones Creek has shade levels ranging from 10 percent to 30 percent, distributed as follows:

% Shade	% of Reach Length
10	16
30	84

In the Little Washougal (Upper) subwatershed, the mainstem of the East Fork Little Washougal River has shade levels ranging from 10 percent to 30 percent, distributed as follows:

% Shade	% of Reach Length
10	49
30	51

In the Boulder Creek subwatershed, the survey includes the mainstem of Boulder Creek from its confluence with the Little Washougal River, upstream approximately 1.6 miles. The mainstem of Boulder Creek has shade levels ranging from 10 percent to 30 percent, distributed as follows:

% Shade	% of Reach Length
10	79
30	21

In the Little Washougal (Lower) subwatershed, the survey includes the mainstem of the Little Washougal River and one tributary entering the Little Washougal River from the east. The mainstem of the Little Washougal River has shade values ranging from 10 percent to 55 percent, distributed as follows:

% Shade	% of Reach Length
10	35
30	53
55	12

Some of the areas described as having relatively low shade in the 2004 LCFRB report are managed timberlands that appear to have been re-planted and may be expected to have higher shade values over time.

The LCFRB habitat assessment for the Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek subwatersheds indicated that all reaches surveyed are currently off-target with respect to the State Forest Practices shade/elevation screen standards.

Management Recommendations

Overall recommended management activities for the Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek subwatersheds include: large wood placement; encouragement of riparian revegetation efforts; monitoring to ensure that timber harvest, land development and road BMPs are implemented; riparian enhancement though plantings, hardwood conversion or conifer release; and spawning gravel enhancement.

Potential Projects

Potential riparian restoration projects for the Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek subwatersheds were identified from review of the 2004 LCFRB Habitat Assessment report, with orthophotography analysis in areas not formally surveyed.

Of all the publicly owned land in the Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek subwatersheds, the majority is owned by Washington State and managed for forestry operations. A significant amount is owned by the City of Camas and similarly managed. It is assumed that these lands would be managed with riparian conservation best management practices in place, and as such would be unavailable for and lack ecological opportunity for county-driven enhancement projects.

Clark County owns one parcel, described in Table 16, which should be preserved as intact forest adjacent to the Little Washougal River

Table 16: Tax Exempt Parcels Overlapping Potential Riparian Restoration Areas

ASSR_SN	ASSR_AC	OWNER	PT1DESC	Description
139908-000	0.8 acres	Clark County	Unused land timbered	Preserve forested riparian vegetation

Figure 4: Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek Shade Values (adapted from R2 Resource Consultants, Inc, 2004)

Floodplain Assessment

A floodplain assessment was not conducted.

Wetland Assessment

Purpose

Wetlands perform important hydrologic, water quality and habitat functions. The primary reasons for the wetlands assessments are to:

- Describe wetland conditions related to how they influence hydrology, water quality and habitat
- Identify priority potential wetland projects to mitigate for stormwater impacts
- Make management recommendations for wetlands related to stormwater management

A primary objective of the wetland assessment is to identify sites containing modestly sized, degraded or ditched wetlands where minor construction projects can be used to improve wetland hydrology. Improved wetland function can reduce peak storm discharges, increase groundwater recharge and improve habitat through increasing biodiversity, species population health and organic input.

Methods

The assessment includes review of existing GIS data for wetlands. Primary information sources are the county wetlands atlas, Draft Watershed Characterization of Clark County Version 3 (Ecology, 2007), and personal communication with other county programs.

Potential project sites have been reviewed and verified through field reconnaissance and are detailed in the results section below.

Tax-exempt parcels often indicate the presence of publicly owned land, schools or churches where large parcel sizes and opportunities for leveraging may exist. Potential wetlands were overlaid with tax-exempt parcels and with county vacant buildable lands model (VBLM) information to identify possible wetland enhancement opportunities.

Results

Figure 5 shows potential wetland areas within the Little Washougal (Upper)/Little Washougal (Lower)/Boulder Creek/Jackson Creek subwatersheds based on data from the county wetlands atlas, including the Clark County wetland model and the National Wetlands Inventory.

The Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek subwatersheds have wetlands associated with the main channels of the rivers and creeks and their tributaries, including natural depressions and man-made impoundments, flood-influenced riverine wetlands, and sloped seep wetlands dominated by groundwater discharge. There are few large complexes of headwater or floodplain wetlands in this system.

Table 17: Distribution of Wetlands by Hydrogeomorphic Class

HGM Class	Area (ac.)	% of Sub-basin*	% of total wetland
Slope Wetlands	16	0.1	5.0
Depressional Wetlands	266	1.4	83.5
Riverine Wetlands	37	0.2	11.5
All Wetlands	319	1.7	
*Subwatershed area 19,002 ac.			

The majority of the wetlands is located in landscape positions (along stream channels) where there are limited opportunities to improve water quality or hydrologic functions in these subwatersheds. Review of the wetland inventories and studies did not identify any significant project opportunities in publicly held or tax-exempt land. Some of the mapped wetlands are located on state-owned (DNR) forest land, but these areas are in forestry use and not potential project sites.

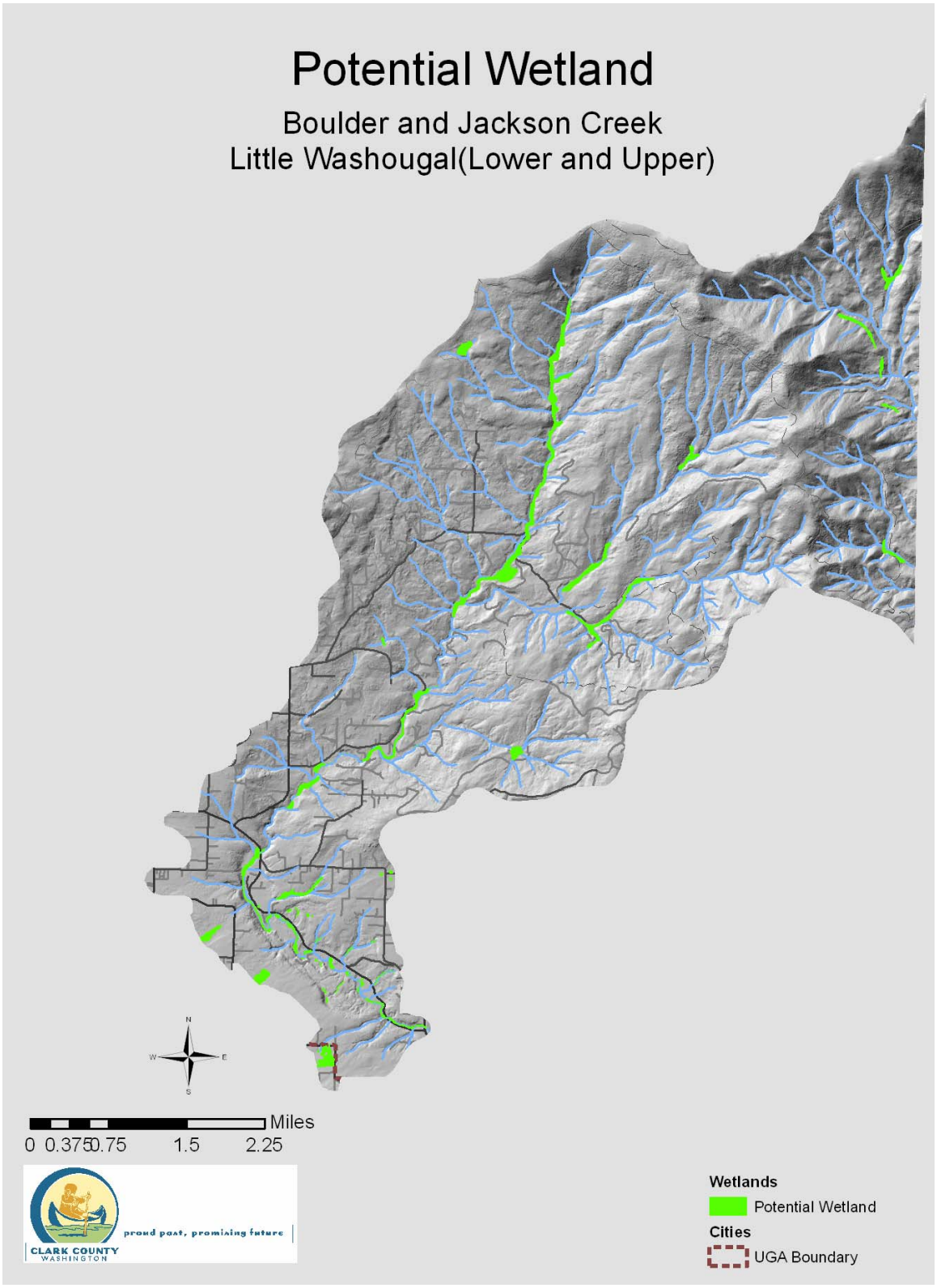

Figure 5: Little Washougal (Upper)/Little Washougal (Lower)/Boulder Creek/Jackson Creek Potential Wetlands

Watershed Characterization

The Washington State Department of Ecology completed the Watershed Characterization and Analysis of Clark County (2009) to assist in planning wetland and riparian habitat restoration and preservation projects.

