DRAFT
REDMOND PAIRED WATERSHED STUDY

EXPERIMENTAL DESIGN SUMMARY REPORT

Prepared for
City of Redmond

Prepared by
Herrera Environmental Consultants, Inc.

HERRERA

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REDMOND PAIRED WATERSHED STUDY

EXPERIMENTAL DESIGN SUMMARY REPORT

Prepared for
City of Redmond
Public Works Natural Resource Division
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July 14, 2015 DRAFT

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1. INTRODUCTION

The Redmond Paired Watershed Study (RPWS) is one of four effectiveness monitoring studies that was selected for implementation starting in 2014 for the Regional Stormwater Monitoring Program (RSMP) for Puget Sound. The goal of effectiveness monitoring under the RSMP is to provide widely applicable information for improving stormwater management in the region. This monitoring is being funded by Municipal Stormwater National Pollutant Discharge Elimination System (Municipal Stormwater Permits) permittees in the Puget Sound Region that are contributing to a Pooled Stormwater Resources Fund that supports the RSMP. Selection of the RPWS for implementation under the RSMP was made based on a monitoring proposal that was presented to permittee representatives at workshops that were held on March 20, 2014 and May 6, 2014. The specific study question to be addressed through the RPWS is as follows:

> *How effective are watershed rehabilitation efforts at improving receiving water conditions at the watershed scale?*

In this context, rehabilitation efforts could include any of the following practices:

- Stormwater retrofits in upland areas that would include facilities for onsite stormwater management (e.g., low impact development [LID] practices), runoff treatment, and flow control
- Riparian and in-stream habitat improvements
- Programmatic practices for stormwater management

This document provides a more detailed description of the experimental design that will be used for the study relative to the description that was provided in the monitoring proposal. It was developed based on information obtained from a literature review (Herrera 2015) that was conducted to identify lessons learned from past studies that have been implemented to achieve similar objectives. This more detailed description was also developed based on input from a steering committee that was formed for the study. The steering committee includes representation from the following agencies:

- City of Redmond
- City of Seattle
- King County
- Kitsap County
- US Environmental Protection Agency
- US Geological Society
- Washington State Department of Ecology (Ecology)

This document is organized to provide additional background information on the history and drivers for the RPWS. It then provides a broad overview of the experimental design that will be used to address the study question identified above. Finally, the following information related to the experimental design is presented:

- A description of the watersheds that will be monitored for the study.
- Indicators that will be used for measuring progress toward rehabilitating a subset of these watersheds in the following categories: hydrologic, water quality, sediment quality, physical habitat, and biological.
- Location, frequency and duration of measurement for each indicator.
- Methods for analyzing the data for each indicator.

Following review and approval by the steering committee identified above, the experimental design described herein will be incorporated into a formal Quality Assurance Project Plan (QAPP) that will be developed in accordance with guidance from the Washington State Department of Ecology (Ecology) in *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology 2004). This QAPP will guide the implementation of all subsequent phases of the RPWS.

2. BACKGROUND

Municipal Stormwater Permits are issued by Ecology to regulate discharges from separated storm sewers owned or operated by Phase I and Phase II cities and counties. The Municipal Stormwater Permits establish the minimum requirements for permittees to address existing and future impacts to receiving waters from urbanization. Municipal Stormwater Permits require cities and counties to execute programmatic (nonstructural) activities and establish design standards for stormwater structural controls triggered by development (low impact development, runoff treatment, and flow control facilities). In theory, if all developed land in a watershed is equipped with nonstructural and structural stormwater controls, the receiving water would be protected from hydrologic and water quality impacts caused by urbanization. However, while the effectiveness of nonstructural and structural controls has been well documented at the site scale, limited data exists on the effectiveness of these controls in aggregate for actually improving conditions in receiving waters.

In February 2014, Ecology approved a Citywide Watershed Management Plan (WMP) (Herrera 2013) for the City of Redmond (City) that allows the City to use a watershed approach for stormwater management pursuant to the Municipal Stormwater Permit, Section 303(d) of the Clean Water Act, and salmon recovery. Through the implementation of this WMP, the City will focus stormwater BMPs in a subset of priority watersheds that are moderately impacted by urbanization and therefore expected to respond more quickly to rehabilitation efforts. This provides a unique opportunity to study the effectiveness of stormwater BMPs for improving receiving water conditions on an accelerated time frame. Recognizing this opportunity, the City is implementing the RPWS to quantify improvements in receiving water conditions based on routine and continuous measurements of various hydrologic, chemical, physical, and biological indicators of stream health. Monitoring for the RPWS will initiate in the fall of 2015 and will be implemented over an anticipated 10-year timeframe with funding from the RSMP.

