2008 Stormwater Needs Assessment Program

Salmon Creek (RM 03.83)/Cougar Creek Subwatershed Needs Assessment Report

Clark County Public Works Clean Water Program

April 2009

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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 Cougar Creek and Salmon Creek (RM 03.83) subwatersheds in the lower Salmon Creek watershed.

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 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 three study area subwatersheds including water quality, biological health, habitat, hydrology, and the stormwater system.

Ongoing projects and involvement

The Salmon Creek Watershed Council, Clark Public Utilities, and Ecology are actively involved in improving and protecting lower Salmon Creek and Cougar Creek through local grass-roots organizing, riparian enhancement work, and ongoing TMDL adaptive management. Clark County is also working on development and redevelopment plans in the Three Creeks Planning Area, Highway 99 Planning Area, and the WSU Agricultural Research Station, all of which lie partly or wholly within the Cougar Creek and Salmon Creek (RM 03.83) subwatersheds.

Clark County Clean Water Program (CWP) participates in the TMDL process through implementation of the Stormwater Management Program, provides water quality monitoring, and supports various local organizations working within this assessment area.

There are five CWP stormwater projects in this area under the 2009 through 2014 Stormwater Capital Improvement Program, and two major road projects in the 2008 through 2013 Transportation Improvement Program (Highway 99 – NE 99th Street to 119th Street, and NE 88th Street from Highway 99 to NE St. John's Rd).

Category	Status
Water Quality	
Overall	• Poor to Very Poor • Multiple segments are included in the 303(d) list of impaired water bodies
Fecal coliform bacteria	• Both subwatersheds fail state bacteria standard • Both included in the Salmon Creek fecal coliform TMDL
Temperature	• Temperatures range from among the coolest (Cougar Creek and Tenny Creek) to among the warmest (Salmon Creek mainstem) within the watershed • Both subwatersheds will be included in Salmon Creek temperature TMDL
Biological	
Benthic macro-invertebrates	• Low biological integrity
Anadramous fish	• Known use by Coho salmon and winter steelhead (Salmon Creek mainstem); Cougar Creek inaccessible due to natural barriers • Medium regional recovery priority (primarily Tier 3 and Tier 4 reaches)
Habitat	
NOAA Fisheries criteria	• Road density, percent forested, and percent impervious area metrics indicate habitat is not properly functioning • Stream crossing density metric is in the properly functioning category
Riparian	• Stream shade levels are highly variable; overall below state targets • Invasive plant species are extensive • Large woody debris recruitment potential is low to medium in SC 03.83; ranges from low to high in Cougar Creek
Wetland	• Large expanses of potential wetland in Salmon Creek floodplain and major tributaries (Suds, Tenny, LaLonde) • Pockets of potential wetland in Cougar Creek headwaters
Hydrology and Geomorphology	
Overall hydrology	• Significantly altered from historical conditions • Streams are very flashy; flows are indicative of unstable channel conditions
Future condition	• Impervious area projected to remain at high levels, with associated channel instability and habitat degradation
Stormwater (Unincorp. areas)	
System description	• Primarily piped system; among the most heavily developed areas in county • Nearly 600 public facilities; numerous private facilities
Inventory	• Nearly complete
System adequacy	• Inadequate treatment and flow control; extensive need for system retrofits • Much of the area built out prior to significant stormwater regulation
System condition	• 77 percent (Cougar Creek) and 67 percent (Salmon Creek (RM 03.83)) of public facility components in compliance with county standards at time of inspection • 62 outfalls discharging to critical areas; six causing significant erosion • 222 outfalls inspected for illicit discharges; two illicit connections found and removed

Opportunities

Projects listed in the SNAP report represent only a small part of those needed to protect and restore streams within the study area. Field work and review of existing information identified numerous projects and actions that can improve stream conditions, including the following:

- Focused stormwater outreach and education to streamside landowners based on assessment results
- Retrofits or new facility construction for numerous stormwater outfalls and piped systems to provide flow control and/or treatment
- Repair, replacement, or installation of numerous energy dissipation devices at stormwater outfalls
- Potential large-scale stormwater control projects within the headwaters of Cougar Creek, particularly at the former WSU Agricultural Research station
- Evaluation of three potential wetland enhancement projects
- Investigation of four potential illicit discharges
- Technical assistance visits to landowners with potential source control and water quality ordinance issues
- Numerous small and large-scale invasive plant removal and riparian restoration projects
- Evaluation/maintenance of several clogged and undersized culverts
- Cleanup of over 30 sites with trash accumulation or dumping
- Evaluation of numerous potential channel rehabilitation projects

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 study area include:

- Continue to coordinate with Washington Department of Ecology during Salmon Creek TMDL adaptive management (fecal coliform and turbidity), and TMDL development (temperature)
- Encourage and participate in intra-departmental coordination during ongoing planning efforts in the Three Creeks and Highway 99 special planning areas
- Replace deteriorated stream name signs at road crossings
- Coordinate and leverage opportunities with groups and agencies active in the Salmon Creek watershed
- Continue to encourage and support riparian planting efforts by private landowners
- Consider stormwater basin planning as a tool to better manage stormwater impacts as redevelopment occurs (a pilot project is planned for Cougar Creek)

- Continue to expand efforts to design and build runoff reduction strategies in county right-of-way
- Focus additional maintenance effort on bioswales, particularly with regard to sediment accumulation
- Focus additional maintenance effort on repairing and maintaining energy dissipaters
- Educate landowners to discourage disposal of trash and yard debris in streams or other receiving waters
- Encourage landowners to adopt runoff reduction practices, such as disconnecting downspouts where feasible
- Focus overall management efforts on achieving a stabilized hydrologic regime and channel structure, which will increase the success of future channel and riparian rehabilitation

Introduction

This Stormwater Needs Assessment includes the Salmon Creek (RM 03.83) and Cougar 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 the 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 initiating wetland banking systems, identifying mitigation opportunities, and providing a better understanding of stream and watershed conditions for use in planning county road projects. Similar information is also needed by county programs implementing critical areas protection and salmon recovery planning under the state GMA and the federal ESA.

Scope

This report summarizes and incorporates new information collected for the 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 the Public Works CWP and Stormwater Capital Improvement Program (SCIP), several programs within the Department of Community Development, and the county's ESA Program. Potential project or leveraging opportunities are also referred to local agencies, groups, and municipalities as appropriate.

Assessment Approach

Priorities for Needs Assessment in Salmon Creek (RM 03.83) and Cougar 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).

Salmon Creek (RM 03.83) and Cougar Creek subwatersheds are categorized as "Unincorporated UGA watersheds". Subwatersheds in this category typically include significant areas of development and potential re-development inside the Vancouver UGA of unincorporated Clark County where the county controls development permitting. These are high priority subwatersheds for stormwater needs assessment considering development pressure, subwatershed characteristics and NPDES permit requirements. A wide range of SNAP tools may be used in assessing subwatersheds in this category.

Assessment Tools Applied in Salmon Creek (RM 03.83) and Cougar Creek

The SNAP utilizes a standardized set of tools for subwatershed assessment; including desktop mapping analyses, modeling, outreach activities, and a variety of field data collection. 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 county-wide.

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

Table 1: Stormwater Needs Assessment Tools	
Stakeholders *	Geomorphology And Hydrology Assessment *
Outreach And Involvement *	Riparian Assessment
Coordination with Other Programs *	Floodplain Assessment
Drainage System Inventory *	Wetland Assessment
Stormwater Facility Inspection *	Macroinvertebrate Assessment *
Review Of Existing Data *	Fish Use And Distribution
Illicit Discharge Screening *	Water Quality Assessment *
Broad Scale GIS Characterization *	Hydrologic Modeling
Rapid Stream Reconnaissance *	Hydraulic Modeling
Physical Habitat Assessment	

Assessment Actions

Outreach Activities

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

- August 2008 -- press release to local media.
- March 2008 & December 2008– articles in Clean Water Program E-Newsletter.
- April 2008 -- SNAP information distributed with Clean Water Program information at Small Farm Expo: 69 participants.
- August 2008 – information on the SNAP distributed at 10-day Clark County Fair.
- Clean Water Program web pages updated as needed on an on-going basis; 138 visitors to the SNAP Web page and 95 unique downloads of SNAP documents (note, these figures are under-reported as tracking software only records top 20 pages and documents monthly).
- A description of the SNAP is included in Clark County's annual stormwater management program plan submitted to Ecology.
- 229 source control technical assistance visits to businesses in SNAP watersheds, most of which were located in this assessment area.

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

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

- Site visits by clean water technical assistance staff.
- Letters detailing specific issues 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.

Coordination with Other Programs

Purpose

Coordination with other county departments and with local agencies or organizations helps to explore potential cooperative projects and ensure that the best available information is used to complete the assessment.

Coordination is a two-way relationship; in addition to bringing information into the needs assessment process, coordinating agencies may use needs assessment results to improve their programs.

Methods

The CWP maintains a list of potential coordinating programs for each subwatershed area. Coordination takes the form of phone conversations, meetings, or electronic correspondence, and is intended to solicit potential project opportunities, encourage data and information sharing, and promote program leveraging.

Potential opportunities for coordination exceeded the scope of CWP and SNAP resources; therefore, not all potentially relevant coordination opportunities were pursued. Coordination was prioritized with departments and groups most likely to contribute materially to identifying potential projects and compiling information to complete the needs assessment.

Results

See Analysis of Potential Projects for an overall list and locations of potential projects gathered during the needs assessment process. Projects suggested or identified through coordination with other agencies are included.

The following list includes departments, agencies, and groups contacted for potential coordination in the Salmon Creek (RM 03.83) and Cougar Creek needs assessment area:

- Vancouver Lake Watershed Partnership
- Lower Columbia Fish Recovery Board
- Clark County Transportation Improvement Program
- Clark County Legacy Lands Program
- Vancouver/Clark County Parks and Recreation
- Washington Department of Ecology
- Clark County Endangered Species Act program
- Salmon Creek Watershed Council
- Clark Public Utilities

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 Workplan
- Clark County Volunteer project data
- Ecology 303(d) list
- WRIA 27/28 Plan
- Ecology EIM data
- Clark County 2004 Subwatershed summary
- Clark County 2004 Stream Health Report
- Clark County LISP/SCMP/ Project data
- Clark County 2003 Salmon Cr temperature
- CPU Salmon Creek WS Plan 2002
- MGS Salmon Creek Model
- 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 describes many subwatershed characteristics such as topography, geology, soils, hydrology, land cover, land use, and GMA critical areas. A standard GIS workspace, including shape files for over 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.

Many of these characteristics are described in greater detail in later sections. For example geology and soils form the cornerstone of the Geomorphology and Hydrology section.

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, conclusions about general subwatershed condition and potential future changes, and potential mitigation or improvement site identification.

Map Products

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

General Conditions and Subwatershed Metrics

General Geography

The study area comprises two subwatersheds in urbanizing lower Salmon Creek: Cougar Creek and Salmon Creek (RM 03.83). Salmon Creek (RM 03.83) subwatershed groups a number of smaller, named urban streams draining to Salmon Creek including LaLonde, Tenny, Rockwell, Suds, and 114th St Tributary Creeks. There are also several small unnamed creeks that headwater at the base of steep canyons. The area is on the relatively level Willamette Valley floor (Figure 1). Land use is urban and continuing to develop within the Vancouver Urban Growth Area. Areas of open space remain chiefly as forested canyons and parklands.

Topography
The study area is generally low rolling hills between 200 and 300 feet in elevation and a high point at Mt Vista near WSU campus. The rolling hills are cut by a streams tributary to Salmon Creek which have their headwaters in what were once poorly drained wetland areas. The Salmon Creek floodplain is approximately 20 feet above sea level Cougar Creek, rising to about 120 feet at the upper extent of the study area near the mouth of Mill Creek. All of the tributary streams that flow into canyons lack floodplains. In some cases, streams cross Ice Age terraces along Salmon Creek before dropping steeply to the mainstem floodplain.

Geology and Soils
The oldest rocks in the study are sedimentary rocks deposited by the ancestral Columbia and local streams. These gravel and sandstone deposits are exposed where streams have cut through Ice age Cataclysmic Flood deposits of sand and silt that blanket the area below about 350 feet elevation. Weathered gravel deposits are also exposed on Mt. Vista. Sandstone forms beds for cascades and waterfalls in lowermost Cougar Creek and Tenny Creek near Klineline Park.

A more in-depth description of geology and geomorphology is included in the chapters describing geomorphology and hydrology for Cougar Creek and the streams in Salmon Creek (RM 03.83).

Fine-grained Ice Age Cataclysmic Flood deposits form dune-like features that appear as hills south of Salmon Creek. These deposits are easily eroded and are prone to landslides in steep canyons.

Recent sand and gravel deposits underlie the Salmon Creek floodplain, and were deposited within the last few thousand years.

Hydrology
Geology and topography play the main role in determining study area hydrologic framework. The relatively flat lying sedimentary deposits are capable of retaining relatively large amounts of rainfall as recharge. This groundwater recharge returns to the streams in summer months from seeps and springs.

All tributary streams in the study area drain urbanized or urbanizing areas. Consequently, stream hydrology is altered considerably from a natural forested condition. The chapter describing geomorphology and hydrology includes a description of hydrology and stream channel forms resulting from current land use conditions.

Clark County has a stream gauge on Cougar Creek, and the data is summarized in the Geomorphology and Hydrology Chapter.

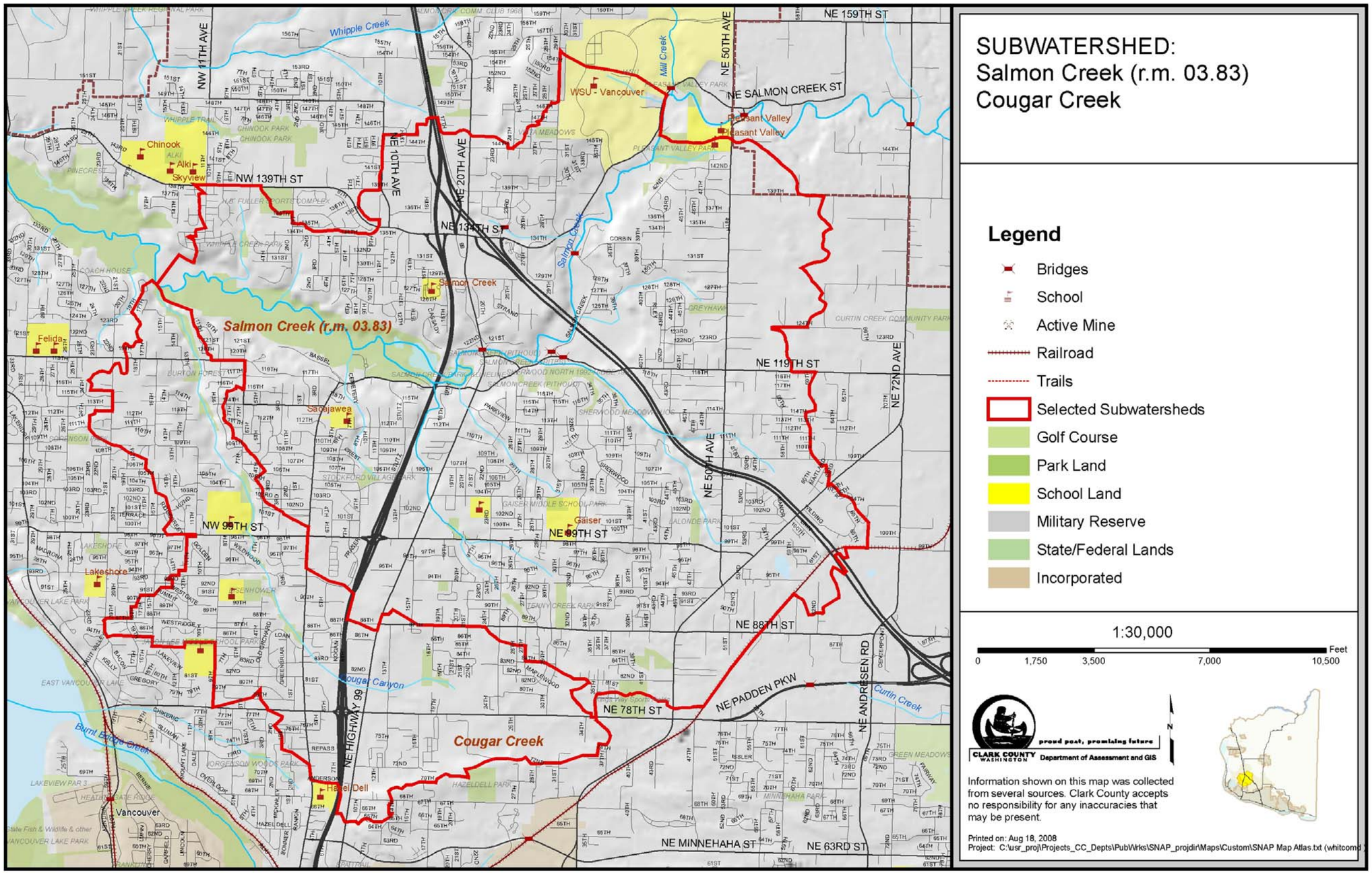


Figure 1: Subwatershed Map: Salmon Creek (RM 03.83) and Cougar Creek Subwatersheds

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 study area has non-functioning stream habitat (Table 2).

Table 2: Watershed Scale Metrics

Metric	Cougar Creek	Salmon Creek rm3.83	Functioning	Non-functioning
Percent Forested (2000 Landsat)	7	13	> 65 %	< 50 %
Percent TIA (2000 Landsat)	51	41	< 5 %	> 15 %
Road Density 2007 data (miles/mile2)	19	17	< 2	> 3
Stream Crossing Density (crossings per stream mile)	1.3	2.6	< 3.2/mile	> 6.4/mile
Percent EIA estimated from the Comprehensive Plan	40	34	< 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.

The study area encompasses one of the most heavily developed areas of Clark County, primarily residential and commercial. Forest cover is minimal and typically confined to stream corridors.

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. Values for both subwatersheds are well beyond the threshold for non-functioning habitat.

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 approximately six-times as dense as the threshold for non-functioning (>3 road miles/mi^2).

Stream Crossing Density
Stream crossing densities are easily measured using available road and stream channel data. The salmon protection standard considers larger fills over 60 feet wide, which would be approximately five to ten foot high road fill. The study area subwatersheds both 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 2008 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 places the study area in the non-functioning category.

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 both subwatersheds would be expected to have very unstable channels.

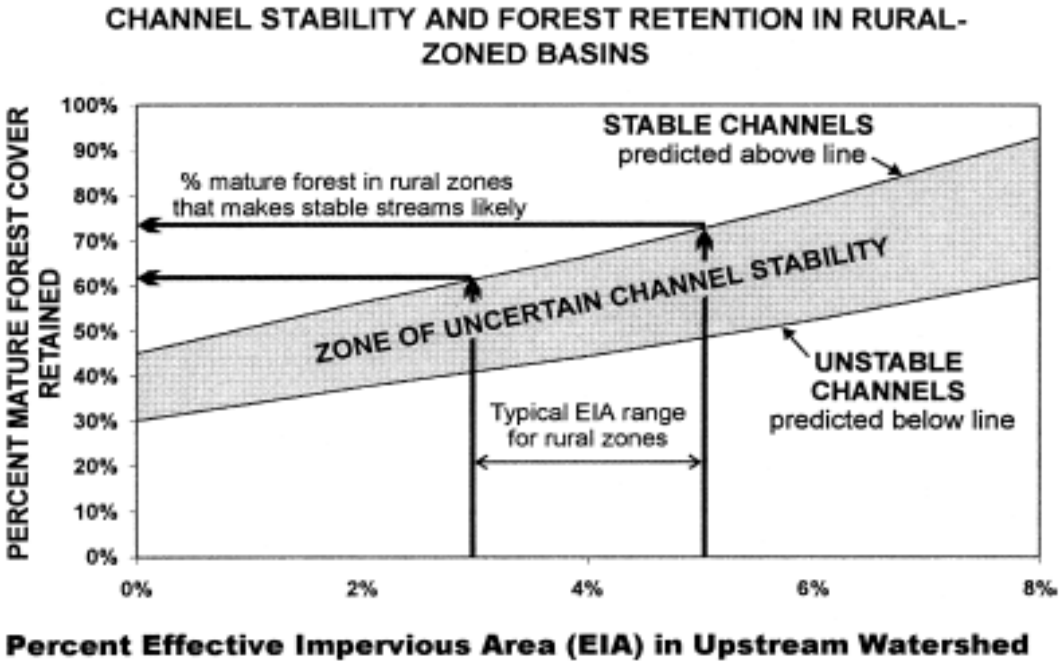


Figure 2: Channel stability in rural areas (Booth, Hartley, and Jackson, June 2002).

Water Quality Assessment

This section briefly summarizes and references available water quality data from the Cougar Creek and Salmon Creek (RM 03.83) 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, Salmon Creek from below the Cougar Creek confluence to the headwaters, 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 Cougar Creek and Salmon Creek (RM 03.83) Subwatersheds

Characteristic	2006 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 may be found on the Ecology website at: http://www.ecy.wa.gov/programs/wq/303d/index.html

Cougar Creek is Category 4a listed (polluted waters with an approved TMDL) for fecal coliform bacteria, and Category 2 listed (Waters of Concern) for pH and dissolved oxygen. The Salmon Creek mainstem has multiple reaches listed within or upstream of the Salmon Creek (RM 03.83) subwatershed, including Category 4a listings for fecal coliform and turbidity, Category 5 listings (polluted waters that require a TMDL) for temperature, dissolved oxygen, and pH; and additional Category 2 listings for temperature, dissolved oxygen, and pH.

Both subwatersheds are included in ongoing TMDL implementation for fecal coliform and in TMDL development for water temperature.

Clark County Stream Health Report

In 2004, the CWP compiled available data and produced the first county-wide assessment of general water quality.

Based on the available dataset including fecal coliform bacteria, general water chemistry (temperature, pH, and dissolved oxygen), and benthic macroinvertebrate scores, overall stream health in the Cougar Creek subwatershed scored in the very poor range, while Salmon Creek (RM 03.83) scored poor.

The 2004 Stream Health Report may be viewed on the county website at: http://www.clark.wa.gov/water-resources/stream.html.

Available Data

A considerable dataset is available for this assessment area; however, the majority of this data comes from the Cougar Creek subwatershed. Limited data exists from the smaller tributary streams within the Salmon Creek (RM 03.83) subwatershed.

A full review and summary of available data and studies is beyond the scope of this document. This summary focuses on recent water quality data collected by the CWP including monthly water quality data from Cougar Creek (2002 through 2007), temperature data collected during the summer of 2003, and a one-year fecal coliform/turbidity study in both subwatersheds conducted for the SNAP during 2007 through 2008. 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	2002-2007 Long-term Index Site Project 2004 Stream Health Report 2007-2008 Focused Bacteria and Turbidity study 2002-2007 Cougar Creek temperature data Salmon Creek Watershed Summer 2003 Stream Temperature

Water Quality Summary

Long-term monthly data and summer temperature data is collected at Station CGR020 (Cougar Creek at NW 119th Street). Bacteria and turbidity data were collected twice monthly at the following stations for twelve months during 2007 and 2008:

- CGR020 (same as above)
- SUD020 (Suds Creek at Salmon Creek Sports Complex)
- TEN010 (Tenny Creek at 117th Street)
- TEN065 (Tenny Creek at 99th Street)
- FOR010 (114th Street tributary at Park View Drive)
- RCW010 (Rockwell Creek at Salmon Creek Avenue)
- LAL030 (LaLonde Creek at 119th Street)

Three stations in this assessment area were included in the Salmon Creek Watershed Summer 2003 Stream Temperature study:

- CGR020
- TEN010
- SMN020 (Salmon Creek at Klineline footbridge)

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 then calculated.

Index scores are categorized as follows:

very poor = 0 to 59; poor = 60 to 79; fair = 80 to 84; good = 85 to 89, and; excellent = 90 to 100.

Figure 3 shows seasonal mean OWQI scores for Station CGR020 from 2002 through 2007. Among 15 long-term monitoring stations county-wide, Station CGR020 ranked second worst in overall water quality during this time period (Hutton and Hoxeng, 2007).

Monthly OWQI values since 2002 ranged from Very Poor to Fair, although for most months (43 out of 62 months sampled) OWQI values were in the Very Poor category. Monthly sub-index scores for total solids and inorganic nitrogen were consistently very poor, while scores for total phosphorus were typically in the poor range. Fecal coliform scores ranged widely, from very poor to excellent. Scores for water temperature, dissolved oxygen, and pH were consistently excellent.

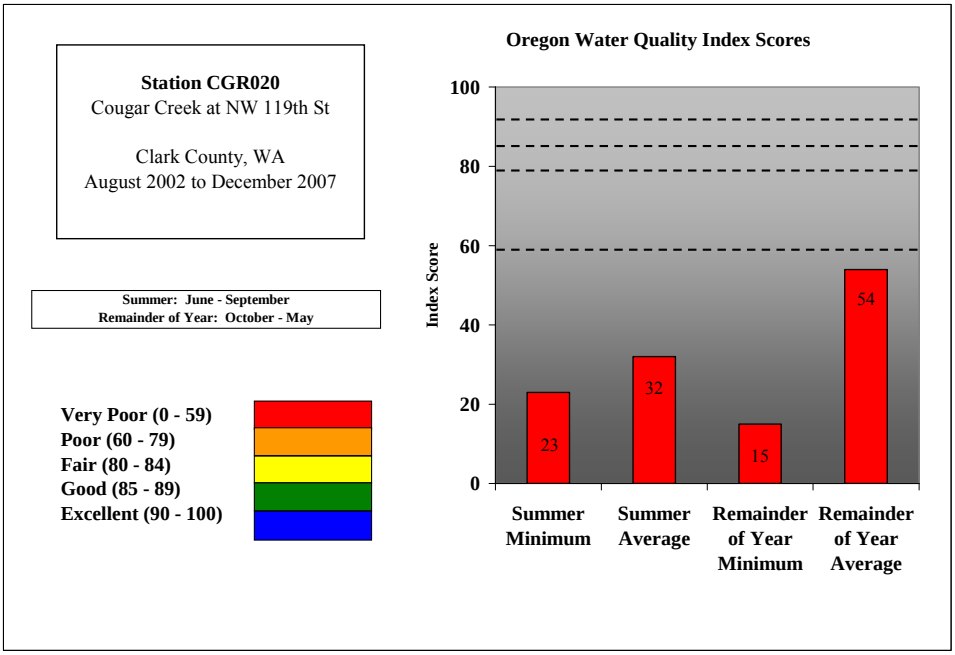


Figure 3: Average Water Quality, Cougar Creek station CGR020, 2002 through 2007, Oregon Water Quality Index

Trends over Time

An analysis of potential statistical trends in OWQI scores based on the 2002 through 2006 dataset found no significant trends at Station CGR020 (Hutton and Hoxeng, 2007).

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 CGR020 between August 2002 and December 2007 ranged from 0.047 mg/L to 0.413 mg/L, and 30 percent of samples exceeded the EPA criterion. Total phosphorus concentrations typically vary seasonally in many locations; however, seasonal median values in Cougar Creek are relatively similar:

- Summer median = 0.102 mg/L
- FWS median = 0.086 mg/L

Turbidity

It is difficult to establish an exact background turbidity level for the assessment area because no data exists 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.

Since May 2002, the median of 75 turbidity samples at Station CGR020 is 3.5 NTU, with individual samples ranging from 1 NTU to 194 NTU.

Higher turbidity readings in the 20 to 40 NTU range are common in Clark County streams during storm events. Very high turbidity values (typically 100 or greater) often indicate a specific sediment source. The 194 NTU value recorded in Cougar Creek came during a significant rainfall event in May 2006.

Fecal Coliform Bacteria

For a full analysis, see the Lower Salmon Creek Focused Assessment: Fecal Coliform and Turbidity report on the CWP web page after May 2009. General results are summarized below.

Based on 24 samples collected over a one-year period, seven out of the eight stations in the focused bacteria study exceeded the geometric mean portion of the state standard (Table 5). Station TEN065 was the only station not exceeding. All eight stations failed the 10 percent not-to-exceed portion of the standard.

Table 5: Summary of fecal coliform sample data from October 2007 to September 2008; highlighted values indicate cases where the state water quality criteria were not met (WAC173-201A-200).

Monitoring Station Code	Number of Samples	Range of Fecal Coliform Concentrations cfu/100 mL	Geometric Mean Fecal Coliform Concentrations cfu/100 mL	90th Percentile Fecal Coliform Concentrations cfu/100 mL
CGR020	24	44-3,000	450	2,200
SUD020	24	20-10,900	405	1,197
TEN010	24	30-17,100	173	1,600
LAL030	24	41-8,900	250	883
RCW010	24	3-28,600	115	1,033
FOR010	24	41-4,400	205	1,345
TEN065	23	7-709	69.5	313
CGR080	24	27-24,600	235	1,507

An evaluation of seasonal and weather differences indicates that wet weather during the dry season (June through October) resulted in by far the highest bacteria levels relative to all other combinations of weather and season (Table 6). Dry weather during the wet season resulted in the lowest values.

Table 6: Fecal Coliform Calculations from All Stations, Grouped by Categories or Weather and Season

Event Category	Event Count	Geometric Mean Value	90th Percent Value	Number of Observations
Dry Weather/Dry Season	6	267	631	47
Wet Weather/Dry Season	3	2,053	20,100	23
Dry Weather/Wet Season	6	95	414	48
Wet Weather/Wet Season	9	175	1,072	72

Long-term data (2002 through 2007) from Station CGR020 indicate consistently elevated fecal coliform values. Based solely on fecal coliform data, this station ranked worst among 15 long-term stations in Clark County from 2002 through 2006 (Hutton and Hoxeng, 2007).

Stream Temperature

One summer of continuous temperature monitoring (2003) at Station CGR020, Station TEN010, and Station SMN020 indicated that Cougar Creek and Tenny Creek (a tributary in the Salmon Creek (RM 03.83) subwatershed) were among the coldest streams in the Salmon Creek watershed. The mainstem at Station SMN020 (Klineline) was among the warmest.

Figure 4 shows 7-DADMax temperatures during the summer of 2003 for 15 stations throughout the Salmon Creek watershed. The 7-DADMax is the maximum of the 7-day moving average of daily maximum temperatures. Ecology standards utilize this metric to determine temperature compliance (criterion for this assessment area is 60.8 degrees F).

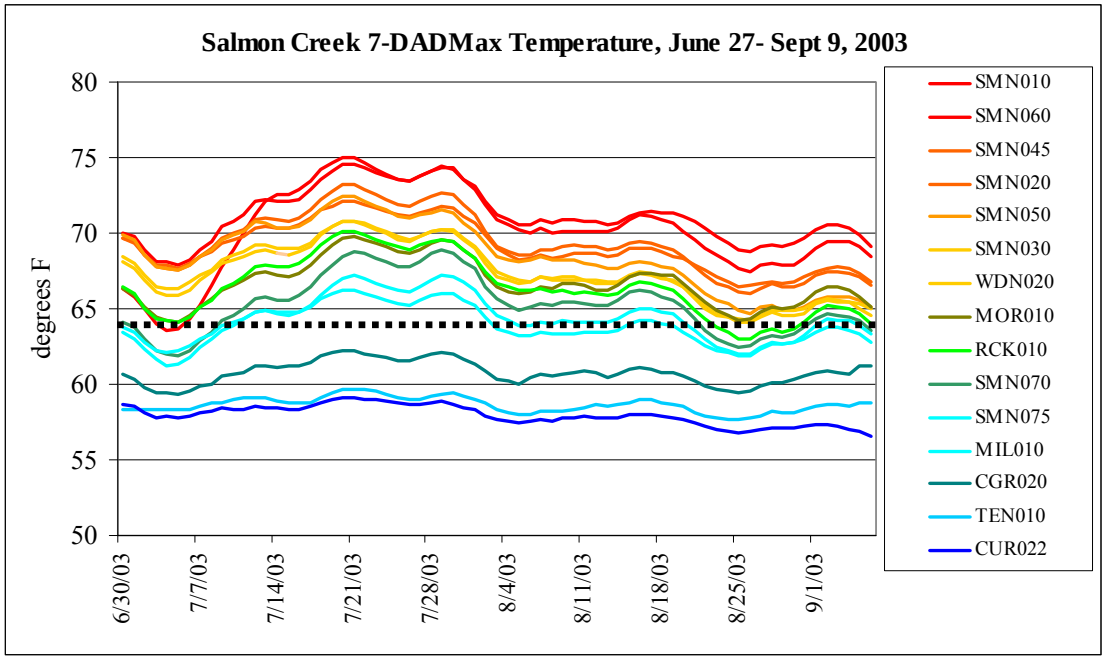


Figure 4: Time-series plot of 7-DADMax temperatures, Salmon Creek, summer 2003. (from Schnabel, 2004). Dotted line at 64° F represents the pre-2006 Washington state stream temperature criterion. The current criterion is 60.8° F.