Results pertaining to the Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek subwatersheds are summarized below.

The Cedar Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek subwatersheds are part of the "Headwater" Rain on Snow and Snow Dominated Mountainous hydrogeologic unit. It is characterized by rain-on-snow and snow dominated precipitation, generally shallow groundwater flow, consolidated bedrock and steep topography (Ecology, 2009).

Figure 6 depicts priority areas for protection and restoration of hydrologic and denitrification processes countywide based on an analysis of the relative importance and level of alteration in each subwatershed.

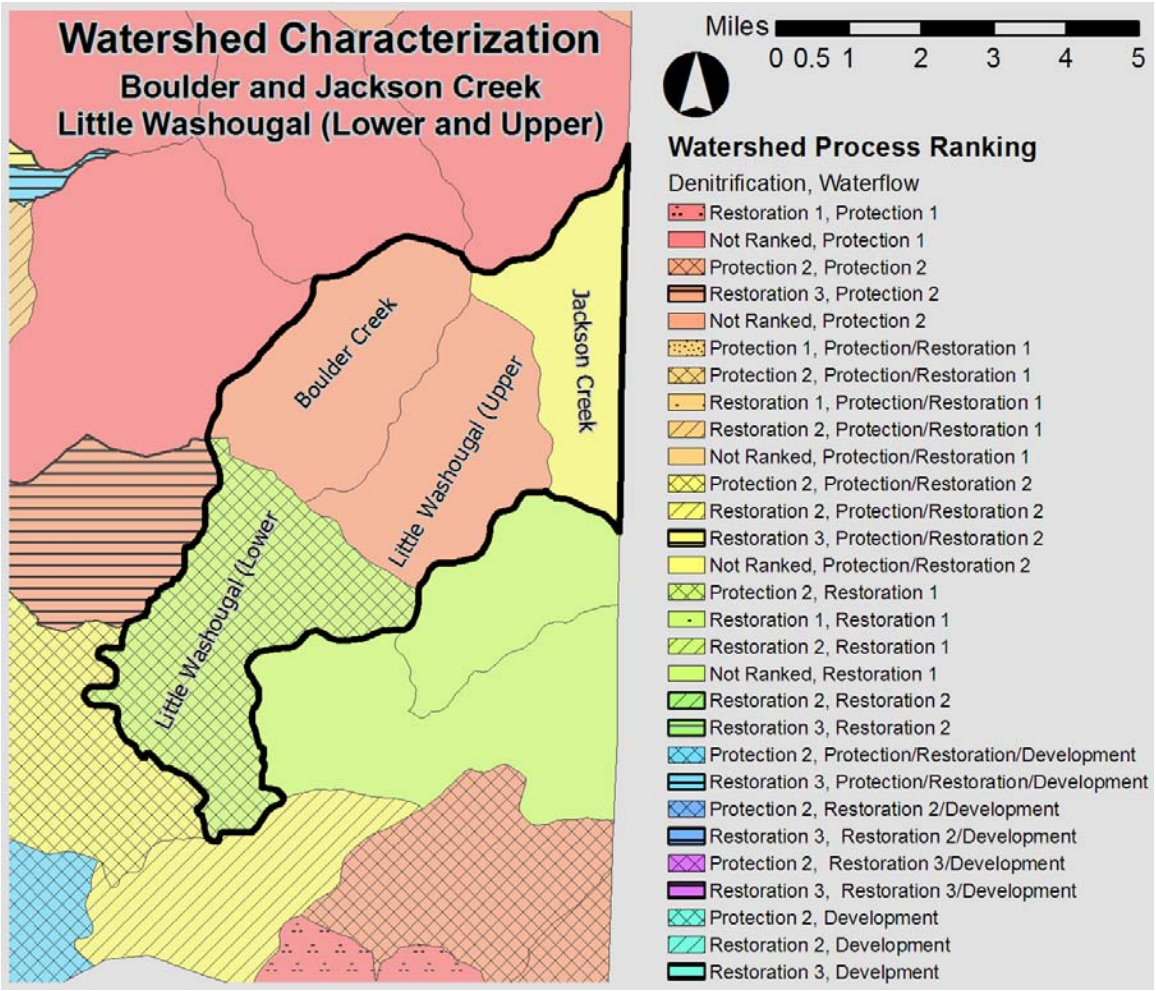

Figure 6: Priorities for suitability of areas for protection and restoration for the hydrogeologic process (from Watershed Characterization and Analysis of Clark County (Ecology, 2009))

In general, red areas have higher levels of importance for watershed hydrologic processes and limited alteration and should be considered for protection. Yellow areas have a higher level of importance for watershed processes and a higher level of alteration and should be considered for restoration unless watershed processes are permanently altered by urban development. Green to blue areas have lower levels of importance for watershed processes and higher levels of alteration and should be considered as more suitable for development. Because green, purple and blue areas represent a transition from restoration areas, planning measures employing both restoration and appropriately sited development should be considered (Ecology, 2009). Hatch patterns represent the importance of denitrification processes.

Protection and restoration of hydrologic (waterflow) processes is recommended for the Boulder Creek and Little Washougal (Upper) subwatersheds (orange) and the Boulder Creek subwatershed (yellow). The Little Washougal (Lower) is recommended for restoration (green), indicating that hydrologic processes are degraded to the point that protection of existing function is not as much of a priority. The Little Washougal (Lower) subwatershed also is ranked for protection of denitrification processes (cross-hatched). The other subwatersheds are not ranked for denitrification processes.

Macroinvertebrate Assessment

Purpose

The Benthic Macroinvertebrate Index of Biological Integrity or B-IBI (Karr, 1998) is a widely used measurement of stream biological integrity or health based on macroinvertebrate populations. Macroinvertebrates spend most of their lives in the stream substrate before emerging as adults. While in the stream, they are subject to impacts from continuous and intermittent pollutant sources, hydrology and habitat changes and high summer water temperatures.

The B-IBI score is an index of 10 metrics describing characteristics of stream biology, including tolerance and intolerance to pollution, taxonomic richness, feeding ecology, reproductive strategy and population structure. Each metric was selected because it has a predictable response to stream degradation. For example, stonefly species are often the most sensitive and first to disappear as human-caused disturbances increase, resulting in lower values for the metric "Number of Stonefly taxa."

In addition to the overall B-IBI scores, examining individual metric scores gives insight into stream conditions and better explains differences in the overall score.

Methods

All field and laboratory work followed CWP protocols for macroinvertebrate sampling and analyses (June 2003). Samples are collected during late summer, preserved and delivered to a contracted lab for organism identification, enumeration and calculation of B-IBI metrics.

Raw data values for each metric are converted to a score of one, three or five, and the 10 individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores 10 to 24 indicate low biological integrity, 25 to 39 indicate moderate integrity, and greater than 39 indicate high biological integrity.

Results are influenced by both cumulative impacts of upstream land use and reach-specific conditions at or upstream of sampling sites. Thus, samples from a reach integrate local and upstream influences. Many of the B-IBI metrics also are influenced by naturally occurring factors in a watershed. For example, the absence of gravel substrate can lower scores.

In the Little Washougal (Upper) subwatershed, samples were collected annually by the CWP from 2002 through 2009 at Station JNS060 (Jones Creek above Camas water intake). One sample was collected in the Boulder Creek subwatershed (Station BDR030; Boulder Cr downstream Boulder Cr Rd) by CWP staff in 2004.

In the Little Washougal (Lower) subwatershed, samples were collected at Station LWG015 (Little Washougal River at Blair Road) in 2002-2004 by Clark County volunteers and in 2009 by CWP staff. In 2004, a single sample was collected by the CWP at Station LWG050 (Little Washougal River at 40th Circle).

Results

In the Lower Little Washougal, a four-year average B-IBI score of 29 places Station LWG015 in the moderate category, while the single 2004 score at Station LWG050 (42) falls in the category of high biological integrity. Scores at LWG015 ranged from 24 to 32.

Table 18 shows eight moderate scores and two low scores among the average results for individual metrics at Station LWG015, compared with six high and four moderate at Station LWG050. Low scores for Number of Intolerant Taxa and Percent Predator Taxa metrics indicate human disturbance. Intolerant taxa typically are the first to disappear as human disturbance increases, while predator taxa are a measure of food web complexity which decreases as human disturbance increases (Fore, 1999).