To guide the development of the experimental design for the RPWS, a literature review was conducted to obtain information on past studies that have been implemented to achieve similar objectives. This literature review specifically involved online searches to identify published journals, proceedings, and gray literature on the following types of studies:

- Studies to quantify trends (5 years +) in receiving water conditions following implementation of stormwater controls and/or habitat improvements
- Paired watershed studies looking at the effectiveness of stormwater controls for improving receiving water conditions
- Studies to quantify changes in receiving water conditions in response to increased watershed urbanization
- General references on sampling strategies/methodologies for detecting change in receiving water conditions.

These searches yielded 123 study references that were then reviewed in detail to identify a subset of 11 priority studies that were found to be the most relevant for informing the experimental design of the RPWS. Detailed descriptions of these studies were subsequently provided in a summary report for the literature review (Herrera 2015). In addition, all the studies were reviewed to determine if they utilized specific indicators for receiving water conditions in any of the following categories: hydrologic, chemical, physical habitat, and biological. These results were subsequently used to synthesize information on the effectiveness of specific indicators in these categories for assessing change in receiving water conditions. Key conclusions and recommendations from the literature review are as follows:

- The scope and nature of the RPWS is unprecedented in the literature. Numerous studies have been conducted with similar goals, but they were generally conducted at the sub-basin scale. In these studies, a hydrologic monitoring station was typically located at the mouth of the study basin. Therefore, monitoring stations at the mouth of the study watersheds for the RPWS was also recommended. However, because the study watersheds for the RPWS will be substantially larger than the sub-basins used in previous studies and rehabilitation efforts will likely occur in the upper reaches of these watersheds, additional hydrologic monitoring stations at a mid-point location was also recommended for the RPWS.

- Continuous flow data collection was used in each applicable study reviewed and is recommended for the RPWS. Furthermore, the most useful and pervasive hydrologic indicator appeared to be frequency and duration of high and low pulse count. These indicators at the least were specifically recommended for the RPWS to assess the success of rehabilitation efforts. Annual flow volume was also commonly used in the literature and should be considered when selecting indicators of hydrologic change. Modeling to quantify changes in hydrology as a function of land use changes and stormwater treatment applications has also been performed in a number of relevant studies. The RPWS provides an opportunity to validate the results from this modeling.

- The literature review indicated that most basin-scale studies have not been able to detect a difference in pollutant concentrations between basins with and without stormwater treatment facilities including LID practices. Load reductions were more easily quantified, but with concentration alone, natural variability tended to overwhelm any signal that could be associated with stormwater treatment applications. The most common parameter groups measured in the literature of relevant studies where nutrients, suspended solids, and metals. Parameters from these groups at the least were recommended for the RPWS.

- The majority of studies that assessed physical habitat response to watershed rehabilitation were conducted in reaches in which channel rehabilitation measures were applied. Consequently, they were design to assess the localized effects of channel alterations. The RPWS will involve both channel rehabilitation and basin-wide BMP application. Consequently, a more synoptic approach was recommended for the RPWS to assess physical habitat recovery. Stations should be selected in reaches that will be restored and in reaches where there will be no physical alterations to the channel. In this way, the RPWS can assess physical habitat response to both localized and basin-wide drivers.

- Studies linking macroinvertebrate and fish response to watershed restoration have primarily focused on responses to in-channel work. Macroinvertebrate metrics can show considerable variation across small spatial scales and will be sensitive to local conditions in the channel which may override influences from higher up in the watershed. Because an objective of the RPWS is to measure both localized and watershed effects on biologic recovery, it was recommended that the biological monitoring program mirror the habitat monitoring program discussed above. Specifically, multiple monitoring locations should be located in both reaches where channel rehabilitation will occur and in reaches that will only be affected by upstream stormwater management activities. Annual monitoring coinciding with the collection of habitat data was recommended.

