

# *2009 Stormwater Needs Assessment*

**Morgan Creek  
Salmon Creek (r.m. 14.66)**



Clark County Clean Water Program  
*Protecting water through stormwater management*





# 2009 Stormwater Needs Assessment Program

Morgan Creek/Salmon Creek (RM 14.66)  
Subwatershed Needs Assessment Report

Clark County Public Works Clean Water Program

March 2010





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## Responsible County Officials

Program Name: Stormwater Needs Assessment Program  
Project Code: SNAP  
Department: Clark County Department of Environmental Services  
Clean Water Program  
Funding source: Clark County Clean Water Fee  
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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

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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 Salmon Creek (RM 14.66) and Morgan Creek subwatersheds in the central portion of the 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 related to stormwater management than regional Water Resource Inventory Area (WRIA) or Endangered Species Act (ESA) plans. Stormwater Needs Assessments are not comprehensive watershed plans or stormwater basin plans.

### Findings

#### Watershed Conditions

The table on the following page summarizes conditions in the two 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 Salmon Creek and its tributaries through local grass-roots organizing, riparian enhancement work, and ongoing TMDL adaptive management.

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.

The CWP Capital Planning Database lists one potential stormwater project in this assessment area. The Salmon Creek Forested Upland Preservation includes property acquisition of a forested 80 acre parcel containing the confluence of Salmon Creek and Morgan Creek. This project is complete; the parcel has been purchased by Clark County under the Legacy Lands program.

There is one major road project (Chelatchie Prairie Rail Trail) in this assessment area under the Public Works 2010-2015 Transportation Improvement Program.

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Category	Status
<b>Water Quality</b> Overall Fecal coliform bacteria Temperature pH Turbidity	<ul style="list-style-type: none"> <li>• General water quality is fair to good</li> <li>• TMDL implementation ongoing for both subwatersheds; concentrations have declined from 1995 levels; however, neither subwatershed meets TMDL targets</li> <li>• In TMDL development for both subwatersheds; this reach of Salmon Creek shows large increases in temperature and is among the warmest in the watershed</li> <li>• TMDL required for Salmon Creek (RM 14.66)</li> <li>• TMDL implementation ongoing for both subwatersheds; Salmon Creek in this reach meets TMDL targets; limited data for Morgan Creek</li> </ul>
<b>Biological</b> Benthic macroinvertebrates Anadromous fish	<ul style="list-style-type: none"> <li>• Moderate biological integrity for both subwatersheds; it is likely that biological integrity could be increased by improving habitat and stream conditions</li> <li>• Coho and winter steelhead use; presumed fall Chinook in limited reaches.</li> </ul>
<b>Habitat</b> NOAA Fisheries criteria Riparian Wetland	<ul style="list-style-type: none"> <li>• Forest cover, impervious area, and road density metrics suggest Non-Functioning habitat</li> <li>• Stream crossing density and estimated effective impervious area fall into the Properly Functioning category</li> <li>• Forest cover approximately 34 percent; tends to be on steeper slopes and confined to stream valleys</li> <li>• Large woody debris recruitment potential is fair</li> <li>• Large expanses of potential wetland area associated with riparian corridors and floodplain areas, large areas of sloped wetlands along base of foothills</li> <li>• Ecology Characterization Management Level is Protection Restoration 2</li> </ul>
<b>Hydrology and Geomorphology</b> Overall hydrology Future condition	<ul style="list-style-type: none"> <li>• Hydrologic data indicates hydrology compatible with stable stream channels</li> <li>• Projected impervious area should remain at levels that places the study area in the functioning category</li> </ul>
<b>Stormwater (unincorporated areas)</b> System description Inventory status System adequacy System condition Retrofit opportunity Maintenance evaluation Offsite assessment	<ul style="list-style-type: none"> <li>• Primarily road-side ditches; 53 (3 public and 50 private) stormwater facilities</li> <li>• Complete; 5700 stormwater infrastructure features mapped</li> <li>• Adequate treatment is probably provided by vegetation in ditches</li> <li>• Minimal flow control other than infiltration in ditches</li> <li>• Largely undocumented but presumed functional; no outfall screening performed</li> <li>• Limited to ditches</li> <li>• One maintenance evaluation conducted; 60 percent of facility objects in compliance with maintenance standards</li> <li>• Sixteen priority outfalls assessed; fifteen in compliance</li> </ul>



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## Opportunities

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

- Evaluation of sixteen potential stormwater control projects within Morgan Creek and Salmon Creek (RM 14.66) to treat road runoff
- Evaluation of six potential wetland enhancement projects and one riparian enhancement/reforestation project
- Evaluation of seven taxlots for property acquisition for habitat preservation
- Technical assistance visits to landowners and businesses with potential source control problems 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
- Evaluation of numerous potential channel rehabilitation projects
- Removal of one fish passage barrier within Morgan Creek
- Consider conducting offsite assessment activities focusing on Priority 2 Outfalls; particularly in areas where higher flows are expected.

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

- Continue to coordinate with Washington Department of Ecology during Salmon Creek TMDL adaptive management (fecal coliform and turbidity), and TMDL development (temperature)
- New facility construction focusing on stormwater infiltration to increase baseflow
- Distribute literature to landowners discussing water quality impacts and other potential hazards of on-line and off-line ponds
- Encourage in-stream habitat improvement projects to increase biological integrity
- 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 Agricultural Best Management Practices that emphasize soil and water conservation, intact riparian buffer areas, and reduction in nutrient load to streams.
- Continue to expand efforts to design and build runoff reduction strategies in county right-of-way

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- Educate private landowners on importance of native riparian vegetation and intact riparian forests for shading streams and preserving hydrology. Emphasize conservation of undeveloped and forested areas, especially within the riparian corridor and floodplain.
- Continue education and public outreach efforts focused on ensuring private stormwater facility owners meet maintenance standards in Clark County's Stormwater Facility Maintenance Manual
- Protect first-order tributary streams from further stormwater impacts by creating stream buffers, establishing conservation easements, and eliminating existing stormwater and agricultural runoff inputs.
- Continue to encourage riparian preservation by employing strategies to prevent riparian degradation, and riparian large wood enhancement by hardwood conversion, conifer release, or riparian plantings.

## Introduction

This Stormwater Needs Assessment includes the Salmon Creek (RM 14.66) and Morgan 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 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.

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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: Department of Environmental Services Clean Water, Stormwater Capital Planning, Legacy Lands, and ESA; Public Works Operations, Development Engineering, and CIP; Community Planning and; Public Health. 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 14.66) and Morgan Creek

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

For SNAP purposes, the Morgan Creek subwatershed is categorized as “Rural Residential with No UGA”. Subwatersheds in this category are generally not heavily forested but have limited stormwater management needs due to the lack of urbanization. Assessment efforts for these subwatersheds focus primarily on summarizing existing information to identify potential restoration projects.

The Salmon Creek (RM 14.66) subwatershed is categorized as “Rural Residential Including City-Serviced Fringes of Urban Growth Area”. Subwatersheds in this category typically include rural areas bordering cities. These subwatersheds often score a high priority for stormwater management in general, but are a lower priority for Clark County due to the rural nature of unincorporated portions. Stormwater management needs tend to be limited in these areas. Urban development in this assessment area is controlled by the city of Battle Ground.

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## Assessment Tools Applied in Salmon Creek (RM 14.66) and Morgan 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 procedures. Tools follow standard protocols to provide a range of information for stormwater management. Though not every tool is applied in every subwatershed, the use of a standard toolbox ensures the consistent application of assessment activities county-wide.

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

**Table 1: Stormwater Needs Assessment Tools**

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

## Assessment Actions

### Outreach Activities

SNAP outreach activities in 2009 focused primarily on raising awareness about the SNAP effort and following up on issues discovered in 2008. Letters were sent to landowners regarding trash accumulations and various agriculture management issues observed on their property during the 2008 SNAP effort.

The following activities were completed:

- July 2009 -- Press release to local media.
- The Clean Water Program E-Newsletter is distributed to 265 subscribers. SNAP articles and updates were included in three E-Newsletter editions in 2009:
  - April 2009 – 2008 SNAP reports available
  - August 2009 – 2009 SNAP update
  - December 2009 – Article highlighting SNAP landowner litter pick-up success.
- April 2009 -- SNAP information distributed with Clean Water Program information at Small Farm Expo: 69 participants.
- August 2009 – Letters were sent to sixty-two landowners with accumulations of trash in or near the stream on their property. Twenty-two landowners responded with phone calls to the SNAP lead for more information or to inform the CWP that cleanup activities had been completed. One landowner reported removing 1200 pounds of trash and another picked up three garbage bags and four five-gallon buckets of litter, six tires, three washing machines, drain pipe, and aluminum siding.
- August 2009 – Information on the SNAP was distributed at the 10-day Clark County Fair.
- November 2009 – Letters were sent to twenty-one landowners with identified agriculture-related issues on their property. The letters described the problem found (improper manure storage, livestock access to the stream, etc.) and identified a suggested management practice to lessen negative impacts on water quality (cover manure piles, fence livestock from the stream). A list of local resources and a brochure highlighting small acreage best management practices were included in the mailing. No follow-up calls or questions from landowners were received by the SNAP lead resulting from these letters and it is unknown whether other agencies listed as resources were contacted by property owners for technical advice.
- Clean Water Program SNAP web pages were updated as needed on an on-going basis; (note, no web visitor/download statistics are available as Clark County had (has) no tracking software during this timeframe).
- A description of the SNAP was included in Clark County's annual stormwater management program plan submitted to Ecology.

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

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

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

## 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 inform and enhance 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 to include 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 identified 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 14.66) and Morgan Creek needs assessment area:

- Lower Columbia Fish Recovery Board
- Clark County Transportation Improvement Program
- Clark County Legacy Lands Program



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- 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:

- Ecology Watershed Characterization and Analysis of Clark County (2009)
- LCFRB Habitat Characterization (2004)
- LCFRB 6-Year Habitat Workplan
- Ecology 303(d) list
- Ecology EIM data
- Clark County 2004 Subwatershed summary
- Clark County 2004 Stream Health Report
- Clark County LISP/SCMP/ Project data (2002 – 2008)
- CPU Salmon Creek WS Plan 2002
- 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. Some of these characteristics are described in greater detail in later sections.

The characterization includes three components:

- A set of four standard map products, as paper maps for SNAP use
- A summary table of selected subwatershed-scale metrics

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- A brief narrative including comparison of metrics to literature values, and conclusions about general subwatershed condition and potential future changes

## Map Products

The four standard SNAP map products are: 1) Stormwater Infrastructure and Hydrologic Soil Groups, 2) Critical Areas information, 3) Vacant Buildable Lands within UGAs, 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 rural upper Salmon Creek: Morgan Creek and Salmon Creek (RM 14.66). Salmon Creek (RM 14.66) subwatershed groups a number of smaller, unnamed streams draining to Salmon Creek. Morgan Creek subwatershed also includes tributaries Baker Creek and Mud Creek. The area rises from the relatively level Willamette Valley floor (Figure 1) to the lowermost foothills of the Cascade Mountains, often called the Troutdale Bench in reference to the underlying Troutdale Formation gravel deposits. Land use is rural with fairly dense rural residential areas such as Hockinson in Morgan Creek subwatershed. The lowermost part of Salmon Creek (rm 14.66) is within Battle Ground's Urban Growth Area and the city.

### *Topography*

The study area has three principal topographic areas: Salmon Creek flows through the middle of the area forming a significant flood plain. Above this is a flat surface underlain by Ice Age Cataclysmic Flood Deposits at about 270 to 300 foot elevation. To the east, the Troutdale Bench forms a low ridge cut by canyons. The Troutdale Bench slopes westward, with elevation generally between 500 feet the west side and 700 feet on the east margin. The Salmon Creek floodplain is approximately 210 feet above sea level at its confluence with Woodin Creek and 320 feet above sea level where it exits a canyon below Rock Creek. Except for Morgan Creek, all of the tributary streams that flow into Salmon Creek in this study area lack floodplains.

### *Geology and Soils*

The oldest rocks in the study area are lava flows exposed along cliffs and in Salmon Creek at the east edge of the area. The rest of the eastern part of the study area is underlain by sedimentary rocks deposited by the ancestral Columbia and local streams. These gravel and sandstone deposits are exposed on the Troutdale Bench hilltop where they are weathered to reddish brown clay and in canyons where the rocks are unweathered.

Ice age Cataclysmic Flood deposits of sand and silt blanket the area below about 300 feet elevation. The deposits are generally flat lying.

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

Soils are generally clayey and poorly drained. Hilltop areas tend to be hydrologic soil group C soils formed on weathered gravel deposits. Flat-lying Ice age Cataclysmic Flood deposits are C and D soils where ground water is shallow and B soils where groundwater is deeper.

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### *Hydrology*

Geology and topography play the main role in determining study area hydrologic framework. Morgan Creek's drainage system is cutting into an upland area underlain by the Troutdale Formation. Headwater streams form in rolling, often cleared hilltop grassy fields and lawns. Small streams descend into shallow valleys. After exiting its canyon Morgan Creek and Mud Creek pass through flat Ice Age Catastrophic Flood deposits. Morgan Creek makes a small canyon as it descends to the Salmon Creek flood plain.

Channel gradients are generally quite steep where Morgan Creek and its tributaries drain the Troutdale Bench and very flat on the valley floor. There are numerous small unnamed tributaries to Salmon Creek 14.66. Most of them are less than one mile long but a larger stream flows south from the Troutdale Bench into Salmon Creek near 190<sup>th</sup> Avenue.

No significant stream flow data is available for Morgan Creek. Hydrologic modeling conducted by MGS (2003) for Clark County and Clark Public Utilities suggested that Morgan Creek subwatershed hydrology is compatible with stable stream channel conditions. Hydrologic data and modeling for Salmon Creek mainstem also suggest hydrology compatible with stable stream channels.



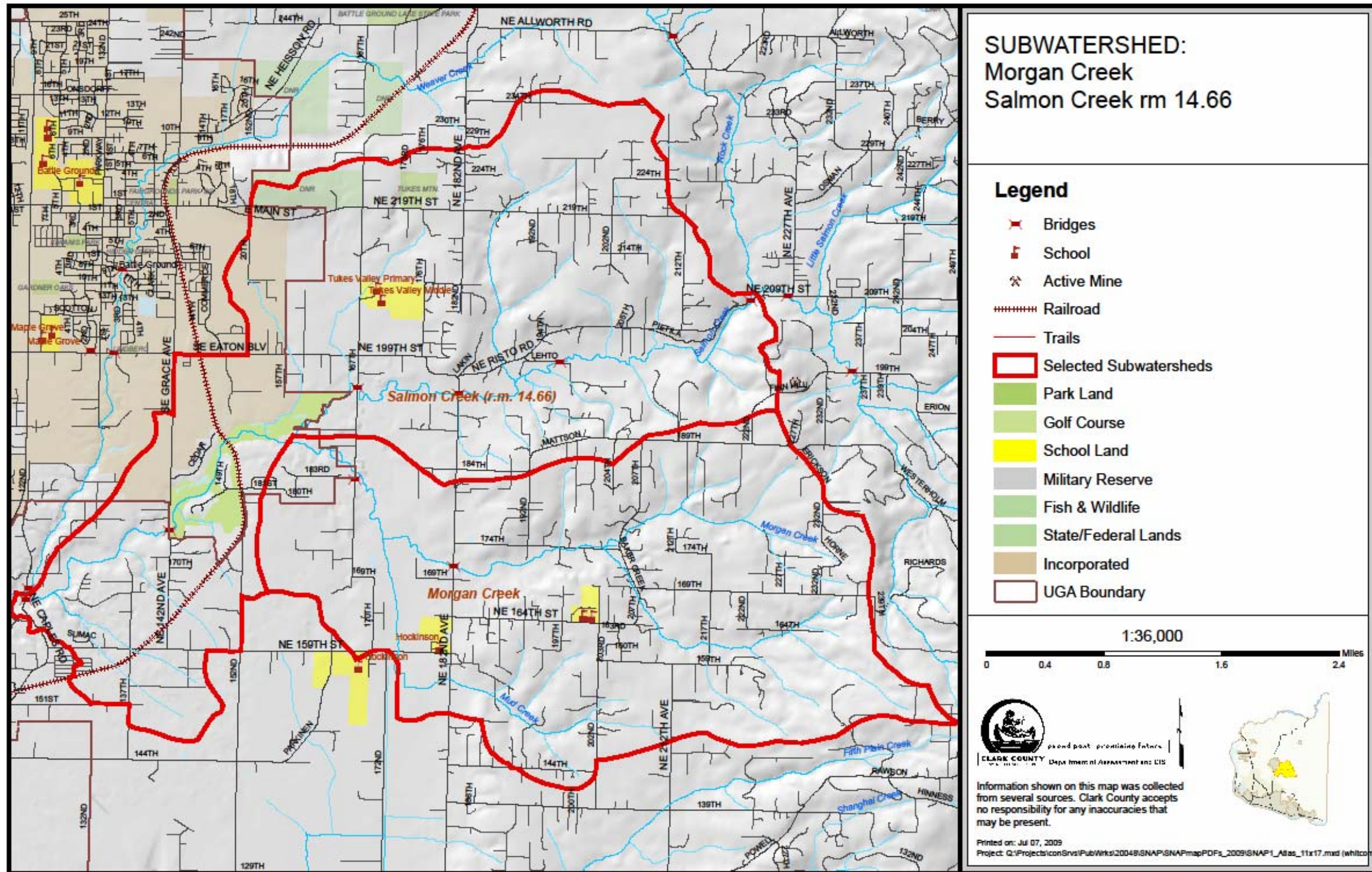


Figure 1: Subwatershed Map: Morgan Creek and Salmon (RM 14.66) Subwatersheds



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## *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 marginally non-functioning stream habitat (Table 2).

**Table 2: Watershed Scale Metrics**

<b>Metric</b>	<b>Morgan Creek</b>	<b>Salmon Creek RM 14.66</b>	<b>Functioning</b>	<b>Non-functioning</b>
Percent Forested (2000 Landsat)	34	34	> 65 %	< 50 %
Percent TIA (2000 Landsat)	18	17	< 5 %	> 15 %
Road Density 2007 data (miles/mile <sup>2</sup> )	7	7	< 2	> 3
Stream Crossing Density (crossings per stream mile)	2.1	1.7	< 3.2/mile	> 6.4/mile
Percent EIA estimated from the Comprehensive Plan	5	9	< 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 includes both areas of forest and low density rural development. Development is densest in the Hockinson area. Forest cover tends to be on steeper slopes and in stream valleys, with flatter areas historically cleared for agriculture and home sites.

## *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

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standard is less than five percent as fully functional and greater than 15 percent as non-functioning. Values for both subwatersheds are slightly higher than the threshold for non-functioning habitat. It should be noted that the LandSAT analysis tends to overestimate impervious surfaces in mixed rural areas.

### *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 twice as dense as the threshold for non-functioning ( $>3$  road miles/mi<sup>2</sup>).

### *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 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 somewhat unstable channels.



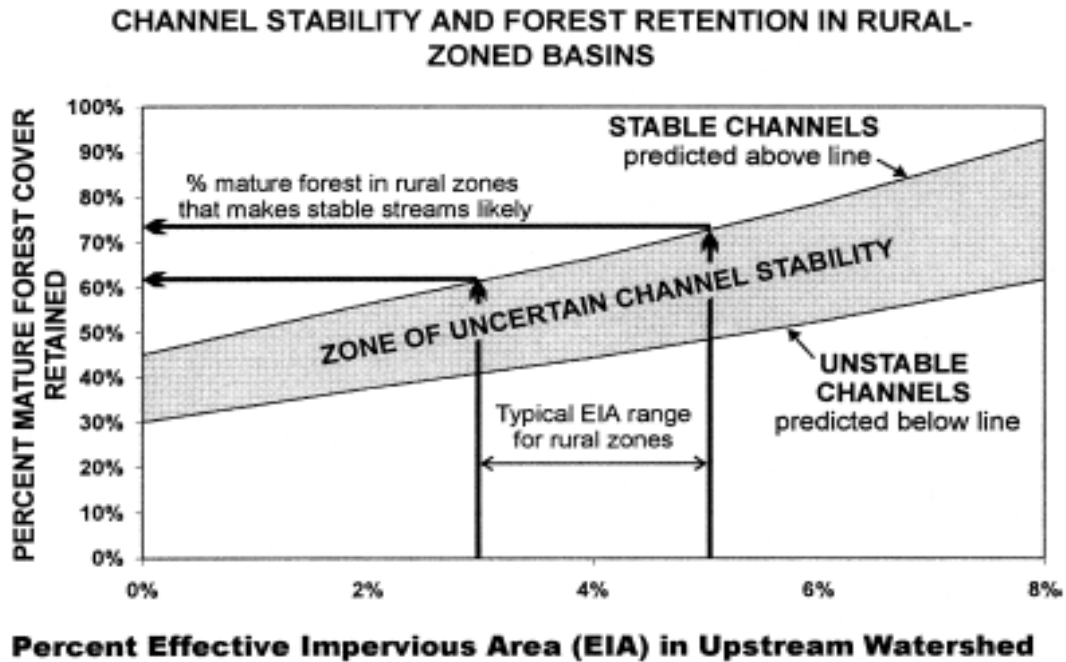


Figure 2: Channel stability in rural areas (Booth, Hartley, and Jackson, June 2002).