Table 18: Station LWG015 and Station LWG050 Average Annual Macroinvertebrate Community Metrics and Total Scores from 2002 through 2009

B-IBI Metrics	LWG015 4-Yr Average metric scores			LWG050 2004		
	Value	Score	Category	Value	Score	Category
Total number of taxa	39.5	3	moderate	38.0	3	moderate
Number of Mayfly taxa	5.5	3	moderate	10.0	5	high
Number of Stonefly taxa	5.5	3	moderate	8.0	5	high
Number of Caddisfly taxa	7.5	3	moderate	7.0	3	moderate
Number of long-lived taxa	4.3	3	moderate	5.0	5	high
Number of intolerant taxa	0.0	1	low	6.0	5	high
Percent tolerant taxa	34.7	3	moderate	7.5	5	high
Percent predator taxa	7.3	1	low	11.4	3	moderate
Number of clinger taxa	20.5	3	moderate	20.0	3	moderate
Percent dominance (3 taxa)	49.9	3	moderate	37.9	5	high
Average annual B-IBI Score		29	moderate		42	high

In the upper Little Washougal, an eight-year average B-IBI score of 47 places Station JNS060 in the category of high biological integrity, while the single 2004 score at Station BDR030 (34) falls in the moderate category. Scores at JNS060 were consistently high, ranging only two points from 46 to 48 over the eight years sampled.

Table 19 shows nine high and one moderate score among the average results for individual metrics at Station JNS060, compared with a mixed result of three high, five moderate and two low scores at Station BDR030. Similar to Station LWG015 in the lower watershed, low scores for Number of Intolerant Taxa and Percent Predator Taxa metrics indicate human disturbance. Intolerant taxa typically are the first to disappear as human disturbance increases, while predator taxa are a measure of food web complexity which decreases as human disturbance increases (Fore, 1999).

Table 19: Station BDR030 and Station JNS060 Average Annual Macroinvertebrate Community Metrics and Total Scores from 2001 through 2009

B-IBI Metrics	BDR030 2004			JNS060 8-Yr Averages		
	Value	Score	Category	Value	Score	Category
Total number of taxa	40.0	3	moderate	58.0	5	high
Number of Mayfly taxa	9.0	5	high	9.4	5	high
Number of Stonefly taxa	7.0	3	moderate	9.0	5	high
Number of Caddisfly taxa	8.0	3	moderate	13.6	5	high
Number of long-lived taxa	6.0	5	high	6.1	5	high
Number of intolerant taxa	2.0	1	low	6.6	5	high
Percent tolerant taxa	15.9	5	high	12.7	5	high
Percent predator taxa	9.6	1	low	13.3	3	moderate
Number of clinger taxa	20.0	3	moderate	35.3	5	high
Percent dominance (3 taxa)	49.7	3	moderate	36.8	5	high
Average annual B-IBI Score		34	moderate		47	high

Booth et al. (2004) found a wide but well defined range of B-IBI scores for most levels of development, but observed overall that B-IBI scores decline consistently with increasing watershed total impervious area (TIA).

By comparing B-IBI scores in the study area with the likely range of conditions for watersheds with similar amounts of development, measured as total impervious area, it is possible to make some general statements about the potential benefits from improving stream habitat.

Figure 7 shows that Station LWG015 B-IBI scores are near the middle and LWG050 is near the upper limit of the range of expected scores (estimated 2000 Total Impervious Area from Wierenga, 2005).

Given that the LWG050 B-IBI score is high for a subwatershed with 13 percent impervious areas, there is limited opportunity to improve scores through habitat rehabilitation in this area. Conversely, the low and moderate scores at LWG015 suggest factors other than impervious area are contributing to relatively low scores. It is likely that biological integrity in this area could be increased by improving habitat and stream conditions.

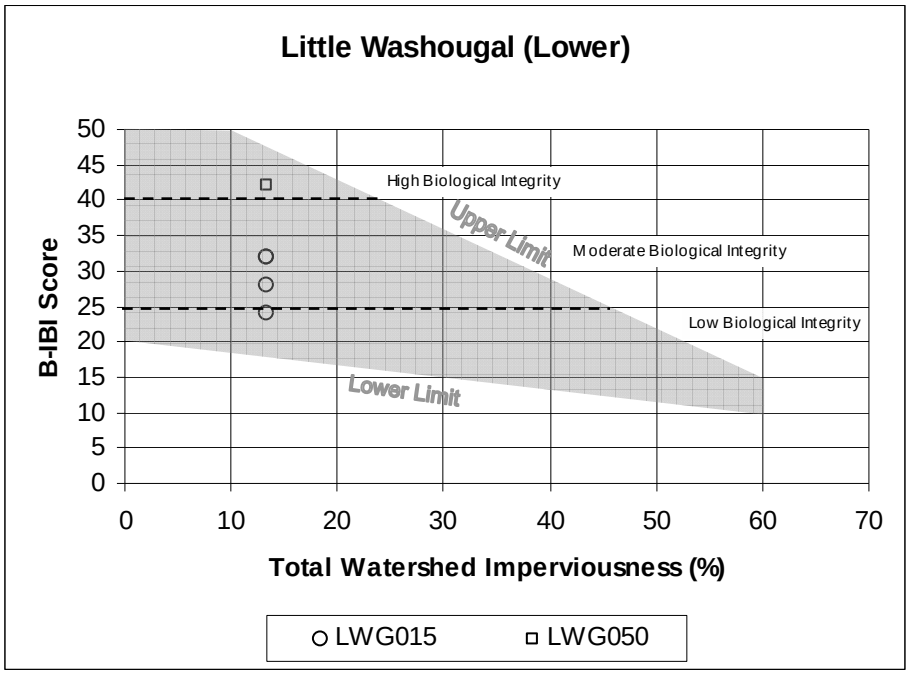

Figure 7: Approximate range of B-IBI in Puget Lowland watersheds, showing progressive decline with increasing imperviousness in the upstream watershed. Adapted from Booth et. al, 2004. Markers indicate B-IBI scores at Station LWG015 and Station LWG050 for particular years, versus estimated 2000 subwatersheds TIA.

In the upper watershed, Figure 8 shows Station JNS060 scores are at the upper limit of the expected range, while Station BDR030 falls near the middle.

The BDR030 B-IBI score is relatively low for a subwatershed with only seven percent impervious area, suggesting factors other than impervious area are contributing to relatively low scores. It is likely that biological integrity in this area could be increased by improving habitat and stream conditions. Scores and habitat conditions at Station JNS060 are in good condition and improvements would not be expected. Protection of intact high quality habitat is key in this area.

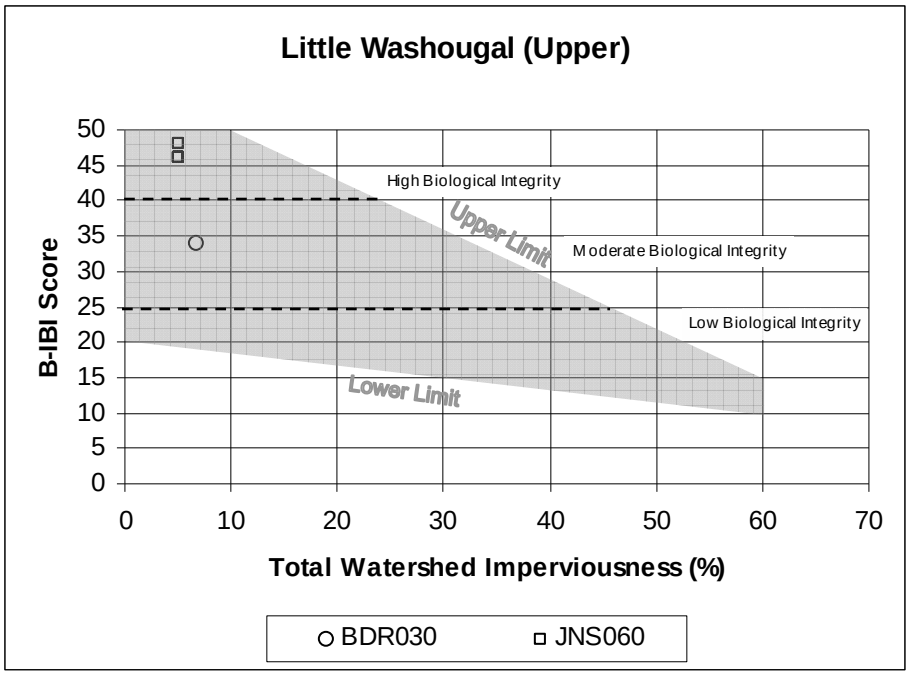

Figure 8: Approximate range of B-IBI in Puget Lowland watersheds, showing progressive decline with increasing imperviousness in the upstream watershed. Adapted from Booth et. al., 2004. Markers indicate Total B-IBI scores at Station BDR030 and Station JNS060 for particular years, versus estimated 2000 subwatershed TIA.