3. EXPERIMENTAL DESIGN

To meet the study objective identified in the Introduction to this document, the experimental design for the RPWS has two primary components:

- **Status and Trends Monitoring:** routine and continuous measurements of various hydrologic, chemical, physical habitat, and biological indicators of stream health over an extended time frame to quantify improvements in receiving water conditions in response to watershed rehabilitation efforts.
- **Effectiveness Monitoring:** measurements of hydrologic and chemical parameters over a relatively short timeframe to document the effectiveness of specific structural stormwater controls that have been constructed to improve receiving water conditions.

The Status and Trends Monitoring will utilize a "paired watershed" experimental design that will involve the collection of these measurements in seven watersheds categorized as follows:

- Three "Application" watersheds with wadeable lowland streams that are moderately impacted by urbanization and prioritized for rehabilitation efforts.
- Two "Reference" watersheds with relatively pristine wadeable lowland streams that do not require rehabilitation.
- Two "Control" watersheds with significantly impacted wadeable lowland streams by urbanization that are not currently targeted for rehabilitation pursuant to the WMP.

As described below, fixed monitoring stations will be established in each watershed for monitoring various indicators of stream health. Due to the scale of the RPWS and the anticipated lag between applying stormwater controls and resultant improvements in receiving water conditions, quantifying a cause and effect relationship between these events may take many years. Therefore, monitoring at the fixed monitoring stations will occur over an anticipated 10-year timeframe. Furthermore, because the effectiveness of watershed rehabilitation practices to be implemented in the Application watersheds (e.g., stormwater retrofits, in-stream habitat improvements, and programmatic practices) may vary for different types of receiving water impairments, a broad suite of indicators for assessing potential improvements will be monitored within the following categories: hydrologic, water quality, sediment quality, physical habitat, and biological. The trend of interest will be evidence that receiving water conditions are improving based on one or more of these indicators in the Application watersheds while conditions in the Reference and Control watersheds remain relatively static.

To implement the Effectiveness Monitoring, roving stations will be established in association with specific structural stormwater controls to verify they are constructed properly and performing as designed. The roving stations will be moved from one year to the next once a facility's effectiveness has been verified and new facilities come online. These sites will be essential to the study, as the explanation of the signal observed within the receiving waters must be tied to the efficacy of rehabilitation efforts within the watersheds.

The Application, Reference, and Control watersheds that have been selected for the RPWS are described in the following subsection. Subsequent subsections then provide more detailed information on the Status and Trends Monitoring and Effectiveness Monitoring, respectively, including the monitoring stations, measurement frequency, indicators, and data analysis methods where applicable.

3.1. Study Watersheds

As described above, monitoring for the RPWS will occur in a total of seven watersheds for the RPWS: three Application watersheds, two Reference watersheds, and two Control watersheds. Table 1 identifies the name, predominant land use/cover, and size of each watershed; the location of all the watersheds is shown in Figure 1. A detailed summary of conditions within each watershed is also provided below with information on planned rehabilitation efforts in the Application watersheds as applicable.

Table 1. Application, Reference, and Control Watersheds for the Redmond Paired Watershed Study.

Watershed Name	Watershed Type	Dominant Land Use/Cover	Watershed Total Area (acres)	Watershed Areas Inside Redmond (acres)
Evans Creek Tributary 108	Application	Residential	397	NA[a]
Monticello Creek	Application	Residential/Commercial	345	264
Tosh Creek	Application	Residential/Commercial	299	276
Colin Creek	Reference	Forest	1,990	90
Seidel Creek	Reference	Forest	1,188	615
Country Creek	Control	Residential/Commercial	212	212
Tyler's Creek	Control	Residential/Commercial	168	167

[a] Entire watershed is located within King County's jurisdiction boundaries.

3.1.1. Application Watersheds

The watersheds for Evans Creek Tributary 108, Monticello Creek, and Tosh Creek were selected as Application watersheds for the RPWS. Conditions within each of these watersheds are described in the following subsections.

3.1.1.1. Evans Creek Tributary 108 Watershed

Evans Creek Tributary 108 is located in the Northeast Quarter, Sections 4, 5, 8, and 9, Township 25, Range 6 East WM, in King County (Figures 1 and 2). Evans Creek Tributary 108 is within the Bear-Evans Creek watershed. The watershed is approximately 397 acres with dominantly Alderwood and Everett soils; land cover in the watershed is approximately 37 percent forest and 16 percent impervious area. The Evans Creek Tributary 108 watershed has experienced a significant amount of residential development that occurred before adequate stormwater controls were required on new development, which has degraded the tributary's water quality/health and contributed to documented degradation of Evans Creek. Currently, average median benthic index of biotic integrity (B-IBI) scores for three stations in the watershed range from 28 to 31, which indicates the stream's health is on the low side of "fair".