Based on current state criteria for Salmon Creek, Tenny Creek was the only station meeting criteria within this assessment area; though Cougar Creek exceeded the criteria only slightly. Despite the addition of cool tributary flow from Tenny Creek and Cougar Creek, mainstem Salmon Creek within this assessment area remains very warm, substantially exceeding the state criterion.

A longer temperature dataset is available for Cougar Creek. Continuous summer temperature monitoring from 2002 through 2008 indicates a remarkably consistent 7-DADMax between 61.7 degrees F and 64.2 degrees F. In five of seven years, the value was between 62.2 degrees F and 62.8 degrees F. While these values exceed the state criteria, Cougar Creek remains among the cooler streams for which temperature data is available.

Impacts to Beneficial Uses and Potential Sources

General water quality in this assessment area is poor according to the overall OWQI and other measures discussed above. Observed water quality may have negative impacts on the listed beneficial uses of: core summer salmonid habitat; primary contact recreation; wildlife habitat; and aesthetic values. Table 6 at the

conclusion of this section summarizes the primary water quality impacts to beneficial uses in Cougar Creek and Salmon Creek (RM 03.83), 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.

Among the CWP activities most likely to have a positive impact on water quality in general are:

- Effective stormwater system designs, retrofitting, and maintenance;
- Source detection and removal projects; and
- Public education programs.

Stormwater system design, retrofitting, and maintenance include a range of activities that can address pollutants of concern. Source detection and removal projects help eliminate specific contributions of pollutants. Education programs are a critical element in modifying behavior and promoting better public stewardship of water resources.

Table 7: Known Water Quality Concerns, Sources, and Solutions for Cougar Creek and Salmon Creek (RM 03.83)				
Characteristic	**Beneficial Use Affected**	**Potential Sources**	**Mechanism**	**Solutions (bold indicates direct Clean Water Program involvement)**
Fecal coliform bacteria	Primary contact recreation	failing septic systems	groundwater seeps storm sewers	Storm sewer screening for source identification and removal Education programs Storm water facility designs/retrofits to optimize bacteria reduction (see Schueler, 1999) Agricultural Best Management Practices Septic and sanitary sewer system inspection and maintenance
		sanitary sewer leaks	groundwater seeps storm sewers	
		livestock, pets, wildlife	overland runoff storm sewers direct access	
Water temperature (mainstem Salmon Creek only)	Core summer salmonid habitat	vegetation removal	direct solar radiation	**Stormwater infiltration to increase baseflow** **Streamside planting/vegetation enhancement/riparian preservation through acquisition** **Education programs** Pond removal or limitation
		low summer flows	decreased resistance to thermal inputs	
Total solids	Core summer salmonid habitat	erosion *(development projects; land clearing; cropland; impervious surfaces; channel erosion)*	overland runoff storm sewers channel dynamics	Erosion control regulations **Storm sewer system cleaning and maintenance** Agricultural Best Management Practices Stream bank stabilization/rehabilitation **Storm water outfall/facility retrofits to reduce flow-induced channel erosion**

Drainage System Inventory

Clark County's drainage system inventory resides in the StormwaterClk GIS database and is available to users through the county's Department of Assessment and GIS, or viewable on the internet through the Digital Atlas located at:
http://gis.clark.wa.gov/imf/imf.jsp?site=digitalatlas&CFID=56651&CFTOKEN=98300052

Drainage system inventory is an ongoing CWP work effort focused on updating the StormwaterClk database to include all existing stormwater drainage infrastructure.

The work effort during 2008 in the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds was focused on identifying and mapping previously unmapped discharge points and stormwater conveyance. Table 8 indicates the number of features previously inventoried in StormwaterClk prior to 2008 SNAP work, and the number of features added to the database as a result of 2008 SNAP and mapping project implementation.

The drainage system inventory for these subwatersheds is generally completed. Inventory is ongoing in 2009 as part of a county-wide inventory update.

Table 8: Drainage System Inventory Results, Salmon Creek (RM 03.83)/Cougar Creek

Database Feature Category	Previously Inventoried	Added to Database during 2008
Inlet	4714	930
Discharge Point (outfall)	211	52
Flow Control	192	67
Storage/Treatment	1099	353
Manhole	2493	375
Filter System	84	65
Channel	1352	422
Gravity Main	9245	2178
Facilities	449	146

Stormwater Facility Inspection

The stormwater facility inspection process includes two components:

- A public stormwater facility inspection using state and county standards.
- An off-site inspection to check for problems such as downstream bank erosion.

Component 1: Public Stormwater Facility Inspection

Purpose

The purpose of the Public Stormwater Facility Inspection project is to verify that maintenance activities are implemented; facilities are properly functioning, and identify possible retrofit projects and major repairs.

Methods

The Public Stormwater Facility Inspection project is derived from county and state standards equivalent to maintenance standards specified in Chapter 4 of Volume V of the 2005 Stormwater Management Manual for Western Washington. The standards list the part or component of the facility that may need repairs, the condition when repair or maintenance is needed, and the expected results. Individual components of a facility are referred to as "facility objects" and are listed in Table 9.

The public stormwater facility inspection process involves inspecting all facility objects to determine if all maintenance is in compliance with the standards. If any facility object does not meet the maintenance standards, the entire facility is not in compliance. Noncompliant stormwater facilities are referred to the appropriate public works departments for repairs or maintenance.

Results

Based on the county's StormwaterClk database, as of October 2008, there were 25 mapped public stormwater facilities in the Cougar Creek subwatershed and 145 stormwater facilities in the Salmon Creek (RM 03.83) subwatershed.

Figure 5 summarizes notable inspection activities in the Cougar Creek subwatershed including general facility location, compliant facilities and referrals of noncompliant facilities.

As listed in Table 9, all 25 public stormwater facilities were inspected in the Cougar Creek subwatershed. These facilities included a total of 211 facility objects or components that were inspected. Of the 211 facility objects inspected, 163 (77 percent) of the facility objects were in compliance. The remaining 48 (23 percent) of the facility objects were not in compliance.

The inspection process in the Cougar Creek subwatershed generated 18 referrals: three referrals were to the Clark County Public Works Clean Water Program engineer; and 15 referrals were to Public Works Maintenance and Operations for needed maintenance activities.

Figure 6 summarizes notable inspection activities in the Salmon Creek (RM 03.83) subwatershed including general facility location, compliant facilities and referrals of noncompliant facilities.

As listed in Table 10, all 145 public stormwater facilities were inspected in the Salmon Creek (RM 03.83) subwatershed. These facilities included a total of 1,147 facility objects or components that were inspected. Of the 1,147 facility objects inspected, 764 (67 percent) of the facility objects were in compliance. The remaining 383 (33 percent) of the facility objects were not in compliance.

The inspection process in the Salmon Creek (RM 03.83) subwatershed generated 149 referrals: three referrals were to the Clark County Public Works Code Enforcement; nine referrals were to the Clark County Public Works Clean Water Program engineer; three referrals were to the Clark County Public Works Clean Water Program for reinspection; and 110 referrals were to Public Works Maintenance and Operations for needed maintenance activities. The same referral may be generated to multiple programs depending on noncompliant issues.

Maintenance Referrals

Referrals made to the public works maintenance and operations department have been either brought into compliance, or will be scheduled for repair or maintenance in early 2009.

Once referrals are addressed, the CWP revisits facilities to conduct a second inspection to ensure compliance.

No major defects or hazardous conditions were discovered; non-compliant issues included excess sediment depth, trash or debris, and vegetative management issues.

Retrofit Opportunities

The public facility inspection process yielded sixteen potential retrofit opportunities; fourteen in the Salmon Creek (RM 03.83) subwatershed and two in the Cougar Creek subwatershed. These opportunities include retrofitting under utilized facilities or using low impact development projects to better treat stormwater runoff (Table 11).

Management Recommendations for the Cougar Creek Subwatershed

The most common facility objects found out of compliance during the public stormwater facility inspection process were energy dissipaters, bioswales, and lack of stormwater facility signage. Excessive sedimentation was the most common noncompliant defect across facility objects. Vegetative management issues were the most common noncompliant defects regarding bioswales. These defects included overgrown bioswales where grasses exceeded 10 inches in height with nuisance weeds and other vegetation starting to take over.

Approximately 45 percent of public stormwater facilities were missing signage. Correcting facility sedimentation issues and maintenance of bioswales, and adding appropriate signage will bring most facilities into compliance.

Management Recommendations for the Salmon Creek (RM 03.83) Subwatershed

The most common facility objects found out of compliance during the public stormwater facility inspection process were flow control structures, conveyance stormwater pipes, energy dissipaters, bioswales, and lack of stormwater facility signage. Excessive sedimentation was the most common noncompliant defect across facility objects. Sedimentation defects were the common noncompliant issue for flow control structures, conveyance stormwater pipes, sediment traps, and energy dissipaters. Vegetative management issues were the most common noncompliant defects regarding bioswales. These defects included overgrown bioswales where grasses exceeded 10 inches in height with nuisance weeds and other vegetation starting to take over. Approximately 33 percent of public stormwater facilities were missing signage. Correcting facility sedimentation issues and maintenance of bioswales, and adding appropriate signage will bring most facilities into compliance.

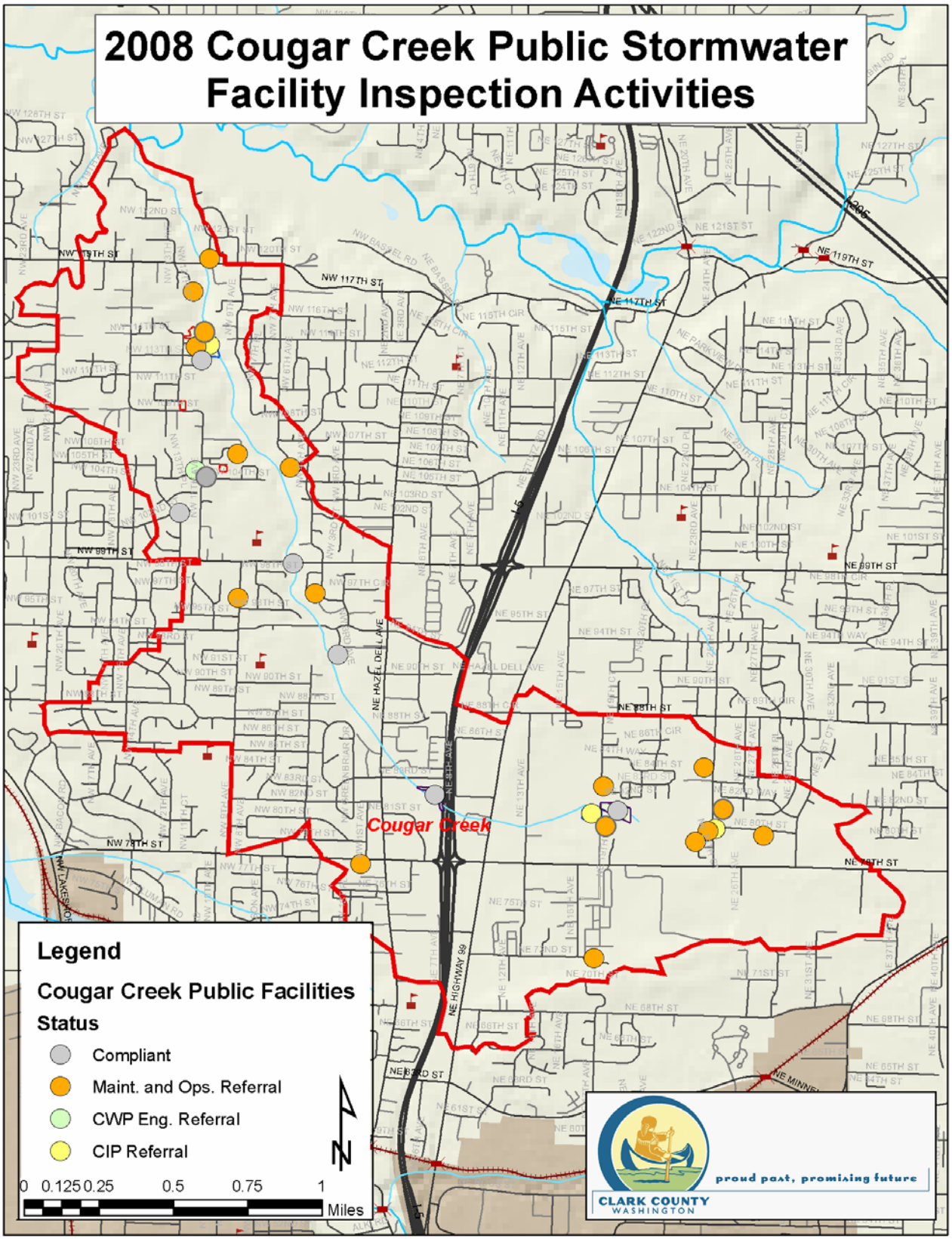


Figure 5: Summary of 2008 Public Stormwater Facility Inspection Activities in the Cougar Creek Subwatershed

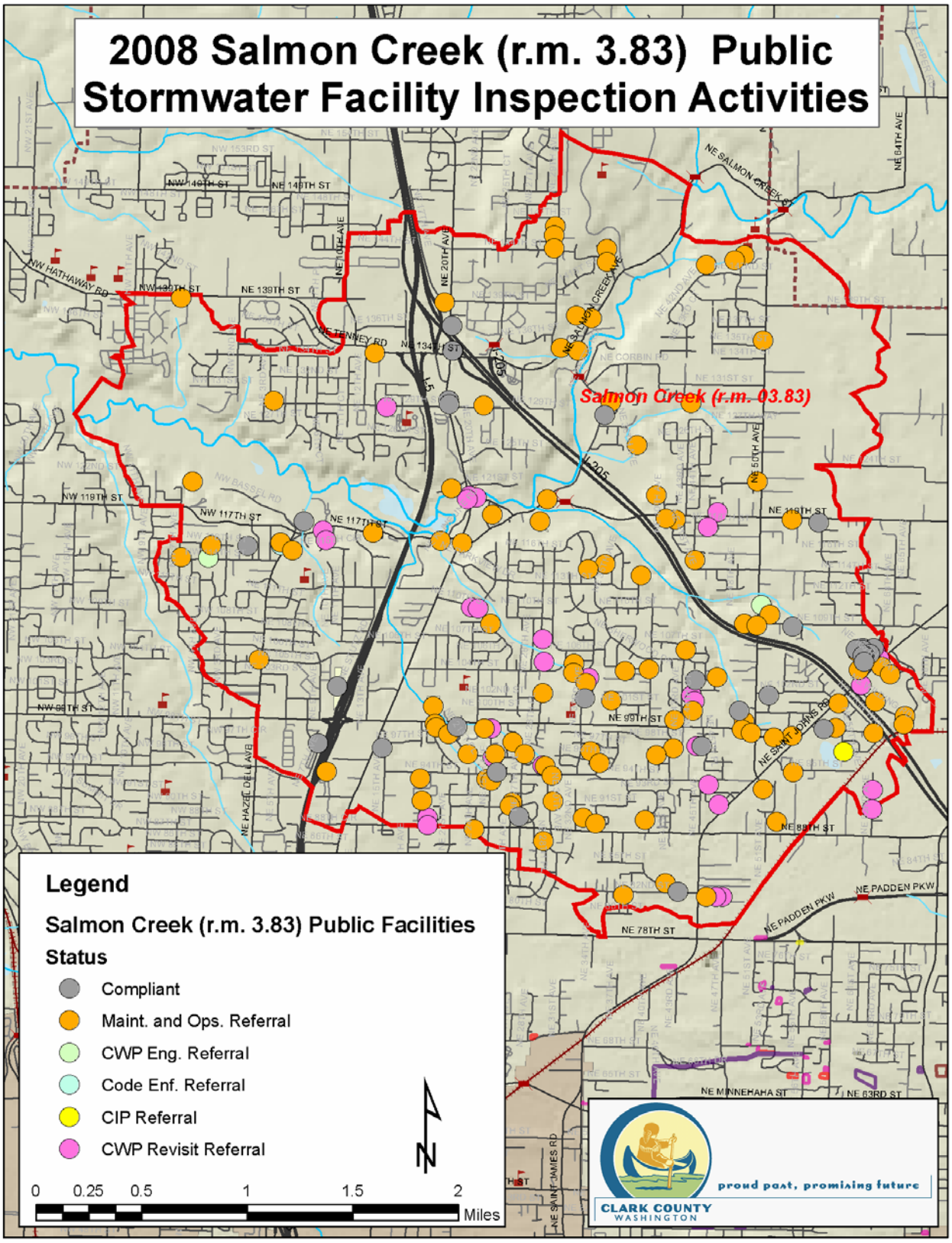


Figure 6: Summary of 2008 Public Stormwater Facility Inspection Activities in the Salmon Creek (RM 03.83) Subwatershed

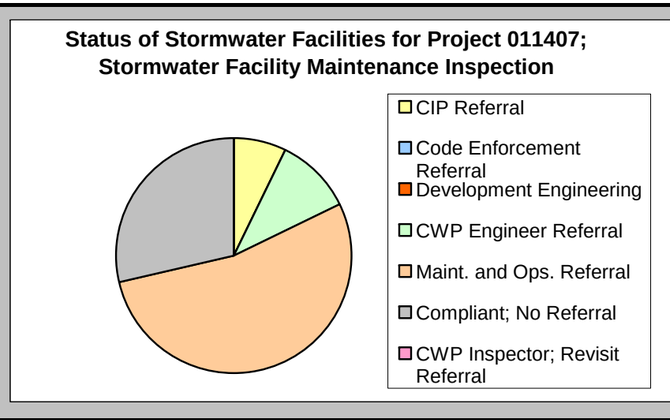
Table 9: 2008 Public Stormwater Facility Inspection Project Activity of the Cougar Creek subwatershed.

SNAP Public Stormwater Facility Inspections

Subject: Cougar Creek Subwatershed; Project 011407 Stormwater Facility Inspection Results

Total SNAP SWF Inspections	**25**
Maintained by Public Works	**25**
Compliant	**8**
Non-Compliant	**17**

Referrals of Non-Compliant SWF's as December 208		**Referral Addressed and Facility Compliant as of December 2008**
CIP Referral	2	n/a
Code Enforcement Referral	0	n/a
Development Engineering	0	n/a
CWP Engineer Referral	3	n/a
Maint. and Ops. Referral	15	n/a
Compliant; No Referral	8	n/a
CWP Inspector; Revisit Referral	0	n/a



Facility Objects Inspected	**Initial Inspections**		**Defect**	**Maintence Trigger**	**Facility Objects Repaired as of December 2008**
	Compliant	**Non-Compliant**			
Access Road or Easement	24	1	road surface	condition of road surface may lead to erosion of the facility or limit access.	N/A
Catch Basin	9	3	sediment & debris	sediment exceeds 60 percent of the sump	N/A
Closed Detention System	1	0	n/a	n/a	N/A
Stormwater StormFilter	2	1	vault structure damage	all 3 vault lid access bolts broken	N/A
Control Structure / Flow Restrictor	12	2	sediment & debris	material exceeds 25% of sump depth	N/A
Debris Barrier & Access Barrier	2	0	n/a	n/a	N/A
Detention Pond	15	1	tree growth & hazardous trees	tree growth does not allow maintenance access or interferes with maintenance activity	N/A
Facility Discharge Point	27	1	off site assessment	erosion, scouring, or headcuts	N/A
Drywell	0	1	sructure damage	cracks wider than 1/2 inch at joints	N/A
Energy Dissipater	10	11	sediment & debris	accumulated sediment that exceeds 20% of the design depth	N/A
Fence, Gate or Water Quality Sign	11	9	sign unreadable	water quality sign is missing or 20% of the surface	N/A
Field Inlet	7	4	sediment	sediment exceeds 60 percent of the sump depth	N/A
Infiltration Basin	1	0	n/a	n/a	N/A
Sand Filter	n/a	n/a	n/a	n/a	N/A
Catch Basin Insert	n/a	n/a	n/a	n/a	N/A
Infiltration Trench	1	0	n/a	n/a	N/A
Filter Strip	n/a	n/a	n/a	n/a	N/A
Conveyance Stormwater Pipe	23	5	sediment & debris	sediment depth is greater than 20% of pipe	N/A
Sediment Trap	4	2	sediment	sediment (in the basin) that exceeds 60 percent of the sump depth	N/A
Typical Biofiltration Swale	9	7	vegetation	grass is taller than 10 inches; nuisance weeds and other vegetation start to take over.	N/A
Wet Biofiltration Swale	n/a	n/a	n/a	n/a	N/A
Treatment Wetland	1	0	n/a	n/a	N/A
Wetpond	4	0	n/a	n/a	N/A
Wetvaullt	n/a	n/a	n/a	n/a	N/A
Total SWF Objects	**163**	**48**			
Total Percentage	**77**	**23**			

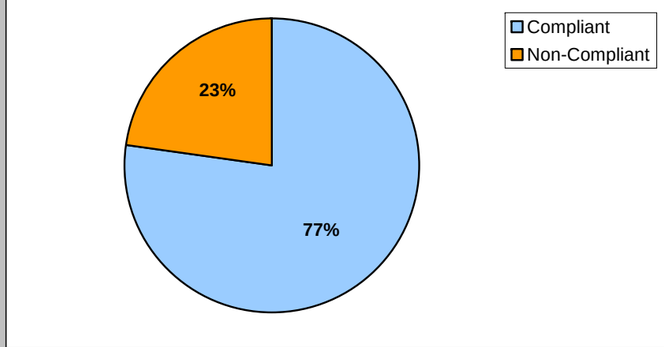


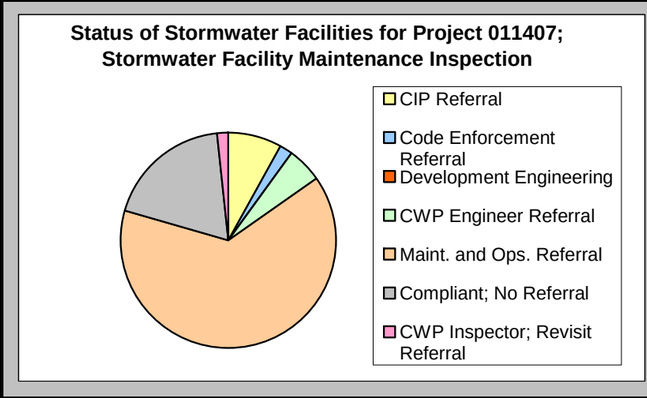
Table 10: 2008 Public Stormwater Facility Inspection Project Activity of the Salmon Creek (RM 03.83) Subwatershed

SNAP Public Stormwater Facility Inspections

Subject: Salmon Creek (r.m. 03.83) Creek Subwatershed; Project 011407 Stormwater Facility Inspection Results

Total SNAP SWF Inspections	**145**
Maintained by Public Works	**145**
Compliant	**32**
Non-Compliant	**113**

Referrals of Non-Compliant SWF's as December 2008		**Referral Addressed and Facility Compliant as of December 2008**
CIP Referral	14	n/a
Code Enforcement Referral	3	n/a
Development Engineering	0	n/a
CWP Engineer Referral	9	n/a
Maint. and Ops. Referral	110	n/a
Compliant; No Referral	32	n/a
CWP Inspector; Revisit Referral	3	n/a



Facility Objects Inspected	**Initial Inspections: Compliant**	**Initial Inspections: Non-Compliant**	**Defect**	**Maintence Trigger**	**Facility Objects Repaired as of December 2008**
Access Road or Easement	134	14	vegetation	any poisonous or nuisance vegetation	N/A
Catch Basin	65	18	storm pipe damaged	storm pipe damaged or elbow missing/not connected preventing normal function	N/A
Closed Detention System	6	0	n/a	n/a	N/A
Stormwater StormFilter	15	7	ladder damaged	ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, cracks, corrosion, or sharp edges	N/A
Control Structure / Flow Restrictor	44	24	sediment & debris	sediment exceeds 60 percent of the sump depth	N/A
Debris Barrier & Access Barrier	16	9	trash & debris / litter	trash or debris that is plugging more than 20% of the openings in the debris barrier	N/A
Detention Pond	51	15	erosion	eroded damage over 2 inches deep on side slope	N/A
Facility Discharge Point	2	3	erosion	soil erosion in or adjacent to rock pad	N/A
Oil Water Separator	1	0	n/a	n/a	
Drywell	21	6	cover damaged or	one maintenance person cannot remove lid	N/A
Energy Dissipater	48	74	sediment & debris	riprap covered with sediment and vegetation	N/A
Fence, Gate or Water Quality Sign	38	48	sign unreadable	water quality sign is missing or 20% of the surface is unreadable	N/A
Field Inlet	49	24	fractures or cracks in basin walls/ bottom	grout has separated or cracked wider than 1/2 inch or any evidence of soil particles entering	N/A
Infiltration Basin	5	0	n/a	n/a	N/A
Open Channel	20	0	n/a	n/a	
Sand Filter	8	1	baffles or internal walls	baffles or walls corroding, cracking, warping	N/A
Infiltration Trench	19	3	drainage slow	decreased capacity that indicates sloe drainage	N/A
Filter Strip	0	1	vegetation	grass is taller than 10 inches; nuisance weeds and	N/A
Conveyance Stormwater Pipe	161	54	sediment & debris	sediment depth is greater than 20% of pipe	N/A
Sediment Trap	16	14	sediment	sediment exceeds 60 percent of the sump depth	N/A
Typical Biofiltration Swale	33	68	vegetation	grass is taller than 10 inches; nuisance weeds and other vegetation start to take over.	N/A
Wet Biofiltration Swale	1	0	wetland vegetation	vegetation is crowded out by very dense clumps of cattail	N/A
Treatment Wetland	1	0	n/a	n/a	N/A
Wetpond	10	0	n/a	n/a	N/A
Total SWF Objects	**764**	**383**			
Total Percentage	**67**	**33**			

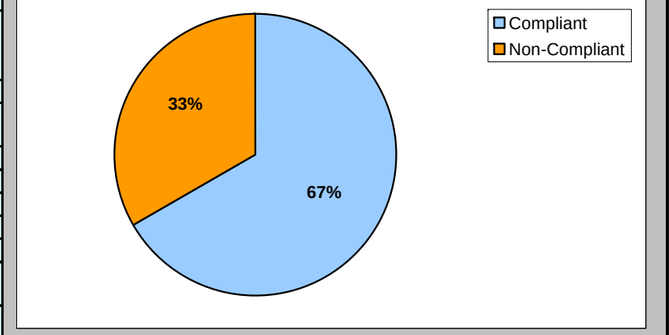


Table 11: Description of Potential Retrofit Opportunities			
Facility ID	**Basis for Project**	**Project Description**	**Subwatershed**
131	Swale and detention pond area can be enhanced to better treat stormwater	Potential retrofit of bioswale or installation of LID practices	Cougar Creek
321	Unmaintained facility; sedimentation of detention pond; large lot with little infrastructure	Stormwater treatment BMP enhancement	Cougar Creek
25	Large lot with little infrastructure	Stormwater treatment BMP enhancement	Salmon Creek (RM 03.83)
29	Large lot with little infrastructure	Stormwater treatment BMP enhancement	Salmon Creek (RM 03.83)
76	Large lot with little infrastructure	Stormwater treatment BMP enhancement	Salmon Creek (RM 03.83)
327	Large lot with little infrastructure	Stormwater treatment BMP enhancement	Salmon Creek (RM 03.83)
335	Large lot with little infrastructure; sedimentation of swale	Stormwater treatment BMP enhancement	Salmon Creek (RM 03.83)
720	Large lot with open areas	Wetpond/detention pond enhancement	Salmon Creek (RM 03.83)
724	Large lot with open areas and little treatment	Wetpond/detention pond enhancement	Salmon Creek (RM 03.83)
745	Large lot with open areas and little treatment	Wet swale and channel enhancement	Salmon Creek (RM 03.83)
758	Large lot with open areas and overgrown detention areas	Wetpond/detention pond enhancement	Salmon Creek (RM 03.83)
764	Large lot with open areas and overgrown detention areas	Wetpond/detention pond enhancement	Salmon Creek (RM 03.83)
769	Large lot with open areas and little treatment	Wetpond/detention pond enhancement	Salmon Creek (RM 03.83)
779	Large lot with open areas and little treatment	Stormwater treatment BMP enhancement	Salmon Creek (RM 03.83)
1185	Facility adjacent to large county owned parcel	Wetland enhancement	Salmon Creek (RM 03.83)
1914	Swale and detention pond area can be enhanced to better treat stormwater	Potential retrofit of bioswale or installation of LID practices	Salmon Creek (RM 03.83)

Component 2: Offsite Assessment

Purpose

Discharge 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 can also increase slope instability problems.

The Offsite Assessment project detects possible 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 were included in the offsite assessment:

- Within 200 feet of a critical area such as a stream channel,
- Within 300 feet of a headwater stream,
- Located on public land,
- Discharges stormwater from a public-dedicated facility that is currently under the two year private maintenance warranty bond.

The offsite assessment inspects all outfalls that discharge into critical areas, as well as a 300 foot survey downstream of the outfall to look for any adverse impacts that may be caused by stormwater discharges.

If any 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.

Results

Based on the county's StormwaterClk database, as of June 2008 there were 34 mapped outfalls in the Cougar Creek subwatershed and 74 mapped outfalls in Salmon Creek (RM 03.83) subwatershed that discharged into critical areas. In addition, one other outfall was assessed as part of the routine stormwater facility inspection process. In Cougar Creek, 27 outfalls were assessed as part of the Stream Reconnaissance project, while seven outfalls were assessed as part of the offsite assessment project. In the Salmon Creek (RM 03.83) subwatershed, 17 outfalls were assessed as part of the stream reconnaissance project, while 54 outfalls (53 mapped and one unmapped) were assessed as part of the offsite assessment project. Four outfalls were not assessed due to construction activities. Outfall assessment activities were conducted as part of both the stream reconnaissance project and the offsite assessment project to minimize duplication visits to outfall locations. Outfalls assessed as part of the Stream Reconnaissance

project are discussed in the Stream Reconnaissance and Feature Inventory section of this SNAP report.

Figures 7 and 8 summarize notable outfall assessment activities including general outfall locations in the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds.