### Water Quality Assessment

This section briefly summarizes and references available water quality data from the Morgan Creek and Salmon Creek (RM 14.66) 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 Morgan Creek and other 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.

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**Table 3: Applicable Water Quality Criteria for Morgan Creek and Salmon Creek (RM 14.66) Subwatersheds**

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

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

### 303(d) Listed Impairments

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

Salmon Creek within the Salmon Creek (RM 14.66) subwatershed is Category 5 listed (polluted waters that require a TMDL) for pH; Category 4a listed (polluted waters with an approved TMDL) for fecal coliform bacteria, and Category 2 listed (Waters of Concern) for temperature and dissolved oxygen. There are no specific listings for Morgan Creek.

As a whole, the Salmon Creek mainstem has multiple reaches listed, including Category 4a listings for fecal coliform and turbidity, Category 5 listings for temperature, dissolved oxygen, and pH; and additional Category 2 listings for temperature, dissolved oxygen, and pH.

Because this study area is upstream of listed reaches, both subwatersheds are included in ongoing TMDL implementation for fecal coliform and turbidity, 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 Salmon Creek (RM 14.66) and lower Morgan Creek subwatersheds scored in the fair range.

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Although no stream data were available for the upper portions of Morgan Creek, a simple predictive model assigned a probable health score of “poor” based on the amount of forested and developed areas within the upper subwatershed.

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 relatively lengthy dataset is available for mainstem Salmon Creek at the lower end of this assessment area. A more limited, one-year dataset exists for the Morgan Creek subwatershed.

This summary focuses on recent water quality data collected by the CWP including monthly water quality data from Salmon Creek (2002 through 2008), temperature data collected during the summer of 2003, and a one-year characterization study in Morgan Creek 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>

In 2009, Ecology (Collyard, 2009) completed a report titled Salmon Creek Nonpoint Source Pollution Total Maximum Daily Load: Water Quality Effectiveness Monitoring (Publication No. 09-03-042). The report incorporates much of the County’s available water quality data and is available on the Salmon Creek TMDL website at:

<http://www.ecy.wa.gov/programs/wq/tmdl/SalmonCr/SalmonCr.html>.

Some information from the Ecology report is summarized in this assessment.

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

**Table 4: Data Sources**

<b>Source</b>	<b>Data and/or Report</b>
Clark County Clean Water Program	2002-2008 Salmon Creek Monitoring Project data 2004 Stream Health Report 2007-2008 Morgan Creek characterization data Salmon Creek Watershed Summer 2003 Stream Temperature Salmon Creek NE 167 <sup>th</sup> Ave to NE Risto Road Temperature Survey (August, 2005)
Ecology	Salmon Creek Nonpoint Source Pollution Total Maximum Daily Load: Water Quality Effectiveness Monitoring Report

## Water Quality Summary

Figure 3 shows the location of monitoring stations referenced in this assessment. Long-term monthly data was collected from 2002-2008 at Station SMN050 (Salmon Cr at Caples Road) in

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the Salmon Creek (14.66) subwatershed. Short-term characterization data was collected monthly from October 2007-September 2008 at three stations in the Morgan Creek subwatershed:

- MOR010 (Morgan Cr at NE 167<sup>th</sup> Street)
- MOR070 (Morgan Cr at NE 196<sup>th</sup> Avenue)
- MUD040 (Mud Cr at NE 159<sup>th</sup> Street)

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

- SMN050
- SMN060 (Salmon Cr at NE 167<sup>th</sup> Street)
- SMN070 (Salmon Cr at Risto Road bridge 216)

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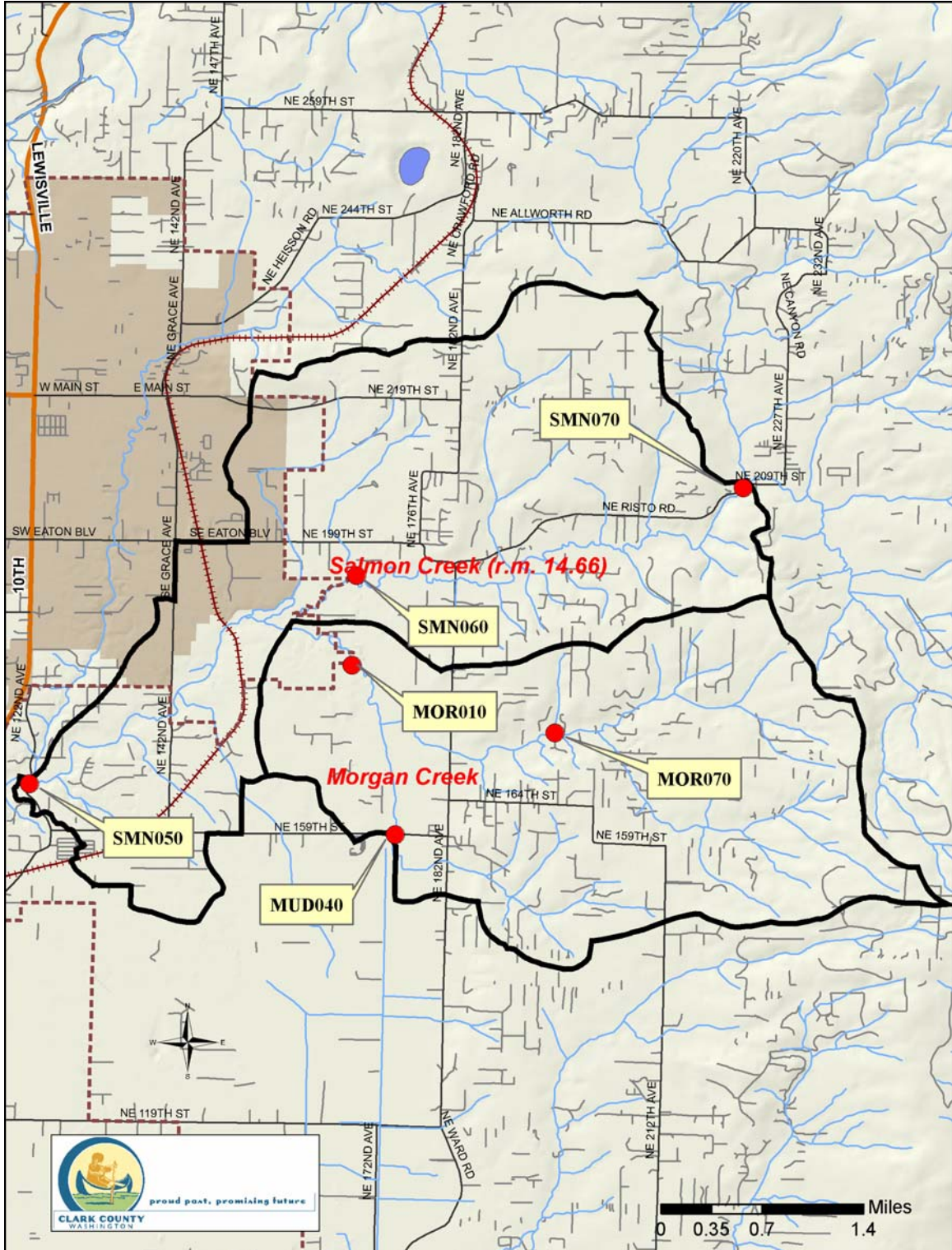


Figure 3: Location of monitoring stations

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### *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.

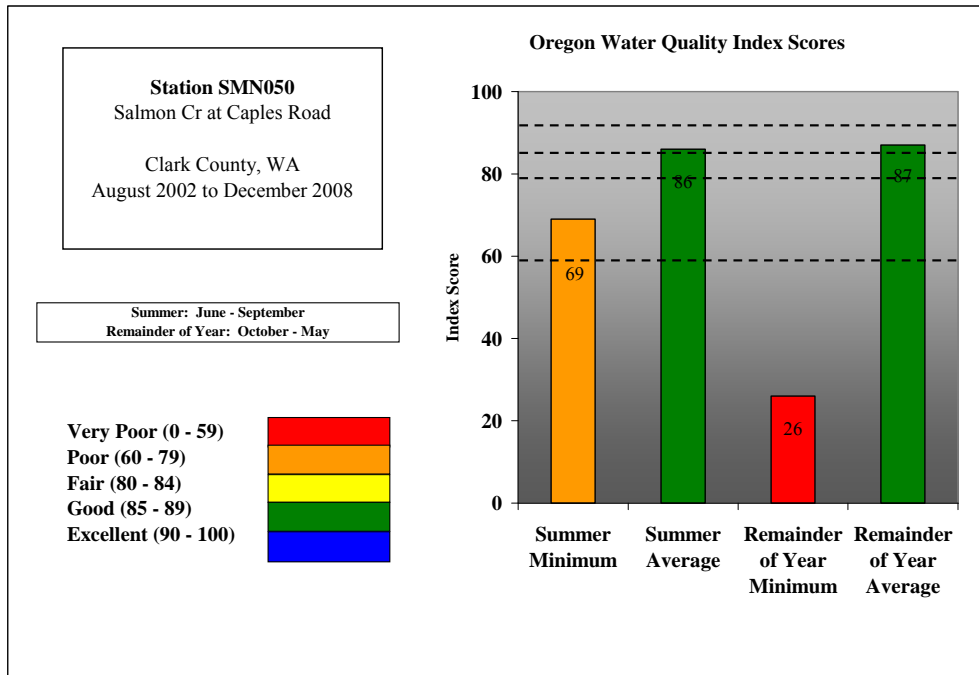
Index scores are categorized as follows:

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

Figure 4 shows seasonal mean OWQI scores for Station SMN050 from 2002 through 2008.

Among 15 long-term monitoring stations county-wide from 2002-2006, Station SMN050 ranked 5th in overall water quality (Hutton and Hoxeng, 2007).

Monthly OWQI values at SMN050 ranged from Very Poor to Excellent, and tended toward the upper end of this range, as 57 of 74 months had OWQI scores in the good or excellent category. Monthly sub-index scores for total solids and inorganic nitrogen ranged widely, with total solids having many fair to good scores and inorganic nitrogen having typically poor to very poor scores. Scores for total phosphorus were typically good to excellent. Fecal coliform ranged widely but was typically excellent. Scores for water temperature, dissolved oxygen, and pH were excellent with occasional lower scores.



**Figure 4: Average Water Quality, Salmon Creek station SMN050, 2002 through 2008, Oregon Water Quality Index**

Seasonal mean OWQI values for Station MOR010, Station MOR070 and Station MUD040 for Water Year 2008 are shown in Figure 5, Figure 6, and Figure 7, respectively. Scores for each station are discussed below:

**MOR010:** The overall annual OWQI score for this station is “fair”, missing the good category by a single point (84). Monthly OWQI values ranged from Poor to Excellent, and tended toward the upper end of this range as 10 of 12 months had OWQI scores in the good or excellent category. Monthly sub-index scores for inorganic nitrogen and total phosphorus ranged widely, with nitrogen scores typically poor with some higher scores and phosphorus showing no particular pattern. Fecal coliform also ranged widely but was typically good to excellent. Scores for dissolved oxygen, temperature, and pH were typically good to excellent, with a few pH scores falling into the fair category. Total solids scores were mostly fair to good.

**MOR070:** The overall annual OWQI score for this station is “good”, with a score one point higher than MOR010 pushing it into the next category (85). Monthly OWQI values ranged from Poor to Excellent, and tended toward the upper end of this range as 11 of 12 months had OWQI scores in the good or excellent category. Monthly sub-index scores for inorganic nitrogen ranged widely but were typically poor. Fecal coliform also ranged widely but was typically good to excellent. Total phosphorus scores ranged from fair to excellent, with the majority toward the upper end of this range. Scores for dissolved oxygen, temperature, and pH were excellent across the board, while total solids scores were mostly fair to good.

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MUD040: The overall annual OWQI score for this station is “fair”. Monthly OWQI values ranged from Very Poor to Excellent, and tended somewhat toward the upper end of this range as 8 of 12 months had OWQI scores in the good or excellent category. Monthly sub-index scores for inorganic nitrogen were typically poor with a few fair and good values. Fecal coliform and total phosphorus ranged widely; however fecal coliform scores were typically excellent while total phosphorus split evenly between very poor and excellent scores. Scores for dissolved oxygen, temperature, and pH were typically good to excellent, with a few pH scores falling into the fair category. Total solids scores ranged widely, with many scores in the good range.

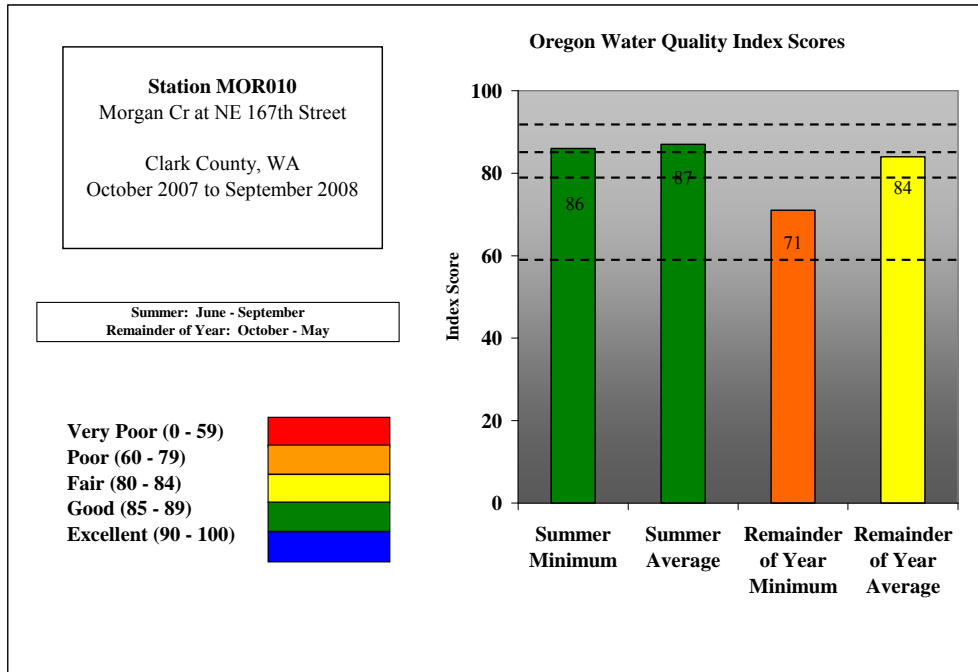


Figure 5: Morgan Creek station MOR010, Oct 2007- Sept 2008, Oregon Water Quality Index



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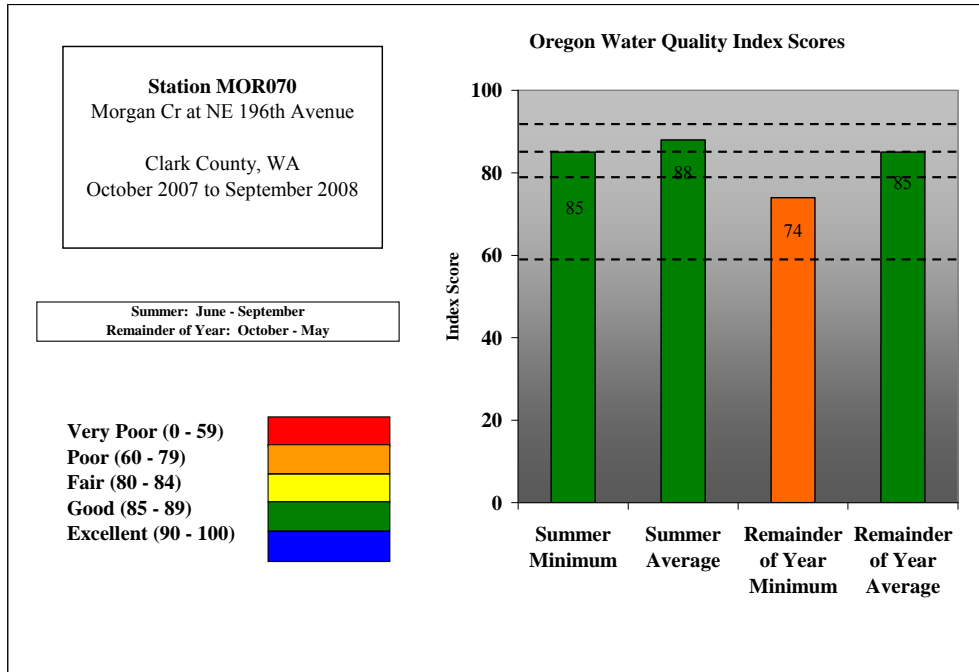


Figure 6: Morgan Creek station MOR070, Oct 2007-Sept 2008, Oregon Water Quality Index

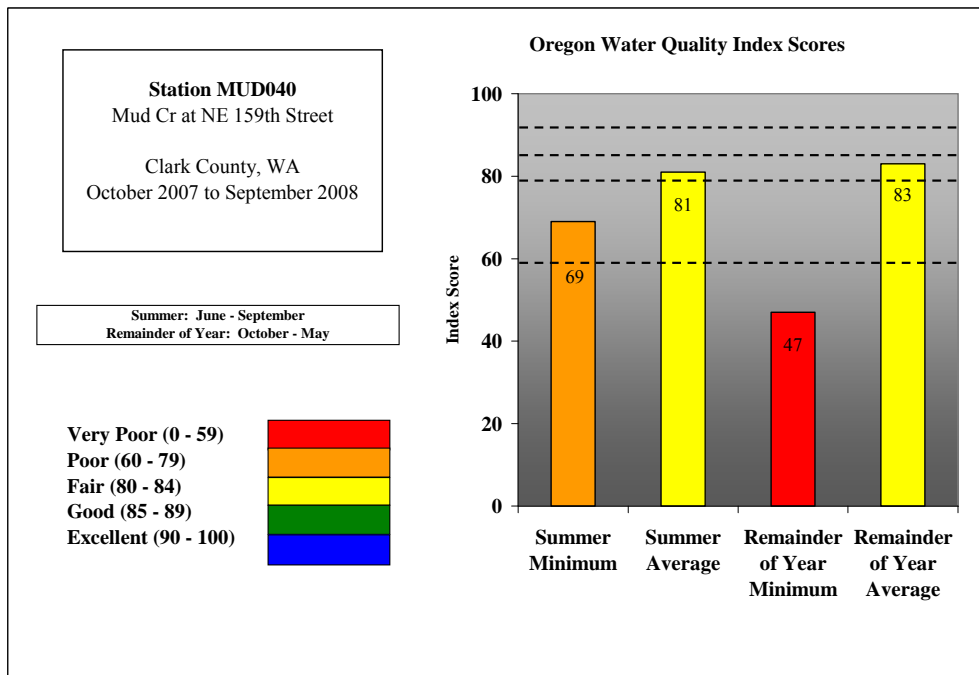


Figure 7: Mud Creek station MUD040, Oct 2007-Sept 2008, Oregon Water Quality Index

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## *Trends Over Time*

An analysis of statistical trends in OWQI scores based on the 2002 through 2006 dataset found a significant decreasing trend in turbidity subindex scores (indicating increasing turbidity) at Station SMN050 (Hutton and Hoxeng, 2007).

Ecology (Collyard, 2009) used a step-trend analysis to evaluate data collected at SMN050 between 1988 and 2007. Statistically significant decreasing trends were found in fecal coliform, nitrate-nitrite, and total phosphorus concentration.

## *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 SMN050 between August 2002 and December 2008 ranged from <0.020 mg/L to 0.190 mg/L; less than three percent of samples exceeded the EPA criterion during this time period. Total phosphorus concentrations typically vary seasonally in many locations; however, seasonal median values at SMN050 are very similar (0.032 mg/L summer and 0.022 mg/L remainder of year).

2008 total phosphorus levels at MOR010 and MOR070 were relatively low, ranging from 0.021 - 0.104 mg/L and 0.005 - 0.066 mg/L, respectively. One sample at MOR010 slightly exceeded the EPA criterion; no samples at MOR070 exceeded. Values ranged more widely at MUD040, from 0.005 - 0.196 mg/L, with 25% of samples exceeding the EPA criterion.

## *Turbidity*

Ecology (Collyard, 2009) found that all stations on Salmon Creek and tributaries met the 2001 TMDL target levels based on a comparison between 1988-1994 and 2005-2007 data. 90<sup>th</sup> percentile values decreased by 63% at SMN050.

Since 2002, the median of 79 turbidity samples at SMN050 was 4.8 NTU, with summer samples having slightly lower turbidity.

## *Fecal Coliform Bacteria*

For a full analysis based on the fecal coliform TMDL, see Collyard, 2009. General results from that report are summarized below.