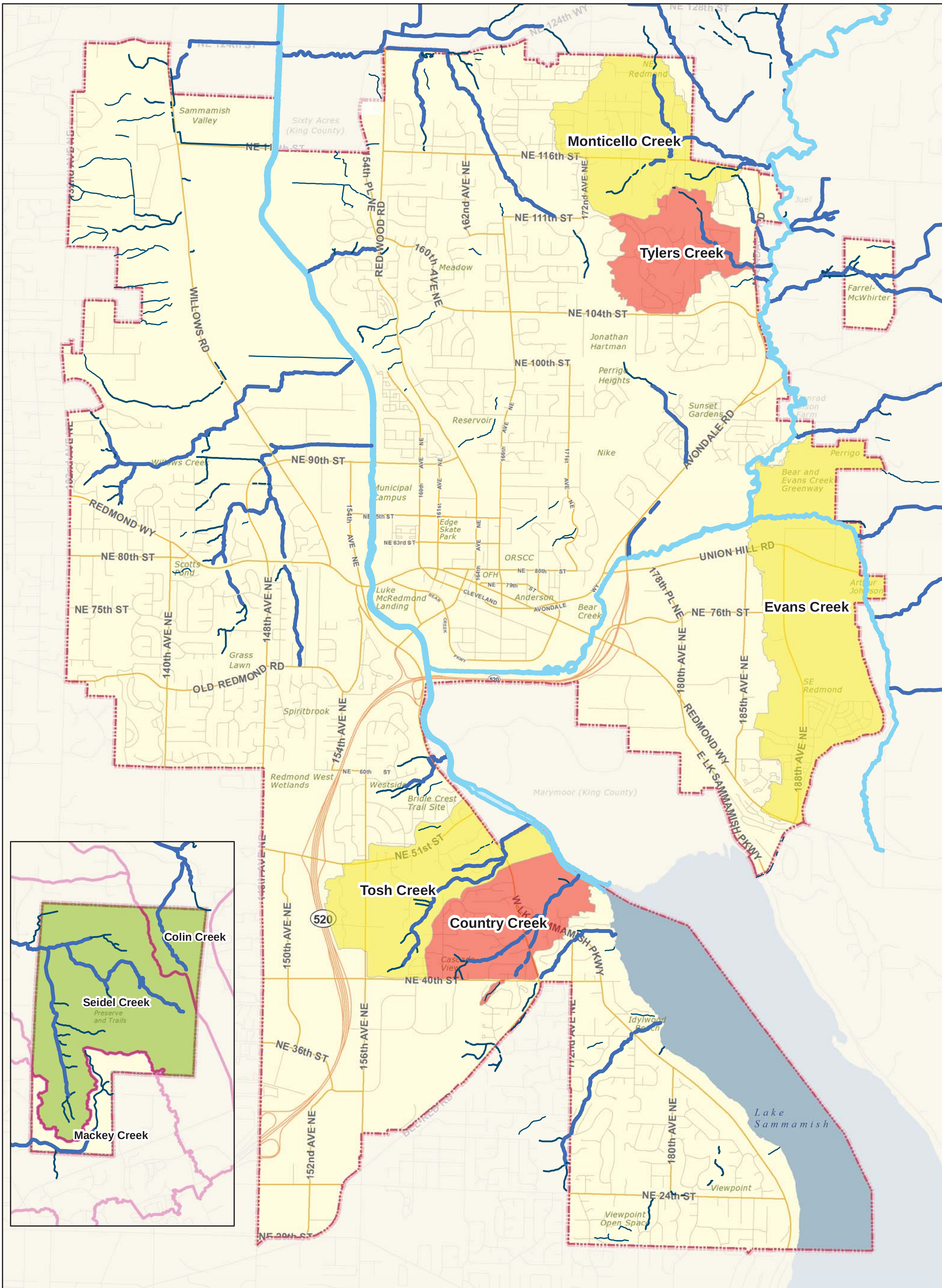

Figure 1 - Application, Reference, and Control Watersheds.