Fish Use and Distribution

Purpose

Fish distribution refers to salmon and steelhead use. This information helps identify stream segments where land-use changes may impact fish populations, inform management decisions, and aid in identifying and prioritizing potential habitat improvement and protection projects.

Methods

Fish distribution for the Little Washougal (Lower), Little Washougal (Upper), Boulder Creek and Jackson Creek subwatersheds is mapped from existing Clark County GIS information, which reflect data collected and analyzed by the Northwest Indian Fisheries Commission (NWIFC). Fish distribution data for Clark County are available on the county's website.

Several sources of barrier assessment data are available and briefly summarized here:

- WDFW passage barrier database.
- SalmonScape (http://wdfw.wa.gov/mapping/salmonscape/)
- Clark County 1997 passage barrier data
- Clark Conservation District/LCFRB passage barrier dataset

Many stream crossings have not been assessed for passage barrier potential, and the extent of public and private road crossings is a good indicator of the potential for additional barriers. Road crossings were mapped by overlaying the county road layer with LiDAR-derived stream data.

The barrier assessment data also were reviewed for specific project opportunities in each subwatershed. Potential project sites have been reviewed and verified through field reconnaissance and are detailed in the results section below.

Results/Summary

Distribution

The available evidence suggests that anadromous fish use in the Little Washougal (Lower) subwatershed is presumed to include chum salmon (Figure 9). The data also show known, documented use by coho (Figure 10), fall Chinook (Figure 11), summer steelhead (Figure 12) and winter steelhead (Figure 13) in the mainstem of the Little Washougal River. Coho and winter steelhead also are documented in a tributary that discharges to the Little Washougal River from the east at appx (45.644723, -122.35285) and presumed to be in a tributary that discharges to the Little Washougal River from the north at appx (45.643711, -122.36641), (Figure 10 and Figure 13).

In the Little Washougal (Upper) subwatershed, data show known use by coho (Figure 10), summer steelhead (Figure 12) and winter steelhead (Figure 13) in Jones Creek. Summer steelhead (Figure 12) and winter steelhead (Figure 13) are shown in the Little Washougal River and East fork Little Washougal River. The East Fork Little Washougal River is shown as having presumed use by coho (Figure 10).

In the Boulder Creek subwatershed, data show known use by coho (Figure 10), summer steelhead (Figure 12) and winter steelhead (Figure 13) in the mainstem of Boulder Creek. Additional upstream reaches and tributaries are shown as having presumed or potential use by coho and winter steelhead.

In the Jackson Creek subwatershed, data show presumed use by coho (Figure 10) and summer steelhead (Figure 12) in Jackson Creek. Data also show known, presumed and potential use by coho and summer steelhead in a tributary to Jackson Creek.

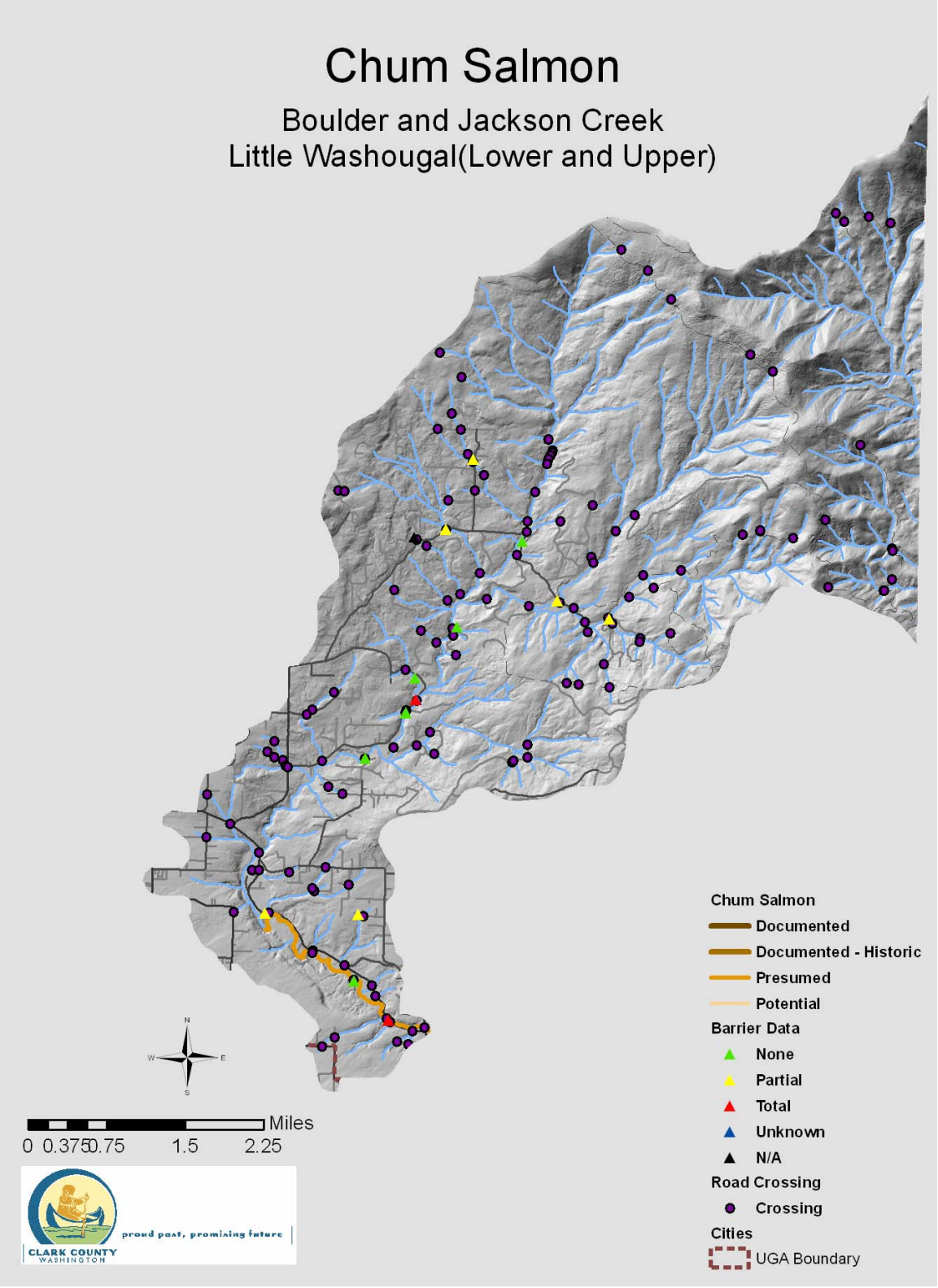

Figure 9: Little Washougal (Lower), Little Washougal (Upper), Boulder Creek and Jackson Creek Chum Distribution and Barriers