Based on monthly data from 2005 - 2007, geometric mean fecal coliform concentrations at Station SMN050 declined sharply during both the wet and dry seasons when compared to values from the 1995 TMDL (Table 5). SMN050 meets the geometric mean criteria during the wet season, but despite the improvements this location still fails the criteria during the dry season.

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90<sup>th</sup> percentile values also decreased substantially. Again, despite improvements SMN050 is not in full compliance with the state criteria and TMDL targets, meeting the criterion during the wet season and failing in the dry season (Table 6).

**Table 5: 1995 TMDL study fecal coliform criterion compared to 2005-7 Clark County data (from Collyard, 2009)**

*Geometric mean values for wet and dry seasons.*

Station	Wet season					Dry season				
	TMDL	05-07	% change <sup>1</sup>	Meets criterion?	% Required change <sup>2</sup>	TMDL	05-07	% change <sup>1</sup>	Meets criterion?	% Required change <sup>2</sup>
SMN010	313	59	-82	Yes	none	129	90	-30	Yes	none
CGR020	722	143	-80	No	30	899	696	-23	No	86
SMN030	182	42	-77	Yes	none	281	151	-46	No	34
MIL010	839	50	-94	Yes	none	282	106	-62	No	6
CUR020	1155	23	-98	Yes	none	743	116	-84	No	14
SMN050	234	21	-91	Yes	none	751	106	-86	No	6
WDN	534	71	-87	Yes	none	857	184	-79	No	46
SMN080	28	6	-79	Yes	none	54	34	-35	Yes	none

<sup>1</sup> Percent change required to meet TMDL target limits.

<sup>2</sup> Additional change required to meet TMDL target limits.

**Table 6: 2001 TMDL report fecal coliform criterion compared to 2005-7 Clark County data (from Collyard, 2009)**

*90<sup>th</sup> percentile values for wet and dry seasons.*

Station	Wet season					Dry season				
	TMDL	05-07	% change <sup>1</sup>	Meets criterion?	% Required change <sup>2</sup>	TMDL	05-07	% change <sup>1</sup>	Meets criterion?	% Required change <sup>2</sup>
SMN010	1917	321	-83	No	-38	301	347	-15	No	-42
CGR020	9243	601	-93	No	-67	1803	1577	-13	No	-87
SMN030	1261	194	-85	Yes	none	806	342	-58	No	-36
MIL010	8763	381	-96	No	-48	1121	483	-57	No	-59
CUR020	4409	93	-98	Yes	none	2608	472	-82	No	-58
SMN050	1125	138	-88	Yes	none	1404	346	-75	No	-42
WDN	9204	468	-95	No	-57	6509	628	-90	No	-68
SMN080	200	22	-89	Yes	none	318	98	-69	Yes	none

<sup>1</sup> Percent change required to meet TMDL target limits.

<sup>2</sup> Additional change required to meet TMDL target limits.

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Based on 12 monthly samples from October 2007 through September 2008 during the Morgan Creek characterization project, stations MOR010, MOR070, and MUD040 all failed one or both criteria. Table 7 summarizes fecal coliform results from the project.

Station MOR010 met both criteria during the dry season, but failed both during the wet season. Station MOR070 and Station MUD040 both met the geometric mean criterion and failed the 90<sup>th</sup> percentile criterion during the wet season, and failed both criteria during the dry season.

**Table 7: Seasonal geometric mean and 90th percentile values for Morgan Creek stations, October 2007 - September 2008**

Station	Wet season				Dry season			
	Geo mean	Meets?	90 <sup>th</sup> percent	Meets?	Geo mean	Meets ?	90 <sup>th</sup> percent	Meets?
MOR010	105	No	900	No	84	<b>Yes</b>	124	<b>Yes</b>
MOR070	94	<b>Yes</b>	515	No	157	No	261	No
MUD040	56	<b>Yes</b>	830	No	130	No	313	No

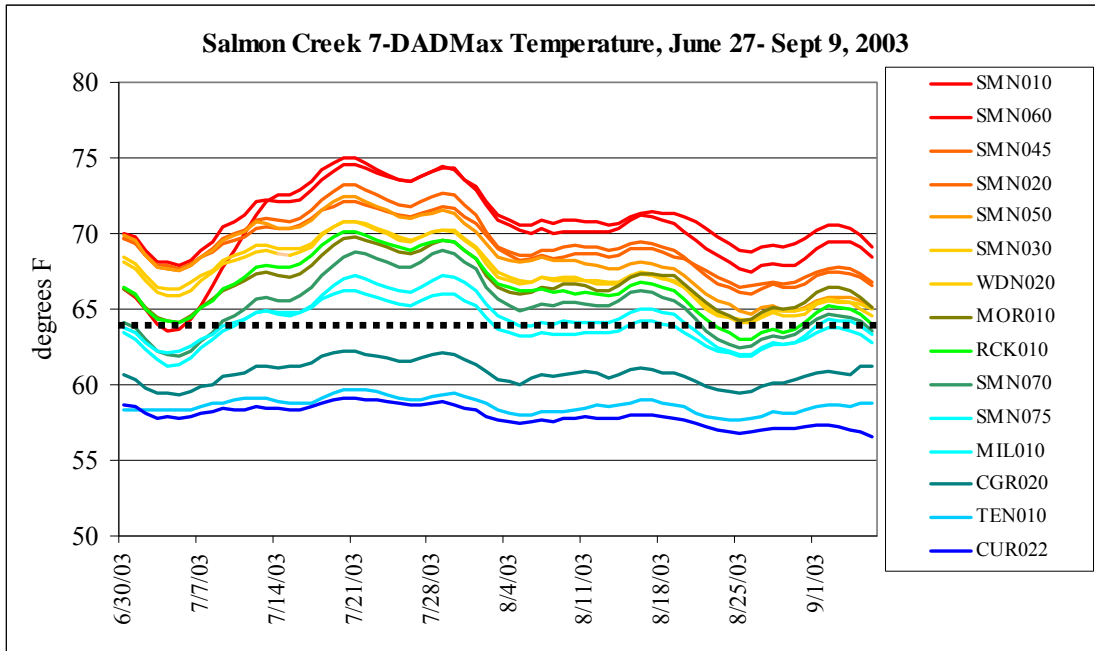
### *Stream Temperature*

One summer of continuous temperature monitoring (2003) at stations SMN050, SMN060, and SMN070 was conducted as part of the Salmon Creek Watershed Summer 2003 Stream Temperature project.

Figure 8 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 (currently the criterion for this assessment area is 60.8 degrees F. At the time of the study, the criterion was 64 degrees F).

All of the stations within this assessment area greatly exceeded the current state criterion and spent significant amounts of time with temperatures exceeding even the pre-2006 criterion. Station SMN060 was the second warmest station monitored in the entire study, with 7-DADMax of nearly 75 degrees F.

The median temperature increased by 5 degrees F between SMN070 and SMN060. This significant jump led to a follow up study to determine possible causes in August 2005 (Schnabel, 2005). The primary reasons for the increase appear to be lack of riparian canopy over the Salmon Creek mainstem and the presence of in-line ponds on numerous small tributaries. Tributaries with in-line ponds contributed water that was much warmer than tributaries with no in-line ponds. Subsequently, riparian project opportunities were outlined and provided to Clark Public Utilities. Several opportunities were incorporated into grant applications and some have been addressed.



**Figure 8: 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.**

### Impacts to Beneficial Uses and Potential Sources

General water quality in this assessment area is fair to good. Significant improvements have been observed throughout the Salmon Creek watershed, particularly in fecal coliform, turbidity, and nutrients. Despite improvements, impacts to listed beneficial uses include core summer salmonid habitat from elevated temperatures, and primary contact recreation as indicated by fecal coliform bacteria. Table 8 at the conclusion of this section summarizes the primary water quality impacts to beneficial uses in Morgan Creek and Salmon Creek (RM 14.66), and probable sources of the observed impact.

### Implications for Stormwater Management

Table 8 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.

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**Table 8: Known Water Quality Concerns, Sources, and Solutions for Morgan Creek and Salmon Creek (RM 14.66)**

<b>Characteristic</b>	<b>Beneficial Use Affected</b>	<b>Potential Sources</b>	<b>Mechanism</b>	<b>Solutions (bold indicates direct Clean Water Program involvement)</b>
Fecal coliform bacteria	Primary contact recreation	failing septic systems	groundwater seeps storm sewers	Storm sewer screening for source identification and removal Education programs 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	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	

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## Drainage System Inventory and Condition

### *Inventory*

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

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

Table 9 indicates the number of features currently inventoried in StormwaterClk. Of the total 53 stormwater facilities, three are identified as publicly owned and operated.

**Table 9: Drainage System Inventory Results, Morgan Creek/Salmon Creek RM 14.66**

<b>Database Feature Category</b>	<b>Inventoried prior to 2007</b>	<b>Added during 2007-2009</b>	<b>Total Features</b>
Inlet	46	83	129
Discharge Point (outfall)	9	580	589
Flow Control	29	6	35
Storage/Treatment	292	43	335
Manhole	21	5	26
Filter System	1	1	2
Channel	387	2436	2823
Gravity Main	424	1311	1735
Facilities	23	30	53

### *Condition*

Stormwater system condition is assessed based on three components:

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

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## *Component 1: Retrofit Evaluation*

### Purpose

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

### Methods

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

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

### Results

Based on the county's StormwaterClk database, as of July 2009, there were no mapped public stormwater facilities in the Morgan Creek subwatershed; there were 3 mapped public stormwater facilities in the Salmon Creek (RM 14.66) subwatershed.

Thirty-three percent (1) of the mapped public stormwater facilities in the Salmon Creek (RM 14.66) subwatershed was evaluated for retrofit opportunities.

No public stormwater facilities were referred for further evaluation as Capital Improvement Projects.

## *Component 2: Inspection and Maintenance Evaluation*

### Purpose

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

### Methods

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



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

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

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

## Results

Only one inspection and maintenance evaluation was conducted in the Salmon Creek (RM 14.66) subwatershed. This facility was found to be out of compliance and included a total of 5 facility objects, of which 3 (60 percent) were in compliance.

The inspection process in the Salmon Creek (RM 14.66) subwatershed generated 1 referral to Public Works Maintenance and Operations for needed maintenance activities.

No major defects or hazardous conditions were discovered in the Salmon Creek (RM 14.66) subwatershed.

## *Component 3: Offsite Assessment*

### Purpose

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

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

### Methods

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

- Within 200 feet of a critical area (e.g. riparian, wellhead protection, landslide hazard, etc)
- Within 300 feet of a headwater stream

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- Located on public land
- Originates from a public-dedicated facility currently under the two-year maintenance warranty bond

Stormwater outfalls are prioritized into three categories:

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

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

### Results

Based on the county's StormwaterClk database, as of June 2009 there were 249 mapped outfalls in the Morgan Creek subwatershed; 3 Priority 1 outfalls, 13 Priority 2 outfalls, and 233 Priority 3 outfalls.

In the Salmon Creek (RM 14.66) subwatershed there were 316 mapped outfalls; 12 Priority 1 outfalls, 28 Priority 2 outfalls, and 276 Priority 3 outfalls.

Figure 9 and

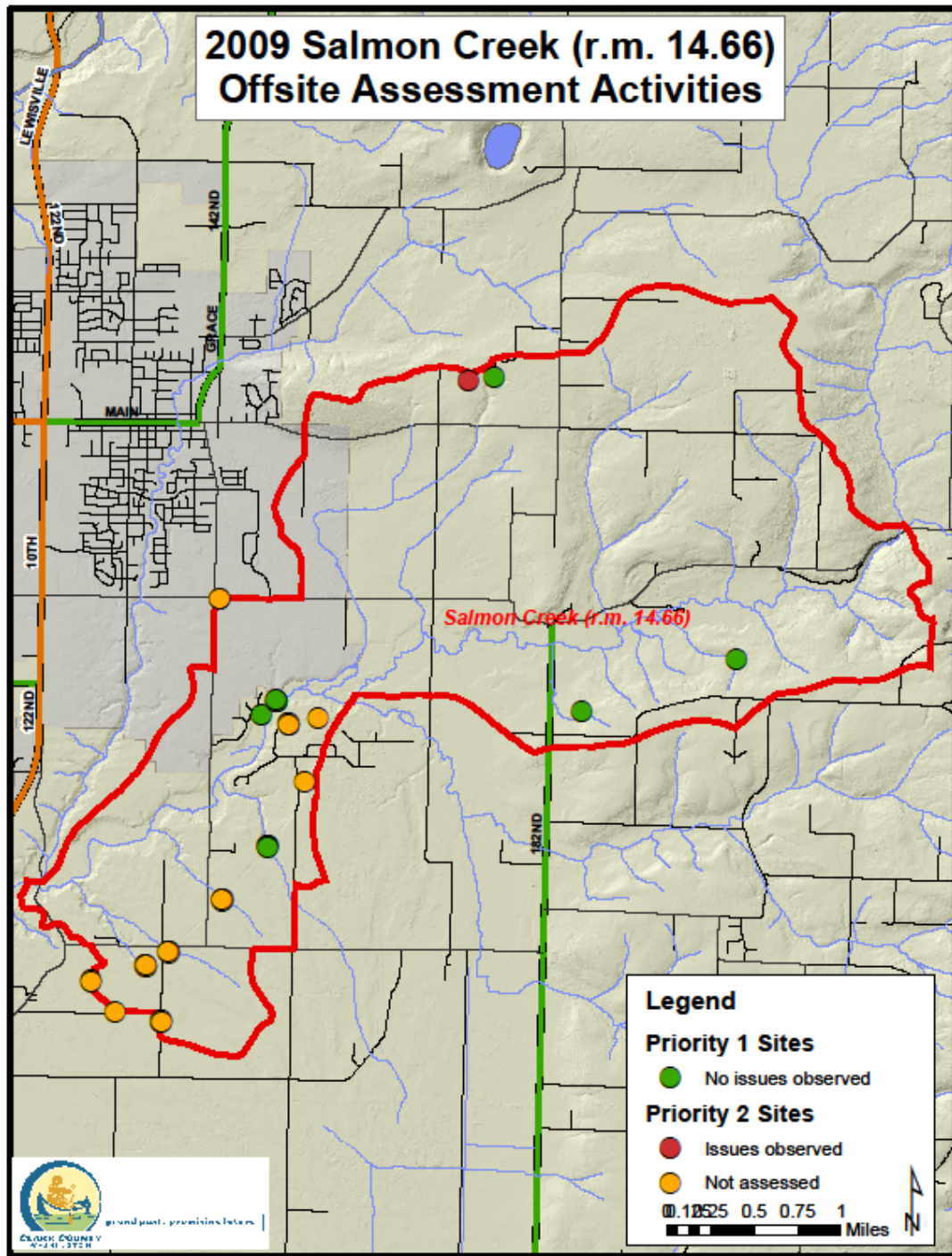


Figure 10 summarize notable outfall assessment activities including general outfall locations in each subwatershed.

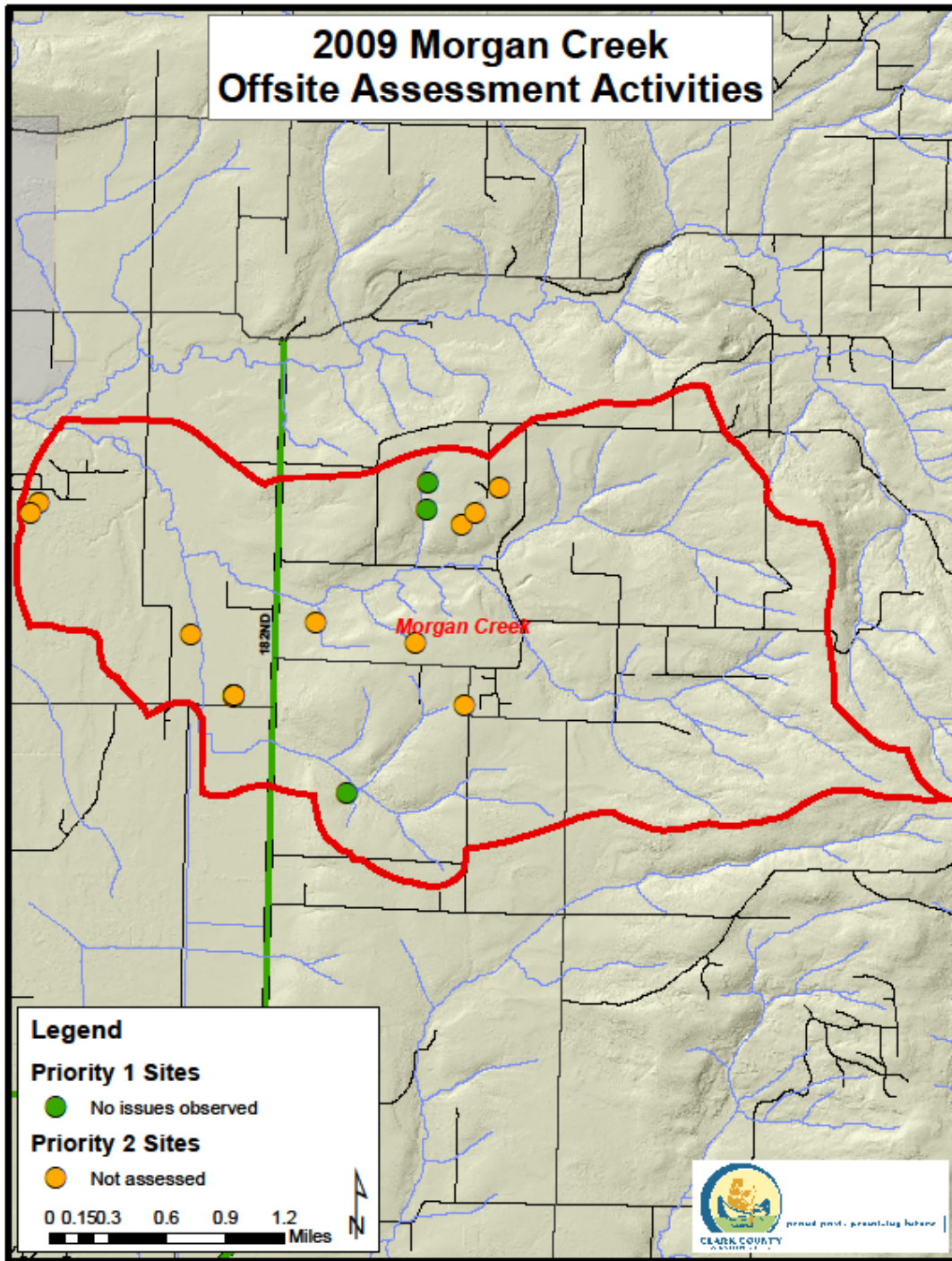


Figure 9: Summary of 2009 Off-site Assessment Activities in the Morgan Creek subwatershed

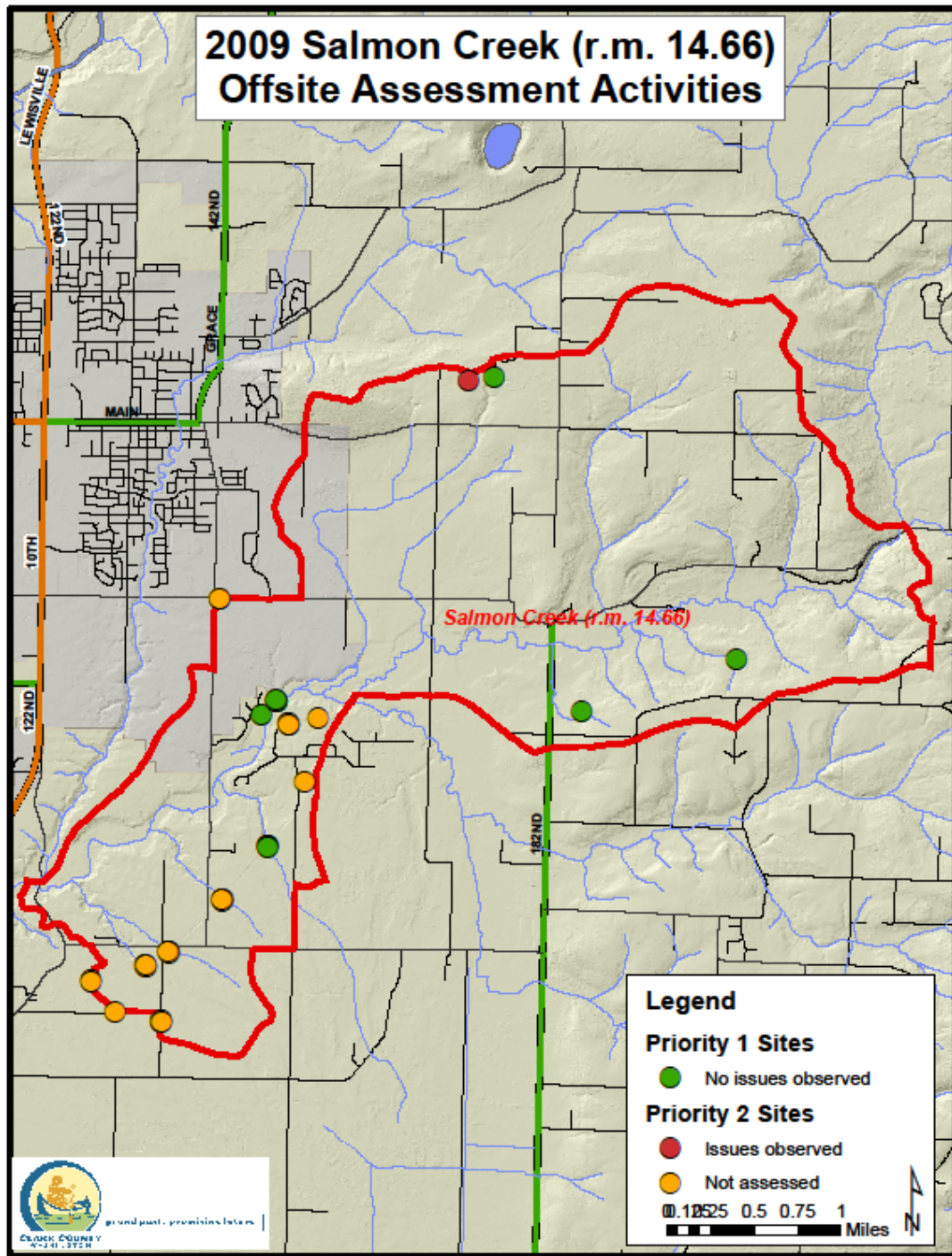


Figure 10: Summary of 2009 Off-site Assessment Activities in the Salmon Creek (RM 14.66) subwatershed

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Table 10 summarizes offsite assessment results from the Morgan Creek subwatershed. There were 249 mapped outfalls discharging to critical areas. Three Priority 1 outfalls were assessed, of which all were found to be in compliance. No Priority 2 or Priority 3 outfalls were assessed.