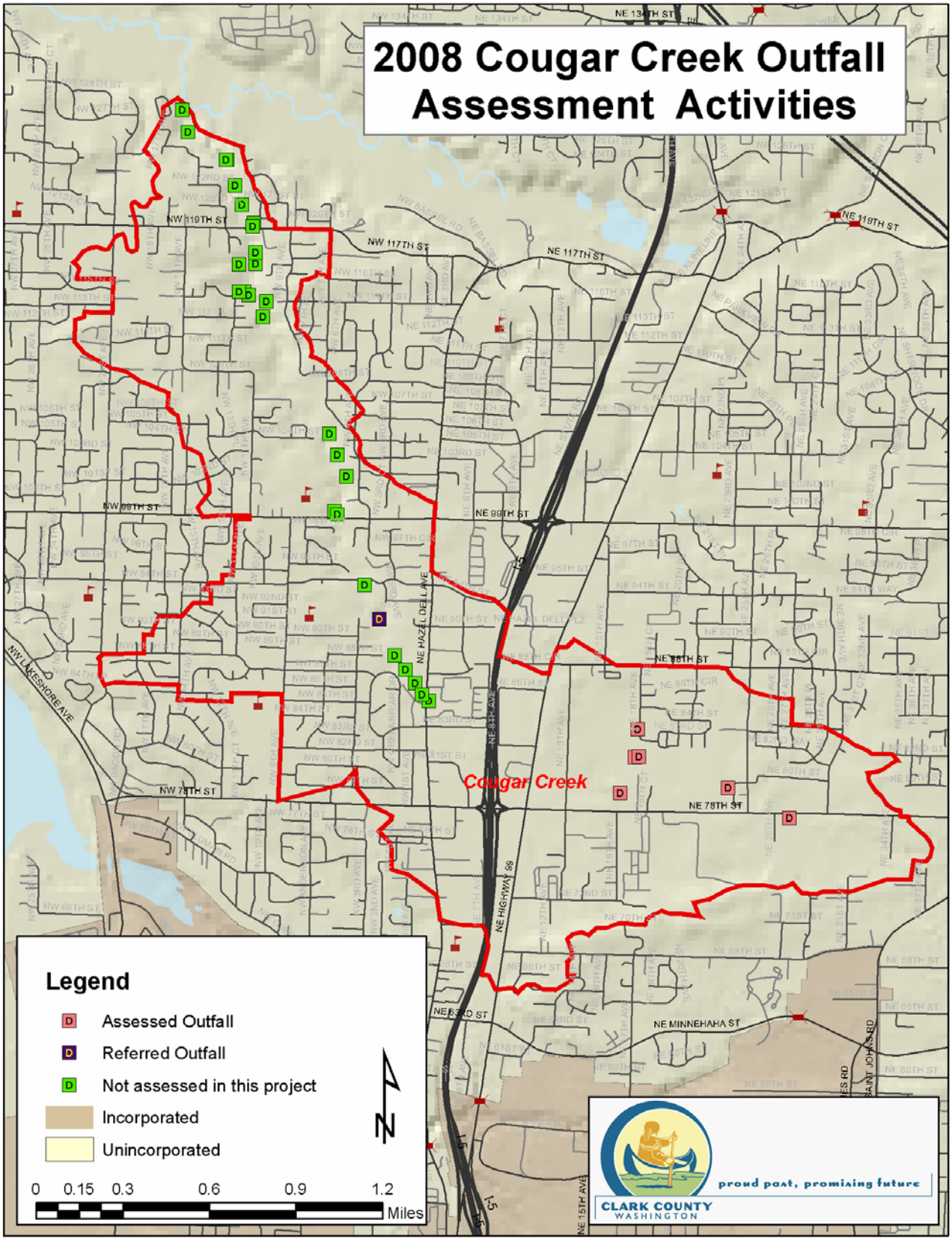


Figure 7: Summary of 2008 Outfall Assessment Activities in Cougar Creek Subwatershed.

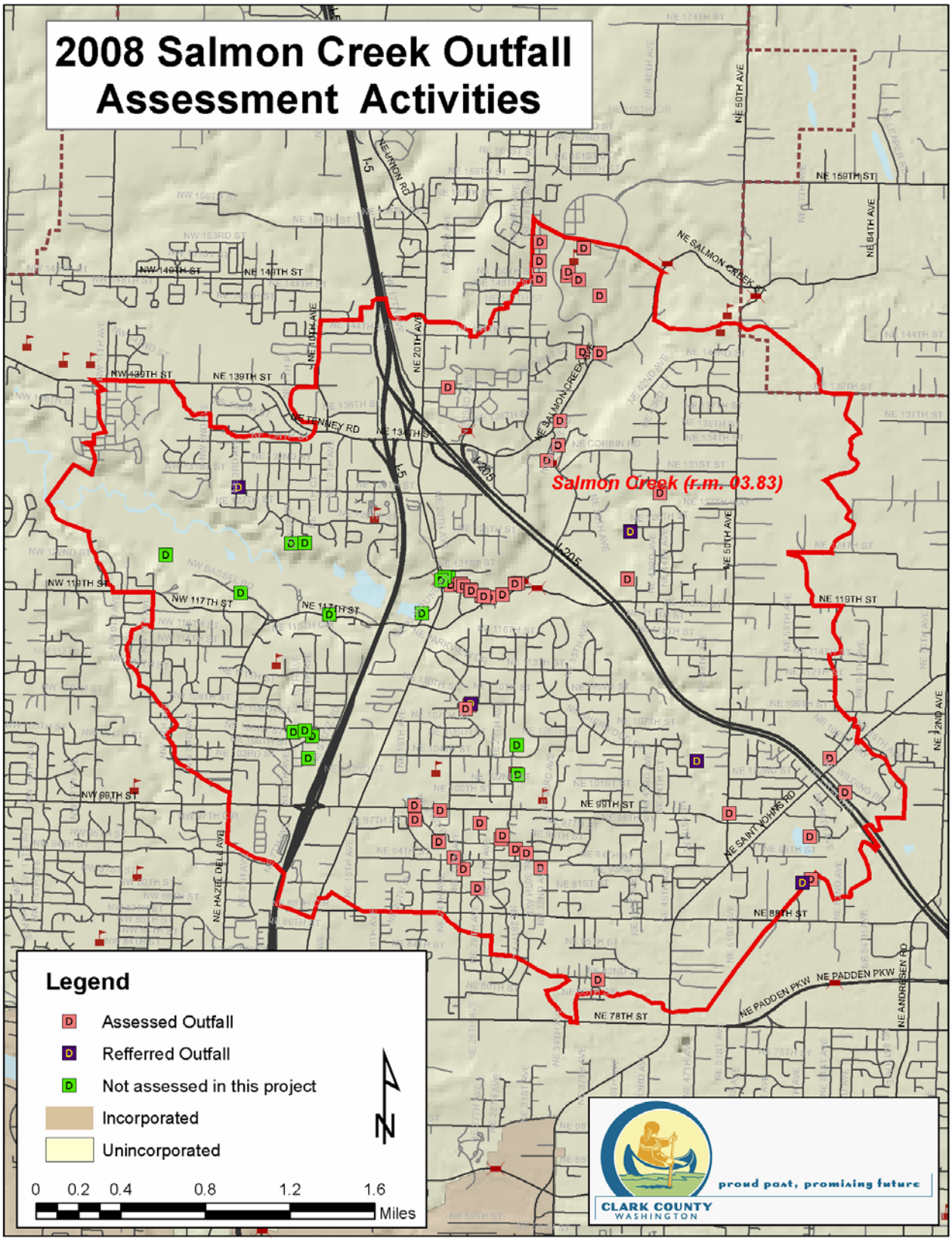


Figure 8: Summary of 2008 Outfall Assessment Activities in Salmon Creek (RM 03.83) Subwatershed

As summarized in Table 12, sixty-two outfalls were assessed (61 mapped outfalls and one unmapped outfall). Fifty-six outfalls that discharged into critical areas were found to be in compliance. Six outfalls that discharged into critical areas were found not to be in compliance.

Table 12: 2008 Outfall Assessment Project Activity Summary of Cougar Creek and Salmon Creek (RM 03.83) Subwatersheds

Metric	Number
Total number of mapped outfalls	108
# of outfalls assessed for the outfall assessment project	62
# of outfalls compliant	56
# of noncompliant outfalls	6
# of referrals initiated	6
# of referrals ongoing	6
# of outfalls fixed	0

Potential Projects

The outfall assessment project yielded six potential retrofit opportunities; five in the Salmon Creek (RM 03.83) subwatershed and one in the Cougar Creek subwatershed. These opportunities include stabilizing banks, installation of energy dissipaters, and flow reduction enhancement (Table 13).

Table 13: Description of Potential Retrofit Opportunities

Outfall ID	Basis for Project	Project Description	Subwatershed
85	Undersized culvert/bank instability	Enlarge culvert, stabilize bank, possible flow reduction enhancement	Cougar Creek
211	Undercutting/scouring	Stabilize bank and add rip rap	Salmon Creek (RM 03.83)
216	Evidence of heavy stormwater flow	Flow reduction enhancement	Salmon Creek (RM 03.83)
675	Undercutting/scouring	Stabilize bank and add rip rap	Salmon Creek (RM 03.83)
680	Undercutting/scouring	Stabilize bank and add rip rap	Salmon Creek (RM 03.83)
823	Undercutting/scouring	Stabilize bank and add rip rap	Salmon Creek (RM 03.83)

Illicit Discharge Detection and Elimination Screening

Purpose

The purpose of the IDDE Screening project is to detect, isolate, and eliminate illicit connections and illicit discharges to Clark County's municipal separate storm sewer system (MS4).

The IDDE screening project is designed to meet the requirements of Clark County's 2007 NPDES permit, which requires identifying and removing illicit connections to the county's MS4.

Methods

IDDE screening includes checking every stormwater outfall for potential illicit discharges, conducting follow-up investigations to track down suspected discharges or connections, and referrals to the proper agencies for termination. Field work is primarily conducted during the dry summer season.

IDDE Screening activities were completed in the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds during 2008.

Results

Based on the county's StormwaterClk database, as of March 2008, there were 222 mapped stormwater outfalls in the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds consisting primarily of pipe outfalls and roadside ditches. Three previously unmapped outfalls were screened.

Figure 9 summarizes notable screening activities including general outfall locations, outfalls where water samples were collected, follow-up investigations performed, referrals made, and sources removed from the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds.

As summarized in Table 14, 212 outfalls were screened and samples were collected at 14 outfalls. Ten mapped outfalls were either not accessible or were mapped incorrectly. Four follow-up investigations were initiated based on laboratory results or visual confirmation of illicit discharge. Two investigations were initiated by notifications from non-IDDE county staff. All four investigations were referred to County Code Enforcement. One investigation was referred to Department of Ecology.

Table 14: IDDE Screening Project Activity Summary of Salmon Creek (RM 03.83) and Cougar Creek Subwatersheds as of December 2008	
Metric	**Number**
# of outfalls screened	212
# of outfalls with sufficient flow to collect water samples	11
# of suspected illicit discharges	2
# of suspected illicit connections	2
# of investigations initiated	4
# of illicit discharge sources located	2
# of illicit connections identified	2
# of outfalls to be re-visited in 2009	4
# of referrals	2
# of illicit discharges removed	0
# of investigations and referrals ongoing	0
# of illicit connections terminated	2
# of cases closed without resolution	0

Samples were collected at 13 flowing outfalls as part of the IDDE screening process. An additional sample was taken by Clark County Health department after a citizen complaint. Laboratory analysis indicated suspected illicit discharges from two of the samples, which initiated investigations DP178 and GM28899. Visual identification by county staff of "floatables" and soapy water at locations GM15041 and GM26075 initiated two more investigations.

Investigation DP178

Discharge Point 178 was a suspected illicit discharge based on Surfactants. The Surfactants concentration was 0.17mg/l with a trigger of greater that 0.0 mg/l. Discharge Point 178 comes out of a stormwater system associated with the Greenbriar Apartments. The site was referred to code enforcement and an on-site investigation was coordinated with CWP section Waste Reduction Specialist. Discharge Point 178 was traced back to an area that was used for washing resident cars. Removal activities included education outreach with both apartment managers and property owners. Discharge Point 178 will be revisited in 2009 to look for recurrences of flow. If flow is found in 2009, effectiveness monitoring will be conducted.

Investigation GM28899

A concerned apartment resident called about water flowing from their building septic system overflow pipe and draining into a Clark County roadside MS4 ditch adjoining their property on February 11, 2008. The water was flowing from Gravity Main 28899 and was sampled by Clark County Health Department. The Health department confirmed that the results for fecal coliform were “off the charts”. The Health Department ordered a “Notice of Violation” to the property owner. The Building Department then sent an "unsafe to occupy" letter and that people were living in a "Dangerous Building" and forced evacuation. The septic tank was then pumped, and the apartment building was razed and the septic pipes removed.

Washington Department of Ecology's Water Quality division was notified of the illicit connection in early 2008. The Illicit connection was eliminated in June of 2008.

Investigation GM15029

Clark County Development Inspector found "Floatables" in a county storm water facility at Teal Pointe (Unique ID 022) on March 7, 2008.

The visual confirmation triggered investigation GM15029 on March 14, 2008. After pulling manholes, the connection was pinpointed to one of three homes in the Teal Pointe subdivision along Salmon Creek trail. Clark Regional Wastewater District followed up with dye testing on the three homes and confirmed the illicit connection. One house had a direct connection from their home sewer line to Clark County's storm pipes (Gravity Main 15041) just 100 feet west of the stormwater facility.

Clark Regional Wastewater District fixed the illicit connection and hooked the sewer line up to their system on March 20, 2008.

Investigation GM15041

Clark County IDDE staff noticed soapy water running from a motorcycle dealership across a parking lot and entering catch basin that drains to a county stormwater facility (Unique ID 1254) on September 4, 2008. Investigation GM15041 was initiated by visual confirmation, no samples were taken. The site was referred to code enforcement and an on-site investigation was coordinated with CWP section Waste Reduction Specialist. Soap run-off was determined to be motorcycle washing in the shop area. Removal activities included education outreach with both business managers and property owners on September 8, 2008. Business will attempt to reduce use of soap in wash water. Wash water enters a treatment facility where it is appears to get proper treatment.

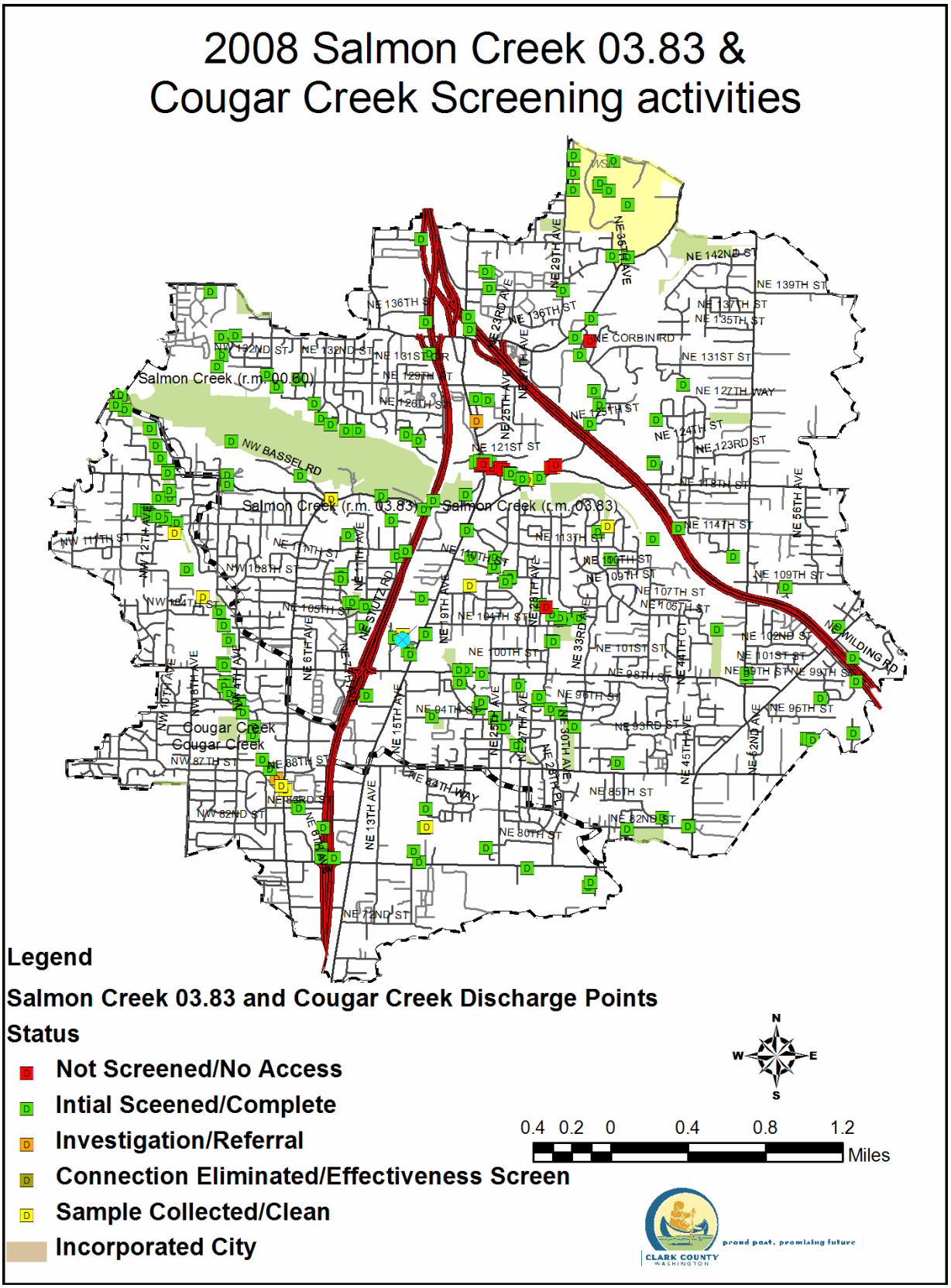


Figure 9: 2008 IDDE Screening Project in Salmon Creek (RM 03.83) and Cougar Creek Subwatersheds

Stream Reconnaissance and Feature Inventory

Feature Inventory Summary – Salmon Creek (RM 03.83) and Cougar Creek subwatersheds

Purpose

The Feature Inventory records the type and location of significant stream impairments, potential environmental and safety hazards, and project opportunities in selected stream reaches. Feature Inventory results are used primarily to document conditions and identify potential improvement projects or management actions for implementation by the CWP or other agencies.

Methods/Limitations

Geographic scope of the Feature Inventory was established by the County with input from Herrera Environmental Consultants, taking into consideration projected TIA, DNR water types, stream gradient, zoning, Clark County development permitting authority, and land ownership.

The Feature Inventory recorded significant conditions in the stream corridor relevant to SNAP components. Feature types are listed in Table 15.

The in-stream assessment approach allowed investigators to observe stream corridor features that are not always identifiable through desk methods, such as analysis of existing aerial photographs and GIS data.

A GPS position, one or more digital photos, and relevant attribute information were collected for each logged feature. All data and linked photos are stored in the Feature Inventory Geodatabase located on the Clark County server at: W:\PROJECT\011403, Needs Assessment Planning and Reports\GIS\Data\Geodatabase. Feature data includes field observations, estimated measurements, and notes describing important feature characteristics or potential projects.

The Feature Inventory project is not intended to be an exhaustive inventory of all human alterations to the stream corridor. Rather, the project seeks to identify the most significant features pertaining to stormwater management and potential stormwater mitigation projects.

Feature dimensions and other attribute data are estimates, and should not be utilized for quantitative calculations.

For additional information pertaining to the Feature Inventory SNAP tool, see Volume 1 of the SNAP.

Study Area

The study area is located in the southwest part of Clark County between Vancouver and the junction I-5 and I-205. The Salmon Creek (RM 03.83) and Cougar Creek subwatersheds are both covered in this report.

Salmon Creek (RM 03.83) Subwatershed

The extent of the completed Feature Inventory in Salmon Creek (RM 03.83) subwatershed is shown in Figure 10. This subwatershed includes all or part of seven tributaries of Salmon Creek. In this report, the named tributaries are referred to by their actual name. Unnamed tributaries are called by a named road near the stream. The following tributaries of Salmon Creek were included in this study:

- Suds Creek
- Tenny Creek
- LaLonde Creek
- Rockwell Creek
- NE 114th Street Tributary
- NW 2nd Avenue Tributary
- NW 7th Avenue Tributary

Approximately 8.9 miles of stream corridor was assessed in the subwatershed. Difficulties in accessing some areas led to two small gaps in the Salmon Creek (RM 03.83) subwatershed survey. The section of Tenny Creek between SCC-126 and SCC-127 was not surveyed due to access issues associated with the I-5 corridor. From the field survey, aerial photograph, and topography, it is unclear whether the stream crosses under I-5 and runs along the west side of the highway before crossing back under again, or if it is simply piped from SCC-126 to SCC-127. Field crews were also unable to survey NE 114th Street Tributary between SCC-97 and the confluence with Salmon Creek. This area was not surveyed because crews were unable to locate the outlet of SCC-97 or the confluence.

Cougar Creek Subwatershed

The extent of the completed Feature Inventory in the Cougar Creek subwatershed is shown in Figure 11. Cougar Creek is a main tributary of Salmon Creek. Approximately 3.8 miles of the stream corridor was assessed in the subwatershed. Difficulties in accessing some areas led to one small gap in the Cougar Creek subwatershed survey. A short portion of one reach on the north tributary in upper Cougar Creek subwatershed was not accessible due to private property concerns (Tax Lot 145529001). However, the overall reach characteristics were noted immediately upstream and downstream of the property; therefore, the reach was not completely removed from the Feature Inventory.

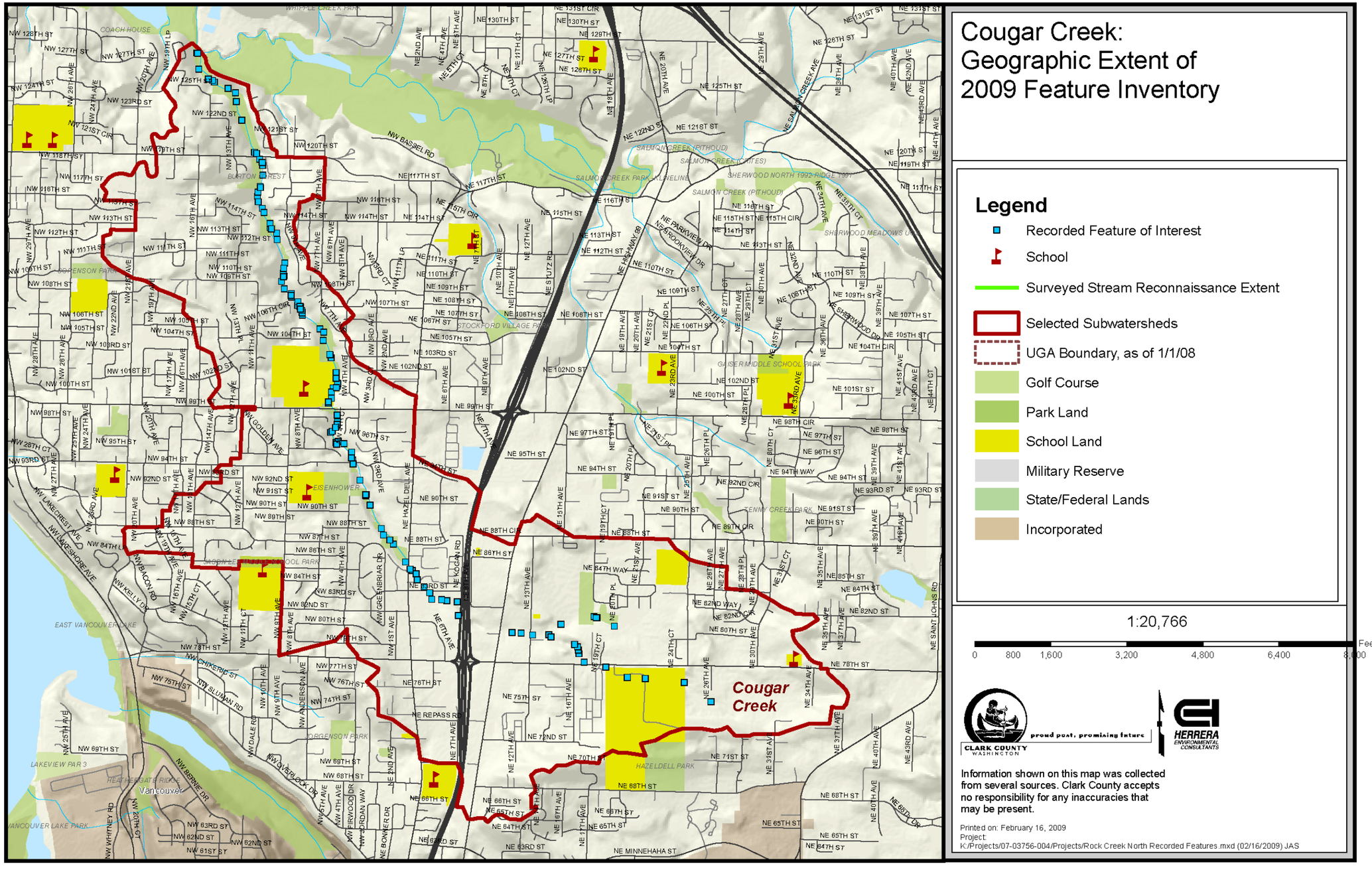


Figure 10: Cougar Creek Geographic Extent of 2009 Feature Inventory

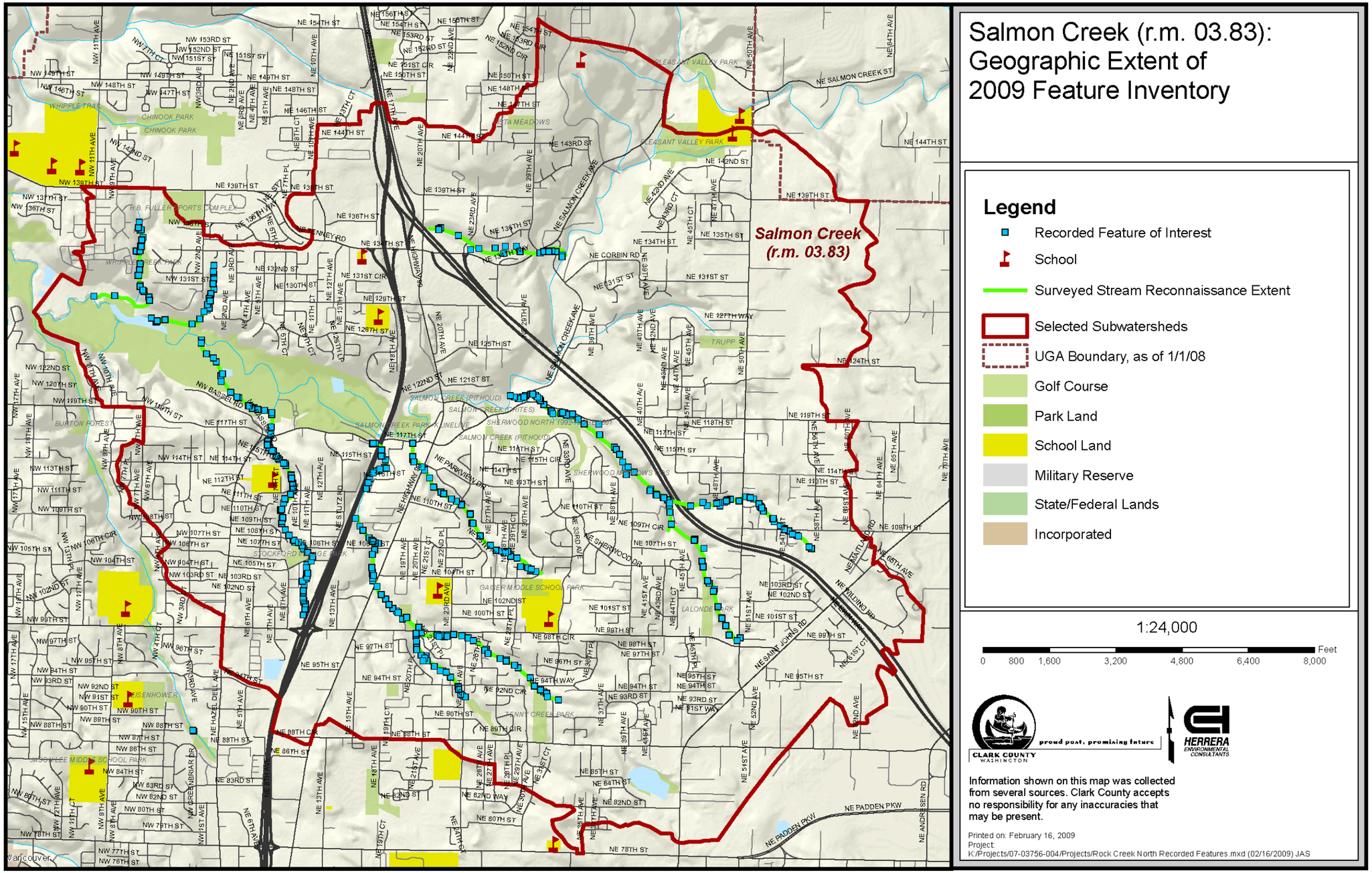


Figure 11: Salmon Creek (RM 03.83) Geographic Extent of 2009 Feature Inventory

Results/Findings

A total of 524 features were identified, with 393 in the Salmon Creek (RM 03.83) subwatershed and 131 in the Cougar Creek subwatershed. A breakdown of recorded features by type is presented in Table 15.

Stormwater outfalls were the most prevalent feature type identified in the Salmon Creek (RM 03.83) subwatershed, followed by stream crossings (culverts, bridges, and a ford) and impacted stream buffers. Trash and debris was much more common than in many other subwatersheds.

Table 15: Summary of Features Recorded in Salmon Creek (RM 03.83) and Cougar Creek Subwatersheds

Feature Type	Number Recorded in Salmon Creek (RM 03.83)	Number Recorded in Cougar Creek
AGR – Aggradation	2	0
AP – Access point	3	6
CM – Channel modification	19	3
ER – Severe erosion	16	4
IB – Impacted stream buffer	66	24
IW – Impacted wetland	0	1
MB – Miscellaneous barrier	20	1
MI – Miscellaneous point	23	5
OT – Stormwater outfall	124	42
RR – Road Reconnaissance feature	0	0
SCB – Stream crossing, bridge	24	6
SCC – Stream crossing, culvert	55	17
SCF – Stream crossing, ford	1	0
TR – Trash and debris	31	17
UT – Utility impact	4	5
WQ – Water quality impact	5	0
Total	**393**	**131**

The following subsections contain general descriptions of the Salmon Creek (RM 03.83) and Cougar Creek subwatershed conditions. The descriptions include observations, trends, and issues that were identified either during the field work or during subsequent review of collected information.

Stormwater Infrastructure

Salmon Creek (RM 03.83) Subwatershed

Suds Creek. The stormwater conveyance to Suds Creek is mainly via a catch basin stormwater collection system and a storm drain conveyance network that discharges directly to the channel by means of outfall pipes. Flow in the subwatershed is predominately southeast to northwest. The predominant source of stormwater in the subwatershed appears to be runoff from urban industrial, residential, commercial, and transportation uses. Runoff from I-5 is conveyed to Suds Creek via storm drain outfalls.

Tenny Creek. Two primary tributaries form the headwaters of Tenny Creek. These tributaries come together immediately downstream of (to the north of) NE 99th Street. The tributary to the northeast was surveyed from NE 99th Street upstream to an outfall source at Tenny Creek Park near NE 94th Way. This outfall conveys stormwater from an upland residential stormwater collection system and storm drain conveyance network. The tributary to the southwest was surveyed upstream to NE 25th Avenue. The tributary at NE 25th Avenue conveys a mixture of both surface runoff and piped stormwater from nearby residential areas as well as natural seepage. Drainage from the northeast and southwest tributaries is collectively referred to as the upper subwatershed, or headwaters, of Tenny Creek.

The stormwater conveyance to Tenny Creek is mainly via a catch basin stormwater collection system and a storm drain conveyance network that discharges directly to the channel by means of outfall pipes. In addition, surface runoff from pastures and fields in the upper headwaters sheets directly to the channel. The predominant source of stormwater in the Tenny Creek subwatershed appears to be runoff from urban residential development, some runoff from agricultural and open space land uses in the upper subwatershed, and some runoff from commercial and industrial land uses in the middle subwatershed. Roadway runoff from I-5, NE Highway 99, NE 117th Street, and NE 99th Street is also conveyed to Tenny Creek via storm drain outfalls and roadside ditches.