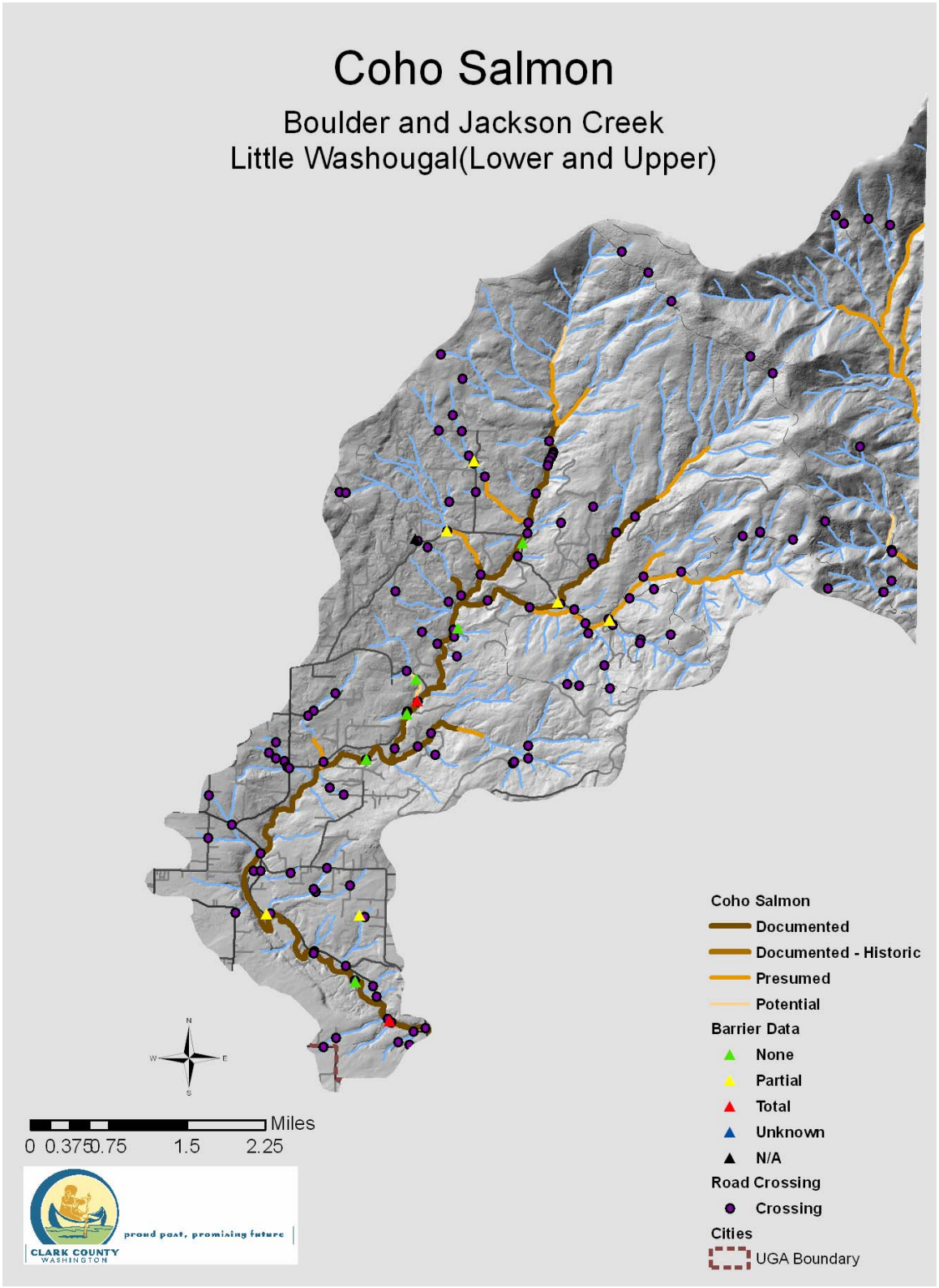

Figure 10: Little Washougal (Lower), Little Washougal (Upper), Boulder Creek and Jackson Creek Coho Distribution and Barriers

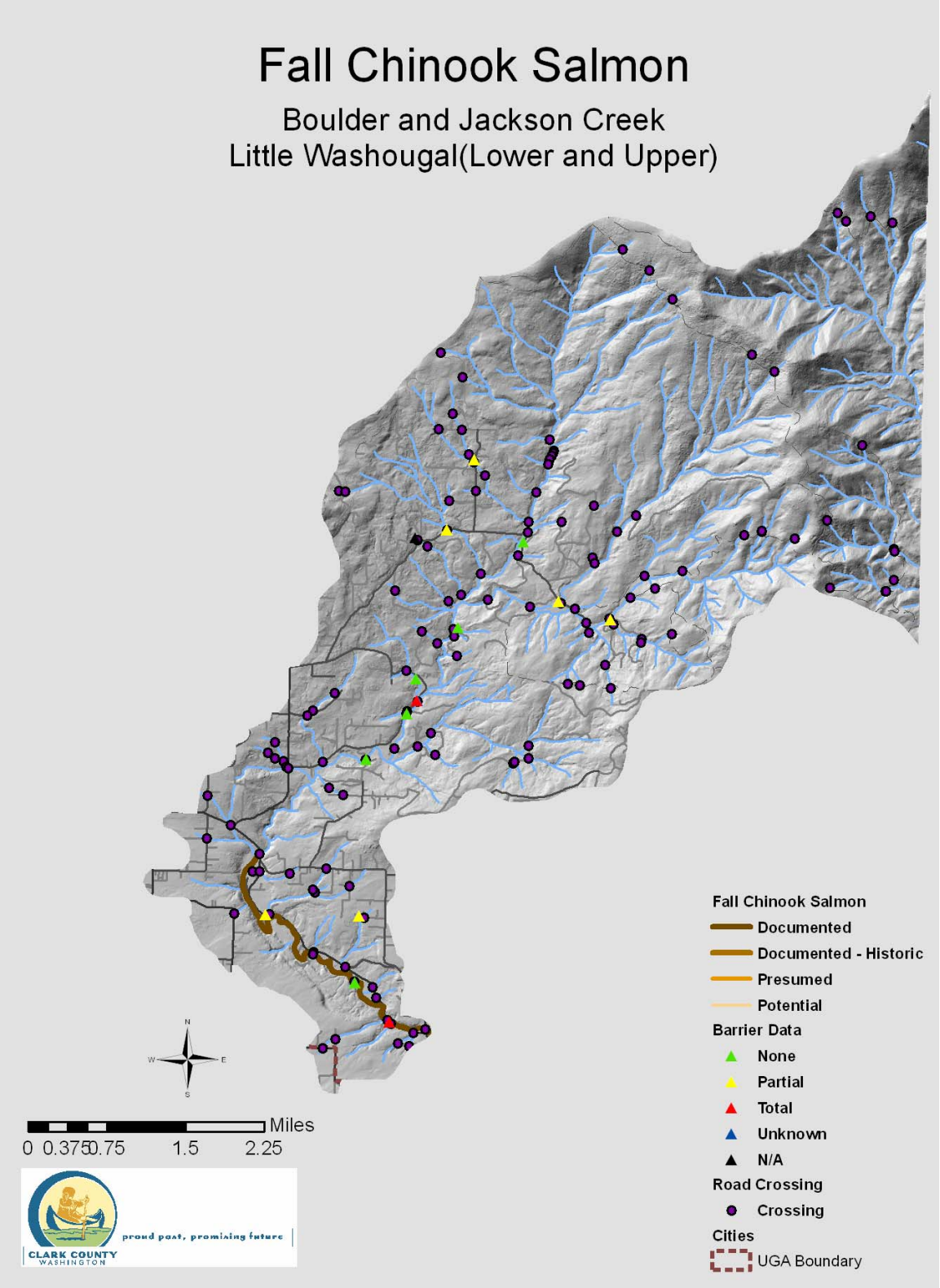

Figure 11: Little Washougal (Lower), Little Washougal (Upper), Boulder Creek and Jackson Creek Fall Chinook Distribution and Barriers

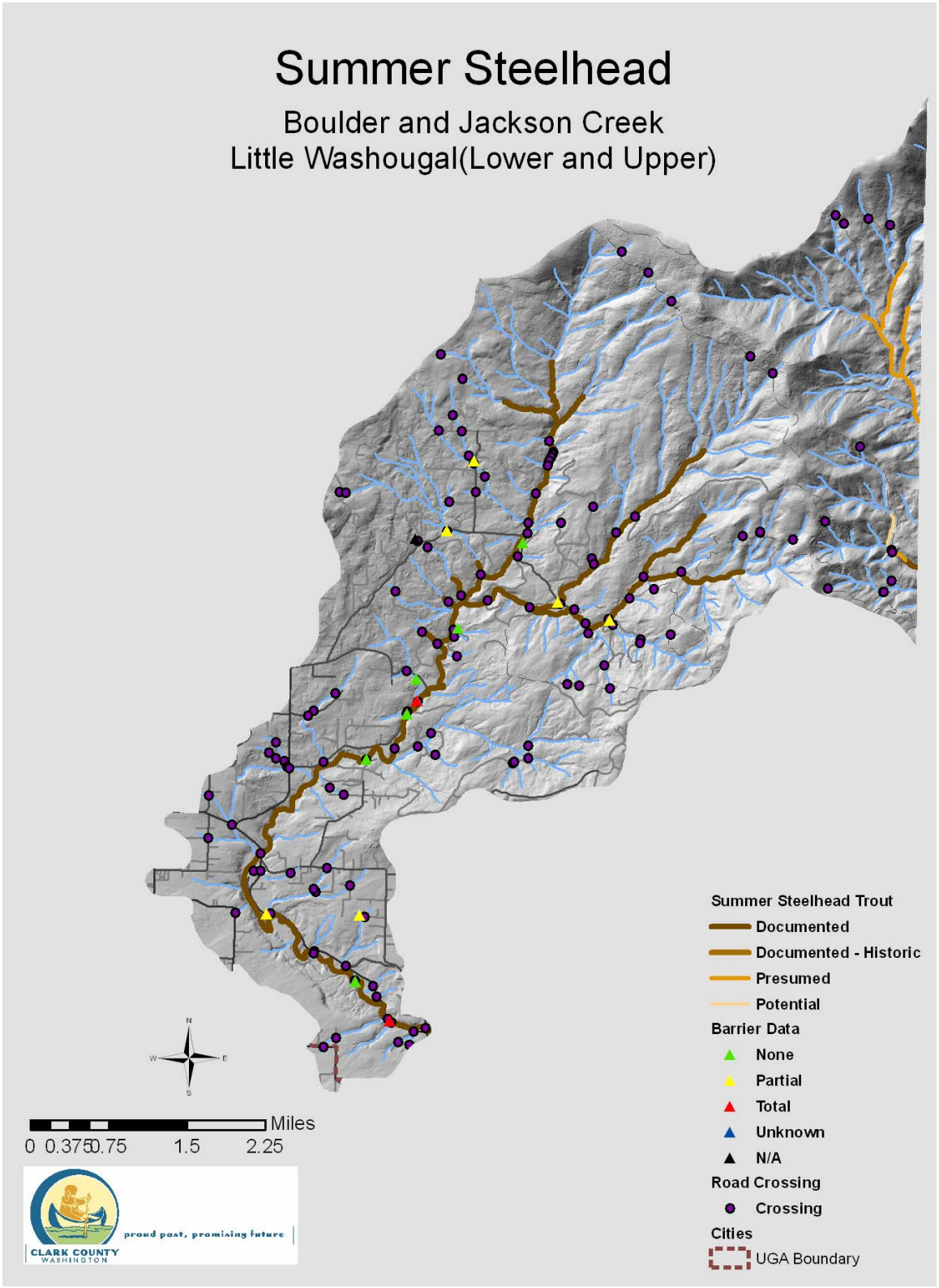

Figure 12: Little Washougal (Lower), Little Washougal (Upper), Boulder Creek and Jackson Creek Summer Steelhead Distribution and Barriers