**Table 10: 2009 Off-site Assessment Project Activity Summary for Morgan Creek subwatershed**

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	3	13	233
# of outfalls assessed	3	0	0
# of outfalls compliant	3	n/a	n/a
# of noncompliant outfalls	n/a	n/a	n/a
# of referrals initiated	n/a	n/a	n/a
# of referrals ongoing	n/a	n/a	n/a
# of outfalls fixed	n/a	n/a	n/a

Table 11 summarizes offsite assessment results from the Salmon Creek (RM 14.66) subwatershed. There were 316 mapped outfalls discharging to critical areas. Twelve Priority 1 outfalls were assessed, of which all were found to be in compliance. One Priority 2 outfall was assessed and found to be out of compliance. No Priority 3 outfalls were assessed.

**Table 11: 2009 Off-site Assessment Project Activity Summary for Salmon Creek (RM 14.66) subwatershed**

Metric	Number of Outfalls		
	Priority 1	Priority 2	Priority 3
Total number of mapped outfalls	12	28	276
# of outfalls assessed	12	1	0
# of outfalls compliant	12	0	n/a
# of noncompliant outfalls	n/a	1	n/a
# of referrals initiated	n/a	1	n/a
# of referrals ongoing	n/a	1	n/a
# of outfalls fixed	n/a	n/a	n/a

### Potential Projects

The offsite assessment project yielded one referral to Operations in the Salmon Creek (RM 14.66) subwatershed. This referral includes channel stabilization (Table 12).

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**Table 12: Description of Potential Project Opportunities**

<b>Identifier</b>	<b>Outfall ID</b>	<b>Basis for Project</b>	<b>Project Description</b>	<b>Subwatershed</b>
OS-171	909	Erosion issues downstream outfall	Stabilize bank and add riprap	Salmon Creek (RM 14.66)

## *Management Recommendations*

A retrofit evaluation and an inspection and maintenance evaluation was conducted at one public stormwater facility in the Salmon Creek (RM 14.66) subwatershed. No referrals were generated for further evaluation as Capital Improvement Projects. Non compliant facility objects included a bioswale and inlet conveyance pipe. Erosion defects were noted for both facility objects. Correcting facility erosion issues, possibly by enhancing flow control efforts will bring this facility into compliance.

Outfall assessments generated one potential project opportunity. Offsite or downstream problems included moderate erosion issues downstream of the outfall. Bank and channel stabilization efforts would prevent further erosion issues. Maintaining the frequency of offsite assessment activities may reduce downstream erosion problems by discovering potential issues before they become a more serious erosion problem. Also, more effective energy dissipaters and an increase in bank stabilization efforts at outfalls where higher flows are expected may also reduce potential erosion problems.

## Illicit Discharge Detection and Elimination Screening

Illicit Discharge Detection and Elimination Screening assessment was not conducted.

## Stream Reconnaissance and Feature Inventory

### 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. They also provide an extensive GIS database of sites that can be evaluated for project mitigation needs and as a county-wide planning tool for riparian and habitat enhancement projects.

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## Methods/Limitations

Geographic scope of the Feature Inventory was established by the CWP, 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 13.

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\CWP Project Planning Database. 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.

## *Study Area*

The extent of the completed Feature Inventory in the Morgan Creek and Salmon Creek (RM 14.66) subwatersheds is shown in Figure 11.

Since Morgan Creek subwatershed is categorized as “Rural Residential with No UGA” and Salmon Creek (RM 14.66) subwatershed is categorized as “Rural Residential Including City-Serviced Fringes of Urban Growth Area”, stormwater management needs tend to be limited in these areas. Feature Inventory efforts in these subwatersheds were restricted to Road Reconnaissance surveys only. Full Feature Inventory field efforts and resources are focused on higher priority areas in more urbanized subwatersheds that have higher stormwater management needs.

## Results/Findings

Only a Road Reconnaissance survey was performed in both Morgan Creek and Salmon Creek (RM 14.66) subwatersheds. No other feature types were recorded. A total of 31 features were assessed during the Road Reconnaissance survey; 24 in the Morgan Creek subwatershed and seven in the Salmon Creek (RM 14.66) subwatershed. A breakdown of recorded features by type is presented in Table 11.



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**Table 13: Summary of Features Recorded in Morgan Creek and Salmon Creek (RM 14.66) Subwatersheds**

<b>Feature Type</b>	<b>Number Recorded</b>	
	<b>Morgan Creek</b>	<b>Salmon Creek (RM 14.66)</b>
RR – Road Reconnaissance feature	24	7



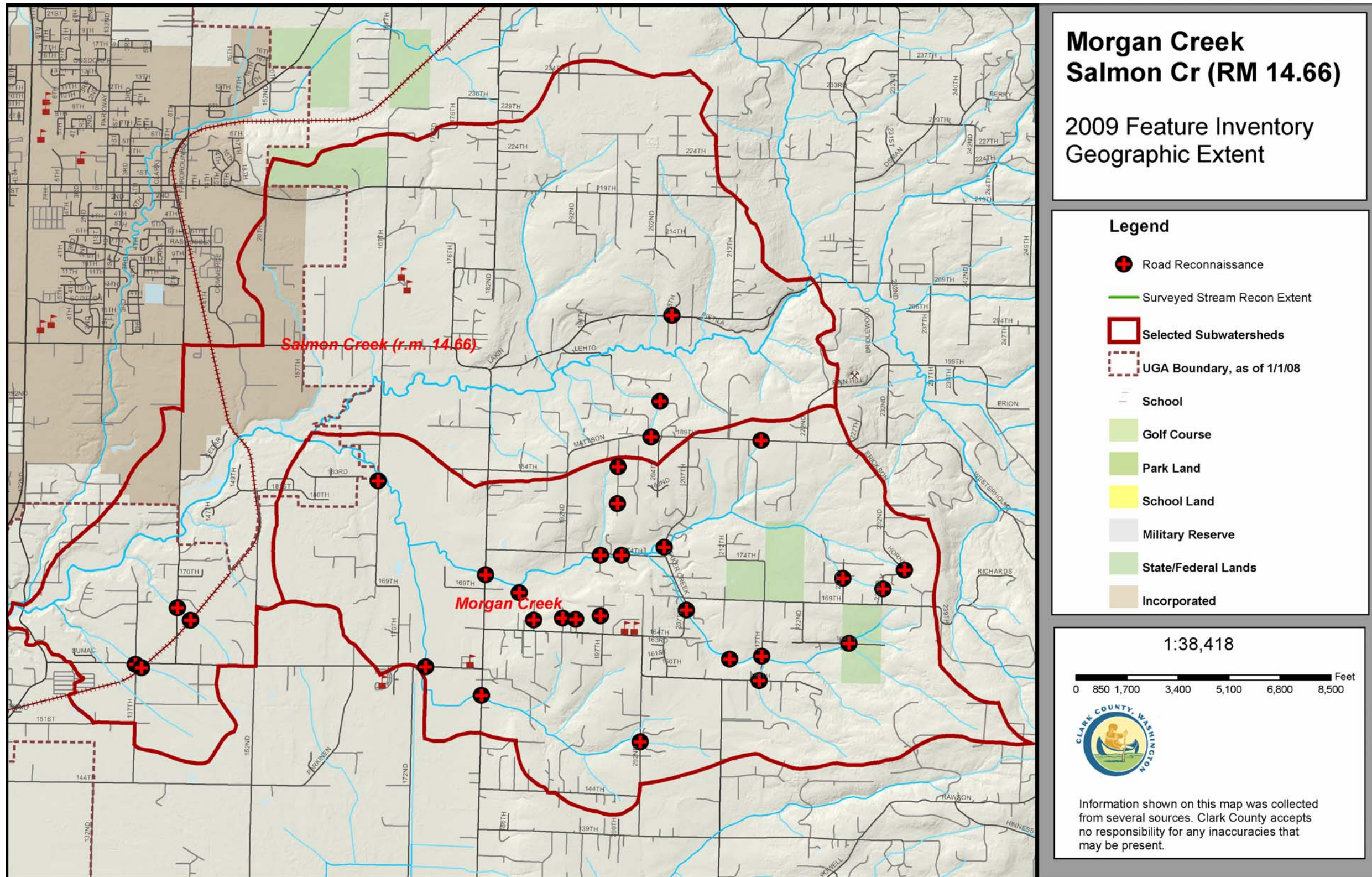


Figure 11: Morgan Creek and Salmon Creek (14.66) Geographic Extent of 2009 Feature Inventory



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The following subsections contain general descriptions of the Morgan Creek and Salmon Creek (RM 14.66) 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*

Due to the prevalence of agricultural land use in the Road Reconnaissance surveyed reaches, existing stormwater infrastructure is minimal. The stormwater conveyance to Morgan Creek, Salmon Creek (RM 14.66), and their tributaries is mainly via roadside ditches and small open channels that drain deforested, agricultural land located on the sloping terrain adjacent to the narrow wooded valleys that contain the streams.

Flow in the Morgan Creek subwatershed is predominately east to west for larger tributaries, with first order inputs and smaller drainage pathways (manmade and otherwise) flowing to the primary streams from the north and south. Flow in the Salmon Creek (RM 14.66) subwatershed is predominately northeast to southwest for larger tributaries, first order inputs, and smaller drainage pathways (manmade and otherwise) flowing to the primary streams from the north and south.

The predominant sources of stormwater in the surveyed areas of these subwatersheds are overland runoff from agricultural land and road surfaces. These sources are located throughout the reaches of the subwatershed. A large golf course east of NE 142<sup>nd</sup> Avenue, in which Salmon Creek flows through, is another likely source of stormwater and water quality impairments. Very few facilities that treat consolidated stormwater flow are mapped in either subwatershed.

### *Riparian Vegetation*

#### Morgan Creek Subwatershed

Although riparian conditions were only observed from the roads surveyed during the Road Reconnaissance, it is clear that impacted stream buffers are prevalent in the Morgan Creek subwatershed. The majority of the headwater areas have established riparian forest canopy along a narrow riparian corridor confined within the steep valley walls. There are occasional breaks in riparian forest canopy where individual landowners have cleared trees to the stream. Most of the clearing is located in areas where steep topography does not isolate the stream. Invasive plant species are widespread, but dense concentrations are intermittent, mainly in areas where the riparian forest canopy is absent.

Field observations during Road Reconnaissance surveys note that undergrowth in portions of the riparian corridor is a mix of native and invasive plant species. Blackberry and reed canary grass are the most prevalent invasive plant species. In general, blackberry is more common in areas of dense canopy cover and reed canary grass is more common in areas with less dense canopy cover and wetter soil conditions. Downstream of the headwater area, the reaches are dominated by agricultural land and pasture in the riparian area. The channel and riparian corridor are not confined by steeper topography, and the majority of woody riparian canopy vegetation has been cleared throughout the reach; especially along Mud Creek and the lower half of Morgan Creek. Invasive plant species are common, but their density is mostly being held in check by grazing or mowing.

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## Salmon Creek (RM 14.66) Subwatershed

The majority of surveyed stream reaches noted during the Road Reconnaissance survey have established riparian forest canopy. Nevertheless, impacted stream buffers and invasive plant species appear to be prevalent in the Salmon Creek (RM 14.66) subwatershed, especially where there are breaks in the canopy cover. In the middle and lower subwatershed in particular, widespread agricultural land use has led to an overall lack of woody riparian vegetation that is adversely affecting water quality and stream bank stability. In most of the observed agricultural areas, invasive plant species are being kept in check through grazing.

In the upper subwatershed, riparian areas have established forest canopy along a narrow riparian corridor confined within the steep valley walls, with woody vegetation and canopy cover. Invasive reed canary grass and blackberry are prevalent adjacent to road crossings. While the riparian forest canopy is typically in good condition, undergrowth in much of the riparian corridor is a mix of native and invasive plant species. Blackberry and reed canary grass are the most prevalent invasive plant species. In general, blackberry is more common in areas of dense canopy cover and reed canary grass is more common in areas with less dense canopy cover and wetter conditions.

### *Additional Results*

It is worth noting again that the most significant impairments observed in both Morgan Creek and Salmon Creek (RM 14.66) subwatersheds were potential water quality impacts and widespread hydrologic impacts associated with agricultural land use. In these areas, the alteration of natural drainage patterns by agriculture and the consolidation of surface flows at road crossings are having clear and significant impacts on stream stability, habitat, and riparian health.

### 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. 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 Morgan Creek and Salmon Creek (RM 14.66) subwatersheds. The CWP will evaluate the potential projects for further development or referral to the appropriate organization. Each potential project is listed in tables, including the basis for the project and a description of the potential project. The location of each potential project is shown in figures Figure 12, Figure 13, Figure 14, and Figure 15 below. Potential project opportunities were categorized into six groups based on the nature of the potential work. A total of 15 potential projects were identified. A summary of identified project opportunities by potential project category is shown in Table 14.

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**Table 14: Breakdown of Potential Project Opportunities by Category**

<b>Potential Project Category</b>	<b>Potential Projects Identified in Morgan Creek</b>	<b>Potential Projects Identified in Salmon Creek (RM 14.66)</b>
Emergency/Immediate Actions	0	0
Stormwater Facility Capital Improvement Projects	0	1
Stormwater Infrastructure Maintenance Projects	0	1
Habitat Restoration/Enhancement Projects	0	0
Property Acquisition for Habitat Preservation	2	0
Referral Projects for other Agencies	8	3