LaLonde Creek. The stormwater conveyance to LaLonde Creek and its tributaries is mainly via a catch basin stormwater collection system and a storm drain conveyance network. The storm drain network discharges water to the stream in two primary ways, depending on local topography.

First, when the stream is located in the bottom of a steep walled valley or ravine, the storm drain network typically discharges from outfall pipes at or near the valley rim. Flow then makes its way downslope to the stream, commonly forming eroding channels or gullies in the valley walls. In some rare instances, outfall pipes have been extended down the valley walls to the stream in order to prevent outfall erosion and potential landslide risk associated with soil saturation.

Second, when the stream is not isolated from development by surrounding topography, the storm drain network typically discharges directly to the channel by means of outfall pipes. This type of outfall was concentrated in the area near NE 119th Street, downstream of OT-136, and where the stream is closest to other major roads such as I-205. Flow in the subwatershed is predominantly southeast to northwest. The predominant sources of stormwater appear to be runoff from urban residential and commercial development as well as impervious surfaces related to I-205, and arterial streets such as NE 119th Street, NE Salmon Creek Avenue, NE 99th Street, and NE 50th Avenue.

The origin of the surveyed reach is a large outfall at the intersection of NE 99th Street/NE LaLonde Drive and NE 50th Avenue. This outfall drains stormwater from multiple sources including two large ponds that accept stormwater from a large area of urban residential and commercial development southeast of NE Saint John's Road.

Rockwell Creek. The stormwater conveyance to Rockwell Creek is mainly via a catch basin stormwater collection system and a storm drain conveyance network, with outfalls concentrated in the reach downstream of NE Salmon Creek Avenue. Flow in the subwatershed is predominantly west to east. The predominant sources of stormwater appear to be runoff from urban residential and commercial development (especially the Legacy Salmon Creek Hospital campus) as well as impervious surfaces related to I-205, NE 20th Avenue, and NE 134th Street/NE Salmon Creek Avenue.

NE 114th Street Tributary. The stormwater conveyance to the NE 114th Street Tributary is mainly via a catch basin stormwater collection system and a storm drain conveyance network. The storm drain network typically discharges water from outfall pipes at the stream channel banks or directly to the stream. In some cases, stormwater is delivered to the stream via open-channels that extend from the top of the valley or roadside ditches, forming eroding channels. Flow in the subwatershed is predominantly southeast to northwest with stormwater conveyance channels entering from the northeast. The predominant sources of stormwater appear to be runoff from urban residential upstream of NE Highway 99 and commercial downstream of NE Highway 99 to the confluence with Salmon Creek, as well as impervious surface related to NE Highway 99, and NE 117th Street.

A 30-inch diameter pipe is the effective origin of the NE 114th Street Tributary. According to a local landowner (Tax Lot 118254696), this pipe was installed to drain the large, natural wetlands located in the headwaters to allow for the development of that area.

NW 2nd Avenue Tributary. The stormwater conveyance to the NW 2nd Avenue Tributary is mainly via a catch basin stormwater collection system and a storm drain conveyance network. The storm drain network typically discharges water

from outfall pipes at or near the valley rim. Flow then makes its way downslope to the stream, commonly forming eroding channels or gullies. In this landslide-prone portion of the subwatershed, stormwater outfalls may also be contributing to unnatural soil saturation and hillslope instability. No engineered detention or treatment facilities were observed from our point of reference within the narrow, confined valley. Flow in this tributary is predominately north to south, with ephemeral first order and stormwater conveyance channels entering from the east and west. The predominant source of stormwater in the subwatershed appears to be runoff from urban residential development.

NW 7th Avenue Tributary. The stormwater conveyance to the NW 7th Avenue Tributary is mainly via a catch basin stormwater collection system and a storm drain conveyance network. The storm drain network typically discharges water from outfall pipes at or near the valley rim. Flow then makes its way downslope to the stream, commonly forming eroding channels or gullies. In this landslide-prone portion of the subwatershed, stormwater outfalls may also be contributing to unnatural soil saturation and hillslope instability. No engineered detention or treatment facilities were observed from our point of reference within the narrow, confined valley. Flow in this tributary is predominately north to south, with ephemeral first order and stormwater conveyance channels entering from the east and west. The predominant source of stormwater in the subwatershed appears to be runoff from urban residential development.

Cougar Creek Subwatershed. The stormwater conveyance to Cougar Creek and its tributaries is mainly via a catch basin stormwater collection system and a storm drain conveyance network that discharges directly to the channel by means of outfall pipes. Flow in the subwatershed is predominately southeast to northwest. The predominant source of stormwater in the subwatershed appears to be runoff from urban residential development in the lower and middle subwatershed, and runoff from a mix of agricultural, industrial, residential, commercial, and transportation uses in the upper subwatershed. Runoff from I-5 is also conveyed to Cougar Creek via storm drain outfalls and roadside ditches.

Riparian Vegetation

Salmon Creek (RM 03.83) Subwatershed

Suds Creek. Impacted stream buffers are ubiquitous on Suds Creek. Invasive plant species – typically blackberry and ivy with some nightshade – dominate the riparian area. The channel also passes through several landscaped back yards and Salmon Creek Sports Complex. The most common condition encountered was partial riparian deciduous forest canopy with a mixture of native and invasive plant species for undergrowth. Through Salmon Creek Sports Complex, Suds Creek has little to no canopy cover with reed canary grass as the predominant vegetation.

Tenny Creek. Riparian vegetation conditions are highly variable along Tenny Creek. Grassy vegetation is common along the open fields and pastures that lie

adjacent to the creek in the upper watershed. In the portion of the reach located within Tax Lot 97760000, the only vegetation along the banks and floodplain is grass and cows have unrestricted access to the channel. Impacted stream buffers are prevalent throughout the subwatershed where invasive plant species – typically blackberry and ivy – dominate the riparian area. The channel does meander through several landscaped backyards in the upper and middle subwatershed. The most common condition encountered was partial riparian deciduous forest canopy with a mixture of native and invasive plant species for undergrowth.

LaLonde Creek. Riparian vegetation conditions are highly variable along LaLonde Creek and its tributaries. Bare ground is common along recently constructed wetlands at the upstream end of the tributary reach. Impacted stream buffers are prevalent in LaLonde Creek where invasive plant species – typically reed canary grass and/or blackberry – dominate the riparian area. In general, blackberry is more common in areas with somewhat dense canopy cover. Reed canary grass is more common in areas with less dense canopy cover and wetter soil conditions. Lack of riparian vegetation due to mowing and landscaping is common in areas where residential development abuts the channel. Typically, this occurs where the stream is not isolated from development by steep valley wall topography. A fairly large expanse of mature riparian forest, with very few invasive plants, exists on private property upstream of the tributary confluence (MI-25, MI-26, and MI-27). The most common condition encountered was partial riparian forest canopy with a mixture of native, non-native/non-invasive, and invasive plant species for undergrowth.

Rockwell Creek. Impacted stream buffers are prevalent on Rockwell Creek. Riparian vegetation is composed primarily of dense thickets of salmonberry and invasive blackberry. The sparse canopy cover is made up primarily of younger deciduous trees, with older conifers more common downstream of NE 23rd Avenue. English ivy is widespread and many of the trees in the valley are being choked by it. In general, dense blackberry is more common in exposed areas upstream of NE 134th Street. Riparian areas downstream of NE 134th Street are urbanized and landscaped with mowed grass and young deciduous trees being the primary riparian vegetation. Some reed canary grass is present at stormwater treatment facilities.

NE 114th Street Tributary. Impacted stream buffers are prevalent on NE 114th Street Tributary. Riparian vegetation is composed primarily of invasive blackberry with presence of horsetail, nightshade, English ivy, and iris. The sparse canopy cover is made up primarily of younger deciduous trees. Immediately upstream of a clogged culvert at NE 28th Avenue, ferns and cedars are present along with invasive nightshade, ivy, reed canary grass, blackberry, and horsetail. The 400 foot reach immediately upstream of NE 117th Street creek lacks vegetation and shading with mowed turf extended to the edge of the excavated channel.

NW 2nd Avenue Tributary. Impacted stream buffers are less prevalent on the NW 2nd Avenue Tributary than in other portions of the Salmon Creek subwatershed. The riparian area has been logged in the past, but the narrow valley and riparian area of this tributary still is characterized by mixed riparian forest canopy with sections of older growth conifers and bigleaf maple. The understory is predominantly a mix of native and non-native, non-invasive vegetation, with localized infestations of invasive blackberry and ivy, particularly in areas where there are breaks in the canopy cover or adjacent to stormwater outfalls.

Once the stream exits its valley and flows onto the Salmon Creek floodplain, the riparian area is dominated by invasive reed canary grass and immature trees.

NW 7th Avenue Tributary. Impacted stream buffers are less prevalent on the NW 7th Avenue Tributary than in other portions of the Salmon Creek subwatershed. The narrow valley and riparian area of this tributary is characterized by mixed riparian forest canopy with sections of older growth conifers and bigleaf maple, even though it has been previously logged. The understory is predominantly a mix of native and non-native, non-invasive vegetation, with localized infestations of invasive blackberry and ivy, particularly in areas where there are breaks in the canopy cover or adjacent to stormwater outfalls.

Once the stream exits its valley and flows onto the Salmon Creek floodplain, the riparian area is dominated by invasive reed canary grass. A large scale revegetation program including mowing of reed canary grass and planting of cedar, dogwood, and other trees is underway in this area.

Cougar Creek Subwatershed

Impacted stream buffers are common in the Cougar Creek subwatershed. Riparian vegetation is composed primarily of an alder and cottonwood canopy and an invasive blackberry and ivy understory. There is a nearly universal absence of coniferous riparian forest. The exceptions include the lower reaches of Cougar Creek that lie within the Salmon Creek Park, where more native vegetation is present. However, it is still surrounded and choked by invasive blackberry. The upper wetland channel reaches of Cougar Creek are surrounded by open fields; however, reed canary grass infestation is prevalent there. There is little to no canopy cover in the upper reaches of Cougar Creek. Additionally, the reaches of Cougar Creek immediately downstream of I-5 wind through dense commercial and residential properties and the channel is heavily armored, artificially confined, and has very minimal riparian vegetation.

Additional Results

Salmon Creek (RM 03.83) Subwatershed

In surveyed subwatersheds, stormwater and water quality impacts, as well as other features of interest were often discovered when field crews ventured up small, first-order tributary channels outside of the area defined by the geographic scope of work. The discovery of numerous features of interest on small tributary channels within other subwatersheds indicates that significant stream impairments, potential environmental and safety hazards, and potential project opportunities may exist outside of the geographic scope of this Feature Inventory.

Suds Creek. Suds Creek is likely the most impacted stream surveyed during the 2008 through 2009 Feature Inventory. The effects of urbanization and stormwater runoff are evident along the entire channel, including incised channel conditions, numerous outfalls, abundant invasive plants, and widespread trash and debris.

Water quality impacts associated with direct discharge from roadways and impervious surfaces to the channel are widespread throughout the subwatershed. Almost all stormwater from impervious surfaces is piped directly to the channel, with no apparent flow attenuation or treatment. Because the existing stormwater network is widespread throughout the subwatershed, additional investigation of potential regional stormwater facilities is warranted.

No tributary streams were identified along the surveyed reaches of Suds Creek. Those tributaries that may have existed have been replaced by piped stormwater conveyance networks. However, several small open channels from outfalls that discharged to the edge of the floodplain or from groundwater seeps were noted.

In the lower section of Suds Creek through Salmon Creek Sports Complex, multiple undersized culverts at access road crossings may cause flooding at high flows. In addition, the on-line pond 900 feet upstream of the confluence with Salmon Creek may have an undersized outlet that could lead to flooding. Flooding risk may be acceptable in these areas since the park is at a significantly lower elevation than the adjacent properties and would drain into Salmon Creek. However, care should be taken that access roads and banks in these areas are adequately reinforced and vegetated to handle potential floods.

Tenny Creek. Aside from the two tributaries that collectively form the headwaters of Tenny Creek, few tributary streams were identified along the surveyed reaches of Tenny Creek. However, small open channels from outfalls that discharged to the edge of the floodplain or from groundwater seeps are common. One small tributary channel enters the left bank of Tenny Creek from the southwest near feature point MI-36. This tributary was not surveyed.

Portions of upper and middle Tenny Creek are characterized by in-channel public stormwater facilities (known as the Swan Ponds) that create significant backwater and on-line ponds. Two floodplain-spanning concrete dams (MB-16 and MB-17) and one channel-spanning concrete dam with a concrete spillway (CM-27) cause in-channel impoundments between NE 99th Street and Highway 99. The dam at MB-16 causes backwater to extend approximately 290 feet upstream to NE 99th Street. The dam at MB-17 causes backwater to extend upstream about 225 feet to a level that is just below the invert elevation of the outlet pipe from MB-16. For both ponds, wetland vegetation was present around the pond perimeter, but green algae and detritus could be seen on the pond water surface. Waterfowl are common in both ponds, with the potential for associated water quality impacts.

The manholes used for outlet control structures and the associated conveyance pipes with trash racks are migratory barriers to fish and amphibians. The downstream-most structure at CM-27 only spans the channel width, rather than the entire floodplain width, and thus does not induce the same extent of backwater as the other dam structures. Backwater from CM-27 creates a wetland-channel type feature that extends approximately 150 feet upstream of the structure. All three of these barriers and channel modifications pose both impacts and benefits to stream water quality and physical condition. All three structures function as significant grade controls, which locally prevent channel incision that might otherwise have resulted from the altered hydrology of a developed upper subwatershed. By slowing channel velocities, the structures also cause pollutant-bound sediments to drop out of suspension and deposit in the pond bottoms.

The wetland vegetation growing in and around the ponds also likely provides some filtration of pollutants and biological uptake of nutrients. However, Clark County has determined the ponds are sources of thermal loading to the channel. The thermal loading, combined with the green algae at the pond surfaces, likely reduces dissolved oxygen concentrations. In addition, the physical stability of the two dams appears questionable and the channel modification at CM-27 is already being undermined and failing. The structural integrity of all three structures should be assessed to determine what maintenance is necessary to avoid catastrophic failure.

One reach of Tenny Creek, immediately downstream of the culvert outlet at SCC-127, parallels I-5 and is artificially confined between the I-5 roadway embankment on the left bank and the hillslope on the right bank. Although channel restoration has occurred within this reach fairly recently (less than five years ago)—likely in combination with recent highway improvements—several of the logs placed as part of this restoration effort are being undermined and are falling into the creek. In addition, erosion is occurring along both banks downstream of the restoration project, at meander bends and other locations where there is no wood armoring or established native vegetation to support bank stability. These log structures should be reevaluated and potentially reinforced

with more wood to prevent their failure. The addition of more LWD or native vegetation plantings downstream of the restoration project area should be considered to prevent further erosion problems and the introduction of fine sediment to the creek.

LaLonde Creek. Few tributary streams were identified along the surveyed reaches of LaLonde Creek, but small open channels from outfalls that discharged to the edge of the floodplain or from groundwater seeps were prevalent. One small tributary channel enters LaLonde Creek from the southwest near feature point AGR-2. Only the lower section of this tributary was surveyed. The headwater of the short drainage is in a low density residential area along NE 107th Street.

The stream reach downstream of the two manmade ponds (MB-12, MB-13) is in excellent condition with significant woody debris in the channel and minimal invasive plant species in the riparian area. The channel is stable and not very incised, in part due to the presence of woody debris providing grade control. This area has been recommended for property acquisition or conservation easement. The ponds themselves are on-channel impoundments that may be serving as large scale stormwater detention and treatment facilities and protecting this reach from some of the effects of altered hydrology in the upper reaches of LaLonde Creek.

A heavily landscaped and modified property that could be described as a private zoo is located on Tax Lots 099359000, 199286000, 199110000, and 119163000. Field crews observed and recorded numerous points of interest in this reach. The most prominent features are an approximately 30-foot high earthen dam forming a large on-line pond, and the outlet from other manmade, off-channel ponds. Field crews also observed numerous footbridge stream crossings and ivy in the riparian area. Ducks were present in the pond immediately upstream of the dam, thus posing a high potential for water quality impacts. A variety of exotic wildlife, including emus and wallabies, were also observed in fenced pastures on the property. Although these pasture areas could be a source of non-point pollution, there was a vegetated, though landscaped, buffer of mature trees and shrubs separating the pasture areas from the channel. Originally, the landowner denied permission to access the property, but during the field work, crews met the landowner and caretakers and were allowed to conduct the Feature Inventory survey through the reach.

Rockwell Creek. Field crews observed multiple channel modifications adjacent to a condominium complex (Tax Lot 186424002). The channel alignment has been altered, creating a side channel with no outlet. Riprap is present on the right bank to prevent a nearby building from being affected by channel erosion. The riprap is also acting as grade control in channel. Levees have been installed in an attempt to prevent flooding. There is a lack of riparian vegetation on the right bank due to mowing and landscaping. This area may experience increasing risk of flooding if stormwater input increases peak flows in the future.

NE 114th Street Tributary. A clogged culvert at NE 28th Avenue results in a wetland extending approximately 500-feet upstream. This reach is characterized by significant sediment aggradation and a lack of defined channel. The wetlands may treat stormwater and serve as large-scale detention. Wetlands restoration of this area could potentially maintain the treatment benefits while providing valuable habitat to local species that simulates the original natural wetlands.

The reach downstream of NE Highway 99 is an excavated channel with tall, steep banks that are eroding in areas where they are not mechanically armored. Reports of flooding (Tax Lot 189517000) were noted after talking to the landowner. Continued bank failure is a concern. This reach culminates with a 40 foot grade change at the Salmon Creek confluence. The grade change will prevent any fish from migrating from Salmon Creek. However, resident fish and other aquatic species could benefit from improved passage and habitat throughout the entire tributary.

NW 2nd Avenue Tributary. Only one significant tributary stream was identified along the surveyed reaches of the NW 2nd Avenue Tributary. Small open channels from outfalls discharging at the rim of the valley or from groundwater seeps were common. The County may want to conduct additional reconnaissance on this first order, ephemeral tributary as these small channels often contained features of interest in other surveyed subwatersheds.

NW 7th Avenue Tributary. Only one significant tributary stream was identified along the surveyed reaches of the NW 7th Avenue Tributary. Small open channels from outfalls discharging at the rim of the valley or from groundwater seeps were prevalent. Based on a brief conversation with one of the local landowners, the hydrology of this small, unmapped tributary is actively changing in response to land use changes in its headwaters on and surrounding Tax Lot 186866000. Based on this evidence, the County may want to conduct additional reconnaissance on this first order tributary.

Of particular concern is the relationship between stormwater runoff and the inherently landslide-prone nature of the steep slopes along this tributary. Many homes have been constructed at the edge of the valley, where landslides could have catastrophic consequences.

Significant channel incision and instability throughout the NW 7th Avenue Tributary, punctuated by two significant headcuts in the lower half of the valley reach, are grounds for additional concern.

Cougar Creek Subwatershed

Few tributary streams were identified along the surveyed reaches of the Cougar Creek subwatershed, but small open channels from outfalls that discharged to the edge of the floodplain or from groundwater seeps were common. Almost all of the middle reaches of Cougar Creek were influenced by the groundwater seeps

expressed in the floodplain. These natural surface water and groundwater interactions would complement efforts to improve floodplain connectivity.

Upper Cougar Creek is naturally broad and flat and was historically characterized by wetlands. Although the channel has been straightened, ditched through pastures, and realigned, there is still significant open space in this portion of the subwatershed, thereby providing unique opportunities to preserve and restore natural hydrologic function and channel processes. At the same time, upper Cougar Creek has a high potential to respond unfavorably to future development of these open spaces. Therefore, land use management in the upper subwatershed should involve collaboration with landowners to identify strategic areas for conservation easements, property acquisition, and open space preservation where possible.

There were a few locations along Middle Cougar Creek where large trees (MI-20 and MI-21) had fallen into and across the channel. Where these logs spanned the channel bottom, they provided grade control and improved channel complexity by creating upstream pools and promoting high floodplain connectivity. They also seemed to locally halt the extreme incision that characterizes the reaches throughout the subwatershed. Such positive effects of large wood contributions to the channel should be considered when developing projects intended to improve channel and floodplain conditions.

Water quality impacts associated with direct discharge from roadways and impervious surfaces to the channel are widespread throughout the subwatershed. Almost all stormwater from impervious surfaces is piped directly to the channel, with no apparent flow attenuation, retention, or treatment. Because the existing stormwater network is pervasive throughout the subwatershed, additional investigation of and analysis for siting and constructing regional stormwater facilities to treat and detain stormwater is warranted.

Potential Project Opportunities

Listed opportunities represent potential projects or project areas. They are not fully developed projects, and therefore require additional evaluation and development by Clark County or consultant staff prior to submittal to the SCIP process. Identifying them as potential projects in this document is the first step in the process of developing SCIP projects.

Potential project opportunities were identified based on the results of the Feature Inventory conducted in the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds. The CWP will evaluate the potential projects for further development or referral to the appropriate organization. Each potential project is listed in Tables B1 - B8 in Appendix B, including the basis for the project and a description of the potential project. The location of each potential project is shown in Figures B1 - B10, also in Appendix B. Potential project opportunities were categorized into six groups based on the nature of the potential work. A

total of 423 potential projects were identified; 309 in the Salmon Creek (RM 03.83) subwatershed and 114 in the Cougar Creek subwatershed. A summary of identified project opportunities by potential project category is shown in Table 16. Project opportunities in the Salmon Creek (RM 03.83) are further summarized by individual tributary stream in Table 17.

Table 16: Breakdown of Potential Project Opportunities by Category

Potential Project Category	Potential Projects Identified in Salmon Creek (RM 03.83)	Potential Projects Identified in Cougar Creek
Emergency/Immediate Actions	12	2
Stormwater Facility Capital Improvement Projects	110	38
Stormwater Infrastructure Maintenance Projects	8	0
Habitat Restoration/Enhancement Projects	10	7
Property Acquisition for Stormwater Mitigation	0	0
Referral Projects for other Agencies	169	67

Table 17: Breakdown of Potential Project Opportunities in the Salmon Creek (RM 03.83) Subwatershed by Tributary Stream

Potential Project Category	Suds Creek	Tenny Creek	LaLonde Creek	Rockwell Creek	NE 114th Street Trib	NW 2nd Avenue Trib	NW 7th Avenue Trib
Emergency/Immediate Actions	1	8	2	0	1	0	0
Stormwater Facility Capital Improvement Projects	31	23	20	4	15	11	6
Stormwater Infrastructure Maintenance Projects	0	4	0	1	1	0	2
Habitat Restoration/Enhancement Projects	1	3	3	0	1	0	2
Property Acquisition for Stormwater Mitigation	0	0	0	0	0	0	0
Referral Projects for other Agencies	35	43	46	13	19	5	8

Physical Habitat Assessment

Limited physical habitat data exists for this assessment area, and was not analyzed for this report.

Geomorphology Assessment

The section below refers specifically to the Cougar Creek subwatershed. A separate write-up covering the Salmon Creek (RM 03.83) subwatershed is included as Appendix C of this SNAP report.

Purpose

This geomorphic assessment is an evaluation of the physical conditions of Cougar Creek based on field reconnaissance and review of remote sensing data. The field reconnaissance included characterizations of the channel, bank, and floodplain conditions throughout the mainstem of Cougar Creek.

The objectives of the geomorphic assessment were the following:

- Detail the geomorphic factors and processes influencing hydrology, sediment delivery, channel form, water quality, and habitat.
- Describe the apparent past influence of land use on geomorphic processes.
- Identify the reaches that are unstable or moving toward unstable conditions under current channel morphologic and hydrologic conditions.
- Identify the reaches that are stable or moving toward stable conditions under current channel morphologic and hydrologic conditions.
- Identify the reaches that are most/least sensitive to future changes in hydrologic conditions.

The results of the geomorphic field reconnaissance and remote sensing analysis have been used to make management recommendations and identify potential projects that may be implemented by Clark County to protect the reaches that are currently unstable or sensitive to future disturbance, and to enhance the reaches that are currently stable or are less sensitive to future disturbance.

Methods

The geomorphic assessment is based on a reconnaissance of the mainstem of Cougar Creek from its confluence with Salmon Creek to its headwater wetlands in Hazel Dell. The geomorphic reconnaissance was conducted in parallel with the inventory of stream features (see Stream Reconnaissance and Feature Inventory). Channel, bank, and floodplain conditions were documented during the reconnaissance on December 2, 3, 4, and 5, 2008. A detailed description of the methods used to document each channel, bank, and floodplain characteristic is provided in the Stormwater Needs Assessment Manual.

The channel conditions that were documented include the bankfull channel width and depth (or bank height where bankfull depth was not discernible), the channel gradient, substrate material conditions, sinuosity, the amount of functioning large woody debris, the channel type, and the channel stability. The channel type classifications were primarily based on the Montgomery and Buffington (1997) process-based classification system, which includes the cascade, step pool, plane bed, pool/riffle, dune/ripple, bedrock, and colluvial channel types. Additional

channel types identified included glide-cohesive/rectangular, excavated/constructed, wetland, impounded, and other. The channel stability status was a field determination of the surveyed reach's channel stability, given the channel's relative equilibrium within the context of its hydrologic regime, sediment supply, and riparian vegetation. Each reach's channel stability was based on visual observations of whether the channel appeared to be stable (dynamic equilibrium), actively incising, actively widening, actively incising and widening, or actively aggrading. It was also noted when a channel was forced into stability by unnatural processes such as mechanical armoring.

The bank conditions that were documented include the location and relative percentage of active bank erosion, bank material conditions, and a classification of bank stability. The general classification of bank stability was based on a protocol which uses indicators of bank vegetation, undercutting/erosion/scalloping, exposed tree roots, and downed trees to classify a stream channel as stable, slightly unstable, moderately unstable, or completely unstable (Scholz and Booth 2001). This classification, together with the other bank assessment methods, provides a means of describing current and potential future bank stability conditions.

The floodplain conditions that were documented include the floodplain width and a classification describing the relative degree of floodplain connectivity between the active channel and the floodplain. The floodplain connectivity metric was intended to describe how frequently the stream channel currently accesses the adjacent floodplain. The floodplain connectivity was characterized using three general, qualitative categories – low, medium, and high. Low floodplain connectivity signifies that the stream rarely exceeds the horizontal and vertical limits of the active/bankfull channel. Medium floodplain connectivity signifies that the stream shows signs of occasionally overflowing the active/bankfull channel. High floodplain connectivity signifies that the stream appears to exceed the limits of the active/bankfull channel and inundate significant portions of the adjacent floodplain or overbank areas at regular (approximately annual) intervals.

Once the geomorphic field reconnaissance data were collected and entered in a geodatabase, they were reviewed with a geographic information system (GIS) platform in association with pertinent and available remote sensing data. For the Cougar Creek geomorphic assessment, the GIS layers that were reviewed include:

- U.S. Geological Survey 1:100,000 geologic data (USGS 2005)
- National Resources Conservation Service soil data (NRCS 2007)
- Clark County stormwater and sewer utility alignments, parcel boundaries, 2-foot contours based on light detection and ranging (LiDAR) data (Clark County 2009).
- 10-foot contours based on depth to groundwater contours (Swanson and McCarley, 1995).

The geomorphic reconnaissance and remote sensing data was used to delineate the channel network into reaches and define the response potential for each reach. The response potential is a qualitative classification describing the likelihood a reach will experience future channel degradation as a result of hydrologic changes. Each channel reach was classified as having low, moderate, or high response potential.

The response potential is a function of the channel, bank and floodplain conditions, including the existing channel and bank stability, the conditions of the channel and bank material, the channel gradient and level of functional large woody debris, the underlying geologic conditions, and the existing level of development within the drainage areas contributing to the reach. Reaches with low response potential may have geologic conditions that are resistant to channel change, or may be artificially confined, armored, or lined so as to limit channel response. Reaches with moderate response potential have geologic and/or geomorphic conditions susceptible to alluvial changes caused by historic, ongoing, or future land use and hydrologic change in the watershed. Reaches with high response potential exhibit alluvial characteristics, and are susceptible to extreme channel or geomorphic change should land use and/or hydrologic patterns in the watershed change. Additionally, response potential generally increases as functional LWD and floodplain connectivity decrease.

Geologic Setting

The geology of the Cougar Creek subwatershed includes limited outcrops of the Troutdale Formation and widespread deposits of cataclysmic flood deposits. The Troutdale Formation is from 3.6 to 28.4 million years old (Pliocene and/or Miocene) and includes fluvial deposits by the ancestral Columbia River from source areas east of the Cascade Range (Everts 2004). In the Cougar Creek channel network, the Troutdale Formation outcrops as massive sandstone overlain by conglomerate containing small gravel to boulder-sized material. Both the sandstone and conglomerate are well consolidated and relatively resistant to erosion; however, the uppermost layers are commonly weathered to clay or clay and resistant clasts such as quartzite pebbles. This weathered zone can range from a few feet thick to over 50 feet in depth.

Cataclysmic flood deposits mantle the Troutdale Formation and are widespread throughout the watershed. These silt-to-sand-sized sediments are interpreted as slack-water deposits of large floods initiated by the failure of ice dams at Glacial Lake Missoula in western Montana during the late Pleistocene, regionally dated between 17,000 and 13,000 years before present (Everts 2004). The flood deposits are unconsolidated and are susceptible to erosion.

The Troutdale Formation and cataclysmic flood deposits are overlain throughout the watershed by various silt loam soils. These soils are characterized by moderate to poor permeability that may locally inhibit infiltration.

Hydrologic Setting

Similar to other subwatersheds in lower Salmon Creek and along the I-5 corridor, Cougar Creek drains from relatively flat upland areas with shallow groundwater into a canyon cut into the underlying sandy catastrophic flood deposits and Troutdale Formation. Another characteristic of these subwatersheds is a lack of significant natural drainage network formed on the relatively young catastrophic flood deposits. Before clearing and development, such a drainage pattern would have limited discharge to the mainstem, promoted infiltration, and the formation of wetlands.

Cougar Creek hydrology is significantly altered from pre-development forested conditions due to agricultural, and later, urban development. Creation of rural ditches over 100 years ago and a piped storm drainage system in the mid to late 20th Century greatly modified watershed hydrology.

There is one stream gauge on Cougar Creek, located at the upper end of the lower Cougar Creek reaches at 119th Street. This gauge is operated by Clark County and has been in place since early 2003.

Another source of hydrologic data is provided by an HSPF hydrologic model for Salmon Creek watersheds (Barker, March 2003). This model broke Cougar Creek basin into three model points, Coug1 at the mouth, Coug3 at 99th Street, and Coug5 at Interstate 5. Metrics reported for these points include the ratio of predeveloped forest 10- year flood to current 2-year flood; and flood-frequency values for historic, existing and future conditions.

Table 18 shows typical flows in Cougar Creek. The table also contains a column listing the number of days each water year that surpass the historical 1-year flood peak based on HSPF modeling. There are five to eight days each year when the daily average flow exceeds the 1-year historical peak flow of about 15 cfs, indicating the watershed hydrology has been altered.

Peak discharges from 15 minute flow data were also reviewed. In Table 19, yearly peak events from gauge data are compared to model simulations for historical conditions. Flows greater than 50 cfs are presented as an indicator of significant erosive flows based on a simulated historical 2-year peak of 47 cfs (Table 20).

The ratios of historic 10-year event to existing 2-year event were all about 0.4, which is indicative of unstable channel conditions. Generally, ratios above 1.0 are associated with stable channel conditions, while ratios below 1.0 indicate unstable channels (Booth others, 2002).