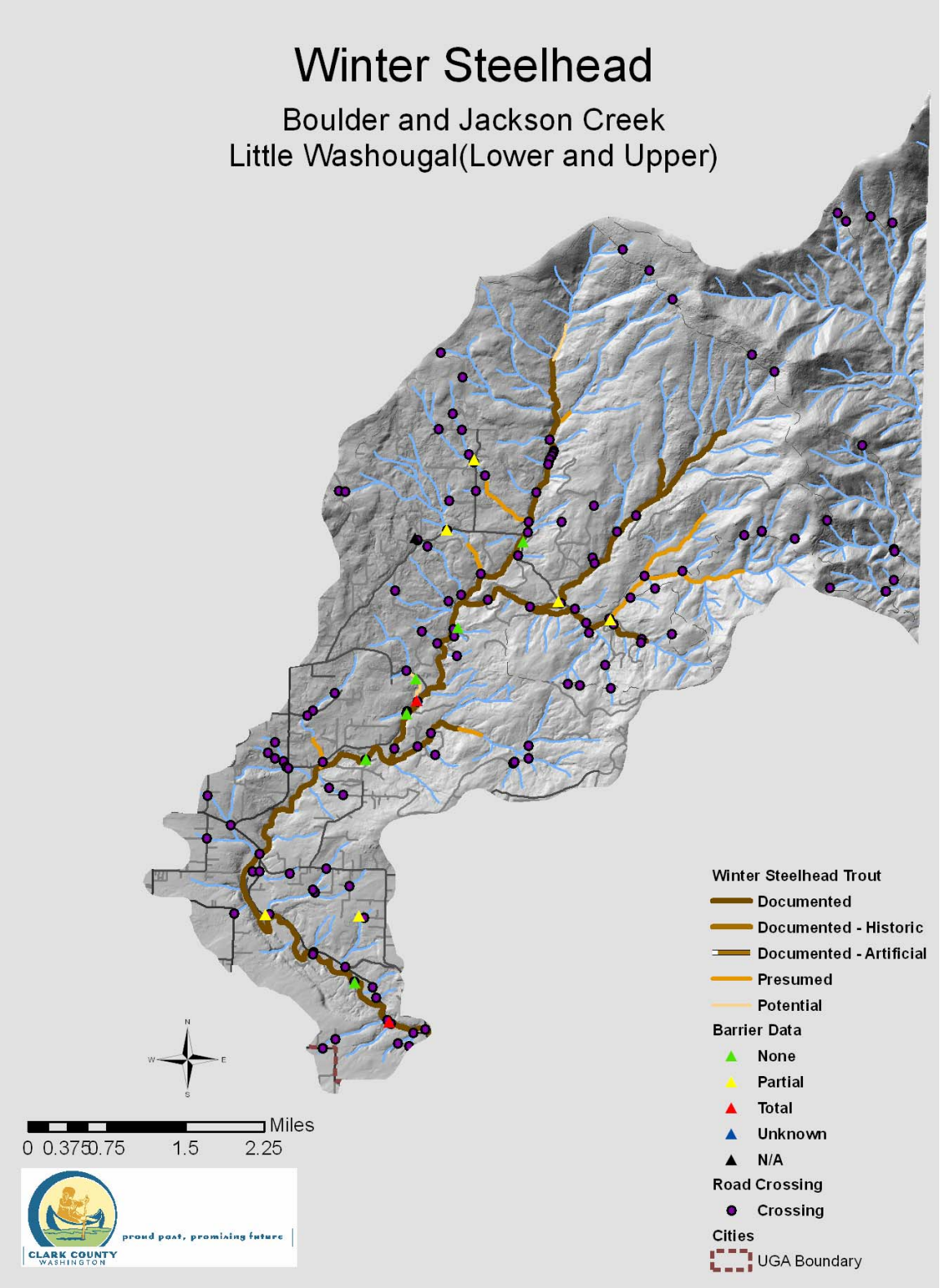

Figure 13: Little Washougal (Lower), Little Washougal (Upper), Boulder Creek and Jackson Creek Winter Steelhead Distribution and Barriers

Barriers

The WDFW barrier database provides the most complete assessment of barriers in the Little Washougal (Lower), Little Washougal (Upper), Boulder Creek and Jackson Creek subwatersheds (Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13).

In the Little Washougal (Upper) subwatershed, no total barriers are mapped. There are two mapped partial barriers; one at a culvert on Jones Creek (45.667126, -122.320088) and one at a culvert on the East Fork Little Washougal River (45.664666, -122.309841).

In the Little Washougal (Lower) subwatershed, two total barriers are mapped on tributaries to the Little Washougal River, close to the confluences with the mainstem. One is a culvert on Stauffer Rd at (45.653026, -122.347528); the other is a culvert on SE Blair Rd at (45.608556, -122.351518). Data also identify two partial barriers at culverts on tributaries.

In the Boulder Creek subwatershed, there are no mapped barriers on the mainstem of Boulder Creek. Two partial barriers are shown on tributaries discharging into the mainstem of Boulder Creek from the west.

There are no mapped barriers in the Jackson Creek subwatershed.

Recommendations

The Little Washougal (Lower), Little Washougal (Upper) and Boulder Creek subwatersheds contain a number of total and partial fish barriers in tributaries. However, improvement or replacement of these barriers is not recommended as a priority by LCFRB (LCFRB 2004, 2009). Several total barriers mapped on tributaries where they pass through culverts should be removed as stream crossing infrastructure is replaced or upgraded.

Hydrologic and Hydraulic Models

Hydrologic and Hydraulic models were not assessed.

Analysis of Potential Projects

The analysis of potential projects:

- Briefly summarizes stormwater conditions, problems and opportunities
- Notes recently completed or current projects within the study area that may be relevant to SNAP project selection
- Describes the analytical approach
- Lists recommended projects and activities for further evaluation

Projects or activities are placed in one of several categories.

Project descriptions often summarize more detailed descriptions found in report sections. Project planners are encouraged to reference the longer descriptions and use information found for each potential project in the Stormwater Capital Planning database available from the Clean Water Program. Reference IDs for the database are included in the tables for each project.

Summary of Conditions, Problems, and Opportunities

Conditions and Problems

This section briefly summarizes important results from the assessment chapters and identifies overall stormwater-related problems.

Coordination with Other Programs

The CWP actively coordinates with the Washington State Department of Ecology, Lower Columbia Fish Recovery Board, Clark County Legacy Lands and Vancouver-Clark Parks and Recreation in efforts to improve stream health. In the study area, there are no planned road improvement projects included in the 2010-2015 Clark County Transportation Improvement Program or in the Stormwater Capital Program.

Broad-Scale Characterization

The study area is mainly forested and rural residential land drained by several small streams. Areas of open space include large amounts of forested area in the Yacolt Burn State Forest. The topography is generally mountainous terrain, with elevation roughly 1,400 to 2,000 feet, which drains to the Washougal River at an elevation of about 150 feet.

Geology consists mainly of volcanic andesite lava flows and Ice Age sedimentary rock deposits. Alluvial deposits occur along stream channels. Stream hydrology is not altered considerably from a natural forested condition.

Standard subwatershed scale metrics, such as percent forest, percent total impervious area, road density and effective impervious area, when compared with NOAA fisheries standards, suggest stream habitat is properly functioning.

Water Quality Assessment
Jones Creek (a tributary to the Upper Little Washougal River) is Category 2 listed (Waters of Concern) for pH. There are no listings for Jackson Creek, Boulder Creek or the Little Washougal River.

Overall data indicate water quality is good in the upper portions of the Little Washougal and fair in the lower portions of the Little Washougal.

A relatively large water quality dataset is available for the area, as Clark County maintains a long-term station on Jones Creek (2002–2009). A more limited, one-year (2004) summer stream temperature dataset exists for four stations on the Little Washougal.