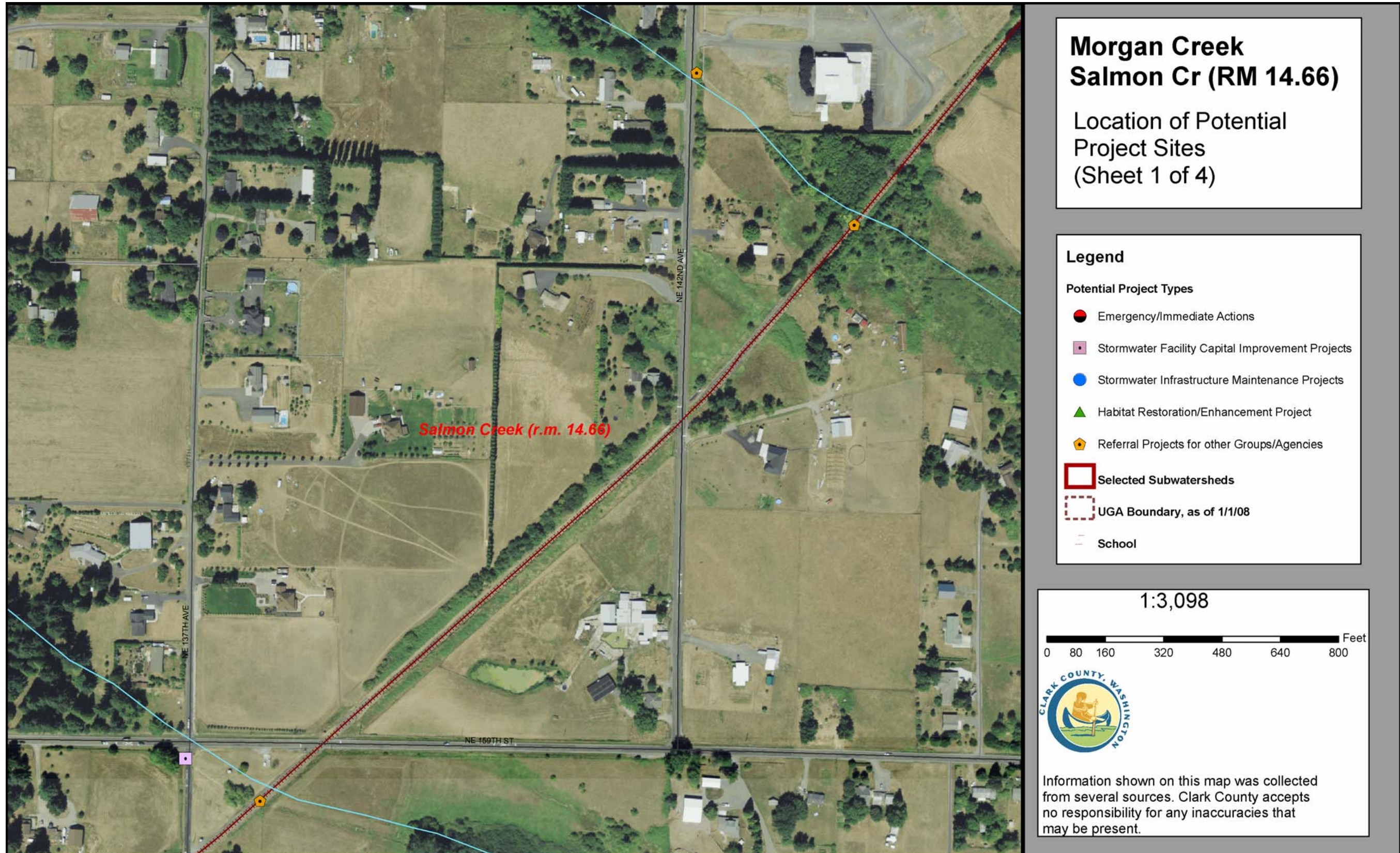


Figure 12: Salmon Creek (RM 14.66) Location of Potential Project Sites



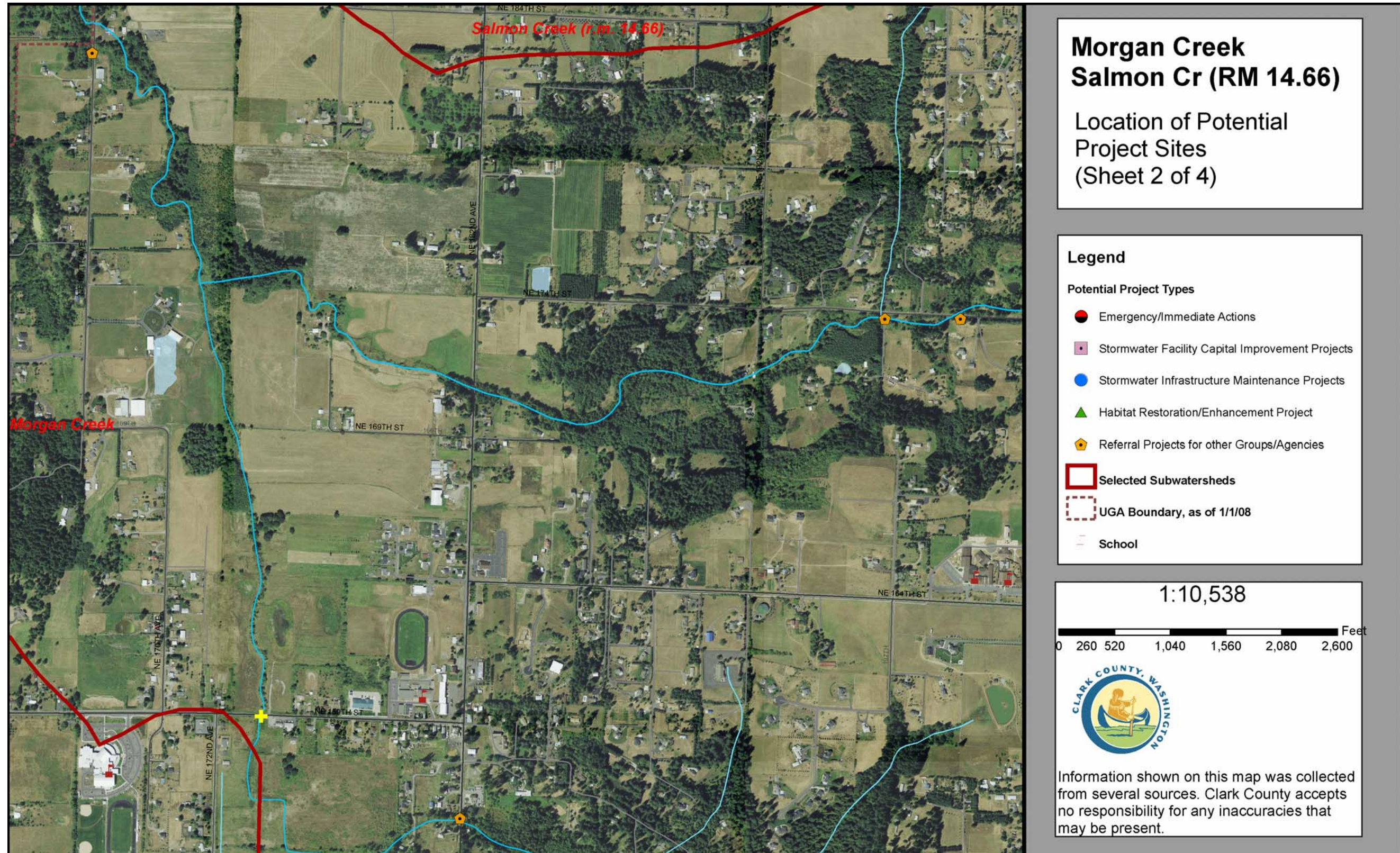


Figure 13: Morgan Creek Location of Potential Project Sites



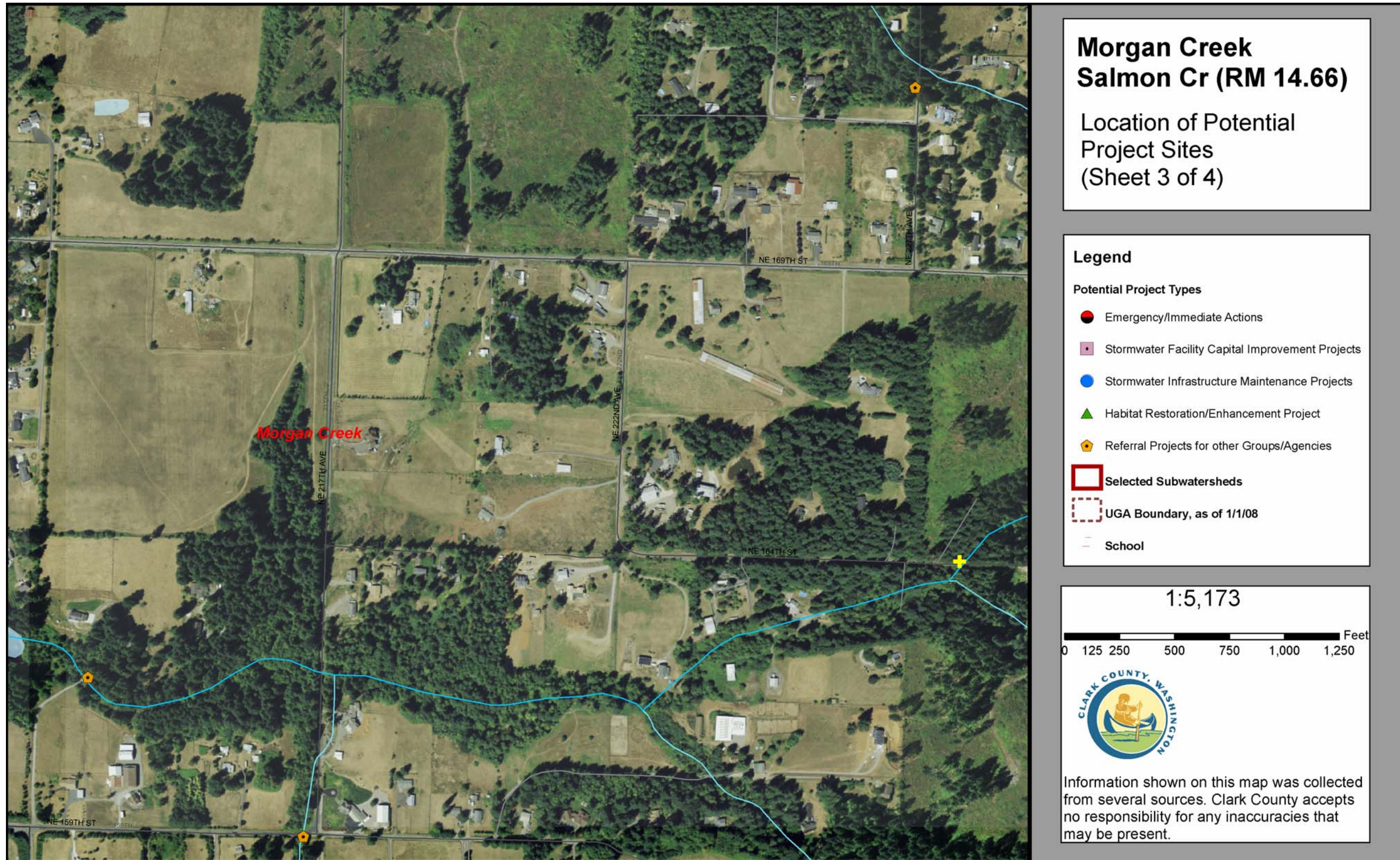


Figure 14: Morgan Creek Location of Potential Project Sites



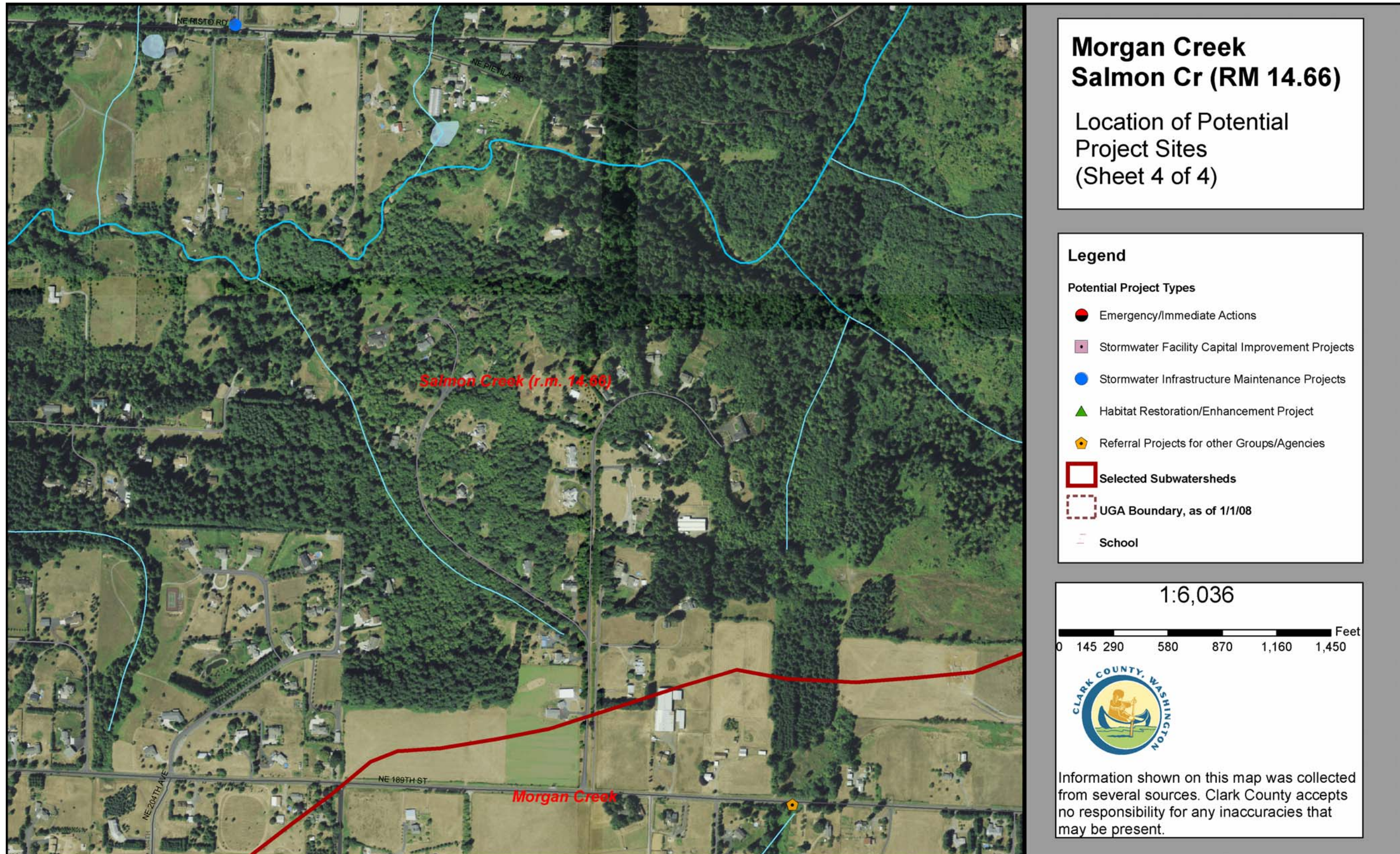


Figure 15: Salmon Creek (RM 14.66) and Morgan Creek Location of Potential Project Sites





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### *Emergency/Immediate Actions*

Emergency/Immediate Actions require an immediate site response project to address a potential or imminent threat to public health, safety, or the environment.

No projects of this type were identified during the Road Reconnaissance survey.

### *Stormwater Facility Capital Improvement Projects*

Stormwater Facility Capital Improvement Projects are projects that create new or retrofit existing stormwater flow control or treatment facilities. Facility retrofits include projects that will increase an existing facility's ability to control or treat stormwater in excess of the original facility's design goals. Referral Projects for Stormwater Facility Capital Improvement Projects are identified based on the results of the Feature Inventory are described in Table 15 and Table 16.

**Table 15: Description of Potential Stormwater Infrastructure Maintenance Project Opportunities – Salmon Creek (RM 14.66)**

<b>ID</b>	<b>Basis for Project</b>	<b>Project Description</b>
RR-90	Small eroding gully drains stormwater from ditch source in the direction from railroad tracks on Clark Public Utilities owned property.	Construct a new stormwater facility to detain and treat runoff appropriately. Remove culvert as flows daylight under 159th; work with landowner to fence off livestock access.

**Table 16: Description of Potential Stormwater Infrastructure Maintenance Project Opportunities – Morgan Creek**

<b>ID</b>	<b>Basis for Project</b>	<b>Project Description</b>
RR-46	Drainage receives untreated stormwater from roads; potential source of water quality impairments	Investigate the feasibility of construction of facility in right of way to treat stormwater runoff for water quality improvement

### *Stormwater Infrastructure Maintenance Projects*

Stormwater Infrastructure Maintenance Projects include potential projects which address and repair maintenance defects affecting existing stormwater infrastructure. Infrastructure maintenance projects are required by the County NPDES municipal stormwater permit. Projects in this category with estimated costs exceeding \$10,000 are considered under the SCIP process. Projects addressing simpler maintenance defects are referred directly to the County Public Works Operations and Maintenance staff. Referral Projects for Stormwater Infrastructure Maintenance Projects are identified based on the results of the Feature Inventory are described in Table 17.

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**Table 17: Description of Potential Stormwater Infrastructure Maintenance Project Opportunities – Salmon Creek (RM 14.66)**

<b>ID</b>	<b>Basis for Project</b>	<b>Project Description</b>
RR-103	18 inch diameter concrete culvert under NE Risto Road is being undercut by stormwater flow. Flow is piping under culvert and not entering culvert. Road may be compromised in the future if not corrected.	Repair or replace with larger diameter culvert that is adequate to stormwater flow.

### *Habitat Restoration/Enhancement Projects*

Habitat Restoration/Enhancement Projects include potential projects which result in the restoration or enhancement of wetlands, upland forest, or riparian habitat. In-stream channel habitat and bank protection projects do not fall within the scope of Clark County's CWP, and are placed under the category of Referral Projects for other Groups/Agencies.

No projects of this type were identified during the Road Reconnaissance survey.

### *Property Acquisition for Habitat Preservation*

Property Acquisition for Stormwater Mitigation Projects includes potential acquisitions of properties for any purpose that meets permit requirements to mitigate for stormwater impacts. This includes preservation or restoration of upland forest and riparian habitat zones. Referral Projects for Property Acquisition for Stormwater Mitigation are identified based on the results of the Feature Inventory are described in Table 18.

**Table 18: Description of Potential Referrals to Other Groups/Agencies – Morgan Creek**

<b>ID</b>	<b>Basis for Project</b>	<b>Project Description</b>
RR-51	Large property parcel with intact habitat located in headwater area.	Investigate the feasibility of obtaining Tax Lot 203798000 for habitat preservation.

### *Referral Projects for Other Groups/Agencies*

Referral Projects for other Groups/Agencies includes potential projects that do not fall within the defined scope of Clark County's CWP. This includes, but is not limited to, in-channel restoration, agricultural BMPs, fish-passage barrier removals, and invasive plant management. It also includes referrals for projects such as trash removal, stream culvert repairs/maintenance, and drainage projects. Referral Projects for other Groups/Agencies identified based on the results of the Feature Inventory are described in Table 19 and Table 20.

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**Table 19: Description of Potential Referrals to Other Groups/Agencies – Morgan Creek**

<b>ID</b>	<b>Basis for Project</b>	<b>Project Description</b>
RR-52	Culvert under NE 227th Avenue (north of NE 169th Street) is a fish passage barrier due to an estimated 2-foot drop height at the outlet and lack of streambed material in barrel.	Conduct additional barrier analysis and replace crossing and restore channel to facilitate fish passage.
RR-47 RR-49 RR-55 RR-61	Widespread invasive plant species within and immediately adjacent to the floodplain.	Eradicate blackberry; reestablish native undergrowth and canopy vegetation to shade out invasive plants.
RR-58	Small stream has been channelized downstream of the culvert crossing. The channel flows along the property line and appears to be incising due to lack of LWD or other energy dissipating features. Left bank and right bank is mowed just behind tree line. This is a potential source of nutrient loading and sediment contribution through channel erosion.	Develop a project to revegetate the riparian corridor with the cooperation of the landowner to reduce erosion and improve shading. Educate them on the importance of native riparian vegetation. Look into opportunities for channel stabilization using LWD.
RR-45 RR-57	Widespread invasive plant species within the floodplain upstream of culvert. Predominantly reed canary grass.	Eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.

**Table 20: Description of Potential Referrals to Other Groups/Agencies – Salmon Creek (RM 14.66)**

<b>ID</b>	<b>Basis for Project</b>	<b>Project Description</b>
RR-91 RR-92	Livestock have access to creek throughout this reach upstream of the culvert under the railroad tracks. Likely water quality issues.	Segregate livestock from riparian area and restore riparian vegetation. Investigate quality of agricultural runoff, and apply source control, develop off channel watering, and/or construct appropriate facilities to enhance water quality.
RR-93	Stream is piped several hundred feet across private property.	Upstream; remove culvert and reestablish native undergrowth and canopy vegetation through a large-scale revegetation project to enhance riparian and aquatic habitat. Downstream; eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.

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## Stormwater Management Recommendations

A number of general stormwater management measures should be implemented throughout Morgan Creek and Salmon Creek (RM 14.66) subwatersheds:

- Due to the agricultural nature of the assessment area, stormwater management recommendations should be closely coordinated with agricultural extension services, soil and water conservation districts, and other agencies that regularly work with farms and ranches. These agencies may already have educational and financial assistance programs available.
- Educate private landowners on importance of riparian buffers and native riparian vegetation for shading streams.
- Educate private landowners concerning importance of invasive plant removal, and suggest removal techniques.
- Encourage appropriate agricultural practices that emphasize soil and water conservation, intact riparian buffer areas, and reduction in nutrient load to streams.
- Post stream identification signs where roads cross streams. Repair or replace deteriorated signs if necessary.
- Do not overlook stormwater and agricultural runoff inputs to small tributary streams that were not surveyed as a part of this Feature Inventory. These inputs may be more numerous than originally anticipated and likely represent the most significant source of water quality impairment in the subwatershed.
- Protect first-order tributary streams from further stormwater impacts by creating stream buffers, establishing conservation easements, and eliminating existing stormwater and agricultural runoff inputs. Encourage reforestation of lower gradient headwaters.
- Consider conducting additional investigation to locate water quality problems in reaches that are dominated by agricultural land use. Numerous ponds are evident in the aerial photography, and lack of riparian vegetation is widespread.

## Physical Habitat Assessment

### Purpose

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

### Methods

Physical habitat measurements were made for a reach of Salmon Creek (Salmon 27, RM 21.3 to RM 22.3) by R2 Resource Consultants, Inc. (December 2004) for the Lower Columbia Fish Recovery Board. The project followed modified USFS Level II protocols.

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Limited physical data exist for Morgan Creek assessment area, and was not analyzed for this project.

### Results

The R2 Resource Consultants, Inc. (R2) report includes a good narrative summary of the habitat survey results, including figures and tables, some of which are presented here. The full report may be found on the CWP website at:

<http://www.clark.wa.gov/water-resources/documents-monitoring.html#strmac>

The Salmon 27 survey reach encompasses the upper portion of the Salmon Creek (RM 14.66) subwatershed. This survey reach is classified as a large, contained channel type. The reach has a map gradient of 1.4 percent. The channel is strongly controlled by bedrock. The lower section likely becomes semi-alluvial to alluvial, and has a lower gradient (0.5%). Habitat consists primarily of pools, which represents 49 percent of the survey reach habitat by length, followed by small riffle (40 percent), and lesser amounts of glide. The maximum depth of pools averages greater than 1.0 meter.

R2 noted that the dominant and subdominant substrate classes of streambed riffles are comprised of gravel (49 percent) and cobble (24 percent). The overall mean embeddedness level is 32 percent. Table 21 summarizes habitat evaluations based on Washington Conservation Commission and NOAA Fisheries Properly Functioning Condition standards.

**Table 21: Summary of Habitat Evaluations of Salmon Creek (Salmon 27 Survey Reach) Based on Washington Conservation Commission and NOAA Fisheries Properly-Functioning Condition Standards**

<b>Parameter</b>	<b>WCC<sup>1</sup></b>	<b>PFC<sup>2</sup></b>
% Pool by Surface Area	Fair	
Pool Frequency		Not properly functioning
Pool Quality	Good	Properly functioning
LWD	poor	Not properly functioning
Substrate	poor	Not properly functioning
Streambank Stability	good	Properly functioning
Water temperature		

<sup>1</sup> Available Ratings: Good; Fair; Poor

<sup>2</sup> Available Ratings: Properly Functioning; At Risk; Not Properly Functioning

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## Geomorphology Assessment

A geomorphology assessment was not conducted.

## Riparian Assessment

### Purpose

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

The need for riparian rehabilitation tends to be widespread and exceeds the scope and resources of the CWP mission of stormwater management. Therefore, potential riparian projects are usually referred to agencies such as the LCFRB, Lower Columbia Fish Enhancement Group (LCFEG), Clark Public Utilities, Fish First, 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). 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.

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## Results

Results are based primarily on the 2004 LCFRB Habitat Assessment for the Salmon Creek (RM 14.66) and Morgan 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, LWD recruitment potential and shade rating analyses were based on a qualitative review of 2007 orthophotographs.

### *Riparian (Large Woody Debris (LWD) Delivery)*

LWD recruitment potential frequency values as predicted by the Ecosystem Diagnosis and Treatment Model (EDT) for Salmon Creek (RM 14.66) and Morgan Creek subwatersheds are summarized in Table 22.

Within the Salmon Creek (RM 14.66) subwatershed, the assessment reaches include portions of the mainstems of Salmon Creek. Based on predicted LWD recruitment potential frequency, the mainstem of Salmon Creek is shown as having primarily "Fair" LWD recruitment potential (60% of reaches) followed by "Good" (24% of reaches) and "Poor" (16% of reaches) along the distance assessed.

A field surveyed reach of Salmon Creek (RM21.3 to RM 22.3) includes an approximately 0.75 mile reach of "Low" LWD recruitment potential on the mainstem of Salmon Creek, starting at about NE 206<sup>th</sup> St, continuing upstream (south) to approximately 0.3 miles south of NE199th St

Within the Morgan Creek subwatershed, the assessment reaches include the mainstems of Morgan Creek, Mud Creek, and Baker Creek, as well as several unnamed tributaries to Morgan Creek. Based on predicted LWD recruitment potential frequency, the Morgan Creek subwatershed is shown as having primarily "Fair" LWD recruitment potential (55% of reaches) followed by "Poor" (23% of reaches) and "Good" (22% of reaches) along the distance assessed.