City of Redmond, Washington

06/18/2015

0 0.25 0.5 1 1.5 Miles

City of Redmond WASHINGTON

Legend

- Class I Stream
- Class II Stream
- Class III Stream
- Class IV Stream
- City Limits
- Reference Watersheds
- Application Watersheds
- Control Watersheds

Disclaimer: This map is created and maintained by the Natural Resources Division of the City of Redmond, Washington, for reference purposes only. The City makes no guarantee as to the accuracy or completeness of the features shown on this map.

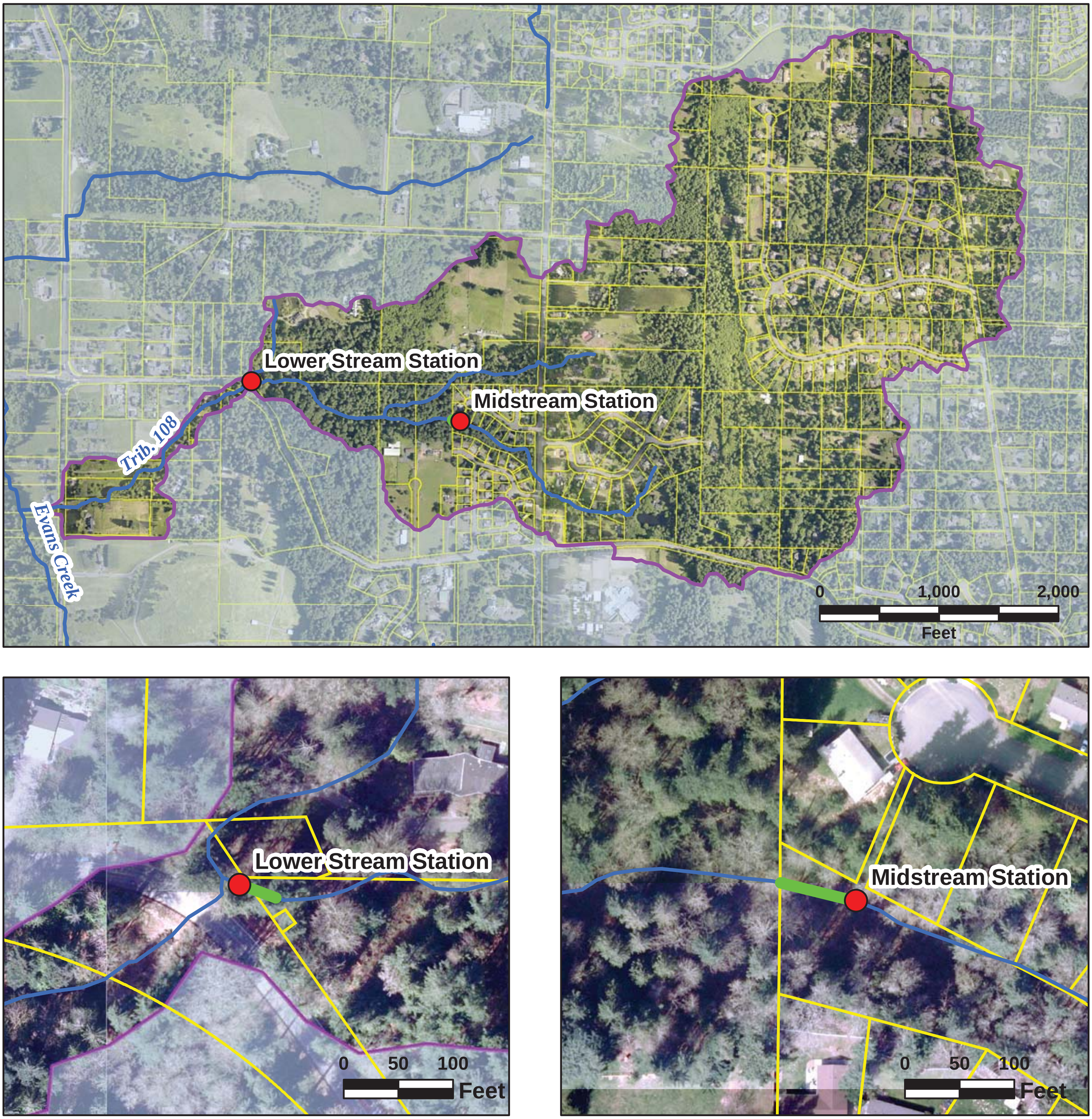

Figure 2 - Evans Trib. 108 Paired Basin Study Monitoring Locations.