Table 18: Average Daily Discharge for Cougar Creek Gauge				
WY	Mean (cfs)	Maximum (cfs)	Minimum (cfs)	# Days > HSPF modeled Historical 1-year peak
2004	3.5	17.0	0.86	5
2005	3.8	41.0	0.97	7
2006	3.4	32.0	0.95	8
2007	3.3	51.0	1.1	5

Table 19: Simulated Peak Discharge Events in CFS						
	Recurrence Interval in Years for Coug1					
Model run	1.01	2	10	25	50	100
Historic	15	47	84	104	119	134
Existing	87	184	294	354	400	448
Future	105	221	356	429	486	546

Table 20: Yearly Peak Discharge Events for Cougar Creek Gauge and Historical Flood Peaks			
WY	Peak (cfs)	Flow duration > 50 cfs	Approximate HSPF Historical Peak Event
2004	78	1.5 hr	10 yr
2005	89	7 hrs	10 yr
2006	140	5hrs	100 yr
2007	143	3 hrs	100 yr

The HSPF model report also included flow duration curves for several sites, one of which was Coug1. The report noted that the under current conditions, a 50 cfs discharge, roughly the historic 2-year peak, would have an aggregate duration ten times longer than under forested conditions, which should produce readily observable erosion and habitat degradation.

Results

The findings of the geomorphic field reconnaissance indicate that Cougar Creek has been and continues to be influenced by both its natural geologic characteristics and human development within the watershed. The geomorphic characteristics of the channel were also found to be influenced by localized features such as bank hardening, channel crossings, riparian vegetation, and stormwater and sewer infrastructure.

To aid in the discussion of the results and the management suggestions, the 20 delineated stream reaches have been combined into four groups:

- The confluence with Salmon Creek: Reach 1
- Lower Cougar Creek: Reaches 2 through 5
- Middle Cougar Creek: Reaches 6 through 16
- Upper Cougar Creek: Reaches 17 through 20.

The reaches in each group are generally influenced by similar land uses and geomorphic characteristics. The geomorphic data collected for each reach are summarized in Table 21.

Confluence with Salmon Creek

The upstream end of Reach 1 begins at the Salmon Creek floodplain valley wall and becomes gradually less confined as it extends toward the confluence with Salmon Creek (Figure 12). Reach 1 is located within the Salmon Creek Park system and the historical Cougar Creek alluvial fan. As indicated by the ample gravel and cobble in the substrate material, this reach has the potential to be an alluvial, aggrading reach. A gravel bar at the mouth of Cougar Creek at its confluence with Salmon Creek is evidence of the ongoing sediment delivery. Reach 1 is characterized by a plane-bed channel, with a simplified rectangular cross-section; there is a pedestrian bridge associated with the Salmon Creek Park Trail mid-way along the reach. Angular riprap and rock are present along the banks, extending approximately 75 feet both upstream and downstream of the bridge abutments. This riprap inhibits floodplain connectivity, and there is very little channel complexity or diversity in channel form. Because of the potential for future channel aggradation and the rapid avulsion that can occur with alluvial floodplain settings, Reach 1 is characterized as having moderate response potential.

Table 21: Results of Geomorphic Survey of Cougar Creek

Reach	Inventory Site ID #	Channel Conditions									Bank Conditions					Floodplain Conditions		Underlying Geologic Material	Response Potential
		Bankfull Channel Width (ft)	Bankfull Channel Depth (ft)	Channel Gradient (%)	Substrate Material		Sinuosity	Functional LWD	Channel Type	Channel Stability	Active Bank Erosion	Eroding Banks (%)	Bank Stability	Bank Material		Floodplain Width (ft)	Floodplain Connectivity		
					Primary	Secondary								Primary	Secondary				
1	GG-13	10	3	1-2	Gravel	Cobble	Low (1.0-1.2)	Not prop functioning	Plane bed	Stable	Both banks	5 - 30	Slightly unstable	Cohesive fines	Gravel	30	Medium	Alluvium	Moderate
2	GG-12	5	5	> 8	Bedrock	Cobble	Low (1.0-1.2)	Not prop functioning	Cascade	Stable	None	< 5	Stable	Bedrock	Bedrock	20	Low	Sandstone	Low
3	GG-11	5	7	> 8	Boulder	Cobble	Low (1.0-1.2)	Not prop functioning	Cascade	Stable	Both banks	60 - 100	Slightly unstable	Gravel	Cobble	20	Low	Conglomerate	Low
4	GG-10	10	4	1-2	Cobble	Gravel	Low (1.0-1.2)	Not prop functioning	Pool riffle	Incising	Both banks	30 - 60	Moderately unstable	Gravel	Cobble	20	Medium	Conglomerate	Moderate
5	GG-9	10	4	1-2	Sand	Cobble	Low (1.0-1.2)	Not prop functioning	Pool riffle	Incising & widening	Both banks	5 - 30	Slightly unstable	Cohesive fines	Cohesive fines	45	Medium	Conglomerate	Moderate
6	GG-8	12	3	1-2	Sand	Cohesive fines	Medium (1.2 - 1.5)	At risk	Dune ripple	Incising	Both banks	30 - 60	Moderately unstable	Cohesive fines	Cohesive fines	150	Low	Flood deposits	High
7	GG-7	15	3	1-2	Sand	Gravel	Medium (1.2 - 1.5)	At risk	Pool riffle	Widening	Both banks	5 - 30	Slightly unstable	Cohesive fines	Cobble	300	Medium	Conglomerate	Moderate
8	GG-6	14	4	< 1	Sand	Sand	Low (1.0-1.2)	Not prop functioning	Dune ripple	Widening	Both banks	5 - 30	Slightly unstable	Cohesive fines	Fines	400	Medium	Flood deposits	High
9	GG-5	12	5	< 1	Cohesive fines	Gravel	Low (1.0-1.2)	Not prop functioning	Glide - rectangular	Incising & widening	Both banks	30 - 60	Moderately unstable	Cohesive fines	Fines	250	Low	Flood deposits	High
	GG-4	12	3	< 1	Gravel	Sand	Low (1.0-1.2)	Not prop functioning	Glide - rectangular	Incising & widening	Both banks	30 - 60	Moderately unstable	Cohesive fines	Gravel	200	Low	Flood deposits	High
10	GG-3	10	3	< 1	Sand	Gravel	Low (1.0-1.2)	Not prop functioning	Glide - rectangular	Widening	Both banks	30 - 60	Slightly unstable	Fines	Gravel	150	Low	Flood deposits	High
11	GG-2	10	5	< 1	Gravel	Sand	Low (1.0-1.2)	Not prop functioning	Pool riffle	Incising & widening	Both banks	30 - 60	Moderately unstable	Cohesive fines	Fines	150	Low	Flood deposits	High
12	GG-1	8	3	< 1	Cobble	Sand	Low (1.0-1.2)	Not prop functioning	Glide - rectangular	Incising & widening	None	5 - 30	Stable	Fines	Cohesive fines	80	Medium	Flood deposits	High
13	GG-22	8	5	< 1	Cohesive fines	Fines	Medium (1.2 - 1.5)	Not prop functioning	Glide - rectangular	Incising & widening	Both banks	5 - 30	Moderately unstable	Fines	Fines	50	Medium	Flood deposits	Moderate
14	GG-21	12	5	< 1	Cohesive fines	Fines	Low (1.0-1.2)	Not prop functioning	Glide - rectangular	Incising	Both banks	5 - 30	Slightly unstable	Fines	Fines	40	Medium	Flood deposits	Moderate
15	GG-20	4	3	< 1	Cobble	Sand	Straight (1.0)	Not prop functioning	Excavated/constructed	Forced stability	None	< 5	Slightly unstable	Fines	Fines	20	High	Flood deposits	Low
16	GG-19	4	2	< 1	Gravel	Sand	Straight (1.0)	Not prop functioning	Excavated/constructed	Forced stability	None	< 5	Moderately unstable	Fines	Fines	15	Low	Flood deposits	Low
17	GG-18	15	2	< 1	Fines	Cohesive fines	Straight (1.0)	Not prop functioning	Wetland channel	Stable	None	< 5	Stable	Fines	Fines	80	High	Flood deposits	High
18	GG-17	2	1	< 1	Fines	Cohesive fines	Straight (1.0)	Not prop functioning	Wetland channel	Stable	None	< 5	Stable	Fines	Fines	200	High	Flood deposits	High
	GG-15	3	1	< 1	Fines	Cohesive fines	Straight (1.0)	Not prop functioning	Wetland channel	Stable	None	< 5	Stable	Fines	Fines	50	High	Flood deposits	High
19	GG-16	15	5	1-2	Fines	Cohesive fines	Straight (1.0)	Not prop functioning	Wetland channel	Stable	None	< 5	Stable	Fines	Fines	30	Medium	Flood deposits	High
20	GG-14	10	2	< 1	Fines	Gravel	Straight (1.0)	Not prop functioning	Wetland channel	Stable	None	< 5	Stable	Fines	Fines	50	High	Flood deposits	High

LWD = Large woody debris

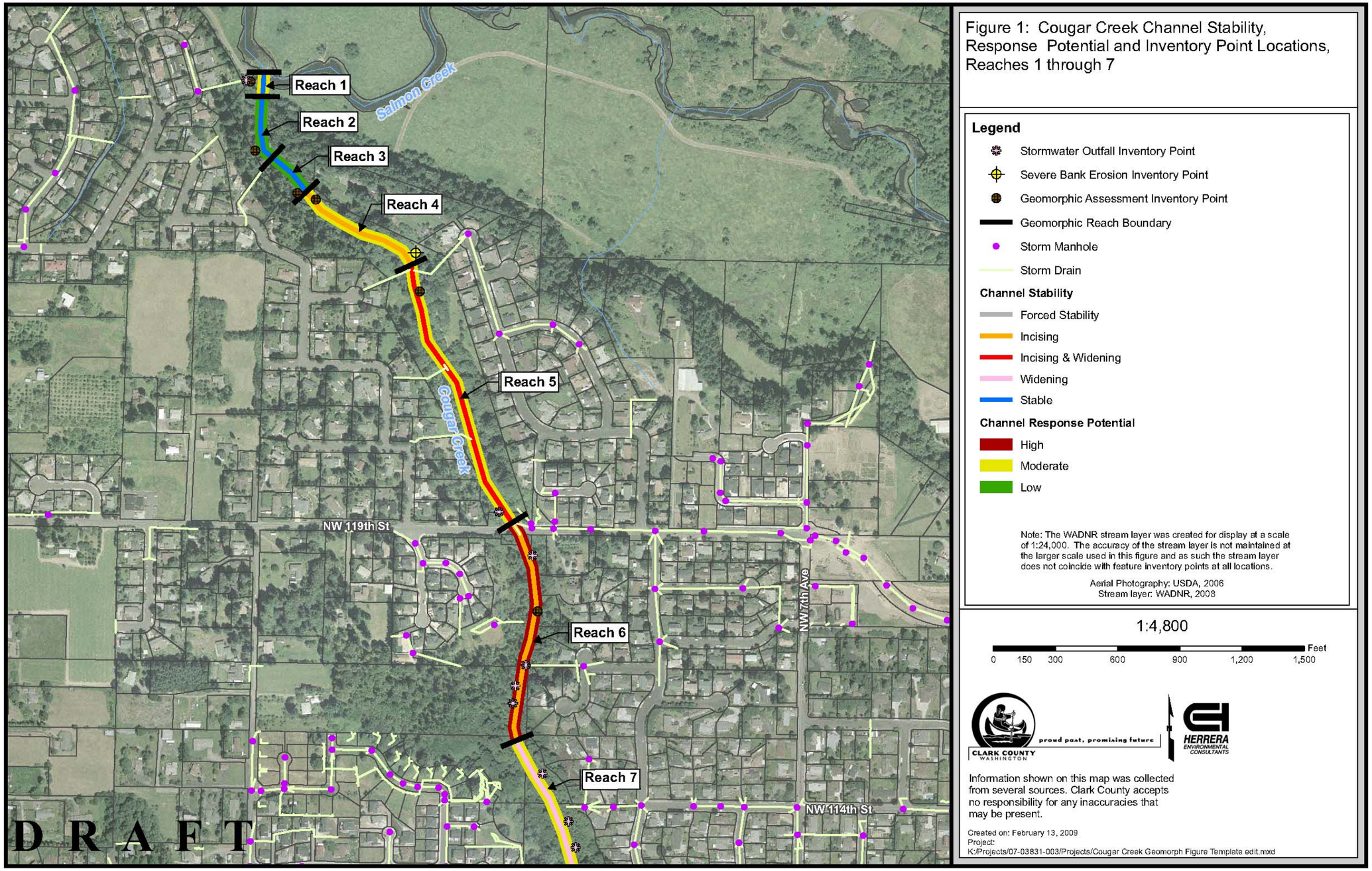


Figure 12: Cougar Creek: Channel Stability, Response Potential and Inventory Point Locations, Reaches 1 through 7.

Lower Cougar Creek

Reaches 2 through 5 of lower Cougar Creek are also located within the Salmon Creek Park system, extending from the confluence with Salmon Creek upstream to NW 119th Street (Figure 13). These reaches of lower Cougar Creek are experiencing incision within the context of a disturbed hydrologic regime. The uplands surrounding lower Cougar Creek are predominantly urban residential land. However, the stream lies within a natural ravine and transition zone between the upland watershed and the valley floor of Salmon Creek. Cougar Creek becomes increasingly confined by the ravine walls in the downstream direction, and the channel incises through the conglomerate and sandstone as it approaches Salmon Creek. Because the geology of the lower reaches is relatively resistant to erosion, the channel response potential for lower Cougar Creek is low to moderate. In contrast, several first-order drainages entering the ravine were observed to be incising and have high response potential to future stormwater discharges. Tributary drainages to Cougar Creek, however, were not explicitly surveyed for this geomorphic assessment.

Reach 2 is eroding into the conglomerate of the Troutdale Formation. The gradient exceeds eight percent for much of the reach, which functions as a narrow cascade, with no substrate other than the sandstone. The average channel width is approximately five feet, while the average height of the incised sandstone channel is between four and five feet. There is no vegetation on the banks, which are bare sandstone. Although this incision may have been occurring for thousands of years, the recent rate of channel incision may have been exacerbated by increased peak flows from stormwater inputs during the last few decades of increased development within the watershed. In this context, Reach 2 has a low channel response potential due to its resistant geologic characteristics.

Reach 3 is slowly incising through the conglomerate outcrops of the Troutdale Formation. Similar to Reach 2, it has a cascade morphology, but with the bed and banks composed of cemented cobbles, gravel, and sand. Aside from moss, vegetation has not become established on the consolidated banks of the channel. Also like Reach 2, Reach 3 appears to be able to readily transport smaller bedload material during small to moderate flow events. Although the rate of channel incision may have been recently exacerbated by increased peak flows from stormwater inputs, Reach 3 is characterized as having a low channel response potential due to fairly resistant geologic characteristics.

The boundary between Reach 3 and Reach 4 is a nickpoint in the conglomerate between the naturally incised cascade reaches downstream (Reaches 2 and 3) and the incising pool/riffle reaches upstream (Reaches 4 and 5). The nickpoint is moving upstream, causing incision that will further isolate the channel from its floodplain. As the nickpoint continues to propagate upstream, it could eventually threaten or undermine infrastructure, such as culverts or stormwater outfall locations. Unlike Reaches 2 and 3, which would respond to increases in peak flows more slowly, Reach 4 is much more vulnerable and is therefore

characterized as having a moderate channel response potential. As Cougar Creek meanders through the narrow floodplain within Reach 4, it has intermittently eroded through the conglomerate deposits. The upstream portion of the reach is characterized by pool/riffle sequences, but a plane-bed morphologic pattern emerges as the slope increases in the downstream direction. Pools are present only at meanders or where large woody debris is present. The banks are composed of consolidated sand and fines where the creek has not yet eroded through to the conglomerate.

Reach 5 is similar to Reach 4 in that it too would be moderately responsive to increases in peak flows. Reach 5 has the broadest floodplain (approximately 45 to 50 feet) of the lower reaches of Cougar Creek. However, in many places the channel is artificially confined by the trail, which parallels the channel through Salmon Creek Park. The trail disconnects the channel from its floodplain and occasionally from native bank and floodplain vegetation. Invasive vegetation, especially Himalayan blackberry, is common where the canopy is primarily deciduous instead of coniferous. The upstream portion of the reach is characterized by dune/ripple sequences, but as the slope increases in the downstream direction, a pool/riffle morphology becomes dominant. Bank stability is limited to where large trees or other hard points are present, and channel complexity is dictated by isolated pieces of large woody debris. The banks are composed of consolidated sand and fines where the creek has not yet eroded through to the conglomerate. About mid-way through Reach 5, there is a stream crossing culvert and associated embankment for a sewer line crossing. This crossing provides localized grade control and creates a slight backwater effect. There was erosion along the upstream side of the culvert embankment and a two-foot drop to the scour pool water surface from the culvert outlet.

Middle Cougar Creek

Middle Cougar Creek (Reaches 6 through 16) extends from NW 119th St upstream to the drainage system beneath Interstate 5 (I-5) (Figures 13 through 15). The reaches in middle Cougar Creek demonstrate the greatest impacts of past and ongoing changes in watershed land use and the hydrologic regime. In contrast to lower Cougar Creek, middle Cougar Creek generally has a moderate to high channel response potential. The only exceptions are Reaches 15 and 16 which are hardened by bank armoring and were therefore classified as having forced channel stability and a low response potential. Urban residential land use characterizes much of the middle portion of the watershed. A protected riparian buffer exists along most of the channel, with the exception of the reaches farthest upstream (Reaches 15 and 16), where Cougar Creek weaves through residential backyards and is channelized along lot boundaries.

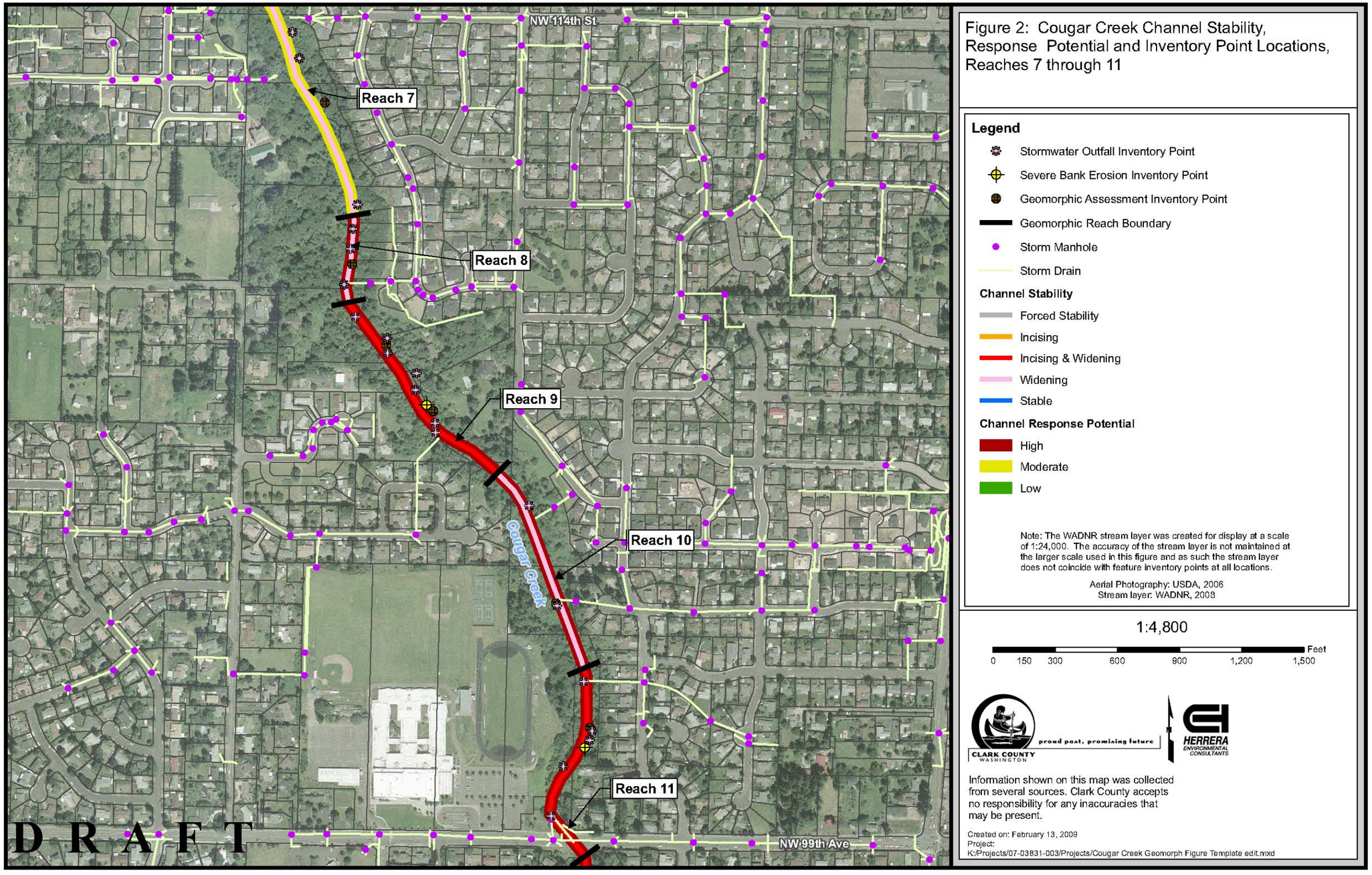


Figure 13: Cougar Creek: Channel Stability, Response Potential and Inventory Point Locations, Reaches 7 through 11.

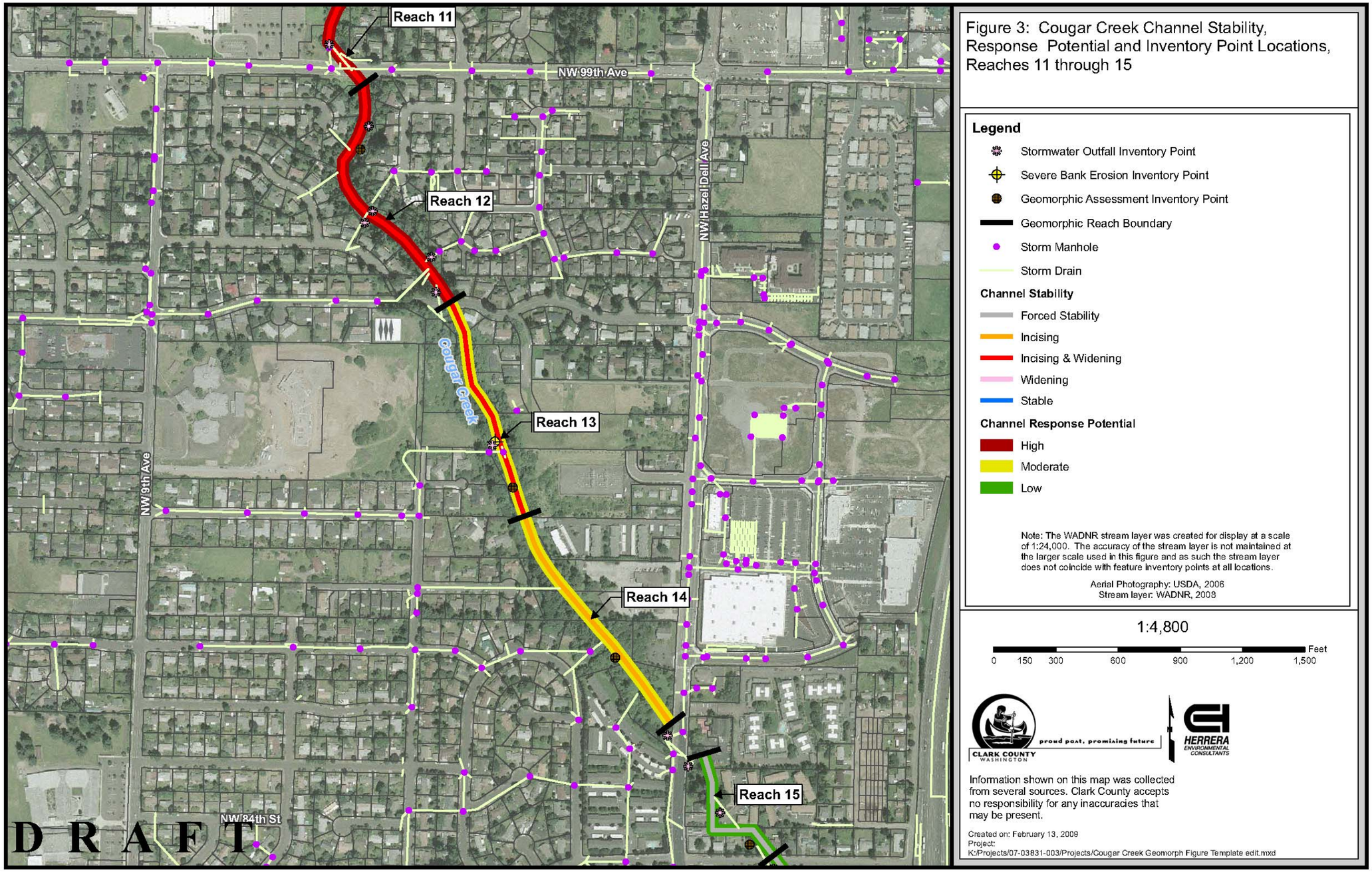


Figure 3: Cougar Creek Channel Stability, Response Potential and Inventory Point Locations, Reaches 11 through 15

Legend

- Stormwater Outfall Inventory Point
- Severe Bank Erosion Inventory Point
- Geomorphic Assessment Inventory Point
- Geomorphic Reach Boundary
- Storm Manhole
- Storm Drain

Channel Stability

- Forced Stability
- Incising
- Incising & Widening
- Widening
- Stable

Channel Response Potential

- High
- Moderate
- Low

Note: The WADNR stream layer was created for display at a scale of 1:24,000. The accuracy of the stream layer is not maintained at the larger scale used in this figure and as such the stream layer does not coincide with feature inventory points at all locations.

Aerial Photography: USDA, 2006
Stream layer: WADNR, 2008

1:4,800

0 150 300 600 900 1,200 1,500 Feet

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Figure 14: Cougar Creek: Channel Stability, Response Potential and Inventory Point Locations, Reaches 11 through 15.

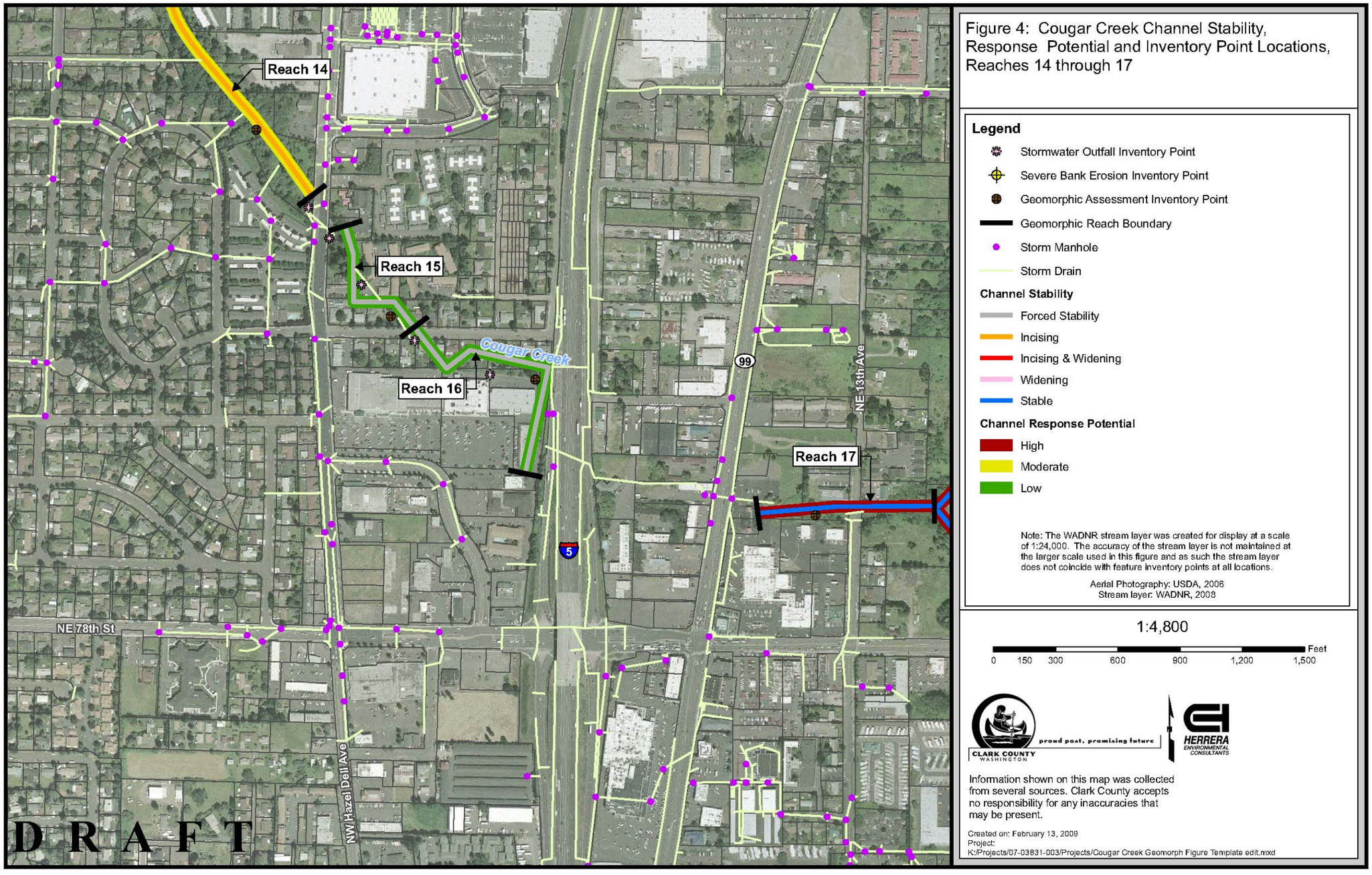

Figure 15: Cougar Creek: Channel Stability, Response Potential and Inventory Point Locations, Reaches 14 through 17.

Most of the residential developments adjacent to middle Cougar Creek include piped storm drainage systems that outfall directly to the creek. The storm drainage system includes drains from roofs, yards, and side streets (see stormwater outfall locations in Figures 2 through 4). In addition, I-5 and the commercial land uses along NE Hazel Dell Avenue and NW 78th Street contribute stormwater to the middle reaches of Cougar Creek.

The stormwater outfall density is much higher for middle Cougar Creek than for lower or upper Cougar Creek. Impacts from the stormwater-altered hydrologic regime, such as channel incision and bank erosion, are compounded by the high response potential of cataclysmic flood deposits (hereafter referred to as *flood deposits*), which are the primary surface geologic unit in middle Cougar Creek. The flood deposits are unconsolidated and highly susceptible to erosion. As a result, the stream channel degrades by adjusting its physical form to accommodate increases in stormwater and changes in the hydrologic regime. Chronic channel instability and ongoing degradation is indicated by widespread incision and bank erosion throughout middle Cougar. In addition, this chronic channel degradation is exacerbated by the local influence of stormwater outfalls lacking energy dissipation, or where stormwater infrastructure was actually failing and falling into the creek, causing localized scour and erosion.

The reaches of middle Cougar Creek are generally characterized by low to moderate slopes (less than one percent to two percent), low to moderate sinuosity, rectangular glide channel types, and moderately unstable channel and banks (Table 4). Natural groundwater seeps contribute consistent seepage base flow to the channel through this section as well. In the limited locations where mature coniferous canopy is present along the banks and in the floodplain, the channel appears to be better capable of maintaining channel and bank stability, and the physical channel topography is more complex. However, most of the riparian corridor of middle Cougar Creek is characterized by a mature deciduous canopy (red alder) and invasive undergrowth vegetation, such as English ivy and Himalayan blackberry. The poor root cohesion of these invasive plants contribute to limited channel complexity and contribute to the rectangular/glide channel type through most of the middle Cougar Creek reaches.