Figure 16 shows the Salmon Creek (RM 14.66) and Morgan Creek subwatersheds LWD delivery potential.

**Table 22: Large Wood Recruitment for Salmon Creek (RM 14.66) and Morgan Creek; EDT frequency based on 2002/2003 photo data sets (R2 Resource Consultants, Inc. 2004)**

Condition	Frequency	
	Morgan Creek	Salmon Creek (RM 14.66)
Good	22%	24%
Fair	55%	60%
Poor	23%	16%

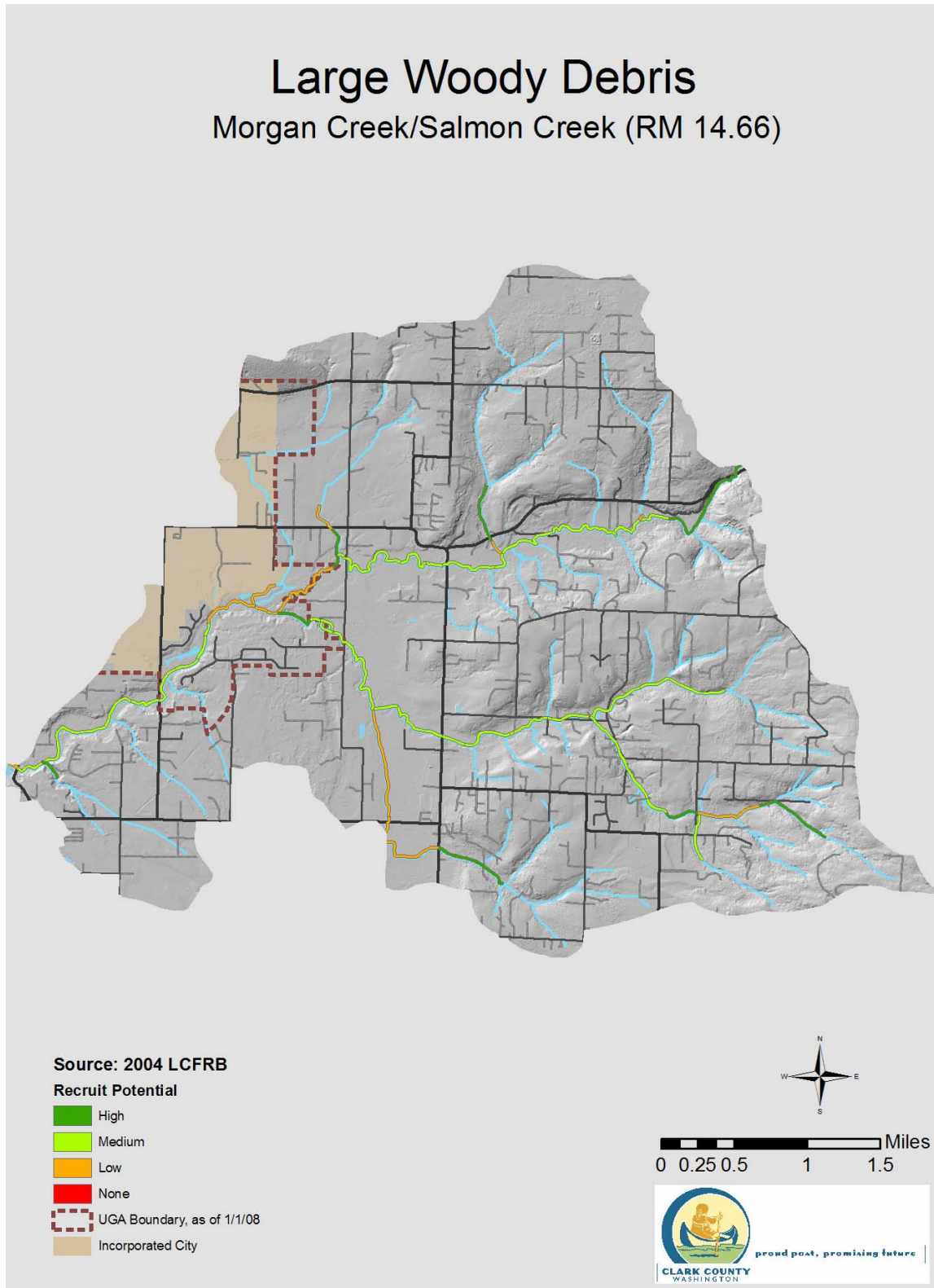


Figure 16: Salmon Creek and Morgan Creek LWD Recruitment Potential (adapted from Lower Columbia Fish Recovery Board, 2004)



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### *Shade*

The Salmon Creek (RM 14.66) and Morgan Creek subwatersheds shade ratings from the 2004 LCFRB Habitat Assessment are illustrated on Figure 17. Within the Salmon Creek (RM 14.66) subwatershed, the survey covered the mainstem of Salmon Creek and several unnamed tributaries. The majority of the mainstem of Salmon Creek within the Salmon Creek (RM 14.66) subwatershed has shade levels in the 10 percent to 30 percent range. Higher shade levels ranging from 30 percent to 55 percent were observed within the approximately 1 mile reach immediately downstream of its confluence with Rock Creek. Tributaries to Salmon Creek within this subwatershed generally scored higher for shade, with values of 80 percent for the majority of reach length examined.

The width of some of the reaches of the mainstem of Salmon Creek are estimated to be wide enough to allow solar radiation to reach the channel even if the riparian zone contained mature forest stands growing immediately adjacent to the channel. However in narrower reaches, such as “Salmon 27” which is included in the Salmon Creek (RM 14.66) subwatershed, it is estimated that the reach would receive “considerable” shade if mature forest stands existed adjacent to the channel (R2 Resource Consultants, Inc. 2004).

Within the Morgan Creek subwatershed, shade ratings were in the range of 10 percent to 55 percent in the surveyed reaches of the mainstem of Morgan Creek. Of these, the lower shade ratings are found within an approximately 1.5 mile reach immediately downstream (west) of NE 182<sup>nd</sup> Ave (M2 and M3a, both 10%). Higher shade ratings for Morgan Creek are found upstream of NE 182<sup>nd</sup> Ave, as well as near the confluence with Salmon Creek.

Also within the Morgan Creek subwatershed, shade ratings for Mud Creek were 10 percent downstream (west) of NE 182<sup>nd</sup> Ave, and 80 percent upstream (east) of NE 182<sup>nd</sup> Ave.

The LCFRB habitat assessment for the Salmon Creek (RM 14.66) and Morgan 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 14.66) and Morgan Creek subwatersheds include riparian forest restoration in areas degraded by residential, recreational, and agricultural land use, disconnecting or shading ponds, and the acquisition of existing forest land for future protection of streams and watersheds.

### Potential Projects

Potential riparian restoration projects for the Salmon Creek (RM 14.66) subwatershed were identified from review of the 2004 LCFRB Habitat Assessment report, along with the 2002 Salmon Creek Limiting Factors Analysis, 2002 Salmon Creek Watershed Analysis and 2005 NE 167<sup>th</sup> Ave to NE Risto Road Temperature Survey (Schnabel 2005), with orthophotography analysis in areas not formally surveyed. Recommended actions included improving riparian condition and large woody debris recruitment potential by hardwood conversion, conifer release, or riparian plantings along the mainstem of Salmon Creek (R2 Resource Consultants, Inc. 2004).

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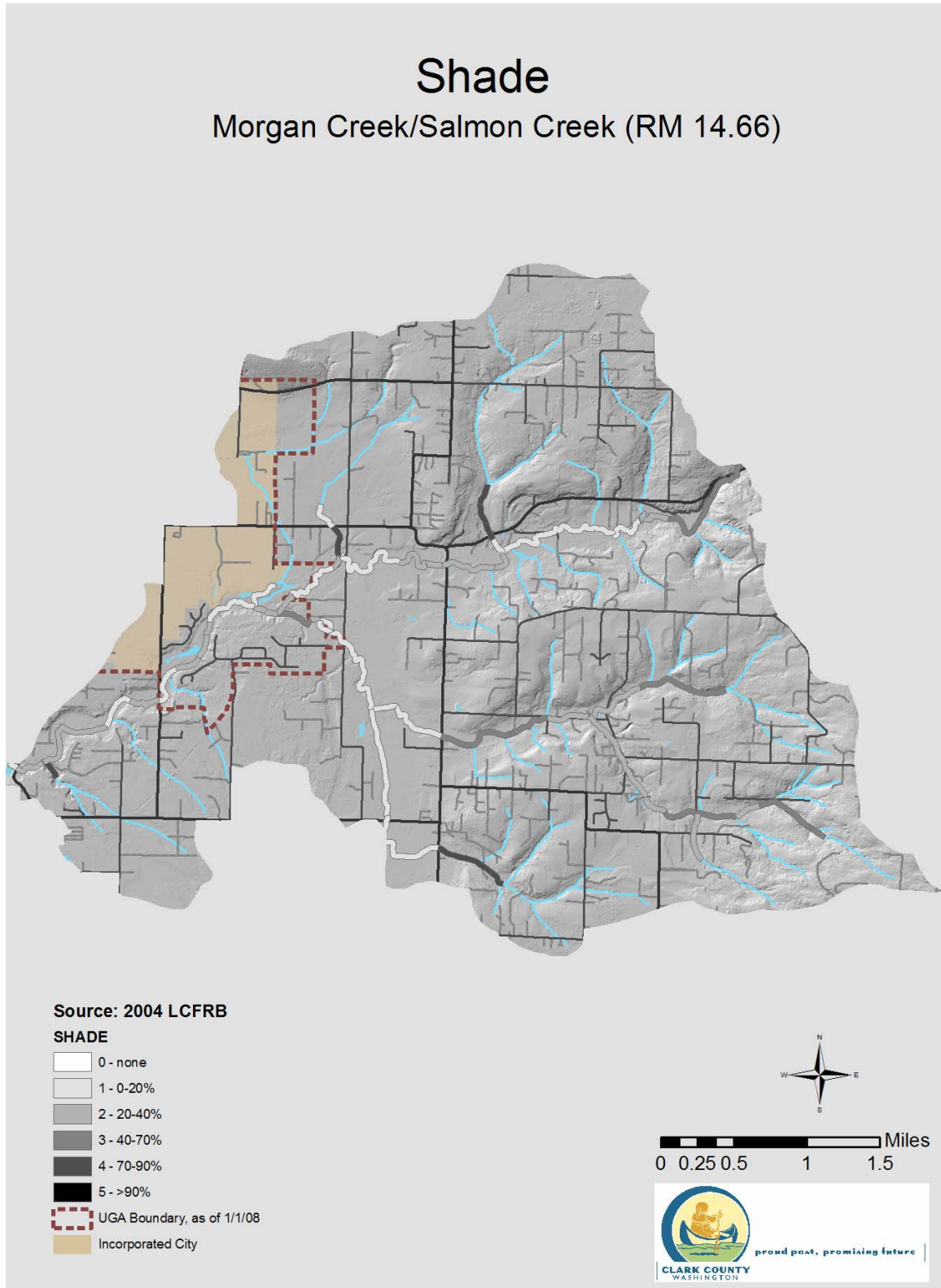
Recommended restoration projects also included restoring the riparian canopy along sections of the mainstem of Salmon Creek. Specific reaches are identified in Schnabel 2005, and are not listed here. These reaches were referred to CPU in 2005; several were incorporated into CPU project planning and grant applications.

Potential riparian restoration projects for the Morgan Creek subwatershed were identified from review of the 2004 LCFRB Habitat Assessment Report, along with orthophotography analysis in areas not formally surveyed. Recommended restoration projects include restoring the riparian canopy along reaches of Morgan Creek and Mud Creek that currently lack adequate vegetation to provide shading and LWD recruitment. Specific reaches may include the approximately 1.5 mile reach of Mud Creek beginning at NE 182<sup>nd</sup> Ave heading downstream (west), and the approximately 1 mile reach of Morgan Creek beginning at NE 182<sup>nd</sup> Ave heading downstream (west).

Most of the riparian areas within the Salmon Creek (RM 14.66) and Morgan Creek subwatersheds are on privately owned land. One exception may be at the confluence of Morgan Creek and Salmon Creek (Parcel # 194601-000; see Table 23), which is in the Capital Planning database (OS-22). That parcel contains mature forest vegetation which contributes moderate levels of shade, and Low to High LWD recruitment. Preservation of this forested property will help ensure continuation of those functions.

**Table 23: Tax Exempt Parcels Overlapping Potential Riparian Restoration Areas**

<b>ASSR_SN</b>	<b>ASSR_AC</b>	<b>OWNER</b>	<b>PT1DESC</b>	<b>Description</b>
194601-000	Approx. 72.23 acres	Cedars Golf LLC (to be purchased by Clark County)	Prime Developable Ground	Preserve mature forest near the confluence of Morgan Creek and Salmon Creek; project identifier OS-22 in the Capital Planning database.



**Figure 17: Salmon Creek and Cougar Creek Shade Values (adapted from Lower Columbia Fish Recovery Board, 2004)**

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## Floodplain Assessment

A floodplain assessment was not conducted.

## Wetland Assessment

### Purpose

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

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

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

### Methods

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

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

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

### Results

Figure 18 shows potential wetland areas within the Morgan Creek and Salmon Creek (RM 14.66) subwatersheds based on data from the county wetlands atlas, including the Clark County wetland model, National Wetlands Inventory, and high-quality wetlands layer.

The Morgan Creek/ Salmon Creek (RM 14.66) subwatershed has large expanses of potential wetland areas associated with the Salmon and Morgan Creek riparian corridors and floodplain areas, large areas of sloped wetlands along base of the foothills (running north from Hockinson to Salmon Creek) and SE Battle Ground. There are also depressional wetlands in headwater areas of many minor tributaries and some isolated, locally closed, basins in the southwestern portion of the subwatershed (south of Brush Prairie and west of Hockinson). Mud and Morgan Creeks flow through a substantial portion of the sloped wetland areas near Hockinson. Table 24 shows the total area and proportion of wetland classes estimated to be present in the subwatershed.

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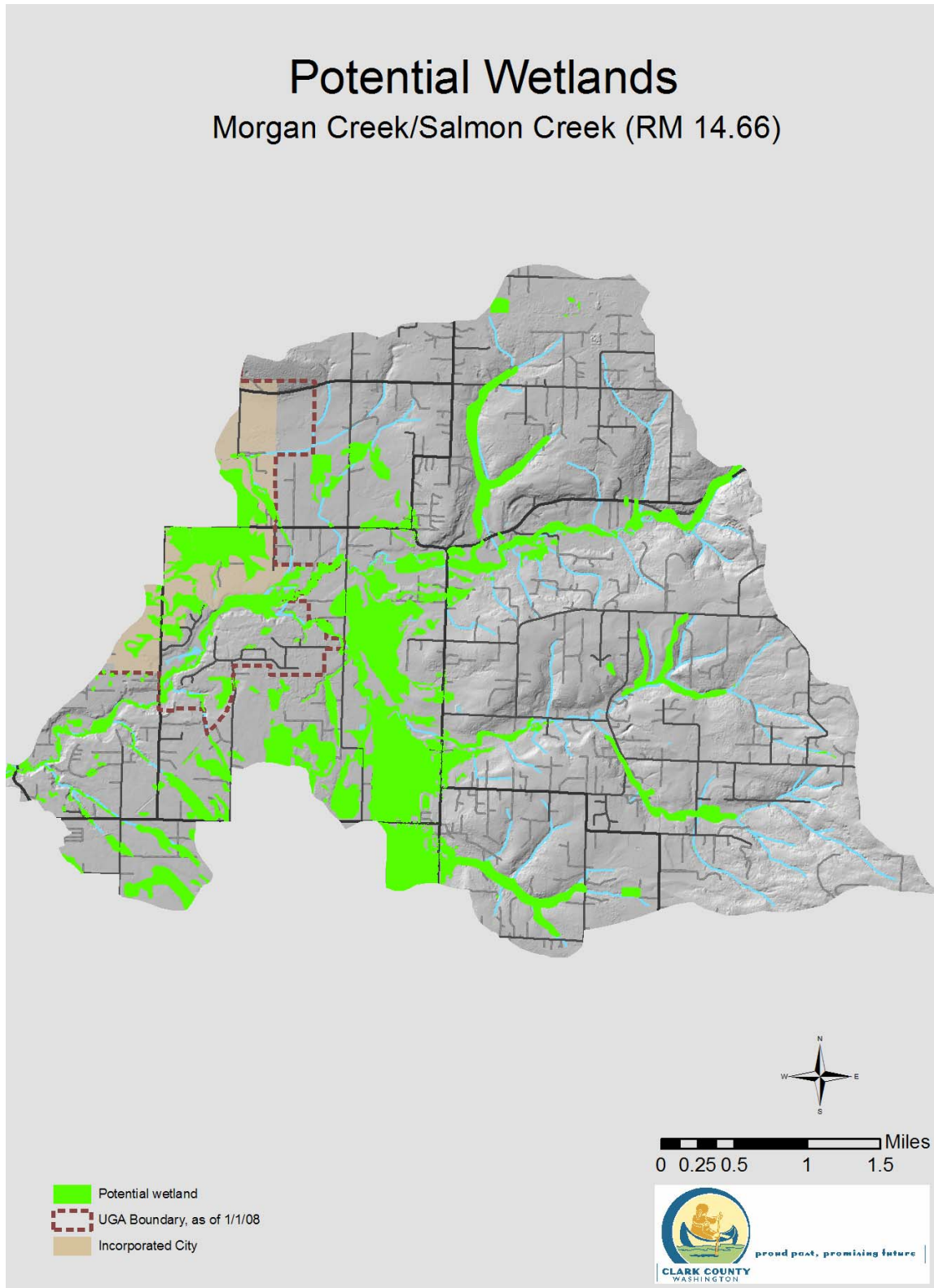
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**Table 24: Distribution of Wetlands by Hydrogeomorphic Class**

<b>HGM Class</b>	<b>Area (ac.)</b>	<b>% of Sub-basin*</b>	<b>% of total wetland</b>
Slope Wetlands	905	8%	59%
Depressional Wetlands	233	2%	15%
Riverine Wetlands	397	4%	26%
All Wetlands	1535	14%	

\*Subwatershed area 10,949 Ac.

A majority of the wetlands outside the stream floodplains have been cleared and partially drained for agricultural use. There is tremendous restoration potential; however there is very little publicly held or tax-exempt land containing wetlands in the subwatershed. There is potential for the County to encourage off-site wetland mitigation and development of mitigation banks to restore or enhance wetland functions near the Brush Prairie and Hockinson areas. Without a land acquisition program, there are limited opportunities for further public wetland restoration projects in this subwatershed.



**Figure 18: Morgan Creek/ Salmon Creek (RM 14.66) Creek Potential Wetlands**

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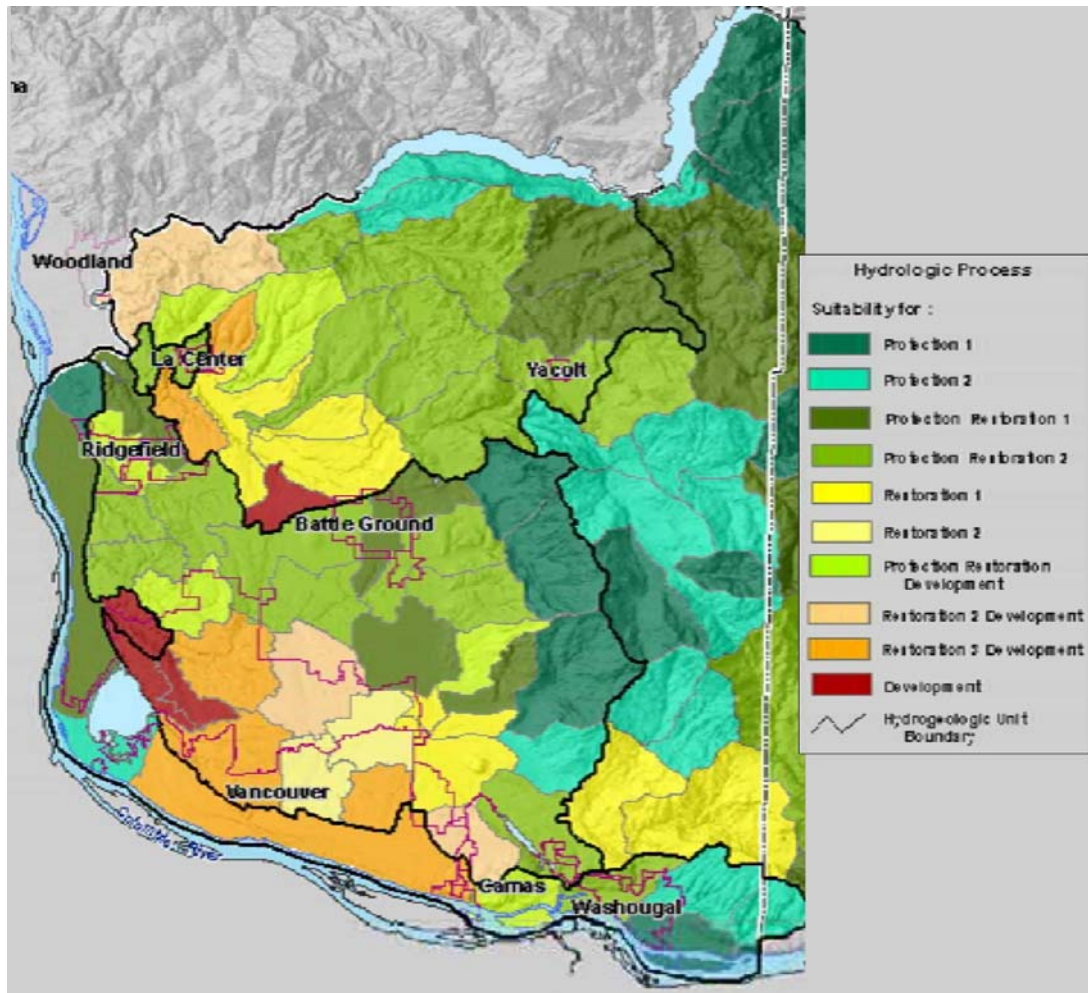
### *Draft Watershed Characterization*

The Washington Department of Ecology completed a prototype watershed assessment to assist in planning wetland and riparian habitat restoration and preservation projects. The Watershed Characterization and Analysis of Clark County (Washington Department of Ecology, 2009) may be found on the Ecology website at: [http://www.ecy.wa.gov/mitigation/docs/09-06-019\\_small.pdf](http://www.ecy.wa.gov/mitigation/docs/09-06-019_small.pdf)

Results pertaining to the Morgan Creek/ Salmon Creek (RM 14.66) subwatersheds are summarized below.