King County, Washington

July 2, 2015

Flow, WQ, Sediment Monitoring

Habitat and Biological Monitoring

Streams and Rivers

King County Parcels

Basin Boundary

King County
Department of Natural Resources and Parks
Water and Land Resources Division

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In February 2015, King County received a draft water quality funding offer through the Stormwater Financial Assistance Program to design and construct two stormwater retrofit detention vaults in a residential area within the Evans Creek Tributary 108 watershed. These retrofits will be designed to meet performance standards that are identified in the Stormwater Management Manual for Western Washington for onsite stormwater management and flow control. The goal of these retrofits is to improve B-IBI scores in the watershed to a "good" condition or better (i.e., 38 to 50).

King County is also performing analyses to evaluate the feasibility of converting two existing detention facilities in the watershed (D92411 and D92289) from detention facilities to infiltration facilities since those facilities have been known to be dry during most storm events and are located within infiltrative soils. The goal will be to develop pre-design reports for retrofit of these facilities to apply for an Ecology Stormwater Retrofit Construction Grant in the fall of 2015.

3.1.1.2. Monticello Creek Watershed

Monticello Creek is a right bank tributary of Bear Creek (Figure 1). The main stem originates in King County, north of the city boundary, and flows south and east. A right bank tributary joins the main stem from the west within the city, and another right bank tributary enters the stream from the south in King County. The headwaters of Monticello Creek are in King County and are dominated by large lots and pastures. The northernmost reach within the city limits flows through Northeast Redmond Neighborhood Park, a 5-acre wooded parcel. The mouth of the creek is located in the Middle Bear Creek Natural Area. The total stream length is 9,878 linear feet; 6,125 linear feet are within the city, of which 3,170 linear feet are designated as a Class II stream. An average of 3.5 stormwater outfalls can be found per 1,000 feet along the creek.

The Monticello Creek watershed is 345 acres; 264 acres are within the city limits. Land use is predominantly single-family residential, parks and undeveloped land (Figure 3.21). There is a relatively low effective impervious surface (EIS) area within the city portion of the watershed (23 percent). Land cover is mostly landscaping (Figure 3). The watershed is experiencing significant redevelopment, converting low density (1- to 5-acre lots) to high density residential development (less than 0.25-acre lots). Most of the development is vested to current flow control standards, meaning vaults or ponds designed to mimic forested runoff conditions for storms ranging from one-half the 2-year through the 50-year storm events.

Ecology included a segment of Monticello Creek on the 2012 Section 303(d) list as a Category 5 water body due to high temperature. Monticello Creek also has an Ecology-drafted and US Environmental Protection Agency-approved Total Maximum Daily Load (TMDL) study and Implementation Plan to address impairment from fecal coliform bacteria. The listed segment is located in King County from the east boundary of the city near 178th Street downstream to the mouth (Ecology 2012). The median B-IBI score for Monticello Creek based on data collected by the City as part of the Annual Benthic Monitoring study (2005 through 2010) is 36, indicating "fair" conditions (PSSB 2011). Next to the scores for Mackey Creek, these are the highest B-IBI scores on any City stream outside the Redmond Watershed Preserve Park, and above the B-IBI score threshold indicative of supporting self-sustaining salmonid populations.