Middle Cougar Creek has a high potential for both positive and negative responses to future land use and hydrologic changes. Although the bed material consists mostly of gravel and sand, the bank material is composed mostly of unconsolidated fines, thereby making the banks extremely sensitive to erosion and prone to contributing fine sediment to downstream reaches. Through incision and widening, the channel continues to adjust its form to hydrologic changes and localized disruptions in riparian connectivity (i.e., failing stream crossing culverts, erosion from stream crossings at abandoned roadway or sewer line embankments or at access points from pedestrian footpaths). At the same time, some of these existing stream crossings function as grade controls, inhibiting incision from nickpoint migration. However, many of the old stormwater pipes

and outfalls are also failing, either because lack of energy dissipation has led to localized bank erosion and bed scour, or because severe bank erosion at outfalls has caused the entire outfall pipe to fail and contribute debris to the channel. Additionally, a sewer main runs along much of middle Cougar Creek and the channel has eroded around and exposed many manholes.

Upper Cougar Creek

Upper Cougar Creek (Reaches 17 through 20) extends from the storm drainage network under I-5 to the backwaters located in pastures and open wetland fields east of Highway 99 (Figures 4 and 5). Upper Cougar Creek is naturally broad and flat and was historically characterized by wetlands formed on depressions in cataclysmic flood deposits. The channel bed and banks predominantly composed of fine material. The upper Cougar Creek watershed includes a variety of land uses that have altered the hydrologic regime, including agricultural, industrial, residential, commercial, and transportation uses. There are stormwater contributions from NW 78th Street, as well as from the urban residential developments and the commercial and industrial land uses that lie adjacent to headwater wetlands and channel. However, there is still significant open space in this portion of the subwatershed, providing unique opportunities to preserve and restore natural hydrologic function and geomorphic processes. At the same time, upper Cougar Creek has a high potential to respond unfavorably to future development of these open spaces.

The downstream limit of Reach 17 is the storm drain network that conveys the flow below parking lots, Highway 99, and I-5. The open channel of Reach 17 continues upstream to the confluence of two tributaries (here termed the south and north tributaries), located just east of NE 13th Avenue (Figure 16). The riparian vegetation downstream of NE 13th Avenue is dominated by invasive vegetation, including reed canary grass, Himalayan blackberry, and cattails. There is no overstory and no distinctive channel form. Instead the water filters through a 50- to 80-foot-wide floodplain composed of fine sediment and full of dense, invasive vegetation. The dense vegetation and fine wetland sediments cause a backwater condition through the culvert beneath NE 13th Avenue. On the day of the geomorphic survey, backwater filled two-thirds of the culvert. It is possible that some of the backwater observed was compounded by high groundwater levels at the time of the observations. There is some deciduous canopy upstream of NE 13th Avenue, but invasive vegetation such as Himalayan blackberry, reed canary grass, and nightshade, surround the creek. Throughout the reach, the channel type was characterized as wetland; however, portions of the reach exhibit modified or excavated characteristics and it is likely that the channel was at one time excavated or realigned and has subsequently become infested with invasive vegetation.

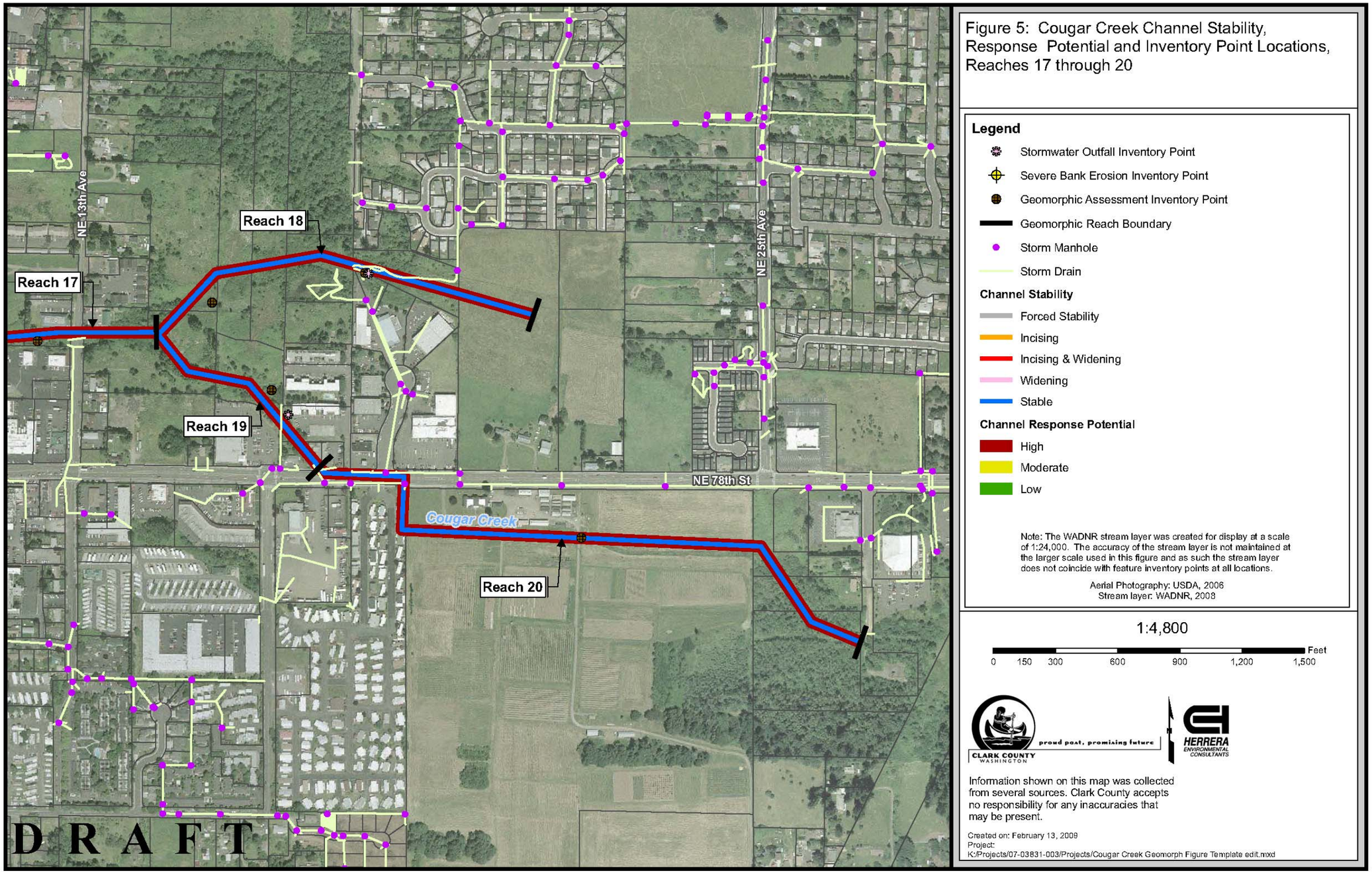

Figure 5: Cougar Creek Channel Stability, Response Potential and Inventory Point Locations, Reaches 17 through 20

Legend

- Stormwater Outfall Inventory Point
- Severe Bank Erosion Inventory Point
- Geomorphic Assessment Inventory Point
- Geomorphic Reach Boundary
- Storm Manhole
- Storm Drain

Channel Stability

- Forced Stability
- Incising
- Incising & Widening
- Widening
- Stable

Channel Response Potential

- High
- Moderate
- Low

Note: The WADNR stream layer was created for display at a scale of 1:24,000. The accuracy of the stream layer is not maintained at the larger scale used in this figure and as such the stream layer does not coincide with feature inventory points at all locations.

Aerial Photography: USDA, 2006
Stream layer: WADNR, 2008

1:4,800

0 150 300 600 900 1,200 1,500 Feet

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Figure 16: Cougar Creek: Channel Stability, Response Potential and Inventory Point Locations, Reaches 17 through 20.

Reach 18 extends along the north tributary, from the confluence with the south tributary and upstream to where the channel emerges from pastures just west of NE 25th Avenue (Figure 16). Portions of the reach exhibit characteristics typical of modified or excavated channels (e.g., rectangular form and straightened channel alignment). The channel flows through undeveloped private properties, which are completely covered by reed canary grass and partly by Himalayan blackberry. These invasive plants frequently choke the channel and limit physical channel complexity. At the same time, however, the invasive plants provide significant roughness relative to the channel flow, thereby preventing incision and bank erosion. The bed and bank material is composed of fine sediment.

Reach 19 extends along the south tributary, from the confluence with the north tributary and upstream to the culvert outfall just downstream of NE 78th Street (Figure 16). The lower portion of the reach is very similar to Reach 18, as it passes through undeveloped properties that are covered by reed canary grass and trash. Portions of the reach exhibit characteristics typical of modified or excavated channels (e.g., rectangular form, straightened channel alignment). Along the lower reach, there are several old culverts associated with abandoned stream crossing roadways or driveways that disrupt channel continuity. The portion of the reach just downstream of NE 78th Street passes between apartment buildings and stores that discharge stormwater to both banks via ditches and stormwater outfalls. The channel bed and banks are composed of clay, silt, and sand, and this characteristic combined with the prevalence of reed canary grass, and lack of native vegetation, contributes to a simplified, rectangular channel shape and limited channel complexity. Similar to the conditions in Reach 18, the reed canary grass in Reach 19 roughens the channel and prevents channel incision and bank erosion.

Reach 20 extends along the south tributary from the culvert under NE 78th Street upstream to the wetlands and fields just east of NE 26th Avenue (Figure 16). The lower portion of Reach 20 is a ditch between two property boundaries. The main channel makes a 90-degree turn to the east and heads through an open field. The channel is rectangular and has a fine sediment and gravel bed, and the banks are composed of fine material. Although the channel appears to have been straightened and used as an agricultural ditch, it has the potential for good floodplain connectivity. The reed canary grass, cattails, and duckweed that choke the channel promote channel bed and bank stability.

Management Recommendations

Based on the results of the geomorphic assessment and information from the other relevant inventories (e.g., stream features inventory), management recommendations have been developed to emphasize the following objectives:

- Protect reaches that are currently unstable or sensitive to future disturbance.
- Enhance reaches that are currently stable or are less sensitive to future disturbance.

Recommendations to protect reaches include the implementation of projects that will prevent further degradation to the channel from changes in the watershed land use and hydrology. Recommendations to enhance reaches include the implementation of projects that will improve and help rehabilitate the geomorphic functions of existing reaches. For example, enhancement is recommended in reaches that have characteristics similar to the Middle Cougar Creek, a self-forming alluvial channel.

In general, the management recommendations have been grouped according to (1) broadly defined watershed management strategies for each of the four geomorphic reach groups, and (2) specific categories of rehabilitation projects: channel, bank, and floodplain projects. The watershed management strategies and channel, bank, and floodplain rehabilitation projects are described in the following subsections.

Watershed Management Strategies

Because various portions of the Cougar Creek subwatershed present unique opportunities and challenges for management, the watershed management strategies are also grouped and discussed according to the same four geomorphic reach groups defined in the results section.

The geomorphic processes of Cougar Creek are intrinsically intertwined with hydrologic processes and land use management throughout its watershed. Therefore, the geomorphic-based management recommendations cannot be successful without addressing development trends and processes throughout the watershed. From a practical standpoint, the existing hydrologic regime is unlikely to change in a significant way other than experiencing additional runoff from future development, assuming the development uses stormwater BMPs to address other concerns. Stormwater management must consider this fact and act accordingly to target protection and restoration where efforts have the greatest opportunity for success

Overall

If runoff from existing developed areas can be managed effectively, the incidence of erosive flows in the channel network will be reduced, and the creek will have less power to transport sediments downstream. However, much of Cougar Creek was developed before the establishment of stringent flow control requirements (Ecology 2005). Consequently, the watershed management strategies should consider opportunities for retrofitting the existing stormwater facilities, incorporating detention to limit the volumes and durations of potentially erosive flows in addition to peak rates of runoff. Clark County could look for opportunities throughout the watershed to infiltrate and disperse significant volumes of runoff or to retrofit existing regional stormwater facilities.

Confluence with Salmon Creek
The confluence of Cougar Creek and Salmon Creek lies within Salmon Creek Park, providing Clark County with easy access the channel. Given the depositional nature and strong potential for hydrologic connectivity within this reach, the management strategies could focus on providing the channel with space to function as an alluvial fan. This would encourage the mosaic of channel alignments, depositional features, and wetlands that might naturally occur.

The management strategies could continue to preserve riparian areas, while limiting or controlling access points to the creek. In addition, promoting the establishment of native vegetation would promote both the success of the specific potential rehabilitation projects described below as well as the natural ability of the channel to sustain physical channel complexity.

Lower Cougar Creek
While the location of lower Cougar Creek within the Salmon Creek Park system enables access to the channel for potential management projects, the current channel morphology and dynamics (incising and widening) limit the potential for the channel to respond to management actions. As discussed previously in the results section, the channel is naturally incising through the conglomerate and sandstone bedrock.

Middle Cougar Creek
Most of middle Cougar Creek was categorized as having a high channel response potential to ongoing and future changes in hydrology. Therefore, the management recommendation actions for Middle Creek focus on both protection and enhancement. Most of the stormwater from the residential developments as well as the commercial and transportation land uses in the upper watershed are tightlined directly to the creek.

The existing sewer alignment that parallels the channel through much of this portion of Cougar Creek is threatened by channel erosion and channel migration. This situation should be reviewed to determine the need for further action as a joint county-sewer district effort.

Upper Cougar Creek
Because much of upper Cougar Creek is adjacent to open space, this part of the watershed provides opportunities to both protect and restore wetland and stream hydrologic processes. This in turn, can help prevent future hydrologic changes downstream and improve summer low flows by increasing recharge.

Opportunities may exist for Clark County to acquire properties and set aside areas for parks or rehabilitated wetlands. Parks and rehabilitated reaches could serve as opportunities to further educate nearby landowners on watershed processes. At a minimum, the county could work to preserve riparian buffer areas, rehabilitate native vegetation, and work with nearby landowners to educate

them on minimizing hydrologic and geomorphic impacts. The county could also work with the owners of agricultural areas to preserve and enhance riparian buffers and to separate livestock from the channel.

County stormwater capital projects could include multiple use sites, including restoration of wetlands hydrology on county properties including the former county poor farm on NE 78th Street.

Channel, Bank, and Floodplain Rehabilitation Projects

This section describes and categorizes potential projects that could be implemented to improve or maintain channel, bank, and/or floodplain conditions in Cougar Creek. Table 22 summarizes where project categories are most appropriate by reach. Project options by reach are described in Appendix A.

Channel Rehabilitation

Potential actions that could promote in-channel stabilization throughout Cougar Creek are the following.

Grade Control. Grade control features are intended to limit channel incision, increase the base channel elevation, and improve overbank and floodplain connectivity. Placement of grade control structures is recommended in reaches where reducing channel incision will improve stream stability and function.

Grade control would be most appropriate in reaches, such as those in Middle Cougar, where incision is common and ongoing, and where the channel exhibits self-forming alluvial characteristics and the potential for rehabilitating floodplain connectivity. In addition, grade control structures could be especially beneficial if added in strategic locations where nickpoint migration threatens to cause increasing channel incision and channel degradation, or where further incision or associated bank erosion could threaten infrastructure, such as road crossings and utility alignments.

Large Woody Debris (LWD). In-channel large woody debris (LWD) creates hydraulic and habitat complexity. Placement of LWD is recommended where it can improve stream function by increasing channel complexity and stability as well as enhance floodplain connectivity. LWD can also be placed to function as grade control. The character of Middle Cougar Creek (a self-forming alluvial channel) makes it an appropriate place for the placement of LWD (i.e., specific recommendations for LWD placement throughout Cougar Creek are described in Appendix A: Potential Projects Opportunities). Due to elevated risk of failure because of the urban environment, LWD placement should be carefully engineered.

Table 22: Potential Channel, Bank, and Floodplain Rehabilitation Projects for Cougar Creek														
		Channel Rehabilitation Project Categories												
		Channels						Banks						Floodplain
Reach		Grade Control		LWD Placement		Channel Realignment		Stabilization		Revegetation		Structure Removal		Revegetation
1				X						X		X		X
2										X				X
3		X						X		X				
4		X						X		X				X
5		X		X				X		X				X
6		X		X				X		X				X
7		X		X		X		X		X		X		X
8				X				X		X				
9		X		X				X		X				
10		X		X				X		X				
11		X		X				X		X				
12		X		X		X		X		X		X		
13		X		X				X		X		X		
14		X		X						X		X		
15										X		X		
16										X				
17										X				X
18						X				X				X
19						X				X				X
20						X				X				X

Channel Realignment. In several reaches (especially Reaches 7, 12, and 13) within middle Cougar Creek, the channel has eroded and incised and begun to threaten the nearby infrastructure of the sewer mainline. In these areas, further evaluation will be necessary to determine the best steps for protecting or relocating the sewer mainline. Realignment of the channel is one possibility for protecting the infrastructure in these areas. There are also opportunities in upper Cougar Creek to realign the channel, especially where it has been previously straightened and artificially confined, thereby improving and restoring the geomorphic and hydrologic processes.

Bank Rehabilitation

Bank Stabilization. Bank stabilization structures are intended to stabilize a failing or eroding bank. Bank stabilization structures could incorporate LWD placement as well as revegetation with native species. Placement of bank stabilization features is recommended where these structures would improve overall bank conditions, prevent further degradation at locations of severe erosion, and/or protect infrastructure.

Bank Revegetation. Bank revegetation is intended to restore vegetation quality and quantity. Revegetation with native species can help control the spread of invasive species. Bank revegetation can improve bank stability, stream cover, and eventually supply large wood debris for restoring and preserving channel habitat. These goals are applicable in almost any stream reach. They can be leveraged on county open space improvements such as train construction. Revegetation efforts would need to be coupled with the removal of invasive species and regular maintenance to ensure the survival of native plant species.

Bank Structure Removal (e.g., Riprap Removal). Previous treatments may no longer be functioning as originally intended or may be failing altogether. Removal of these obsolete or failing structures is recommended where removal can improve stream function and habitat. This management recommendation is proposed at least once in lower, middle and upper Cougar Creek.

Floodplain Revegetation

Floodplain revegetation is intended to restore vegetation quality and quantity that influence floodplain habitat, woody debris delivery, shade and flood control functions. Reestablishment of native species can help control invasive weeds throughout the creek's floodplain areas. Floodplain revegetation should be considered in conjunction with other riparian planting strategies such as bank revegetation.

Potential Rehabilitation Projects

Potential rehabilitation projects have been identified using the field information, analysis, and management recommendations described previously. These projects focus on methods for restoring natural geomorphic processes and providing channel stability in currently unstable reaches or in reaches that could become unstable under future conditions. The potential channel, bank, and floodplain rehabilitation projects identified for each geomorphic reach are summarized in Table 2. A more detailed description of these potential projects is provided in Appendix A

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, the Washington State University (WSU) Watershed Stewards Program, and the Clark Conservation District for possible implementation.

This section focuses on opportunities likely to be considered by the CWP SCIP, which are primarily 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, primarily the Habitat Assessment reports prepared for the Lower Columbia Fish Recovery Board (R2 Resource Consultants, Inc., 2004), but also with analysis of the Salmon Creek Limiting Factors Analysis Report (HDR Engineering, Inc., 2002) and the Salmon Creek Watershed Assessment (Pacific Groundwater Group, 2002). 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 2002 Salmon Creek Limiting Factors Analysis and 2002 Salmon Creek Watershed Analysis, along with the 2004 LCFRB Habitat Assessment report were also reviewed for specific project opportunities within 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 Salmon Creek (RM 03.83) and Cougar 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 within the subwatersheds not included in the habitat assessment (tributaries to Salmon Creek, such as Tenny Creek and portions of Suds Creek and LaLonde Creek), LWD recruitment potential and shade rating analyses were based on a qualitative review of 2007 orthophotographs.

At the subwatershed scale, the LCFRB rated the riparian conditions within the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds as impaired.

Riparian (Large Woody Debris (LWD) Delivery)

Figure 17 shows the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds LWD delivery potential. Within the Salmon Creek (RM 3.83) subwatershed, the survey includes the mainstem of Salmon Creek and portions of Suds and LaLonde Creeks. The mainstem of Salmon Creek is shown as having primarily low LWD recruitment along the approximate three mile distance surveyed. Review of the surveyed area and non-surveyed areas of Suds Creek, Tenny Creek and LaLonde Creek indicated primarily low LWD recruitment levels, with some small areas of medium recruitment.

The Cougar Creek subwatershed survey addresses only the lower reaches of Cougar Creek, which transitions from high levels of recruitment near the mouth of the creek, to lower levels further upstream. Review of orthophotography in the upper reaches estimated LWD recruitment potential ranging from low to none, with the lowest levels of recruitment located near the headwaters of Cougar Creek.

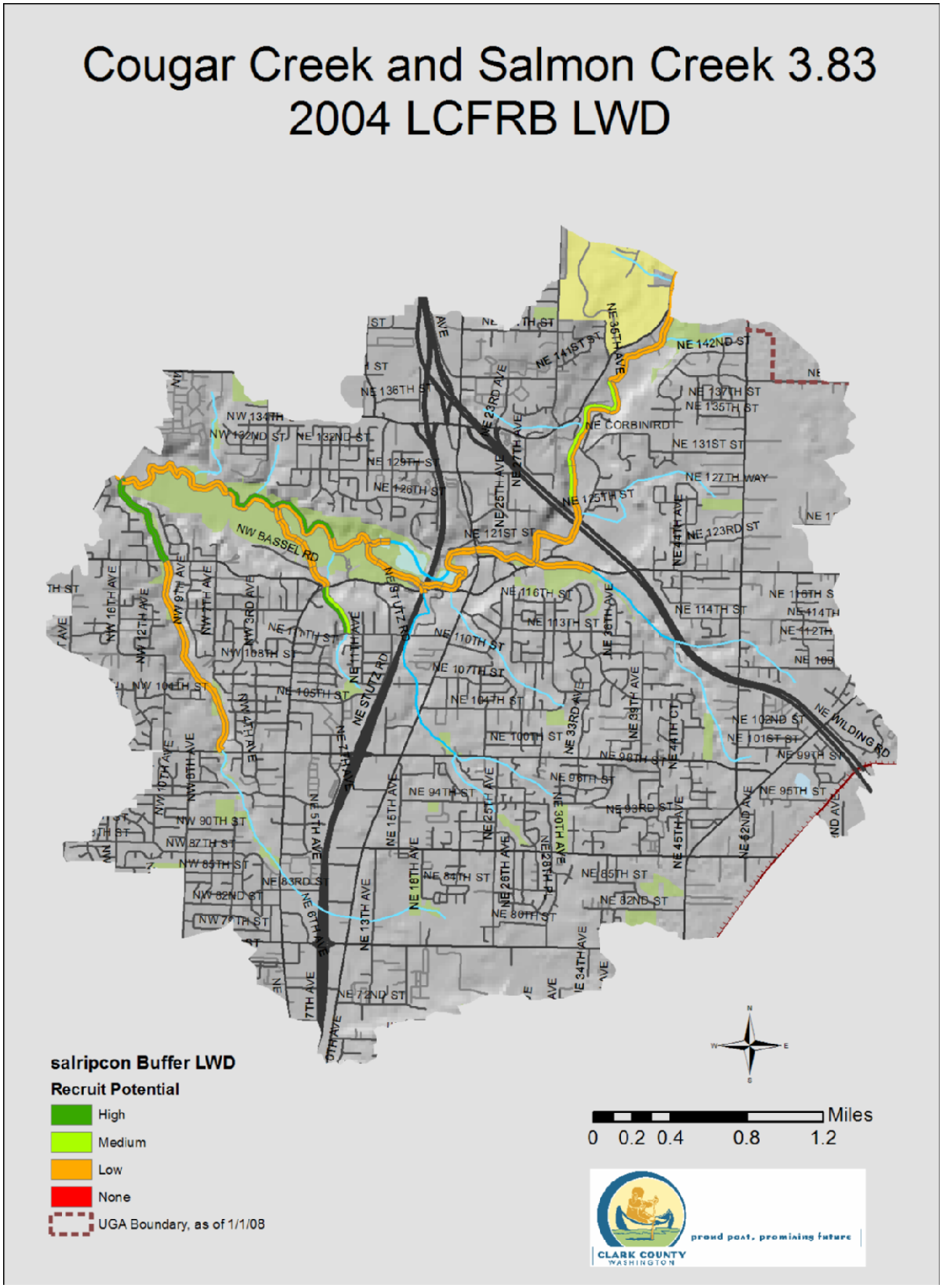

Figure 17: Salmon Creek (RM 03.83) and Cougar Creek LWD Recruitment Potential (adapted from R2 Resource Consultants, Inc., 2004)

Shade

The Salmon Creek (RM 03.83) and Cougar Creek subwatersheds shade ratings from the 2004 LCFRB Habitat Assessment are illustrated on Figure 18. Within the Salmon Creek (RM 03.83) subwatershed, the survey covered the mainstem of Salmon Creek and portions of Suds and LaLonde Creeks. The mainstem of Salmon Creek within the Salmon Creek (RM 03.83) subwatershed has shade levels ranging from 0 percent to 40 percent. Review of the surveyed area and non-surveyed areas of Suds Creek and LaLonde Creek indicated shade levels of varying from 0 percent to 70 percent. Tenny Creek is estimated to have shade levels ranging from 0 percent to 40 percent, based on orthophotography review.

Within the Cougar Creek subwatershed, shade ratings were in the range of 40 percent to 70 percent in the surveyed reaches of the mainstem of Cougar Creek. Lower shade ratings are found in the uppermost reaches of Cougar Creek (which were not formally surveyed) and are estimated to be in the 0 percent to 40 percent range based on orthophotography review.

The LCFRB habitat assessment for the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds indicated that the majority of the reaches are currently off-target with respect to the State Forest Practices shade/elevation screen standards.

Management Recommendations

Overall recommended management activities for the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds include riparian forest restoration in areas degraded by residential land use and road improvement/realignment projects, acquisition of existing forest land for future protection of streams and watersheds, and invasive species removal.

Potential Projects

Potential riparian restoration projects for the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds were identified from review of the 2004 LCFRB Habitat Assessment report, along with the 2002 Salmon Creek Limiting Factors Analysis and 2002 Salmon Creek Watershed Analysis, with orthophotography analysis in areas not formally surveyed. Recommended restoration projects in the Salmon Creek (RM 03.83) subwatershed included riparian forest restoration and invasive species removal on the smaller tributaries to the mainstem of Salmon Creek (Suds Creek, Tenny Creek and LaLonde Creek). Reforestation of the mainstem of Salmon Creek should be limited to conifer plantings or hardwood conversions in those areas with limited frequency of floodplain disturbance (R2 Resource Consulting, Inc., 2004).

Restoration projects in the Cougar Creek subwatershed included riparian forest restoration along Cougar Creek with additional plantings of trees and shrubs (with an emphasis on native conifers) and invasive species removal.

Specific priority project areas within the Salmon Creek (RM 03.83) subwatersheds are reforestation and invasive species removal on the smaller tributaries to Salmon Creek (Suds Creek, Tenny Creek and LaLonde Creek). Suds Creek would benefit from reforestation within its lower reaches, which are located within the Salmon Creek Greenway. Tenny Creek and LaLonde Creek would benefit from reforestation in their lower reaches, as well as in areas disturbed by residential development and significant invasive species growth.

Within the Cougar Creek subwatershed, riparian reforestation/invasive species removal would be beneficial in the upper reaches of Cougar Creek starting from just north of NE 99th Street and traveling east to the creek's headwaters located east of Interstate 5.

Reforestation of these areas within the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds would provide both improved riparian LWD recruitment and stream channel shading.

There are several potential project areas within the mainstem of Salmon Creek, and also the smaller Salmon Creek tributary streams within the Salmon Creek (RM 03.83) subwatershed and the Cougar Creek subwatershed that are located on publicly owned land. These projects are identified and described in Table 23. Within the Salmon Creek (RM 03.83) subwatershed, the potential projects are located on the mainstem of Salmon Creek, Suds Creek, Tenny Creek and LaLonde Creek, and involve reforestation and invasive species removal.

Within the Cougar Creek subwatershed, two potential project areas were identified on the mainstem of Cougar Creek. The first involves reforestation near the headwaters, in a degraded area with little riparian cover. The second project is located in a riparian area that has been significantly impacted by encroachment of invasive species.

Table 23: Tax Exempt Parcels Overlapping Potential Riparian Restoration Areas				
ASSR_SN	**ASSR_AC**	**OWNER**	**PT1DESC**	**Description**
TBD	Approx. 200 acres	Clark County Parks and Recreation	Unused or vacant land	Areas of potential reforestation on the mainstem of Salmon Creek within the Salmon Creek Greenway from downstream of Klineline Pond to the mouth of Cougar Creek.
187198-000	16.73 acres	Vancouver School District #37	Outdoor sports arenas, stadiums, coliseums.	Potential reforestation area near mouth of Suds Creek within Salmon Creek Greenway
117957-000	2.26 acres	Clark County	Designated floodplain	Potential reforestation area on Tenny Creek north of NE 99th Street
097630-000	1.50 acres	Clark County	Vacant land	Potential reforestation/invasive species removal area near headwaters of LaLonde Creek
145525-003 145370-000	4.55 acres	Clark County	Vacant land	Degraded riparian area near headwaters of Cougar Creek
145252-000 145355-000	2.18	Vancouver Housing Authority	Unused platted land & Multi-family	Degraded Cougar Creek riparian area
189231-000	6.98 acres	Vancouver School District #37	Private - Preschools, Nurseries, & Daycare Centers	Degraded Cougar Creek riparian area

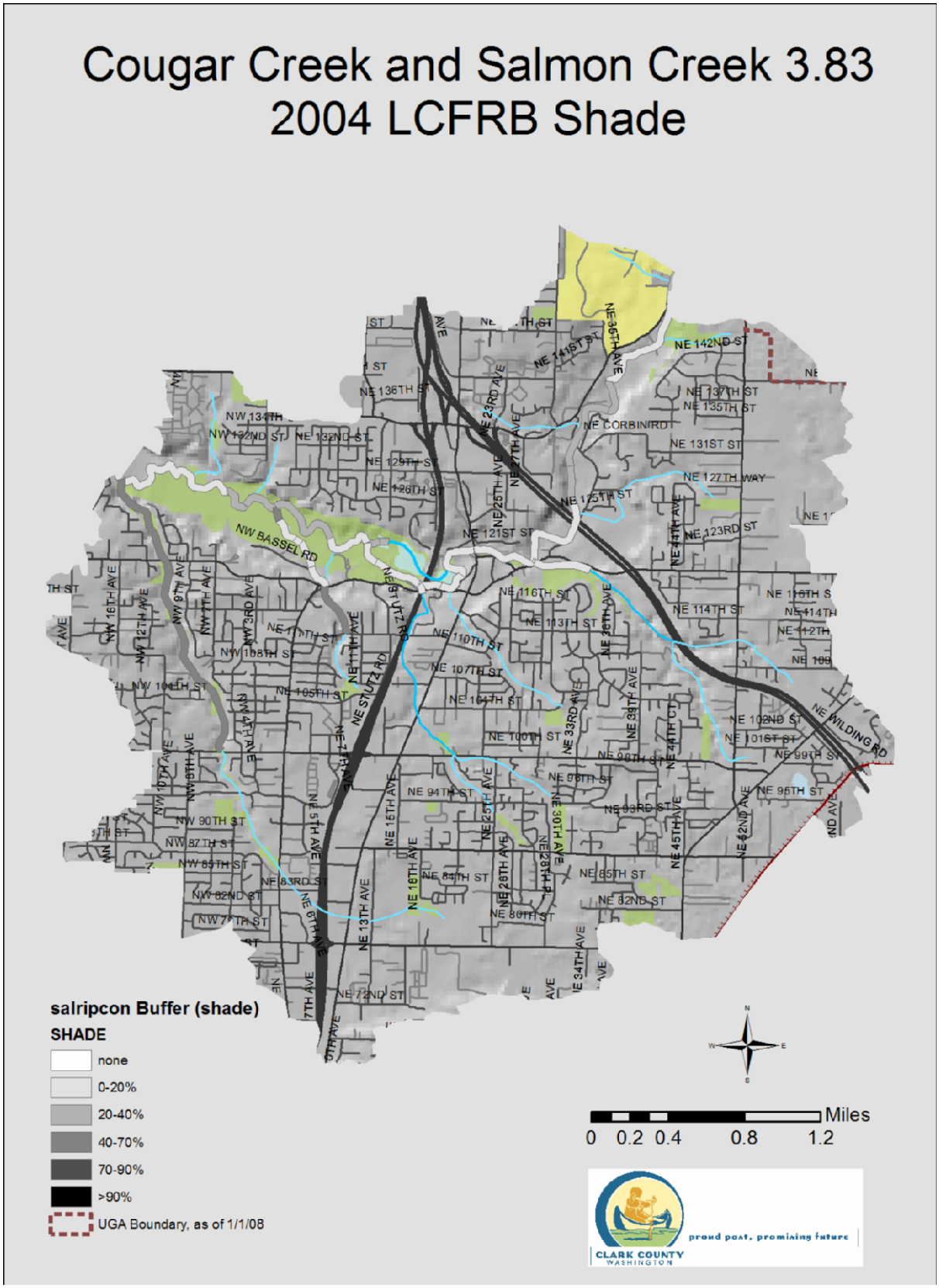

Figure 18: Salmon Creek (RM 03.83) and Cougar Creek Shade Values (adapted from R2 Resource Consultants, Inc., 2004)

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; and
- 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.