The Morgan Creek/ Salmon Creek (RM 14.66) 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, 2009).

Figure 19 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 19: Priority areas for protection and restoration of hydrologic processes (from Watershed Characterization and Analysis of Clark County (Ecology, 2009))**

In general, blue and 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, 2009).

Protection Restoration 2 (green) is the hydrologic process priority for the Morgan Creek/ Salmon Creek (RM 14.66) subwatersheds.



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## 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 multiple locations and varying frequencies, with little recent data available. Morgan Creek macroinvertebrate samples were collected in the lower portion of the watershed near NE 167<sup>th</sup> Avenue for Clark Public Utilities in 2001 (Clark Public Utilities, 2002), and at station MOR070 on the south side of NE 174<sup>th</sup> Street by the CWP in 2008. Samples were collected along the main stem within Salmon Creek (RM 14.66) for Clark Public Utilities (Clark Public Utilities, 2002) at Caples Road/NE 122<sup>nd</sup> Avenue in 1996 and at NE 142<sup>nd</sup> Avenue (lower portion of subwatershed) and NE 182<sup>nd</sup> Avenue (middle portion of subwatershed) in 2001.

### Results

Morgan Creek’s total B-IBI score of 32 in 2001 and Station MOR070’s 2008 score of 36 places it in the middle to upper portion of the moderate biological integrity category. Salmon Creek’s

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(RM 14.66) total B-IBI scores for 1996 of 26 and two 2001 scores of 30, place it in the lower half of the moderate biological integrity category.

Table 25 shows one low, five moderate, and four high scores among the average of results for individual metrics at station MOR070. The low score for the number of intolerant taxa metric suggests signs of degraded water and habitat quality since intolerant taxa are among the first organisms to disappear as human disturbances increase (Fore, 1999).

**Table 25: Station MOR070 Annual Macroinvertebrate Community Metrics and Total Scores from 2008**

B-IBI Metrics	MOR070 2008		
	Value	Score	Category
Total number of taxa	45	5	high
Number of Mayfly taxa	7	3	moderate
Number of Stonefly taxa	5	3	moderate
Number of Caddisfly taxa	9	3	moderate
Number of long-lived taxa	3	3	moderate
Number of intolerant taxa	1	1	low
Percent tolerant taxa	16.2	5	high
Percent predator taxa	10.5	3	moderate
Number of clinger taxa	29	5	high
Percent dominance (3 taxa)	42.0	5	high
Summary of avg. metric scores		36	moderate

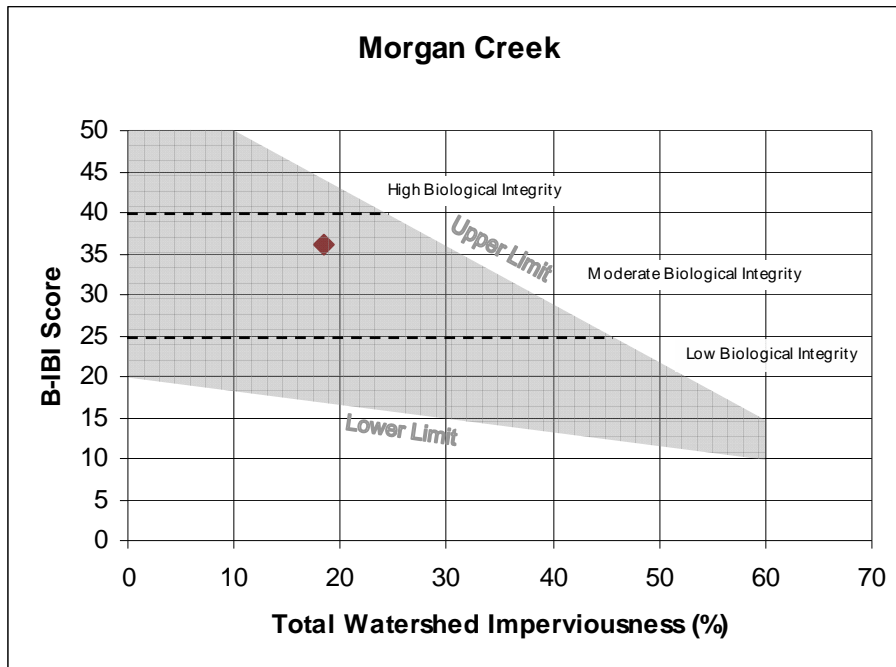
Booth et al. (2004) found that there is a wide but well defined range of B-IBI scores for most levels of development, but observed overall that B-IBI scores decline consistently with increasing watershed total impervious area (TIA).

By comparing Morgan Creek and the Salmon Creek mainstem within Salmon Creek (RM 14.66) 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.

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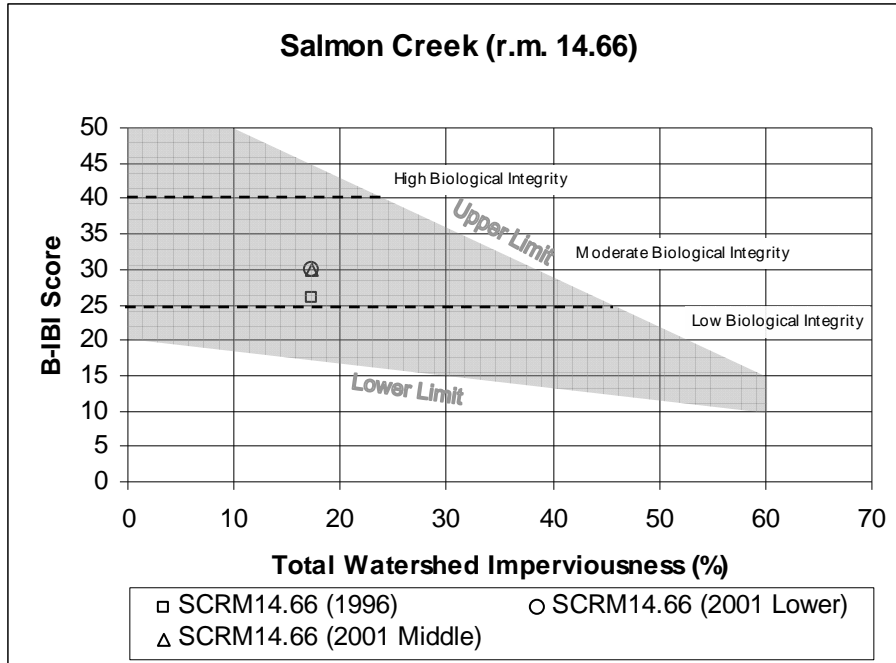
Figure 20 shows that the 2008 Station MOR070 B-IBI score is in the upper third of the range of expected scores (estimated 2000 Total Impervious Area from Wierenga, 2005).

Given that Morgan Creek's B-IBI score falls somewhat below the maximum possible for subwatersheds with 18 percent impervious area, there may be opportunities to improve biological integrity by improving habitat and stream conditions.



**Figure 20: 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. Marker indicates Total B-IBI score at Station MOR070 in 2008, versus estimated 2000 subwatersheds TIA.**

Figure 21 shows that B-IBI scores within Salmon Creek (RM 14.66) are mostly in the middle third of the expected range of scores (estimated 2000 Total Impervious Area from Wierenga, 2005). With B-IBI scores falling toward the lower end of the typical range for subwatersheds with about 17 percent impervious area, Salmon Creek in this area significantly underperforms given its moderate levels of TIA. It is likely that factors other than impervious area are contributing to the low scores, and biological integrity could probably be increased by improving habitat and stream conditions.



**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 stations within the SCRM14.66 subwatershed (Sample year and relative location within subwatershed) for particular years, versus estimated 2000 subwatersheds TIA.

### Management Recommendations

The upper moderate (Morgan Creek) and lower moderate (Salmon Creek (RM 14.66)) biological integrity scores suggest management strategies to rehabilitate impaired habitat and minimize water quality impacts are needed to maintain or improve biological integrity. These strategies might include protecting forested riparian areas and rehabilitating those that are impaired, promoting forestry best management practices, increasing overall forest cover, and minimizing sediment loading especially from near stream agricultural use and development runoff.

### 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 14.66) and Morgan Creek subwatersheds is mapped from existing GIS information in the WDFW SalmonScape database, and is available at <http://wdfw.wa.gov/mapping/salmonscape/>

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

- WDFW passage barrier database.
- 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 available evidence suggests that anadromous fish use within the Salmon Creek (RM 14.66) subwatershed includes Coho salmon and winter steelhead (Figure 22 and Figure 23).

SalmonScape also identifies the presumed presence of fall Chinook within the mainstem of Salmon Creek (Figure 24).

The Morgan Creek subwatershed also contains Coho and winter steelhead, and fall Chinook are presumed present within the lower reaches of Morgan Creek. Chinook presence further upstream is likely constrained by the species biological preference to spawn in larger, lower gradient waters.

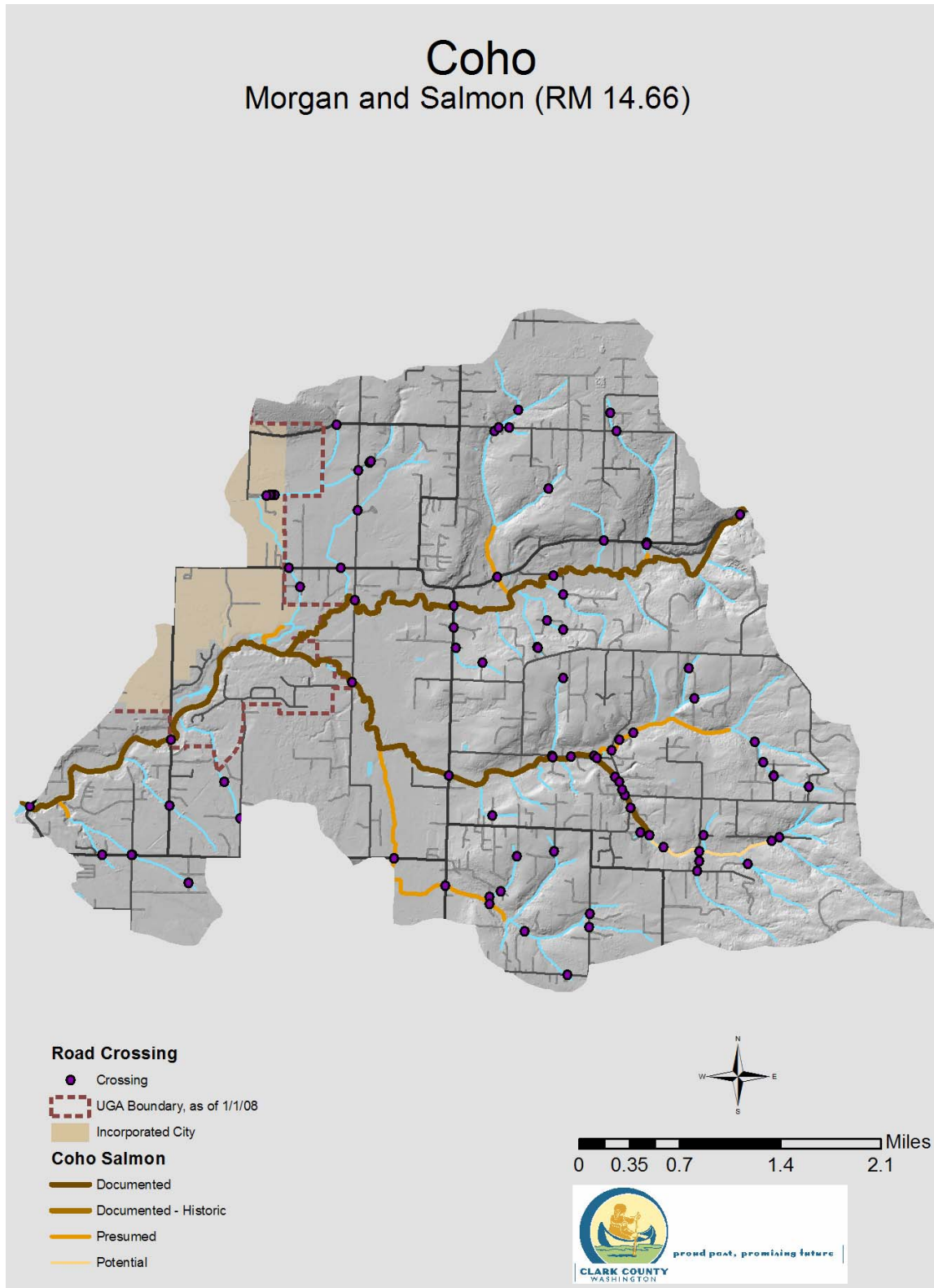


Figure 22: Salmon Creek (RM 14.66) and Morgan Creek Fish Distribution and Barriers

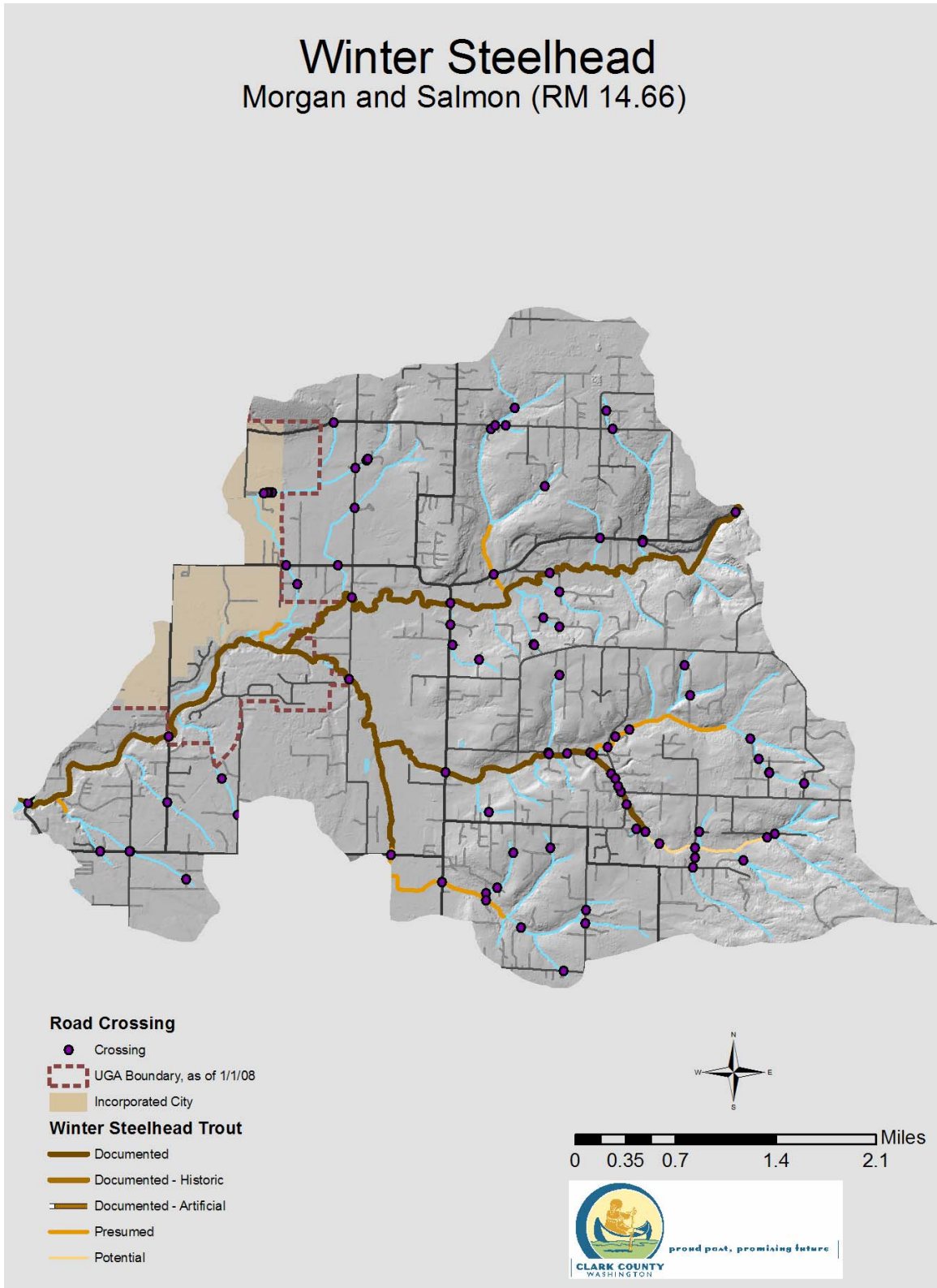


Figure 23: Salmon Creek (14.66) and Morgan Creek Fish Distribution and Barriers

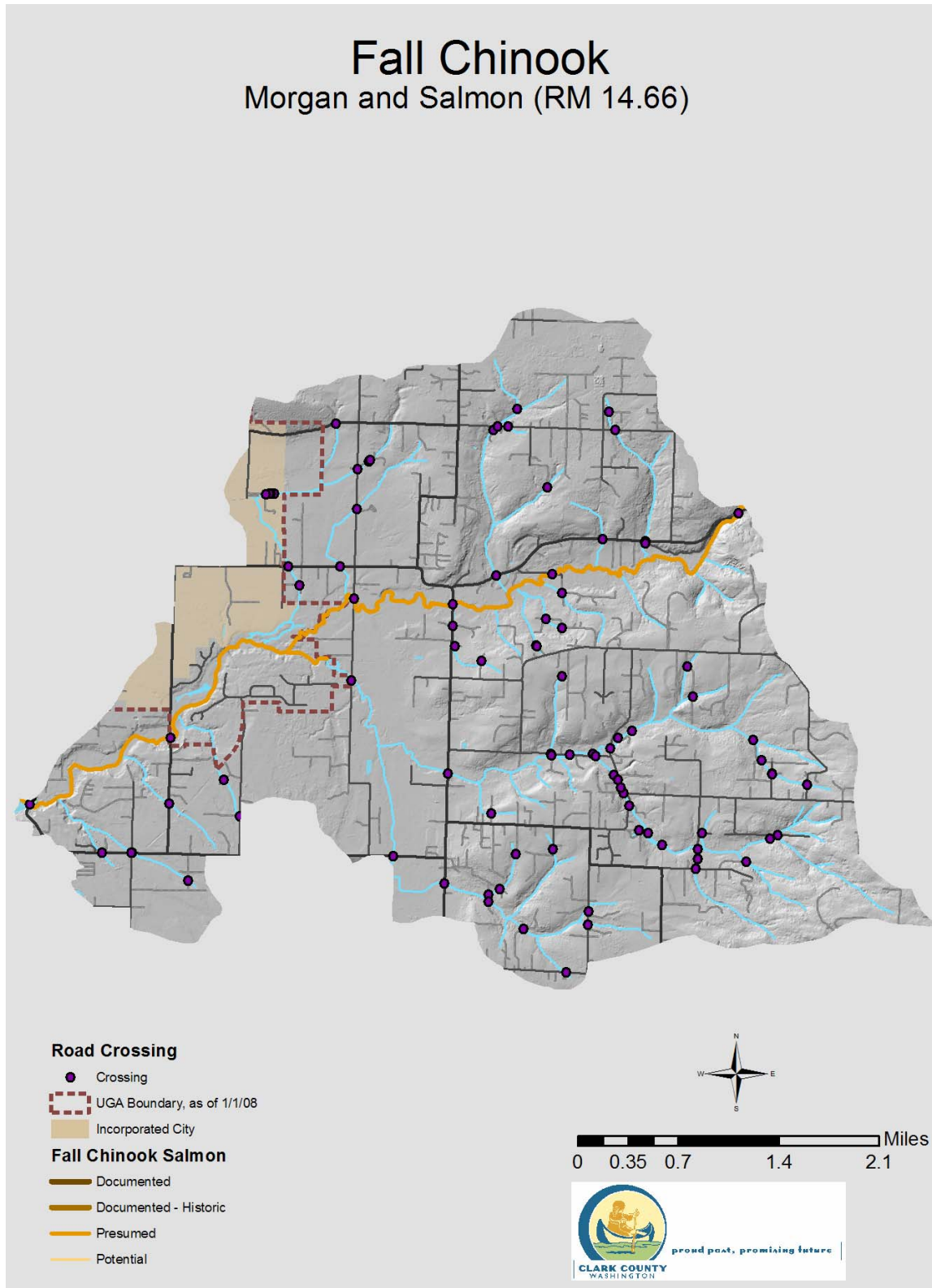


Figure 24: Salmon Creek (14.66) and Morgan Creek Fish Distribution and Barriers



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### Barriers

The WDFW barrier database provides the most complete assessment of barriers in the Salmon Creek (RM 14.66) and Morgan Creek subwatersheds (Figure 22, Figure 23, and Figure 24).