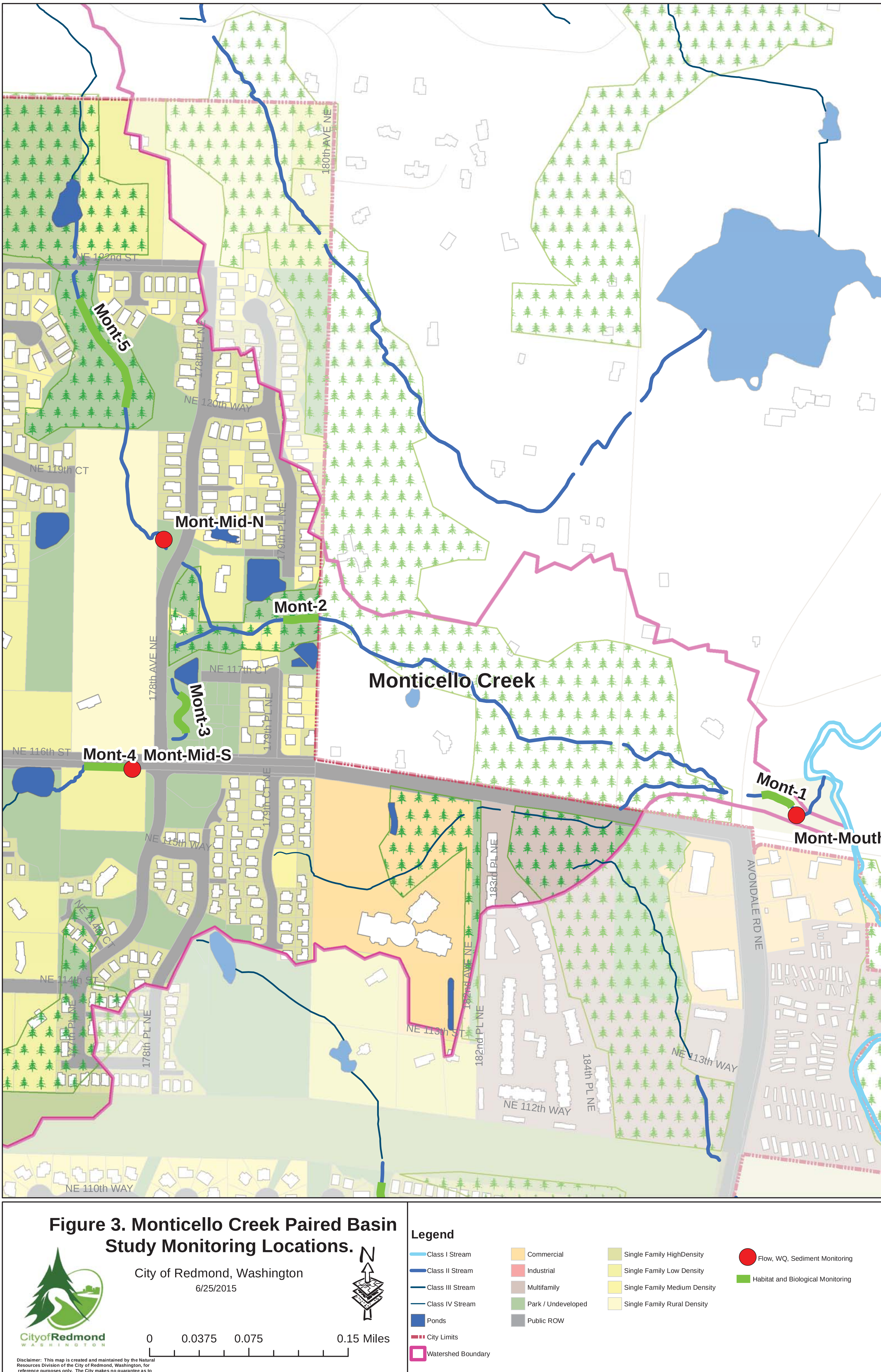

Figure 3. Monticello Creek Paired Basin Study Monitoring Locations.

City of Redmond, Washington

6/25/2015

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Riparian buffers are relatively dense in the upper stream channel, with a narrow band of trees on both sides of the channel. Riparian buffers on the main stem downstream, along Avondale Road Northeast, are modest. Riparian buffers on the west tributary lack tree cover in most areas (Washington Trout 2005).

There are five full fish passage barriers on the main stem and west tributary and two other partial barriers. In addition, steep gradients and unknown channel conditions between the city limits and Avondale Road Northeast may create fish passage issues. Fish passage through the culvert under Avondale Road Northeast is questionable. Significant salmonid use has been documented in the lower 2,400 feet of the main stem (Washington Trout 2005).

The City has recently initiated development of the Monticello Creek Watershed Restoration Plan. This plan will provide detailed engineering analysis to identify a comprehensive rehabilitation strategy for Monticello Creek. With partial funding obtained through a National Estuaries Program grant, King County and the City have partnered to develop this plan. After its completion in 2017, the plan will identify all projects required to fully rehabilitate the creek and provide preliminary designs for the three highest ranked projects in terms of their overall benefit. It is anticipated that these projects will not be constructed and operational in the Monticello watershed until 2020. Because the benefits of these structural stormwater controls will not be realized in the watershed for some time, the City is targeted this watershed for nonstructural stormwater controls (such as increased street sweeping, public outreach, business inspections, municipal best management practices, etc.) in the near-term. Furthermore, the significant pace of redevelopment in the watershed described above is also triggering requirements for implementing structural stormwater controls at the individual project site scale. Monitoring conducted through the RPWS will initially be performed to evaluate potential improvements to stream health from these later rehabilitation strategies until the structural stormwater controls from the Monticello Creek Watershed Restoration Plan come online.