Stream Reconnaissance and Geomorphology/Hydrology assessments may also discover potential wetland-related project opportunities. 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 19 shows potential wetland areas within the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds based on data from the county wetlands atlas, including the Clark County wetland model, National Wetlands Inventory, and high-quality wetlands layer.

The Salmon Creek (RM 03.83) subwatershed has large expanses of potential wetland areas associated with the Salmon Creek riparian corridor and floodplain areas. The majority of the wide floodplain associated with Salmon Creek is designated as wetlands, as the vast majority of Salmon Creek's floodplain lies adjacent to its mainstem. The main tributaries to Salmon Creek (Suds, Tenny and

LaLonde Creeks) also have multiple potential wetlands associated with their floodplains.

In the Cougar Creek subwatershed, pockets of potential wetlands are primarily associated with the headwaters and stream channel floodplains of Cougar Creek, with the exception of an approximately 70 acre potential wetland area east of Interstate 5 and south of NE 78th Street, in the vicinity of the Southwest Washington Experimental Station.

Review of the wetland inventories and studies identified several project opportunities within publicly held or tax-exempt land. Within the Salmon Creek (RM 03.83) watershed, there are potential wetlands in the vicinity of the headwaters of Tenny Creek. Additionally, potential wetland areas owned by Clark County are located at the headwaters of Cougar Creek.

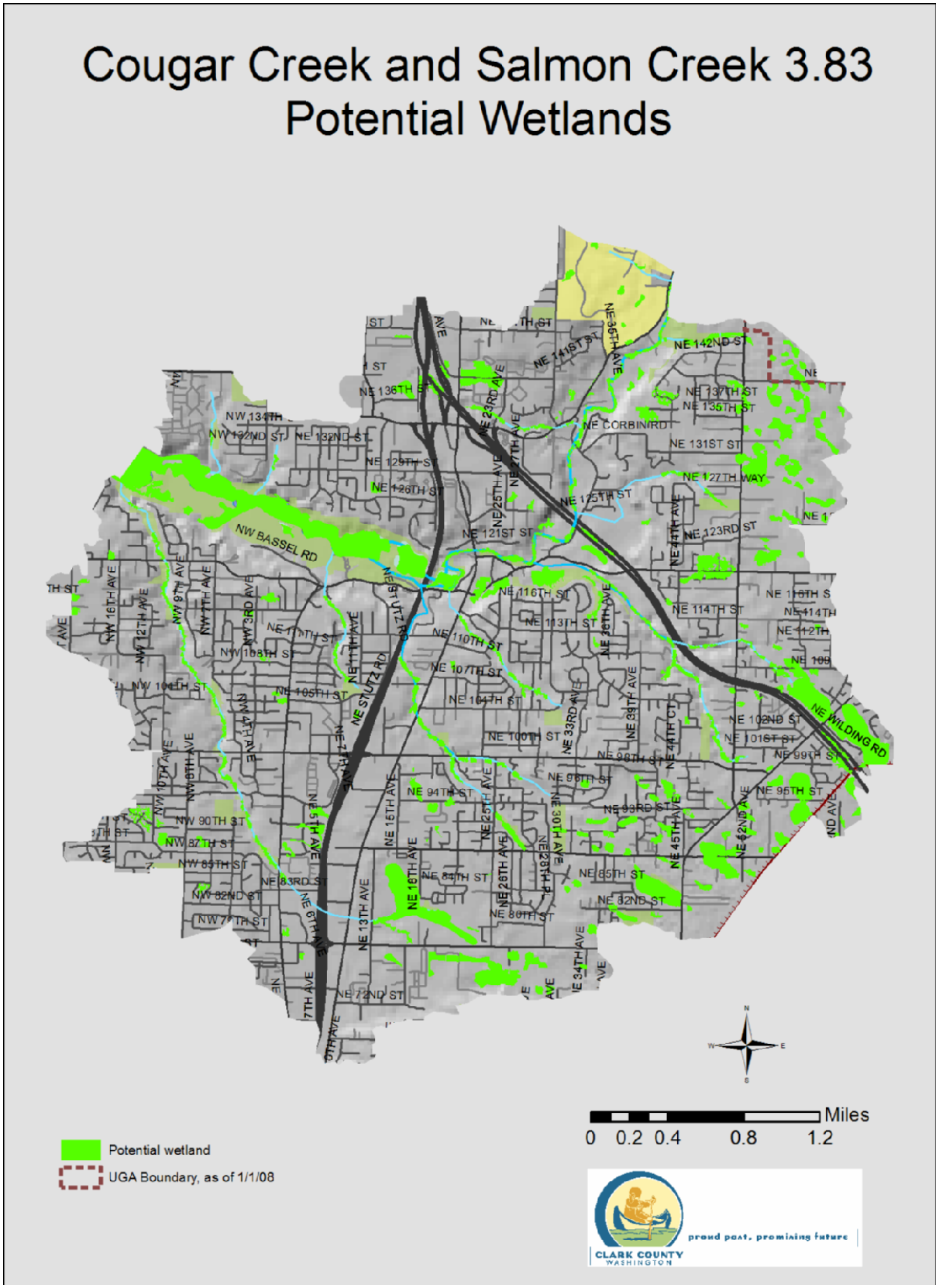

Figure 19: Salmon Creek (RM 03.83) and Cougar Creek Potential Wetlands

Draft Watershed Characterization

The Washington Department of Ecology completed a prototype watershed assessment to assist in planning wetland and riparian habitat restoration and preservation projects. The Draft Watershed Characterization (Washington Department of Ecology, 2007) may be found on the Clark County website at: http://www.clark.wa.gov/mitigation/watershed.html

Results pertaining to the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds are summarized below.

The Salmon Creek (RM 03.83) and Cougar Creek subwatersheds are part of the Terrace hydrogeologic unit. This unit is dominated by rain; has a westward to southwestern trending groundwater flow pattern; a large delta (now a terrace) formed by glacial floods consisting of gravels, sand, silts and clay; and a relatively level to moderately steep topography in the foothills and slopes above the Columbia River (Ecology, 2007).

Figure 20 depicts priority areas for protection and restoration of hydrologic processes county-wide based on an analysis of the relative importance and level of alteration in each subwatershed.

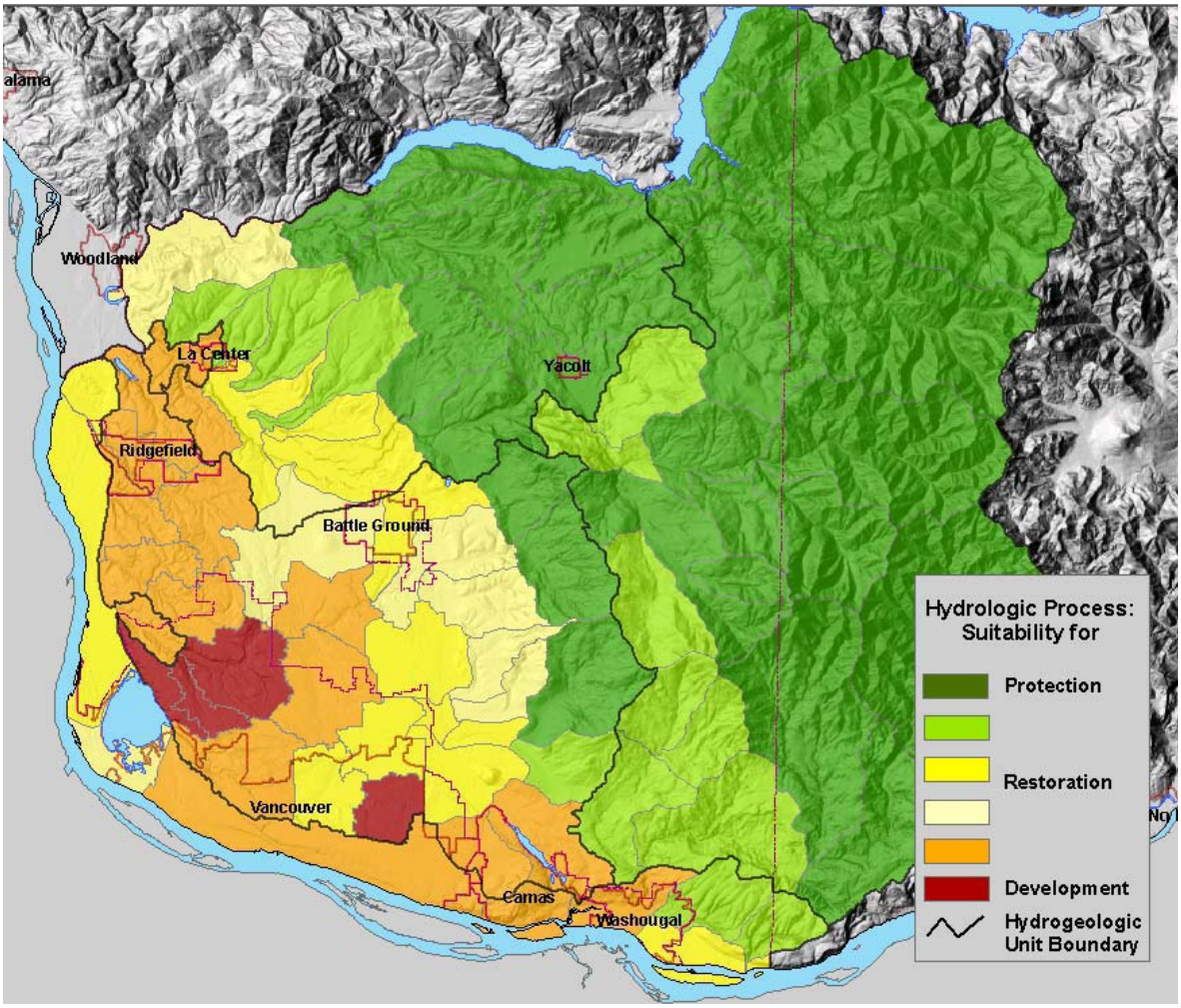

Figure 20: Priorities for suitability of areas for protection and restoration for the hydrologic process (from Draft Watershed Characterization of Clark County (Ecology, 2007)).

In general, green 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. Orange to red areas have lower levels of importance for watershed processes and higher levels of alteration and should be considered as more suitable for development. Because orange areas represent a transition from restoration areas, planning measures employing both restoration and appropriately sited development should be considered (Ecology, 2007).

Development (red) is the hydrologic process priority for the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds.

Potential Projects

Potential project locations for further exploration based on this wetland assessment include the following:

- Table 24 includes tax exempt parcels that overlap with potential wetlands from the Clark County wetlands model.

Table 24: Tax Exempt Parcels Overlapping Potential Wetlands

ASSR_SN	ASSR_AC	OWNER	PT1DESC	Description
096623-129 096626-547	2.02 acres	Clark County	Unused platted land	Potential wetlands associated with headwaters of Tenny Creek
145525-003	2.45 acres	Clark County	Vacant land	Degraded wetland near headwaters of Cougar Creek
148084-000	78.92	Clark County	Community colleges, universities, etc.	Degraded ditch and wetland tributary to Cougar Creek at WSU Agricultural Extension.

One of these sites (Tax Lot 096623-129 and Tax Lot 096626-547) was evaluated by Ecological Land Services and is presented in Table 25 as a potential project. The site is located in the headwaters of Tenny Creek.

Table 25: Description of Potential Project Opportunities

ID	Basis for Project	Project Description
IW1-SC	Lack of native wetland vegetation and widespread invasive plant species within wetland area adjacent to GPS point. Invasive species is predominantly reed canary grass.	Re-establish native undergrowth and canopy vegetation within wetland area to shade out invasive plants and enhance wetland habitat. Eradicate reed canary grass.

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 ten 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 the 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 ten individual metrics are added to produce an overall B-IBI score ranging from 10 to 50. Scores from 10 to 24 indicate low biological integrity, from 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 are also influenced by naturally occurring factors in a watershed; for example, the absence of gravel substrate can lower scores.

Macroinvertebrate monitoring in the assessment area has occurred at varying frequencies and multiple locations. Cougar Creek macroinvertebrate samples were collected annually by the CWP over seven years from 2001 through 2007, except for 2003. Five of the six annual samples were from Station CGR020 located upstream from NW 119th Street, while the 2001 sample was near Columbia River High School.

In 2007, the CWP performed macroinvertebrate sampling on three lower Salmon Creek tributaries within the RM 03.83 subwatershed: Suds Creek, Tenny Creek, and LaLonde Creek.

Results

Station CGR020's five-year average B-IBI score of 19 places it in the low category whereas Station CGR050's one year score of 26 falls in the moderate biological integrity category. The annual B-IBI scores ranged over six points for Station CGR020, varying from a minimum of 16 in 2002 to a maximum of 22 in both 2004 and 2007.

Table 26 shows seven low and three moderate scores among the average results for individual metrics at station CGR020, compared to three low, six moderate, and one high at Station CGR050. Station CGR020's wide range of low scoring metrics suggest the presence of chemicals such as heavy metals, human disturbance impacts, less varied stream habitat, water quality degradation, habitat impacts on the most sensitive species, excess fine sediments, and reduced prey food sources (Fore, 1999).

Table 26: Station CGR020 and Station CGR050 Average Annual Macroinvertebrate Community Metrics and Total Scores from 2001 through 2007						
	CGR020 5-Year Averages			CGR050 1-Yr 2001 Averages		
B-IBI Metrics	Value	Score	Category	Value	Score	Category
Total number of taxa	25.6	3	moderate	38.0	3	moderate
Number of Mayfly taxa	2.6	1	low	3.0	1	low
Number of Stonefly taxa	0.6	1	low	1.0	1	low
Number of Caddisfly taxa	2.4	1	low	5.0	3	moderate
Number of long-lived taxa	2.2	1	low	5.0	5	high
Number of intolerant taxa	0.2	1	low	1.0	1	low
Percent tolerant taxa	26.7	3	moderate	32.8	3	moderate
Percent predator taxa	3.9	1	low	12.5	3	moderate
Number of clinger taxa	10.6	1	low	15.0	3	moderate
Percent dominance (3 taxa)	65.5	3	moderate	57.9	3	moderate
Summary of avg. metric scores		16	low		26	moderate
Multi-year average B-IBI Score		19	low		26	moderate

All three of Salmon Creek (RM 03.83) subwatershed tributaries 2007 B-IBI scores differ by at most two points and all fall in the low biological integrity category, with Station SUD020 at 18, Station TEN015 at 20, and Station LAL030 also at 18.

Tables 27 through 29 show the individual sub-metric results for all three Salmon Creek (RM 03.83) subwatershed tributaries, with several of them being similar to those for Cougar Creek. Additionally, several of these metrics had identical low scores patterns across all three tributaries. Specifically, for all three tributaries the number of Mayfly, Caddisfly, and intolerant taxa as well as the percent predator taxa consistently scored in the low category. The number of Stonefly taxa scored low for Suds Creek and LaLonde Creek. Percent tolerant taxa also scored low on Tenny and LaLonde Creeks suggesting increasing stream impacts from human disturbance since these tolerant taxa will represent an increasingly large percentage of the population with greater disturbances. A low score for the

number of long-lived taxa was identified for Suds Creek, suggesting exposure to chronic or recurring water quality or habitat impacts.

Table 27: Station SUD020 Average Annual Macroinvertebrate Community Metrics and Total Score from Within the Period 2007

B-IBI Metrics	SUD020 1-Year Averages		
	Value	Score	Category
Total number of taxa	31.0	3	moderate
Number of Mayfly taxa	4.0	1	low
Number of Stonefly taxa	0.0	1	low
Number of Caddisfly taxa	2.0	1	low
Number of long-lived taxa	1.0	1	low
Number of intolerant taxa	0.0	1	low
Percent tolerant taxa	31.7	3	moderate
Percent predator taxa	7.2	1	low
Number of clinger taxa	12.0	3	moderate
Percent dominance (3 taxa)	67.4	3	moderate
Total B-IBI Score		18	**low**

Table 28: Station TEN015 Average Annual Macroinvertebrate Community Metrics and Total Score from Within the Period 2007			
B-IBI Metrics	**TEN015 1-Year Averages**		
	Value	**Score**	**Category**
Total number of taxa	30.0	3	moderate
Number of Mayfly taxa	4.0	1	low
Number of Stonefly taxa	4.0	3	moderate
Number of Caddisfly taxa	4.0	1	low
Number of long-lived taxa	3.0	3	moderate
Number of intolerant taxa	0.0	1	low
Percent tolerant taxa	68.6	1	low
Percent predator taxa	6.3	1	low
Number of clinger taxa	19.0	3	moderate
Percent dominance (3 taxa)	62.7	3	moderate
Total B-IBI Score		20	**low**

Table 29: Station LAL030 Average Annual Macroinvertebrate Community Metrics and Total Score from Within the Period 2007			
B-IBI Metrics	**LAL030 1-Year Averages**		
	Value	**Score**	**Category**
Total number of taxa	31.0	3	moderate
Number of Mayfly taxa	3.0	1	low
Number of Stonefly taxa	2.0	1	low
Number of Caddisfly taxa	2.0	1	low
Number of long-lived taxa	3.0	3	moderate
Number of intolerant taxa	1.0	1	low
Percent tolerant taxa	60.2	1	low
Percent predator taxa	6.2	1	low
Number of clinger taxa	15.0	3	moderate
Percent dominance (3 taxa)	57.5	3	moderate
Total B-IBI Score		18	**low**

Booth et al. (2004) found that there is 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).

Figure 21 and 22 show the available B-IBI scores generally fall in the middle portion of the range of expected scores (estimated 2000 Total Impervious Area from Wierenga, 2005). By comparing these four Salmon Creek tributaries to 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 21 shows that three of the five annual Station CGR020 B-IBI scores are in the middle and two are at the upper limit of the range of expected scores, whereas Station CGR050's single B-IBI score is above the upper limit (estimated 2000 Total Impervious Area from Wierenga, 2005).

Given most of Cougar Creek's B-IBI scores fall within or slightly above those typically found for subwatersheds with 50 percent impervious areas, there may be limited opportunity to improve scores into the moderate range through habitat rehabilitation.

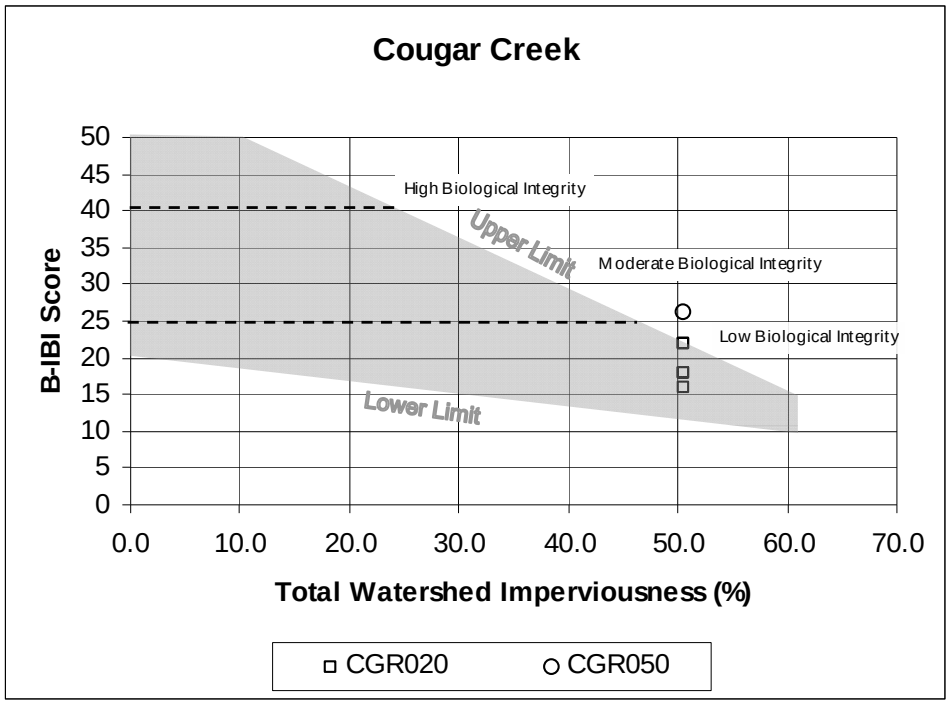

Figure 21: Approximate range of B-IBI in Puget Lowland watersheds, showing progressive decline with increasing imperviousness in the upstream watershed. Adapted from Booth et al., 2004. Markers indicate Total B-IBI scores at Station CGR020 and Station CGR050 for particular years, versus estimated 2000 subwatershed TIA.

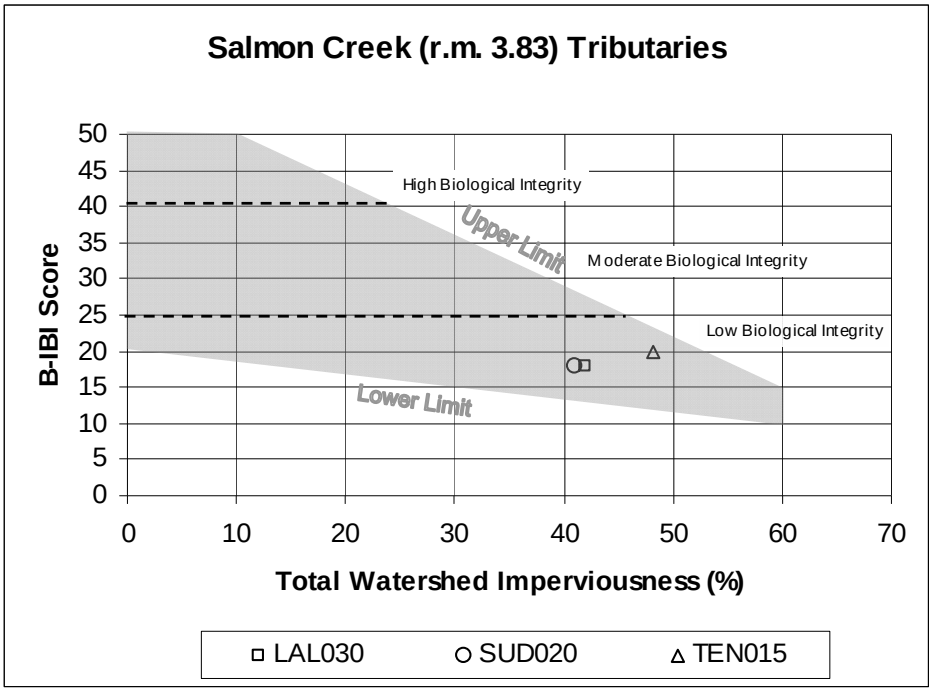

Figure 22: Approximate range of B-IBI in Puget Lowland watersheds, showing progressive decline with increasing imperviousness in the upstream watershed. Adapted from Booth et al., 2004. Markers indicate Total B-IBI scores at Station LAL030, Station SUD020, and Station TEN015 for particular years, versus estimated 2000 subwatershed TIA.

These three Salmon Creek tributaries B-IBI scores fall mostly in the middle of the expected ranges for their relatively high estimated 41 percent to 48 percent impervious areas. This implies an opportunity to increase the level of their biological integrity by improving habitat and stream conditions. Management strategies that limit further degradation and promote stewardship are important to possible improve biological integrity.

Fish Use and Distribution

Purpose

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

Methods

Fish distribution for the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds is mapped from existing Clark County GIS information, which reflects data collected and analyzed by the Northwest Indian Fisheries Commission (NWIFC). Fish distribution data for Clark County is available on the County's website.

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

- 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 was also reviewed for specific project opportunities within 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 fish distribution mapped from Clark County GIS information (Figure E) varied slightly from fish distribution data originating from the SalmonScape database. These differences are described within the individual subwatershed discussions below. For the purposes of this report, when the fish distribution mapping figures differ from SalmonScape fish distribution data, it is assumed that the SalmonScape distribution is more accurate.

The fish distribution mapping figure suggests that anadromous fish use within the Salmon Creek (RM 03.83) subwatershed includes Coho salmon and winter steelhead (Figure 23). The SalmonScape fish distribution data also identified the known presence of fall Chinook within the mainstem of Salmon Creek.

The Cougar Creek subwatershed was not listed as having any known anadromous fish use. The SalmonScape fish distribution data identified the presumed presence of Coho salmon and winter steelhead within the mainstem of Cougar Creek. A series of waterfalls and cascades near its mouth probably block fish passage.

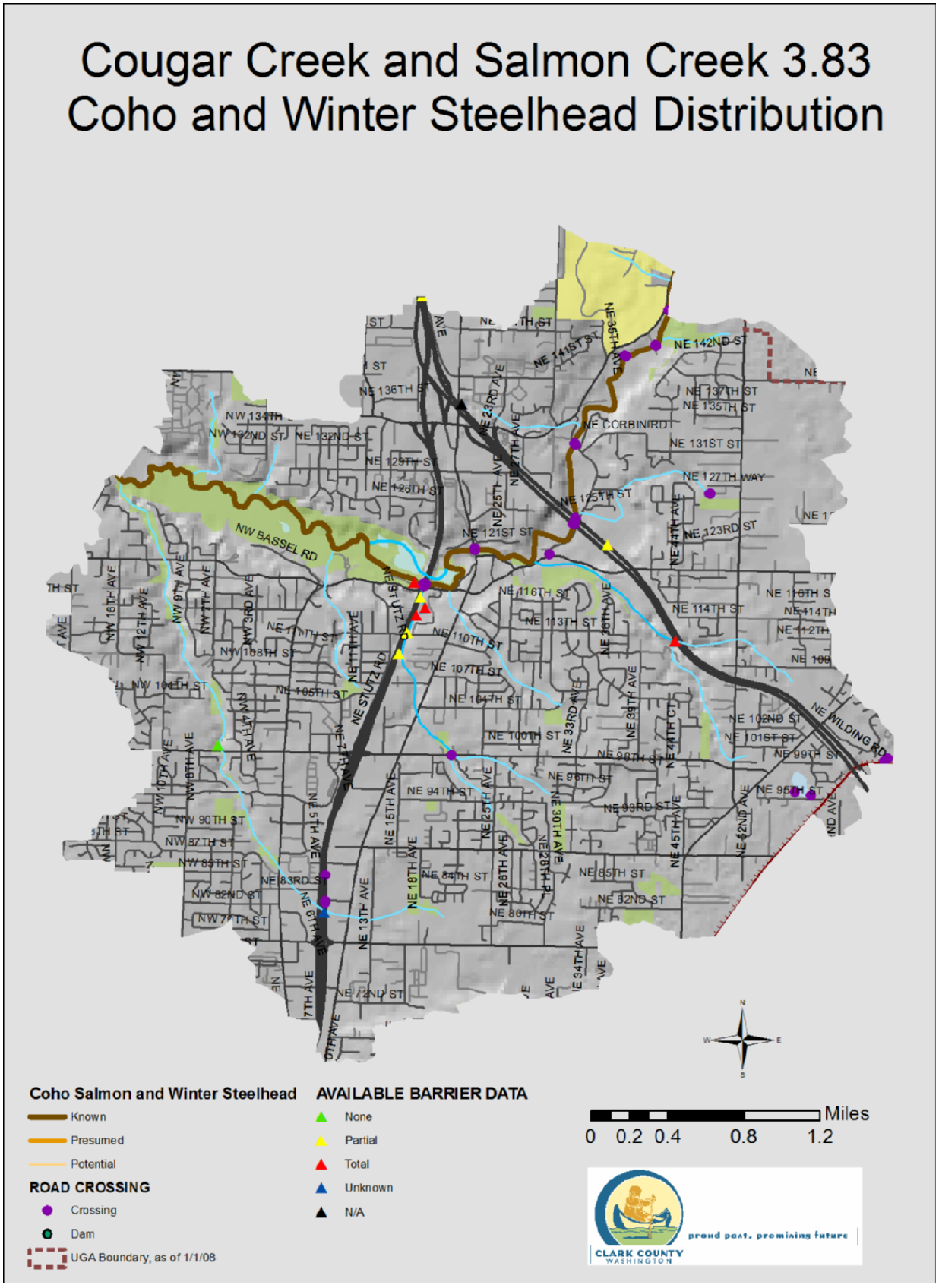

Figure 23: Salmon Creek (RM 03.83) and Cougar Creek Fish Distribution and Barriers

Barriers

The WDFW barrier database provides the most complete assessment of barriers in the Salmon Creek (RM 03.83) and Cougar Creek subwatersheds (Figure E). Additional barrier information was provided within the Salmon Creek Limiting Factors Analysis Report (HDR Engineering, Inc., 2002) and the Salmon Creek Watershed Assessment (Pacific Groundwater Group, 2002).

There is only one mapped barrier (Figure E) within the mainstem of Salmon Creek within the Salmon Creek (RM 03.83) subwatershed. This barrier is listed as being located just upstream of the 117th Street highway overpass; however, this information has been determined to be out of date, as this barrier was eliminated when road improvements were completed in this section several years ago. A partial barrier at the Highway 99 Klineline Bridge was recently removed as part of a project to replace the aging bridge.

There are multiple barriers identified on several Salmon Creek tributaries. According to the 2002 Limiting Factors Analysis Report, the entire length of LaLonde Creek is inaccessible. Fish passage is blocked due to the gradient of the creek near its mouth, and further upstream an additional full barrier is located near Interstate 205. Multiple full barriers also block upstream passage on Tenny Creek, which is blocked by both a full barrier waterfall and culvert (road) crossing.

Within the Cougar Creek subwatershed, Cougar Creek has a partial barrier just upstream from its mouth at NE 119th Street, and another at barrier at NE 99th Street. The 99th Street culvert is listed as a full barrier; however, a fish ladder and culvert baffles are in place. There is also a natural waterfalls barrier at the mouth of Cougar Creek.

Recommendations

The Salmon Creek (RM 03.83) and Cougar Creek subwatersheds contain a number of full and partial fish barriers within Salmon Creek tributaries; however, improvement or replacement of these barriers is not recommended as a priority. The reasons are a lack of access due to the natural barrier near the mouth, poor water quality, and the fact that culverts function as grade controls on a downcutting stream channel.

Barriers should be removed over time as stream crossing infrastructure is replaced or upgraded.

Hydrologic and Hydraulic Models

No new modeling was performed for this assessment.