General water quality in Jones Creek is excellent, with trend analysis showing no significant changes of water quality. Among 15 long-term monitoring stations countywide from 2002-2006, Station JNS060 ranked first in overall water quality.

Continuous stream temperature monitoring (2004) at four sites indicated the Little Washougal River routinely exceeded stream temperature target levels of 64º F. In addition, stream temperatures and time exceeding 64º F increased consistently from upstream to downstream stations. As of 2006, the temperature criterion changed from 64º F to 60.8º F for all these stream segments.

Drainage System Inventory
Significant updates to the drainage mapping database were completed in 2008 and 2009. More than 2,070 stormwater infrastructure features were added during this time. A total of 2,222 features are mapped in this study area, including four stormwater facilities that are privately owned and operated. Capital project retrofit opportunities and maintenance evaluations were not completed because there are no public stormwater facilities in the study area. Off-site evaluations were not conducted in this study area.

Illicit Discharge Screening
Illicit discharge detection and elimination screening was not conducted.

Source Control
Only one site qualified for a source control inspection in this study area. One visit was conducted and no source control issues were noted.

Stream Reconnaissance Feature Inventory
A stream reconnaissance feature inventory was not conducted.

Physical Habitat
Physical habitat measurements were made in 2004 (R2 Resource Consultants, Inc., 2004) on portions of the mainstem of Little Washougal River and for one reach of Boulder Creek.

The mid and upper survey reaches in Little Washougal River are classified as a moderate gradient mixed control type, with a map gradient transitioning from 3 percent to 2 percent. Habitat consists mainly of small cobble riffle. In both reaches, parameters including pool frequency, pool quality, LWD, substrate and water temperature were classified as at risk or not properly functioning.

The lower end of the survey reach has a gradient of 1.1 percent, and transitions from a moderate gradient contained type in the canyon to a moderate gradient mixed control type for the remainder of the reach. Habitat consists mainly of pools and large cobble riffle. In this reach, parameters including pool frequency, pool quality, LWD, substrate and water temperature were classified as at risk or not properly functioning.

Boulder Creek was classified as a moderate gradient mixed control type with a map gradient of 3.0 percent. Habitat consists mainly of small cobble riffle. In this reach, parameters including pool frequency, pool quality and substrate were classified as at risk or not properly functioning. LWD was classified as properly functioning.

Geomorphology and Hydrology
A geomorphology and hydrology assessment was not conducted.

Riparian Assessment
In the 2004 LCFRB Habitat Assessment, overall riparian conditions were rated moderately impaired. Large woody debris recruitment potential was primarily moderate for both the Little Washougal (Upper and Lower) subwatersheds. The Boulder Creek subwatershed is shown as having primarily low LWD recruitment potential. The Jackson Creek subwatershed was not surveyed, but review of aerial photographs indicates Moderate to High levels of LWD recruitment potential.

The LCFRB habitat assessment for the Little Washougal (Upper), Little Washougal (Lower) and Boulder Creek subwatersheds indicated that all reaches surveyed are currently off-target with respect to the State Forest Practices shade/elevation screen standards.

Wetland Assessment
Wetlands comprise only 1.7 percent of this assessment area. The Little Washougal (Upper), Little Washougal (Lower), Boulder Creek and Jackson Creek subwatersheds have wetlands associated with the main channels of the rivers and creeks and their tributaries, including natural depressions and man-made impoundments, flood-influenced riverine wetlands, and sloped seep wetlands dominated by groundwater discharge. There are few large complexes of headwater or floodplain wetlands in this system.

Ecology's watershed characterization of Clark County places the assessment area in a category of protection and restoration of hydrologic processes for Boulder Creek and Little Washougal (Upper) subwatersheds. The Little Washougal (Lower) is recommended for restoration indicating that hydrologic processes are degraded to the point that protection of existing function is not much of a priority. The Little Washougal (Lower) subwatershed also is ranked for protection of denitrification processes. The Jackson Creek subwatershed was not ranked.

Macroinvertebrate Assessment
Based on samples collected from 2001-2009, biological integrity is moderate to high throughout this assessment area. B-IBI scores are in the predicted range for areas with similar levels of total impervious area.

Fish Use and Distribution
The available information suggests that anadramous fish use in the study area includes Coho salmon and summer and winter steelhead. Chum and fall Chinook salmon have been documented or presumed to be in the lower portions of the Little Washougal River.

The Little Washougal (Lower), Little Washougal (Upper) and Boulder Creek subwatersheds contain a number of full and partial fish barriers in tributaries. Several total barriers mapped on tributaries where they pass through culverts should be removed or upgraded to increase fish habitat.

Recently Completed or Current Projects

There are no stormwater projects planned for these four subwatersheds in the Stormwater Capital Program or 2010-2015 TIP.

Analysis Approach

Purpose
The Analysis of Potential Projects narrows the initial list of possible opportunities to a subset of higher priority items. Listed opportunities in sections of the SNAP report include sites requiring immediate follow-up, possible stormwater capital improvement projects, internal followup by DES staff, and, in some cases, information to be forwarded to other county departments or outside agencies.

Stormwater capital improvement project opportunities are recommended for further evaluation by engineering staff and potential development into projects for consideration through the capital planning process. Sites flagged for internal action by ongoing programs, such as illicit discharge screening, operations and maintenance and source control outreach, receive follow-up within the context and schedules of the individual programs. Information forwarded to other county departments, such as Public Health, or to outside agencies, such as Clark Conservation District and Clark Public Utilities, may lead to additional activities outside the scope of DES work.

Methods
An initial review is conducted for all potential projects identified during the stormwater needs assessment. Field notes, descriptions, field photos and other associated information are reviewed. In some cases, additional field reconnaissance is performed.

In general, capital project opportunities initially are evaluated by considering problem severity, land availability, access, proximity and potential for grouping with other projects, and potential

for leveraging resources. Staff considers supporting data and information from throughout the SNAP report to assist in the initial project review.

Based on this review, lower priority opportunities are removed and higher priority opportunities are recommended for further consideration below.

Emergency/Immediate Actions

Emergency/Immediate actions may be pursued by Clark County staff or referred to other appropriate agencies. These cases represent a potential or immediate threat to public health, safety or the environment, and require timely follow-up.

No projects of this type were identified.

Potential Stormwater Capital Projects

Stormwater Capital Improvement Projects include projects that create new or retrofit existing stormwater flow control or treatment facilities, substantial infrastructure maintenance projects, habitat enhancement projects, or property acquisition to mitigate for stormwater impacts. Facility retrofits refer to projects that will increase an existing facility's ability to control or treat stormwater in excess of the original facility's design goals.

Stormwater Facility Capital Improvement Projects
No projects of this type were identified.

Stormwater Infrastructure Maintenance CIPs
No projects of this type were identified.

Stormwater Class V Underground Injection Control (UIC) Projects
No projects of this type were identified.

Habitat Rehabilitation/Enhancement Projects
No projects of this type were identified.

Property Acquisition for Stormwater Mitigation
No projects of this type were identified.

Follow-up Activities for Referral within DES

This category includes opportunities other than capital projects that are dependent on DES programs or oversight. Examples include referrals to: Public Works Operations for public stormwater infrastructure maintenance or private facility inspection; DES Sustainability and Outreach for landowner letters regarding trash pickup or agricultural BMPS; the Illicit Discharge screening project; general reach information forwarded to DES engineers for capital planning

purposes. Other opportunities, such as possible fish barriers or culvert maintenance issues, also may be included.

Private Stormwater Facilities Maintenance
No projects of this type were identified.

Public Works Stormwater Infrastructure Maintenance
No projects of this type were identified.

CWP Outreach/Technical Assistance
No projects of this type were identified.

CWP Infrastructure Inventory
No projects of this type were identified.

CWP Capital Planning
No projects of this type were identified.

CWP Illicit Discharge Screening
No projects of this type were identified.

Other

Identifier	Issue	Project	Action
Little Washougal (Lower)			
OS-240	Total Fish Barrier; Stauffer Rd at (45.653026, -122.347528)	Removal or modification of fish barrier to allow fish passage	DES Assessment and Monitoring to inform WDFW
OS-241	Total Fish Barrier; SE Blair Rd at 45.608556, -122.351518)	Removal or modification of fish barrier to allow fish passage	DES Assessment and Monitoring to inform WDFW

Non-Project Management Recommendations

Non-project stormwater management recommendations address areas where county programs or activities could be modified to better address NPDES permit components or promote more effective mitigation of stormwater problems. Information of this type contributes to adaptive management strategies and more effective stormwater management during the permit term.