There is one mapped partial barrier within a Morgan Creek tributary. The barrier exists due to the presence of four successive push-up dams within the creek in close proximity to each other. A visual inspection of these dams revealed they are significant enough to be total barriers to anadromous fish passage. The dams have created in-stream ponds that are periodically stocked with rainbow trout for private fishing.

The SalmonScape data also show the replacement of four previous barriers along a tributary to Morgan Creek near NE 174<sup>th</sup> Street and Baker Creek Road. The data suggest fish passage was restored at the NE 174<sup>th</sup> Street crossing and three private driveway crossings.

### Recommendations

Removal of the one barrier within the Morgan Creek subwatershed is considered a low priority for anadromous fish. The push-up dams are all located on private property and were constructed to provide private fishing opportunities, so landowner cooperation could be problematic. All four dams would need to be removed in order to provide any tangible upstream access. Finally, given their location in the upper portion of the subwatershed, the amount of additional upstream habitat available for spawning would not be significant.

### **Hydrologic and Hydraulic Models**

Hydrologic and Hydraulic Models were not created.



## 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 chapters and identifies overall stormwater-related problems.

### *Coordination with Other Programs*

The Washington Department of Ecology coordinates local agency actions as part of ongoing TMDL implementation and adaptive management. The Clean Water Program actively participates in TMDL development and implementation, and coordinates on an ongoing basis with the Lower Columbia Fish Recovery Board, Clark County Legacy Lands, and Vancouver-Clark Parks and Recreation. 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. The Clean Water Program regularly communicates with all of these entities.

One major road improvement project is included in the 2010 through 2015 Clark County Transportation Improvement Program (Chelatchie Prairie Rail Trail; WO Number: 361212).

### *Broad-Scale Characterization*

The study area comprises two subwatersheds in rural upper Salmon Creek: Morgan Creek and Salmon Creek (RM 14.66). Salmon Creek (RM 14.66) subwatershed groups a number of smaller, unnamed streams draining to Salmon Creek. The area rises from the relatively level Willamette Valley floor to the lowermost foothills of the Cascade Mountains, often called the Troutdale Bench in reference to the underlying Troutdale Formation gravel deposits. Land use is rural with fairly dense rural residential areas such as Hockinson in Morgan Creek subwatershed. The

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lowermost part of Salmon Creek (RM 14.66) is within Battle Ground's Urban Growth Area and the city.

The study area has three principal topographic areas: Salmon Creek flows through the middle of the area forming a significant flood plain. Above this is a flat surface underlain by Ice Age Cataclysmic Flood Deposits at about 270 to 300 foot elevation. To the east, the Troutdale Bench forms a low ridge cut by canyons. The Troutdale Bench slopes westward, with elevation generally between 500 feet the west side and 700 feet on the east margin. The Salmon Creek floodplain is approximately 210 feet above sea level at its confluence with Woodin Creek and 320 feet above sea level where it exits a canyon below Rock Creek. Except for Morgan Creek, all of the tributary streams that flow into Salmon Creek in this study area lack floodplains.

Overall, 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 on the margin of non-functioning. Both subwatersheds include areas of forest and low density rural development. Forest cover tends to be on steeper slopes and in stream valleys, with flatter areas historically cleared for agriculture and home sites. Based on the latest Clark County Comprehensive Plan, the estimated future subwatershed EIA for both subwatersheds is expected to change little in the near term.

## *Water Quality Assessment*

Multiple stream segments within this assessment area are included on the 2008 303(d) Ecology list of impaired water bodies. Salmon Creek, within the Salmon Creek (RM 14.66) subwatershed, is Category 5 listed (polluted waters that require a TMDL) for pH; Category 4a listed (polluted waters with an approved TMDL) for fecal coliform bacteria, and Category 2 listed (Waters of Concern) for temperature and dissolved oxygen. There are no specific listings for Morgan Creek.

A relatively lengthy dataset (2002-2009) is available for mainstem Salmon Creek at the lower end of this assessment area, as Clark County maintains a long-term station on Salmon Creek (Station SMN050; at Caples Road) k. A more limited, one-year dataset (2007 through 2008) exists for the Morgan Creek subwatershed.

General water quality in this assessment area is good in Salmon Creek and fair to good in Morgan Creek. In Salmon Creek (Station SMN050), trend analysis suggests that turbidity sub-index scores are decreasing over time (indicating increasing turbidity). Ecology (Collyard, 2009), found decreasing trends in fecal coliform, nitrate-nitrite, and total phosphorus concentration.

Fecal coliform bacteria are a concern throughout these subwatersheds. Based on monthly data from 2005 - 2007, geometric mean fecal coliform concentrations and 90<sup>th</sup> percentile values declined sharply in this reach of Salmon Creek when compared to values from the 1995 TMDL. However, neither subwatershed in this assessment area is in full compliance with state criteria.

Continuous stream temperature monitoring (2003) in Salmon Creek and in Morgan Creek indicated that neither stream met the current state criterion (7-day moving average of daily maximum temperatures) of 60.8 degrees F. Results of this study showed that the median

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temperature increased by 5 degrees F in this reach of Salmon Creek. This significant jump led to a follow-up study in 2005 to determine possible causes. Primary reasons for the increase appear to be lack of riparian canopy over the Salmon Creek mainstem and the presence of in-line ponds on numerous small tributaries. Tributaries with in-line ponds were shown to contribute water that was much warmer than tributaries with no in-line ponds.

### *Drainage System Inventory and Condition*

The drainage system inventory is complete in this assessment area. Significant stormwater infrastructure inventory updates took place in 2008 and 2009; 4495 new features were added. There are 5727 total stormwater infrastructure features mapped in this assessment area.

Retrofit evaluations of public stormwater facilities in this assessment area did not generate any potential projects.

Inspection and maintenance evaluations found that the majority of facility objects were in compliance with Clark County maintenance standards.

Off-site assessments were conducted at 16 priority outfalls discharging to critical areas and generated one referral to Operations to stabilize the channel downstream of outfall.

### *Illicit Discharge Screening*

Illicit Discharge Detection and Elimination Screening was not conducted.

### *Stream Reconnaissance Feature Inventory*

A limited feature inventory, restricted to road reconnaissance survey only, was conducted within the assessment area. A total of 31 road crossing points were assessed. Fifteen potential opportunities were identified in five categories and included culvert analysis, property acquisition opportunity, invasives removal and reestablishing native vegetation.

### *Physical Habitat*

Physical habitat measurements in the upper portion of Salmon Creek (RM 14.66) were made in 2004 (R2 Resource Consultants, Inc., 2004) on the mainstem of Salmon Creek (RM 21.3 to RM 22.3).

The survey reach has a gradient of 1.4 percent and is strongly controlled by bedrock. Habitat consists primarily of pools, which represents 49 percent of the survey reach habitat by length, followed by small riffle (40 percent), and lesser amounts of glide. Overall mean embeddedness level was 32 percent, with the dominant and subdominant substrate classes of streambed riffles comprising of gravel (49 percent) and cobble (24 percent). Pool frequency, LWD, and substrate were rated not properly functioning in the survey reach. Streambank stability and pool quality was rated as properly functioning in the survey reach.

### *Geomorphology and Hydrology*

A geomorphology assessment was not conducted.

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## *Riparian Assessment*

The most reliable riparian assessment data for the study area's two subwatersheds are from the 2004 LCFRB Habitat Assessment. Their mainstem streams were both included in this assessment, while more recent qualitative assessments were made from orthophotos for their tributaries. In both Salmon Creek and Morgan Creek, LWD recruitment potential is fair for the mainstem areas.

Overall, shade levels for the Salmon Creek (RM 14.66) subwatershed were low, from 10 to 30 percent, with some areas of greater shade. Within the Morgan Creek subwatershed, shade ratings were in the range of 10 percent to 55 percent in the surveyed reaches of the mainstem and lower shade ratings found within an approximately 1.5 mile reach immediately downstream (west) of NE 182<sup>nd</sup> Ave. The LCFRB habitat assessment indicated that the majority of the reaches in both subwatersheds are currently off-target with respect to the State Forest Practices shade/elevation screen standards.

## *Wetland Assessment*

The Morgan Creek and Salmon Creek (RM 14.66) subwatersheds have large expanses of potential wetland areas associated with the Salmon and Morgan Creek riparian corridors, floodplain areas, and large areas of sloped wetlands along base of the foothills. There are also depressional wetlands that are the headwaters to many minor tributaries and some isolated, locally closed, basins in the southwestern portion of the subwatershed.

A majority of the wetlands outside the stream floodplains have been cleared and partially drained for agricultural use. There is significant restoration potential for the County to encourage off-site wetland mitigation and development of mitigation banks to restore or enhance wetland functions near the Brush Prairie and Hockinson areas.

Ecology's watershed characterization of Clark County places the assessment area in a category suitable for Protection Restoration 2. Under this category, these areas have higher levels of importance for watershed processes and limited impairment and should be considered for protection.

## *Macroinvertebrate Assessment*

Based on samples collected in 2001 and 2008, biological integrity is moderate throughout the Morgan Creek assessment area. In Salmon Creek (RM 14.66), samples collected in 1996 and 2001 also indicate moderate biological integrity.

B-IBI scores for both Morgan Creek and Salmon Creek (RM 14.66) fall near the middle of the typical range for subwatersheds with about 18 percent impervious area. Thus it is likely that factors other than impervious area are contributing to the relatively low scores. It is likely that biological integrity could be increased by improving habitat and stream conditions, particularly in the Salmon Creek (RM 14.66) subwatershed which significantly underperforms given its relatively moderate TIA.

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## *Fish Use and Distribution*

The available information suggests that anadromous fish use in the assessment area includes Coho salmon, winter steelhead, and the presumed presence of fall Chinook within a small portion of the mainstem of Salmon Creek and lower reaches of Morgan Creek.

There is one mapped partial barrier within a Morgan Creek tributary. The barrier exists due to the presence of four successive push-up dams within the creek in close proximity to each other. A visual inspection of these dams revealed they are significant enough to be total barriers to anadromous fish passage.

## Recently Completed or Current Projects

The CWP Capital Planning Database lists one potential stormwater project in this assessment area. The Salmon Creek Forested Upland Preservation includes property acquisition of a forested 80 acre parcel containing the confluence of Salmon Creek and Morgan Creek. This project is complete; the parcel has been purchased by Clark County under the Legacy Lands program.

One county road project, Chelatchie Prairie Rail Trail, is located in this assessment area under the Public Works 2010 through 2015 Transportation Improvement Program.

## 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 illicit discharge 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

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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

No projects of this type were identified.

### Potential Stormwater Capital Projects

#### Stormwater Facility Capital Improvement Projects

ID	Basis for Project	Project Description	Action
<b>Morgan Creek</b>			
RR-46	Drainage receives untreated stormwater from roads; potential source of water quality impairments.	Investigate the feasibility of constructing facility in right of way to treat stormwater runoff for water quality improvement.	Refer to CWP Capital Planning
OS-172 OS-173	Two potential projects:  Large parcels with favorable topography and hydrology for construction of stormwater facility. Drainage receives untreated stormwater from roads; potential source of water quality impairments.	Investigate the feasibility of obtaining properties (Tax lot 203805000, 204104000) and constructing facilities to treat stormwater runoff for water quality improvement.	
OS-174 OS-175 OS-176	Three potential projects:  Large parcels with favorable topography and hydrology for large scale wetland creation/ enhancement projects. Drainages receive untreated stormwater from roads; potential source of water quality impairments.	Investigate the feasibility of obtaining properties (Tax lot 20379400, 204261000, and 194609000) and developing wetland complexes for habitat enhancement and/or construction of facilities to treat stormwater runoff for water quality improvement.	



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<b>Salmon Creek (RM 14.66)</b>			
OS-177 OS-178 OS-179 OS-180 OS-181 OS-182	Six potential projects:  Large parcels with favorable topography and hydrology wetland creation, reforestation, and riparian enhancement projects. Drainages receive untreated stormwater from roads; potential source of water quality impairments.	Investigate the feasibility of obtaining properties (Tax lot 195100000, 191986000, 202132000, 201840000, 201828016, and 191982000) and developing wetland complexes for habitat enhancement and/or possible construction of facilities to treat stormwater runoff for water quality improvement.	Refer to CWP Capital Planning
OS-183 OS-184	Two potential projects:  Large parcels with favorable topography and hydrology for wetland creation, reforestation, and riparian enhancement projects. Drainages receive agriculture runoff; potential source of water quality impairments.	Investigate the feasibility of obtaining properties (Tax lot 191908000 and 192003000) and developing wetland complexes for habitat enhancement and/or construction of facilities to treat stormwater runoff for water quality improvement.	
OS-185	Large parcel with favorable topography and hydrology for construction of stormwater facility. Drainage receives untreated stormwater from roads; potential source of water quality impairments.	Investigate the feasibility of obtaining property (Tax lot 195101000) and construction of facility to treat stormwater runoff for water quality improvement.	
RR-90	Small eroding gully drains stormwater from ditch source in the direction from railroad tracks on Clark Public Utilities owned property.	Investigate the feasibility of construction of facility to treat stormwater runoff for water quality improvement. Remove culvert as flows daylight under 159th; work with landowner to fence off livestock access.	

### Stormwater Infrastructure Maintenance CIPs

ID	Basis for Project	Project Description	Action
<b>Morgan Creek</b>			
RR-103	18 inch diameter concrete culvert under NE Risto Road is being undercut by stormwater flow. Flow is piping under culvert and not entering culvert. Road may be compromised in the future if not corrected.	Repair or replace with larger diameter culvert that is adequate to stormwater flow.	Refer to Public Works Operations

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## Stormwater Class V Underground Injection Control (UIC) Projects

No projects of this type were identified.

## Habitat Rehabilitation/Enhancement Projects

ID	Basis for Project	Project Description	Action
<b>Morgan Creek</b>			
OS-186 OS-187 OS-188 OS-189 OS-190 OS-191	Six potential projects:  Large parcels with favorable topography and hydrology for wetland creation/enhancement projects. Located downstream of large agricultural areas and other potential sources of water quality impairments.	Investigate the feasibility of obtaining properties (Tax lot 203785000, 204018015, 205171000, 204698000, 204709000, and 204231000) and developing wetland complexes for habitat enhancement and water quality improvement.	Refer to CWP Capital Planning
OS-192	Large County-owned parcel favorable for a reforestation project.	Investigate the feasibility of restoring/enhancement of riparian habitat and reforesting parcel for stormwater mitigation.	
OS-194 OS-195 OS-196	Three project opportunities:  Large properties with favorable topography and hydrology for large scale riparian enhancement and reforestation projects.	Investigate the feasibility of obtaining properties (Tax lot 229195000, 192002000, 201657000) and restoration/enhancement of riparian habitat, reforesting parcel for stormwater mitigation.	

## Property Acquisition for Habitat Preservation

ID	Basis for Project	Project Description	Action
<b>Morgan Creek</b>			
RR-51	Large parcel with intact habitat located in headwater area.	Investigate the feasibility of obtaining property (Tax Lot 203798000 and 20379900) for habitat preservation.	Refer to CWP Capital Planning
OS-193	Large parcel with intact riparian habitat.	Investigate the feasibility of obtaining property (Tax lot 204315000) for habitat preservation.	
<b>Salmon Creek (RM 14.66)</b>			
RR-51	Large parcel with intact habitat located in headwater area.	Investigate the feasibility of obtaining property (Tax lot 201438000) for habitat preservation.	Refer to CWP Capital Planning
OS-197	Large parcel with intact riparian habitat with Salmon Creek frontage.	Investigate the feasibility of obtaining property (Tax lot 201179000) for habitat preservation.	

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### Follow-up Activities for Referral within CWP

#### Private Stormwater Facilities Maintenance

No projects of this type were identified.

#### Public Works Stormwater Infrastructure Maintenance

ID	Basis for Project	Project Description	Action
<b>Morgan Creek</b>			
OS-171	Erosion issues downstream of outfall	Stabilize bank to prevent further erosion	Refer to Public Works Operations

#### CWP Outreach/Technical Assistance

ID	Basis for Project	Project Description	Action
<b>Morgan Creek</b>			
RR-47 RR-49 RR-55 RR-61	Four potential projects:  Widespread invasive plant species within and immediately adjacent to the floodplain.	Eradicate blackberry; reestablish native undergrowth and canopy vegetation to shade out invasive plants.	Refer to DES Outreach
RR-58	Small stream has been channelized downstream of the culvert crossing. The channel flows along the property line and appears to be incising due to lack of LWD or other energy dissipating features. Left bank and right bank is mowed just behind tree line. This is a potential source of nutrient loading and sediment contribution through channel erosion.	Revegetate riparian corridor to reduce erosion and improve shading. Educate landowner on the importance of native riparian vegetation. Possible opportunity for channel stabilization using LWD.	
RR-45 RR-57	Two potential projects:  Widespread invasive plant species within the floodplain upstream of culvert. Predominantly reed canary grass.	Eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.	

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<b>Salmon Creek (RM 14.66)</b>			
RR-91 RR-92	Two potential projects:  Livestock have access to creek throughout this reach upstream of the culvert under the railroad tracks. Likely water quality issues.	Exclude livestock from riparian area and restore riparian vegetation. Investigate quality of agricultural runoff, and apply source control, develop off channel watering, and/or construct appropriate facilities to enhance water quality.	Refer to DES Outreach
RR-93	Stream is piped several hundred feet across private property.	Upstream; remove culvert and reestablish native undergrowth and canopy vegetation to enhance riparian and aquatic habitat. Downstream; eradicate reed canary grass. Reestablish native undergrowth and canopy vegetation on floodplain to shade out invasive plants and enhance riparian habitat.	

### CWP Infrastructure Inventory

No projects of this type were identified.

### CWP Illicit Discharge Screening

No projects of this type were identified.

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

<b>ID</b>	<b>Basis for Project</b>	<b>Project Description</b>	<b>Action</b>
<b>Morgan Creek</b>			
RR-52	Culvert under NE 227th Avenue (north of NE 169th Street) is a likely fish passage barrier due to an estimated 2-foot drop height at the outlet and lack of streambed material in barrel.	Conduct additional barrier analysis; add to fish passage barrier database.	Refer to WDFW

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## 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

- Mapping complete for existing storm sewer infrastructure. Continue mapping all new storm sewer infrastructure as development increases with the goal of maintaining a complete stormwater infrastructure inventory

### Coordination of Stormwater Activities

- Continue participation in Ecology's TMDL development and adaptive management processes
- Continue to pursue collaborative habitat restoration projects along the mainstem of Salmon Creek

### Mechanisms for public involvement

- Publish SNAP reports on CWP web page

### Development Regulations for Stormwater and Erosion Control

- None

### Stormwater Source Control Program for Existing Development

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

### Operation and Maintenance Actions to Reduce Pollutants

- None

### Education and Outreach to Reduce Behaviors that Contribute Stormwater Pollution

- Continue to encourage and support appropriate agricultural practices that emphasize soil and water conservation, intact riparian buffer areas, and reduction in nutrient load to streams.
- Perform targeted technical assistance responding to results of field assessments
- Distribute literature to landowners discussing water quality impacts and other potential hazards of 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
- Replace missing or deteriorated stream name signs

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- Continue education and public outreach efforts focused on ensuring private stormwater facility owners meet maintenance standards in Clark County's Stormwater Facility Maintenance Manual

### TMDL Compliance

- Clark County fulfills its TMDL compliance obligations through ongoing implementation of the Stormwater Management Program

### Monitoring Stormwater Program Effectiveness

- None

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