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 summarize more detailed descriptions found in report sections. Project planners are encouraged to reference the longer descriptions and also to utilize the information found for each potential project in the SNAP GIS 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 and identifies overall stormwater-related problems.

Coordination with Other Programs

The assessment area lies within a heavily urbanized area where there are significant ongoing stormwater and water quality programs. Ecology coordinates local agency actions as part of ongoing TMDL implementation and adaptive management. Clark Public Utilities is active in riparian habitat rehabilitation. The Salmon Creek Watershed Council provides a forum for citizens and organizations to participate in on the ground restoration, water quality and advocacy. Two major road improvement projects are included in the 2008 through 2013 Clark County Transportation Improvement Program (Highway 99 from 99th Street to 119th Street, and 88th Street from Highway 99 to St. John's). The Clean Water Program regularly communicates and coordinates with all of these entities, and has also coordinated to the extent possible with Highway 99 sub-area planning activities.

Broad-Scale Characterization

The study area is highly urbanized and is drained by several small streams. Areas of open space remain in forested canyons and parklands. The topography is low rolling hills typical of the relatively level floor of the Willamette valley. Geology consists of sedimentary gravel and sandstone deposited by the ancestral Columbia River, overlain with more recent, easily erodible, fine-grained deposits. Stream hydrology is altered significantly 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 to NOAA fisheries standards, suggest stream habitat is not properly functioning. This assessment area is one of the most heavily developed areas in Clark County.

Water Quality Assessment
Multiple stream segments within this assessment area are included on the 2008 303(d) Ecology list of impaired water bodies. Both subwatersheds are included in the ongoing TMDL implementation for fecal coliform and in the TMDL development for water temperature.

A relatively large water quality dataset is available for the area, as Clark County maintains a long-term station on Cougar Creek and has conducted several focused studies in the lower Salmon Creek area.

Overall data indicates that water quality is poor to very poor, and has been so for many years. Fecal coliform bacteria are a concern throughout these subwatersheds. Stream temperatures in Cougar Creek and Tenny Creek are among the coolest in the Salmon Creek watershed; however, the Salmon Creek mainstem in this area is among the warmest.

Drainage System Inventory
Stormwater infrastructure is extensive in this area, with historical data varying greatly in completeness and accuracy. Overall drainage mapping is nearly complete, though additional research and data quality control are ongoing in 2009 as part of a county-wide database update.

Public Stormwater Facility Inspection
As of October 2008, there were 25 mapped public stormwater facilities in Cougar Creek, and 145 in Salmon Creek (RM 03.83). In Cougar Creek, 77 percent of the facility components were in compliance with standards in the *2005 Stormwater Management Manual for Western Washington Volume 5*. Eighteen referrals were generated for maintenance or engineering evaluation.

In Salmon Creek (RM 03.83), 67 percent of the facility components were in compliance, and 149 referrals were generated for maintenance, engineering evaluation, or code enforcement. Sixteen potential facility retrofit opportunities were also identified.

Excessive sedimentation of bioswales was the most common reason for non-compliance overall. Problems with control structures, energy dissipaters, and missing signage were also common.

Off-site evaluations were conducted at 62 outfalls discharging to critical areas. Six referrals were made for outfall repair.

Illicit Discharge Screening
Screening conducted at 222 known stormwater outfalls resulted in the removal of two illicit connections.

Stream Reconnaissance Feature Inventory
A feature inventory was conducted for nearly 13 miles of stream corridor within the assessment area. Over 500 features were recorded; primarily stormwater outfalls, culverts, impacted stream buffers, and trash dumps. Over 400 potential opportunities were identified in six categories.

Physical Habitat
A physical habitat assessment was not conducted.

Geomorphology and Hydrology
Field reconnaissance indicates the study area has been, and continues to be, influenced by natural geologic characteristics and human development. Hydrology is significantly altered from pre-development forested conditions. Ratios of modeled historic 10-year to existing 2-year flows were around 0.4 in Cougar Creek, indicative of unstable channel conditions on a scale where ratios above 1.0 are associated with stable channels. Erosive response potential varied from low to high among the twenty reaches delineated.

Riparian Assessment
In the 2004 LCFRB Habitat Assessment, overall riparian conditions were rated impaired. Large woody debris recruitment potential was primarily low to medium in the Salmon Creek (RM 03.83) area, and ranged from low to high in Cougar Creek. Shade levels were below state targets.

Wetland Assessment
The Salmon Creek (RM 03.83) subwatershed has large expanses of potential wetland areas associated with the Salmon Creek riparian corridor and floodplain, and significant areas within the major tributaries (Suds Creek, Tenny Creek, LaLonde Creek).

In Cougar Creek, pockets of potential wetlands are primarily associated with the headwaters, including the county property at the former WSU Agricultural Research station.

Ecology's draft watershed characterization of Clark County places the assessment area in a category suitable for development due to a lower level of regional importance and higher level of current alteration from historical conditions.

Macroinvertebrate Assessment
Based on samples collected from 2002 through 2007, biological integrity is low 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 Salmon Creek (RM 03.83) subwatershed includes Coho salmon and winter steelhead. Cougar Creek is inaccessible to anadramous fish due to a series of waterfalls near the mouth.

There are multiple barriers identified on the lower Salmon Creek tributaries. A partial barrier on the mainstem at the Klineline Bridge (Highway 99) was removed during recent bridge replacement.

Recently Completed or Current Projects

The 2009 through 2014 SCIP priority matrix includes five stormwater projects in this assessment area. A number of stormwater treatment and flow control retrofits have also been completed by the CWP since 2000. Two county road projects are also located in this assessment area under the 2008 through 2013 TIP.

Analysis Approach

Purpose

The Analysis of Potential Projects narrows the initial list of possible opportunities to a manageable subset of higher priority potential projects. Listed opportunities in sections of the SNAP report include sites requiring immediate follow-up, possible stormwater capital improvement projects, referrals to ongoing programs, and potential projects for referral 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 SCIP process. Referrals to ongoing programs such as IDDE screening, operations and maintenance, and source control outreach receive follow-up within the context and schedules of the individual program areas. Referrals 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 CWP scope.

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, potential capital projects are evaluated by CWP staff considering problem severity, estimated cost and benefits, 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 projects are recommended for further consideration by the CWP.

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.

Identifier	Issue	Project	Action
Tenny Creek			
SCC-122	Failing 72-inch diameter culvert is completely clogged with sand. Resulting backwater causes ponding around retaining wall and road embankment.	Site visit.	Refer to PW Operations
TR-47	Container of motor oil in creek. Suds and oil on water surface. Also drum of unknown substance on left bank.	Remove containers from channel.	Refer to Public Health

Potential Stormwater Capital Projects

Stormwater Facility Capital Improvement Projects

Identifier	Issue	Project	Action
Suds Creek			
OT-164	Multiple features combine to form headwater stormwater treatment facility (ID #754). Primary source of stormwater to the facility is OT-164. OT-167 is the final discharge point to Suds Creek.	Retrofit for increased storage/treatment.	Evaluate for SCIP.
OT-166	Four foot-diameter CMP outfall is the origin of Suds Creek. Drains treated and untreated stormwater runoff from a very large area of residential and commercial development and arterial streets.	Retrofit/redirect into facility #754 as part of retrofit project.	Evaluate for SCIP.
OT-173 OT-175 Crown Continental Park	18-inch diameter CMP outfall pipe ends at a round, perforated concrete energy dissipater. Two foot diameter rusted metal pipe stubbed out of bank.	New storage and treatment facility on Park property.	Evaluate for SCIP.
OT-177	Four outfall pipes discharge stormwater to a riprap covered slope at the same location. The pipes are a 12-inch diameter CMP, a 24-inch diameter CPP, and two, 4-inch diameter HDPE pipes.	New storage and treatment facility.	Evaluate for SCIP.
OT-178	A riprap lined channel delivers stormwater to the left bank of the channel. A 12-foot-long section of 12-inch diameter CMP is laying on the bank perpendicular to the outfall channel.	New storage and treatment facility. Outfall repair.	Evaluate for SCIP.

Identifier	Issue	Project	Action
OT-179	18-inch diameter CMP outfall pipe discharges stormwater. There is no energy dissipation and the flow has cut a channel across the floodplain from the outfall to the stream.	New storage and treatment facility. Install dissipater.	Evaluate for SCIP.
OT-183	24-inch diameter CMP outfall pipe on left bank. Outlet discharges to a round concrete energy dissipater.	New storage and treatment facility.	Evaluate for SCIP.
OT-186	14-inch diameter CMP outfall pipe discharges stormwater to right bank. No energy dissipation. Large hole scoured with approximate dimensions of 5-foot width, 4-foot depth and an 8-foot long eroded gully to the stream.	Stabilize bank and install dissipater. New storage and treatment facility.	Evaluate for SCIP.
OT-190	18-inch diameter outfall discharges stormwater to the left bank at downstream end of culvert crossing.	Install energy dissipater. New treatment facility.	Evaluate for SCIP.
OS-77	Large open area at Sacajawea school grounds, in an area with limited storage and treatment.	New storage and treatment facility.	Evaluate for SCIP.
OS-62	Large lot with little infrastructure (Facility #25).	Stormwater treatment BMP enhancement.	Evaluate for SCIP.
OS-70	Large lot with open areas and little treatment (Facility #745).	Wet swale and channel enhancement.	Evaluate for SCIP.
OS-76	Swale and detention pond area can be enhanced to better treat stormwater (Facility #1914).	Potential retrofit of bioswale or installation of LID practices.	Evaluate for SCIP.
Tenny Creek			
OT-124 County Park	30-inch diameter outlet at headwaters. Pipe is partially crushed and clogged with sediment. Receives flow from large developed area.	New storage and treatment facility.	Evaluate for SCIP.

Identifier	Issue	Project	Action
OT-144	18-inch diameter pipe conveys roadway runoff through brick wall on right bank slope to a rip-rap lined conveyance pathway to the main channel.	Install dissipater. New storage or treatment facility.	Evaluate for SCIP.
OS-64	Large lot with little infrastructure (Facility #76).	Stormwater treatment BMP enhancement.	Evaluate for SCIP.
OS-68	Large lot with open areas (Facility #720).	Wetpond/detention pond enhancement.	Evaluate for SCIP.
OS-73	Large lot with open areas and little treatment (Facility #769).	Wetpond/detention pond enhancement.	Evaluate for SCIP.
OS-72	Large lot with open areas and overgrown detention areas (facility #764)	Wetpond/detention pond enhancement	Evaluate for SCIP.
LaLonde Creek			
OT-131	Eight inch diameter CMP outfall pipe untreated stormwater runoff directly to the stream.	New treatment facility.	Evaluate for SCIP.
OT-109	3.5-foot diameter CMP outfall pipe with failing riprap dissipater discharges at headwater and into Facility #814 and #1187.	Repair outfall. Retrofit facilities for increased storage.	Evaluate for SCIP.
OT-136 CM-20	18-inch diameter CMP outfall drains stormwater directly to channel.	New treatment facility.	Evaluate for SCIP.
OS-63	Large lot with little infrastructure (Facility #29).	Stormwater treatment BMP enhancement	Evaluate for SCIP.
OS-69	Large lot with open areas and little treatment (Facility #724).	Wetpond/detention pond enhancement.	Evaluate for SCIP.
OS-75	Facility adjacent to large county owned parcel (Facility #1185).	Wetland enhancement.	Evaluate for SCIP.

Identifier	Issue	Project	Action
Rockwell Creek			
OT-118	15-inch diameter CMP pipe drains stormwater to right bank onto gabion dissipaters. Same location as Salmon Creek Avenue culvert carrying mainstem.	New large storage facility adjacent or connected to Facility #71.	Evaluate for SCIP.
NE 114th St Tributary			
OT-91	30-inch diameter pipe is origin of NE 114th Street Tributary. Large drainage area with limited treatment and control.	New storage and treatment facility on Gaiser school grounds.	Evaluate for SCIP.
OT-93	36-inch diameter pipe outfall perched 8 feet above the channel and floodplain. Reused concrete sidewalk pads at base of 6 foot drop provide inadequate energy dissipation.	Energy dissipater, possible treatment retrofit.	Evaluate for SCIP.
OT-96	18-inch diameter pipe outfall is undercut by erosion.	Repair outfall. New storage and treatment facility.	Evaluate for SCIP.
OT-100	12-inch diameter eroded pipe outfall.	Install dissipater. New storage and treatment.	Evaluate for SCIP.
OT-103	18-inch diameter pipe outfall.	New storage and treatment.	Evaluate for SCIP.
OT-106	12-inch diameter pipe drains stormwater directly into manhole.	New treatment facility.	Evaluate for SCIP.
OS-78	Pipe outfall from Discharge Point #215 discharges untreated/uncontrolled runoff.	New storage and treatment facility.	Evaluate for SCIP.
OS-66	Large lot with little infrastructure (Facility #327).	Stormwater treatment BMP enhancement.	Evaluate for SCIP.
NW 2nd Avenue Tributary			
OT-200	Tributary stream enters. Bed and banks showing signs of erosion. A stormwater outfall (Facility #802) is at the head.	Retrofit facility. Review outfall.	Evaluate for SCIP.
OT-207 OT 202	Open gully with eroding bed and banks.	Retrofits to contributing facilities.	Evaluate for SCIP
NW 7th Avenue Tributary			

Identifier	Issue	Project	Action
MI-44	Small tributary entering the main channel. Tributary is showing signs of instability and incision. Discharge Point #2087 and #102 enter with no treatment or detention.	New storage and treatment facilities.	Evaluate for SCIP.
OT-208 OT-209	Discharge Point #7617 may be responsible for gully and hillslope failure at ER-34.	Stabilize and repair outfall. New storage and treatment facility.	Evaluate for SCIP.
OT-212	Open channel gully enters stream. Channel is somewhat eroded and unstable. Likely caused by Discharge Point #101.	Stabilize and repair outfall. New storage and treatment facility.	Evaluate for SCIP.
Salmon Creek Mainstem			
OS-67	Large lot with little infrastructure; sedimentation of swale (Facility #335).	Stormwater treatment BMP enhancement.	Evaluate for SCIP.
OS-74	Large lot with open areas and little treatment (Facility #779).	Stormwater treatment BMP enhancement.	Evaluate for SCIP.
OS-71	Large lot with open areas and overgrown detention areas (Facility #758).	Wetpond/detention pond enhancement.	Evaluate for SCIP.
OS-79	Evidence of heavy stormwater flow from Outfall #216.	Flow reduction.	Evaluate for SCIP.
Cougar Creek			
OT-90 ER-20 AP-21 County and CPU property	36-inch diameter outfall to left bank is two-thirds full of sediment and appears to have failed or have been abandoned. Failed energy dissipation at Outfall #85 likely has contributed to significant left bank erosion.	Repair outfall. New storage and treatment facility.	Evaluate for SCIP.
OT-89	24-inch diameter pipe drains stormwater from NE Hazel Dell Avenue to channel.	New storage and treatment facility.	Evaluate for SCIP.

Identifier	Issue	Project	Action
OT-50	12-inch diameter pipe drains stormwater from residential neighborhood on upper right bank hillslope. Pipe outlet is partially crushed. An oily sheen is present and swale downstream of outfall ends in minor headcut at the main channel.	Repair outfall. New storage and treatment facility.	Evaluate for SCIP.
OT-52	12-inch diameter pipe drains stormwater from residential neighborhood on upper left bank hillslope. Riprap present in swale downstream of outfall, located midway down slope. Slope and banks are unstable, and left bank shows erosion in channel downstream of outfall.	New storage and treatment facility.	Evaluate for SCIP.
OT-58	Incising ditch contributes stormwater from unknown source in direction of residential area on upper right bank hillslope to right bank of channel, causing significant right bank erosion.	New storage and treatment facility.	Evaluate for SCIP.
OT-61	Open channel contributing runoff from unknown source enters at left bank of channel.	New storage and treatment facility.	Evaluate for SCIP.
OT-51	Outfall pipe ends in 25 feet of exposed/failing pipe at toe of right bank. Unknown source of stormwater. Scour pool in channel at pipe outlet.	Repair outfall. New storage and treatment facility.	Evaluate for SCIP.
OT-54	24-inch diameter outfall contributes road runoff from NW 99th Street to channel immediately downstream of stream crossing culvert at NW 99th Street.	New storage and treatment facility.	Evaluate for SCIP.

Identifier	Issue	Project	Action
OT-55	24-inch diameter outfall contributes runoff from unknown source.	New storage and treatment facility.	Evaluate for SCIP.
OT-59	Open channel contributes stormwater, from unknown source in direction of residential area on upper right bank hillslope, to right bank of channel.	New storage and treatment facility.	Evaluate for SCIP.
OT-64	12-inch diameter outfall contributes runoff from unknown source in direction of residential area and roads on upper left bank hillslope.	Install dissipater. New storage and treatment facility.	Evaluate for SCIP.
OT-68	12-inch diameter outfall contributes runoff from unknown source.	Install dissipater. New storage and treatment facility.	Evaluate for SCIP.
OT-69	12-inch diameter outfall contributes runoff from unknown source in direction of residential area on upper right bank hillslope.	Install dissipater. New storage and treatment facility.	Evaluate for SCIP.
OT-71	12-inch diameter outfall contributes runoff from unknown source. Lower 10 feet of pipe are exposed and protruding almost completely across the channel.	Install dissipater. New storage and treatment facility.	Evaluate for SCIP.
OT-75	Open channel contributes stormwater, from unknown source to right bank of channel.	New storage and treatment facility.	Evaluate for SCIP.
OT-80	24-inch diameter outfall contributes runoff from unknown source. Lower 8 feet of pipe are exposed and protruding out to center of channel.	Install dissipater. New storage and treatment facility.	Evaluate for SCIP.
OT-81	Partially crushed metal pipe discharges to a small channel which enters stream at left bank immediately upstream of pedestrian bridge crossing.	New storage and treatment facility.	Evaluate for SCIP.

Identifier	Issue	Project	Action
OT-78	Outfall contributes untreated and undetained runoff.	New storage and treatment facility.	Evaluate for SCIP.
OS-80	Opportunity for large-scale stormwater projects on grounds of WSU extension (Tax Lot 148084-000, 79 ac.) as part of overall area redevelopment.	New storage and treatment facilities; wetland restoration.	Evaluate for SCIP.
OS-65	Swale and detention pond area can be enhanced for better treatment (Facility #131).	Retrofit.	Evaluate for SCIP.

Stormwater Infrastructure Maintenance CIPs

Stormwater Class V Underground Injection Control (UIC) Projects:

Habitat Rehabilitation/Enhancement Projects

Identifier	Issue	Project	Action
NE 114th Street Tributary			
AGR-1 IB-149 SCC-93	Wetland formed immediately upstream of plugged culvert under NE 28th Avenue and serves as a natural detention facility. 36-inch diameter culvert is undersized and completely submerged at downstream end of wetlands. Backwater effects reach approximately 500 feet upstream.	Wetlands restoration. Replace downstream culvert. Eradicate blackberry and nightshade. Reestablish native wetland vegetation to enhance habitat and provide treatment.	Evaluate for SCIP.
Tenny Creek			
OS-81	Potential wetlands associated with County-owned parcels in headwaters of Tenny Creek, Tax Lots 096623-129 and 096626-547.	Wetland restoration.	Evaluate for SCIP.
Cougar Creek			
OS-82	Degraded wetland near headwaters of Cougar Creek.	Wetland restoration.	Evaluate for SCIP.

Property Acquisition for Stormwater Mitigation

No projects of this type were discovered.

Follow-up Activities for Referral within CWP

Private Stormwater Facilities Maintenance

Identifier	Issue	Action
Tenny Creek		
OT-159	Six inch diameter outfall contributes runoff from direction of apartment buildings and parking lot to channel.	Refer for private facility inspection.
OT-160	Six inch diameter outfall contributes runoff from direction of apartment buildings and parking lot to channel.	Refer for private facility inspection.
OS-83	Unmaintained facility (#321); sedimentation of pond; large lot with little infrastructure.	Refer for private facility inspection.

Public Works Stormwater Infrastructure Maintenance

Identifier	Issue	Action
Tenny Creek		
OT-127	12-inch diameter outfall pipe to channel, no energy dissipater.	Refer to PW operations.
OT-151	Inadequate/failing riprap energy dissipation.	Refer to PW operations.
OT-162	24-inch diameter outfall invert elevation is perched about 4 feet above downstream cascade and energy head is causing erosion of riprap and rocks placed in cascade for energy dissipation.	Refer to PW operations.
OT-163	18-inch diameter outfall discharges to embankment above SCC-131. Grass growing on quarry spalls and old silt fence in front of outfall never removed.	Refer to PW operations.
OS-84	Undercutting/scouring near Outfall #211. Stabilize bank and add riprap.	Refer to PW operations.

LaLonde Creek		
OT-111	Outfall is buried by LWD and sediment. LaLonde Parkside # 1555.	Refer to PW operations.
OS-85	Undercutting/scouring near Outfall #675. Stabilize bank and add riprap.	Refer to PW operations.
OS-86	Undercutting/scouring near Outfall #680. Stabilize bank and add riprap	Refer to PW operations.
Rockwell Creek		
OT-122	Open channel drains stormwater from detention pond outlet.	Refer to PW operations.
Cougar Creek		
OT-88	Outfall contributes significant runoff with no energy dissipation.	Refer to PW operations.
OT-60	Outfall plugged.	Refer to PW operations.
NE 114th Street Tributary		
OT-92	Vegetation in filter area poorly established. Facility likely functions as detention, rather than filtration.	Refer to PW operations.
NW 2nd Avenue Tributary		
OS-87	Undercutting/scouring near Outfall #823. Stabilize bank and add riprap.	Refer to PW operations.

CWP Outreach/Technical Assistance

Identifier	Issue	Action
LaLonde Creek		
OT-108 WQ-31	Ducks, goats, bare banks, and significant trash in and surrounding pond. Likely water quality issues. It is unclear if this pond discharges to LaLonde Creek.	Refer to CWP Outreach for technical assistance visit.

CWP Infrastructure Inventory
None

CWP Capital Planning

Identifier	Issue	Action
LaLonde Creek		
OT-114	Oddly oriented section of 1.5-footdiameter CMP pipe. Pipe angles 90 degrees up from horizontal pipe at base. There is evidence that water flows out of the pipe and scours around the outfall. Source of flow could be I-205 to the east.	Refer to CWP Capital Planning for evaluation.
OT-115	18-inch diameter CMP outfall drains stormwater directly to channel from direction of I-205.	Refer to CWP Capital Planning for evaluation.
SCC-96	Undersized culvert under property fence serves no apparent purpose. Long-term tenant reported problems with flooding at culvert during high flows.	Refer to CWP Capital Planning for evaluation.
Tenny Creek		
SCC-116	Submerged culvert inlet and outlet. Culvert backwater creates a large in-channel pool that is covered in green algae.	Refer to CWP Capital Planning for evaluation.
NW 7th Avenue Tributary		
SCC-145	18-inch diameter CPP and concrete culvert through an earthen berm across the channel. Debris could be stored behind the berm until a catastrophic failure occurred.	Refer to CWP Capital Planning for evaluation.
Cougar Creek		
SCC-91	Culvert for embankment for abandoned roadway or sewer line. Culvert entrance almost completely blocked by logs. Manhole lid in creek just upstream of culvert entrance. Embankment erosion around culvert inlet and severe bank erosion and expansion scour downstream of culvert outlet.	Refer to CWP Capital Planning for evaluation.

Illicit Discharge Screening

Identifier	Issue	Action
Tenny Creek		
OT-152	Potential illicit discharge from business to left bank of creek. Pipe tightlined to channel below water surface of in-channel duck pond.	Refer to IDDE.
MI-37	Potential raccoon access to creek on left bank floodplain. Floodplain wetland area appears to be washing area for raccoons.	Refer to IDDE.
Cougar Creek		
OT-83	Six inch diameter PVC contributes significant portion of runoff to creek from unknown source. Additional small outfall pipes on right bank, adjacent to apartment building.	Refer to IDDE.
OT-87	Outfall contributes significant runoff to right bank, although there had been no rain in previous 24 hours.	Refer to IDDE.

Projects for Referral to Other County Departments, Agencies, or Groups

Identifier	Issue	Action
LaLonde Creek		
SCC-111 SCC-112	Four foot diameter CMP culvert under I-205. Culvert outlet is mostly plugged by boulders, tires, and a large log. Sediment fills the pipe behind debris accumulation. Approximate length is 580 feet. A total barrier to fish and wildlife. The outlet end of the culvert discharges to a scoured channel filled with riprap.	Refer to WSDOT.
TR-35	Tires, bottles, and broken PVC pipe in stream. Discarded lumber on valley slope. Additional debris is common in the channel for approximately 80 feet downstream.	Refer for cleanup.
TR-36	Tires, a metal drum, plastic pipe, and washing machine discarded in the stream.	Refer for cleanup.
TR-28	Tires in the channel.	Refer for cleanup.
TR-38	Lumber, fence posts, and barbed wire in the middle of the channel.	Refer for cleanup.
NE 114th Street Tributary		
OT-104	Erosion of ditch undercuts side of road.	Refer to PW Operations.
SCC-97	Culvert under NE 117th. Inlet is manhole with approximate 8 foot drop to culvert inlet. Manhole inlet has trash rack with history of clog and flooding.	Refer to PW Operations.

Suds Creek		
SCC-138	Undersized, 48-inch diameter culvert under access road. Embankment is failing. Observed flowing approximately one-third full. Potential flooding hazard at high flows.	Refer to PW Operations.
SCC-139	Undersized, 48-inch culvert. Embankment is eroding at inlet and outlet. Potential flooding hazard at high flows.	Refer to PW Operations.
CM-30	18-inch tall concrete barrier acting as a dike/levee at top of right bank. Prevents flooding into park.	Refer to Parks.
TR-49	Discarded flowerpots on right bank and miscellaneous debris in the channel: Chicken wire, a metal plate from an appliance, old siding, and a tire.	Refer for cleanup.
TR-50	Bottles, cans, construction debris, metal sheeting, iron pipe, sheet glass, etc. discarded in the channel.	Refer for cleanup.
TR-51	Trash and debris in channel: broken pipe, fence post, and construction debris. Discarded plastic on the right bank.	Refer for cleanup.
TR-52	Abandoned concrete pipe and tires in the channel.	Refer for cleanup.
MB-28	Chain link fence across the channel at the park boundary is collecting trash, logs and debris, and forming a jam that blocks the creek.	Refer to Parks.
Tenny Creek		
ER-23	Failed concrete embankment along channel associated with severe bank erosion.	Refer to CPU and/or CWP Capital Planning
SCC-106	18-inch diameter culvert inlet has a trash rack that is clogged by invasive vegetation and sediment.	Refer to PW Operations.

SCC-117	Sediment deposition composes about a third of the culvert depth.	Refer to PW Operations.
SCC-120	Failing 18-inch corrugated metal culvert. Outlet is partially crushed and filled and blocked by sand and gravel. Riprap around culvert inlet and outlet is failing.	Refer to PW Operations.
SCC-121	Vertical inlet to culvert causes whirlpool at inlet. Culvert embankment is eroding and failing.	Refer to PW Operations.
SCC-124	Box culvert is half full of gravel/sand.	Refer to PW Operations.
SCC-125	106th Street culvert has log protruding into culvert inlet causing a drop of about one foot into culvert. Increased velocity and energy apparent within the culvert downstream of the log.	Refer to PW Operations.
SCC-126	First section of 48-inch diameter concrete culvert inlet has failed. Logs block culvert inlet and some bank erosion around failing culvert section.	Refer to PW Operations.
TR-41	Yard waste, shopping carts, tires, concrete chunks on top of slope above channel.	Refer for cleanup.
TR-42	Failing sections of multiple pipes in creek. Abandoned sewer and water utility infrastructure in channel and on banks.	Refer for cleanup.
TR-43	Failing sections of multiple pipes in creek. Abandoned sewer and water utility infrastructure in channel and on banks.	Refer for cleanup.
TR-44	Shopping cart in stream, blocking flow, and accumulating additional debris.	Refer for cleanup.
TR-45	Tires in the channel.	Refer for cleanup.

TR-46	Trash dump adjacent to vacant lot and right bank hillslope of channel. Cars, tires, glass, wood chunks, concrete, metal present.	Refer for cleanup.
TR-48	Shopping carts, wood planks, bikes, chairs, tires, and drums in channel and on right bank and floodplain.	Refer for cleanup.
Rockwell Creek		
TR-32	Yard debris accumulated at top of gully slope. Could wash into stream and plug culverts.	Refer for cleanup.
TR-31	Yard debris accumulated at top of gully slope. Could wash into stream and plug culverts.	Refer for cleanup.
TR-30	Yard debris accumulated at top of gully slope. Could wash into stream and plug culverts.	Refer for cleanup.
Cougar Creek		
SCC-79	Undersized culvert under NE 26th Avenue. Half-full of sediment.	Refer to PW Operations.
SCC-83	Potentially undersized culvert under NE 78th Street. Outlet is full of sediment and clogged by invasive plant species.	Refer to PW Operations.
SCC-85	Undersized culvert at NE 13th Avenue backwaters the inlet and is clogged with sediment.	Refer to PW Operations.
15 trash sites (see Appendix B)	Various.	Refer for cleanup.

Channel Rehabilitation Projects

A large number of potential channel rehabilitation projects were identified during the Stream Reconnaissance and Geomorphology tasks. These opportunities are listed among the potential project lists the Geomorphology Assessment section and in Appendices A, and B. From a stormwater perspective, channel rehabilitation projects are typically not a high priority and are viewed as treating the symptom rather than the problem.

In general, stormwater managers advise limiting in-channel projects until such time as the hydrologic regime stabilizes in urbanized subwatersheds. Rehabilitation efforts would likely be more effective within a stable channel system and flow regime.

Invasive plant removal and re-vegetation projects:
A large number of potential re-vegetation and/or invasive plant removal projects were noted. These opportunities are listed among the potential project lists in the Riparian Assessment chapter and in Appendix B. Invasive plant removal and vegetation rehabilitation is typically included to the extent feasible in stormwater capital projects.

In general, the need for vegetation projects is ubiquitous within the study area. Suds Creek, Tenny Creek, LaLonde Creek, and the upper reaches of Cougar Creek were identified as specific areas where numerous opportunities exist. Agencies and groups interested in vegetation projects are encouraged to refer to the opportunities listed in this report as a starting point for project planning.

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 with the goal of creating a complete stormwater infrastructure inventory

Coordination of Stormwater Activities

- Encourage coordination between Clark County departments during sub-area plan developments in this area, including the three creeks and Highway 99 special planning areas

Mechanisms for public involvement

- Publish SNAP reports on CWP web page

Development Regulations for Stormwater and Erosion Control

- Consider stormwater basin planning as a tool to better manage stormwater impacts as redevelopment occurs in the study area subwatersheds

Stormwater Source Control Program for Existing Development

- Systematically investigate existing stormwater infrastructure and flow sources. Develop large scale, regional detention and treatment facilities to mitigate for stormwater impacts from historic 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

- Focus additional effort on maintenance of bioswales, particularly excessive sediment conditions
- Focus additional effort on repairing and maintaining energy dissipaters at outfalls

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
- Encourage landowners to adopt runoff reduction practices, such as disconnecting downspouts
- Perform targeted technical assistance responding to results of field assessments

- Develop literature and distribute to landowners educating about the water quality impacts and other potential hazards on on-line and off-line ponds
- Educate private landowners on importance of native riparian vegetation and intact riparian forests for shading streams and preserving hydrology
- Provide a list of suggested plants for stream re-vegetation and local nurseries that stock them for distribution to landowners
- Replace missing or deteriorated stream name signs
- Look for mechanisms to organize stream trash cleanup events

TMDL Compliance

- Continue collaboration on Salmon Creek TMDL development. Clark County fulfills its TMDL compliance obligations through ongoing implementation of the Stormwater Management Program

Monitoring Stormwater Program Effectiveness

None

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