Management and programmatic recommendations in the study area subwatersheds, by NPDES permit component, include:

Storm Sewer Mapping and Inventory

- Continue research and mapping new stormwater infrastructure with the goal of maintaining a complete stormwater infrastructure inventory

Coordination of Stormwater Activities

None

Mechanisms for public involvement

- Publish SNAP reports on CWP web page

Development Regulations for Stormwater and Erosion Control

- Implement development regulations to minimize impacts, particularly from clearing and grading

Stormwater Source Control Program for Existing Development

- Continue to expand efforts to design and build runoff reduction strategies in county right-of-way
- Focus on protecting reaches that are currently unstable or sensitive to future disturbance

Operation and Maintenance Actions to Reduce Pollutants

None

Education and Outreach to Reduce Behaviors that Contribute Stormwater Pollution

- Educate landowners to discourage disposal of trash and yard debris in streams or other receiving waters
- Perform targeted technical assistance to ensure that timber harvest, land development and road BMPs are implemented
- Educate private landowners on importance of native riparian vegetation and intact riparian forests for shading streams and preserving hydrology
- Provide landowners a list of suggested plants for stream re-vegetation and local nurseries that stock them
- Replace missing or deteriorated stream name signs

TMDL Compliance

None

Monitoring Stormwater Program Effectiveness

None

References

Booth, D.B. and C.R. Jackson. (1997). Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detention, and the Limits of Mitigation: Journal of the American Water Resources Association, vol. 33, no. 5, p. 1077-1090.

Booth, D.B., Hartley, D., and Jackson, R. (June 2002). Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts: Journal of the American Water Resources Association vol. 38, no. 3. p. 835-845.

Booth, D. B., et al. (October 2004). Reviving Urban Streams: Land Use, Hydrology, Biology, and Human Behavior: Journal of the American Water Resources Association, pp. 1351-1364.

Center for Watershed Protection (March 2003). Impacts of Impervious Cover on Aquatic Systems: Watershed Protection Monograph No. 1.

City of Vancouver – Surface Water Management (May 2007). Burnt Bridge Creek Watershed Program. Vancouver, WA

Clark County Environmental Services (2010). Clark County Stream Health Report. Vancouver, WA.

Clark County Public Works Water Resources (June 2003). Standard Procedures for Monitoring Activities, pp. 46-48.

Clark County Public Works Water Resources (December 2003). Long-Term Index Site Monitoring Project: 2002 Physical Habitat Characterization.

Clark County Public Works Water Resources (2004). Clark County Stream Health, A comprehensive overview of the condition of Clark County's streams, rivers, and lakes.

Clark County (2004). Regional wetland inventory and strategy: 51 pages.

Cornelius, L. (July 2006). Gee Creek Watershed Restoration Background Report: WSU Clark County Extension.

Cornelius, L. and J. Finley (January, 2008). Gee Creek Watershed Restoration Project 2007 Annual Report: WSU Clark County Extension.

Cramer, S.P. & Associates, Inc. (January 2005). Chapter 4: East Fork Lewis River Basin – Habitat Assessment, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

Cude, C. (2001). Oregon Water Quality Index: A Tool for Evaluating Water Quality Management Effectiveness. Journal of the American Water Resources Association. Vol. 37, No.1.

Everts, Russel C. (2004). Geologic map of the Ridgefield 7.5' quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map 2834, scale 1:24,000. (http://pubs.usgs.gov/sim/2004/2844).

Fore, L.S., City of Bellevue (March 1999). Measuring the Effects of Urbanization on Bellevue Streams.

Hill, K., and M.C. Bidwell (January 2003). A Rapid Land Cover Classification for Clark County: Washington: Department of Landscape Architecture and Urban

Ecology Lab, College of Architecture and planning, University of Washington, Seattle, Washington.

Hutton, R., and C. Hoxeng (April 2007). Clark County Long-term Index Site and Salmon Creek Monitoring Projects' Status and Trends Based on Oregon Water Quality Indices and Turbidity: Clark County Water Resources Program, Vancouver, Washington.

Karr, J.R. (1998). Rivers as Sentinels: Using the Biology of Rivers to Guide Landscape Management, River Ecology and Management: Lessons from the Pacific Coastal Ecosystems. Springer, NY, pp. 502-528.

Law, A.W. (1994). The effects of watershed urbanization on stream ecosystem integrity. Masters Thesis. University of Washington, Seattle Washington.

Lower Columbia Fish Recovery Board. (Dec. 2004). Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Volume II, Subbasin Plan Chapter G, North Fork and East Fork Lewis.

Lower Columbia Fish Recovery Board. (Dec. 2004). Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Volume II, Subbasin Plan Chapter H, Lower Columbia Tributaries Bonneville and Salmon.

Lower Columbia Fish Recovery Board. (Dec. 2004). Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Volume II, Subbasin Plan Chapter I, Washougal.

Lower Columbia Fish Recovery Board. (2007). Regional Culvert Inventory, Project #02-1658N, Final Report.

Lower Columbia Fish Recovery Board. (2008). East Fork Lewis River Community Habitat Restoration Plan and Project Design – Draft Technical Memorandum 1 and 2.

Lower Columbia Fish Recovery Board. (2009) Lower Columbia Salmon Recovery 6-Year Habitat Work Schedule and Lead Entity Habitat Strategy.

Montgomery, David R. and John M Buffington (1997). Channel-reach morphology in mountain drainage basins: GSA Bulletin; May 1997; v. 109; no. 5; p. 596–611.

National Marines Fisheries Service (August 1996). Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale: Environmental and Technical Services Division, Habitat Conservation Branch.

National Marines Fisheries Service (March 2003). ESA Guidance for Analyzing Stormwater Effects: NOAA Fisheries Service, Northwest Region.

Parametrix, Inc. (2002). Burnt Bridge Creek Riparian Habitat Assessment. Prepared for the City of Vancouver.

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 1: Introduction and Methods, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 3: The North Fork Lewis River Basin, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 5: The Salmon Creek Basin, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources

R2 Resource Consultants, Inc. (December 2004). Kalama, Washougal, Salmon, and Lewis River Habitat Assessments Chapter 6: The Washougal River Basin, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

Schnabel, J. (December 2003). Long-Term Index Site Monitoring Project: 2002 Physical Habitat Data Summary: Clark County Public Works Department, Water Resources Program, Vancouver, Washington.

Schnabel, J. (September 2004). Salmon Creek Watershed: Summer 2003 Stream Temperature. Clark County Public Works Department, Water Resources Program, Vancouver, Washington.

Schueler, T. (1999). Microbes and Urban Watersheds: Ways to Kill ‘em. Watershed Protection Techniques. 3(1): 566-574.

S.P. Cramer & Associates, Inc. (January 2005). Chapter 4: East Fork Lewis River Basin – Habitat Assessment, report prepared for the Lower Columbia Fish Recovery Board under contract to Clark County Water Resources.

State of Oregon Department of Environmental Quality (July 2004). Draft Lower Willamette Subbasin TMDL.

Swanson, R.D. (July 2006). Prioritizing Areas for Stormwater Basin Planning: Clark County Public Works, Water Resources Program.

Vancouver Lake Watershed Partnership Technical Group. Technical Foundation for Future Management of Vancouver Lake (November 2008).

Turney, G.L. (1990). Quality of Groundwater in Clark County, Washington: US Geological Survey Water Resource Investigation Report 90-4149, 97 p.

United States Environmental Protection Agency (1986). Quality Criteria for Water 1986: EPA 440/5-86-011, Office of Water Regulations and standards, Washington, DC.

US Army Corps of Engineers (November 2007). Review of Biological Research on Juvenile and Adult Salmonid use of Vancouver Lake. Portland District.

U.S.G.S. (2002). Hydrologic Trends Associated with Urban Development for Selected Streams in the Puget Sound Basin: Western Washington (Water-Resources Investigations Report 02-4040), Tacoma, WA, pp. 40.

Washington Department of Ecology (November 2006). Water Quality Standards for Surface Waters of the State of Washington: Chapter 173-201A WAC. Publication # 06-10-091.

Washington Department of Ecology (April 2005). O'Brien, Ed. 2005 Stormwater Management Manual for Western Washington: Volume I -- Minimum Technical Requirements and Site Planning, Report 05-10-029, Olympia, WA.

Washington State Department of Ecology. Stormwater Management Manual for Western Washington (February 2005). Publication Numbers 05-10-029 through 05-10-033.

Washington Department of Ecology (April 2007). Draft Watershed Characterization of Clark County, Version 3: Shorelines and Environmental Assistance Program.

Washington Forest Practices Board Manual (March 2000).

Washington State University Vancouver (2009). Bollens, Stephen and Gretchen Rollwagen-Bollens. Year One Annual Report: Biological Assessment of the Plankton in Vancouver Lake, WA.

Wierenga, R., Clark County Water Resources, (January 2005). Technical Report: Subwatershed Characterization and Classification: Clark County Washington.

Wierenga, R. (2005.) Benthic Macroinvertebrate and Water Temperature Monitoring for Clark County Watershed Assessments in 2004. Clark County Public Works Department – Water Resources Program. Washington Department of Ecology Grant number G0300020 and Clark County Clean Water Program.