3.1.1.3. Tosh Creek Watershed

Tosh Creek is located in the southwest portion of the city (Figure 1). Tosh Creek enters the left bank of the Sammamish River just upstream of the Willowmoor weir at the boundary of Marymoor Park. The upper reaches flow through residential areas. The majority of the valley reaches are in good condition with wide forested buffers. Numerous seeps and small tributaries help maintain consistent base flows. The channel is straightened and ditched in the reach downstream of West Lake Sammamish Parkway (WLSP). The total stream length is 10,370 linear feet, of which 7,215 linear feet is designated as a Class II stream. The stormwater influence in the Tosh Creek watershed is not as significant as in some of the adjacent watersheds because some of the developed commercial area in the upper reaches is piped to Villa Marina Creek via a stormwater trunk line. An average of 0.8 stormwater outfalls can be found per 1,000 feet along the creek.

The Tosh Creek watershed within the city is 276 acres; the entire watershed is 299 acres. The remainder of the watershed is in unincorporated King County. The Tosh Creek watershed is highly developed with predominantly single-family dwellings (see Figure 4). Within the watershed, approximately 39 percent of the area can be considered EIS. Land cover is divided evenly between landscaped yards and impervious surface (39 percent each), with minor amounts of forest and pasture.

Ecology included a segment of Tosh Creek upstream of WLSP on the 2012 Section 303(d) list as a Category 5 water body due to impairment from fecal coliform bacteria (Ecology 2012). The median B-IBI score for Tosh Creek based on data collected by the City as part of the Annual Benthic Monitoring study (2008, 2009, and 2010) is 19, indicating poor conditions (PSSB 2011). This rating may be misleading because the samplers inadvertently chose locations with some of the poorest water quality on the stream (R. Dane, personal communication, December 5, 2011). The City expects higher B-IBI scores for Tosh Creek in future sampling efforts as a number of other indicators suggest this stream is relatively healthy.

Riparian buffers are generally broad and mostly in good condition with abundant trees in the valley wall reaches. In the upper reaches through residential areas, the riparian buffers are narrower and mature trees are less abundant. However, the steep valley slopes in the upper reaches provide a natural buffer against further development and there are sufficient deciduous trees to provide shade (Washington Trout 2005). There is a minor amount of development (4 percent) within the 30-foot stream buffer.

There are three fish passage barriers on Tosh Creek, and one former barrier that has been removed for fish passage. One of the barriers on a left bank tributary near WLSP is a complete barrier. The other two are partial barriers on the main stem at WLSP. Significant salmonid use has been documented in Tosh Creek as far upstream as the south fork at the headwaters. Abundant gravel in the lower reach makes this stream a potentially important coho spawning stream (Washington Trout 2005).

In February 2015, the City completed the Tosh Creek Watershed Restoration Plan, which identifies a comprehensive rehabilitation strategy for Tosh Creek based on modeling and engineering analyses (City of Redmond et al. 2015). The plan also provides preliminary designs for the three highest ranked projects in terms of their overall benefit to the creek. One of these projects recently received $6,000,000 in funding through Ecology's Stormwater Financial Assistance Program (Fiscal Year 2016) and will involve the construction of a flow-control vault to stabilize erosive flows in Tosh Creek and improve water quality. This vault is expected to be operational in 2016. Monitoring conducted through the RPWS will initially be performed to evaluate potential improvements to stream health from this project. For example, midpoint monitoring stations in the watershed (see descriptions below) were specifically selected to evaluate potential improvements to stream health at locations immediately downstream of the vault. With supplementation of grant and loan funding from Ecology, Redmond could potentially build all three top priority projects within 6 years (i.e., by 2021).

3.1.2. Reference Watersheds

The watersheds for Colin Creek and Seidel Creek were selected as Reference watersheds for the RPWS. Conditions within each of these watersheds are described in the following subsections.

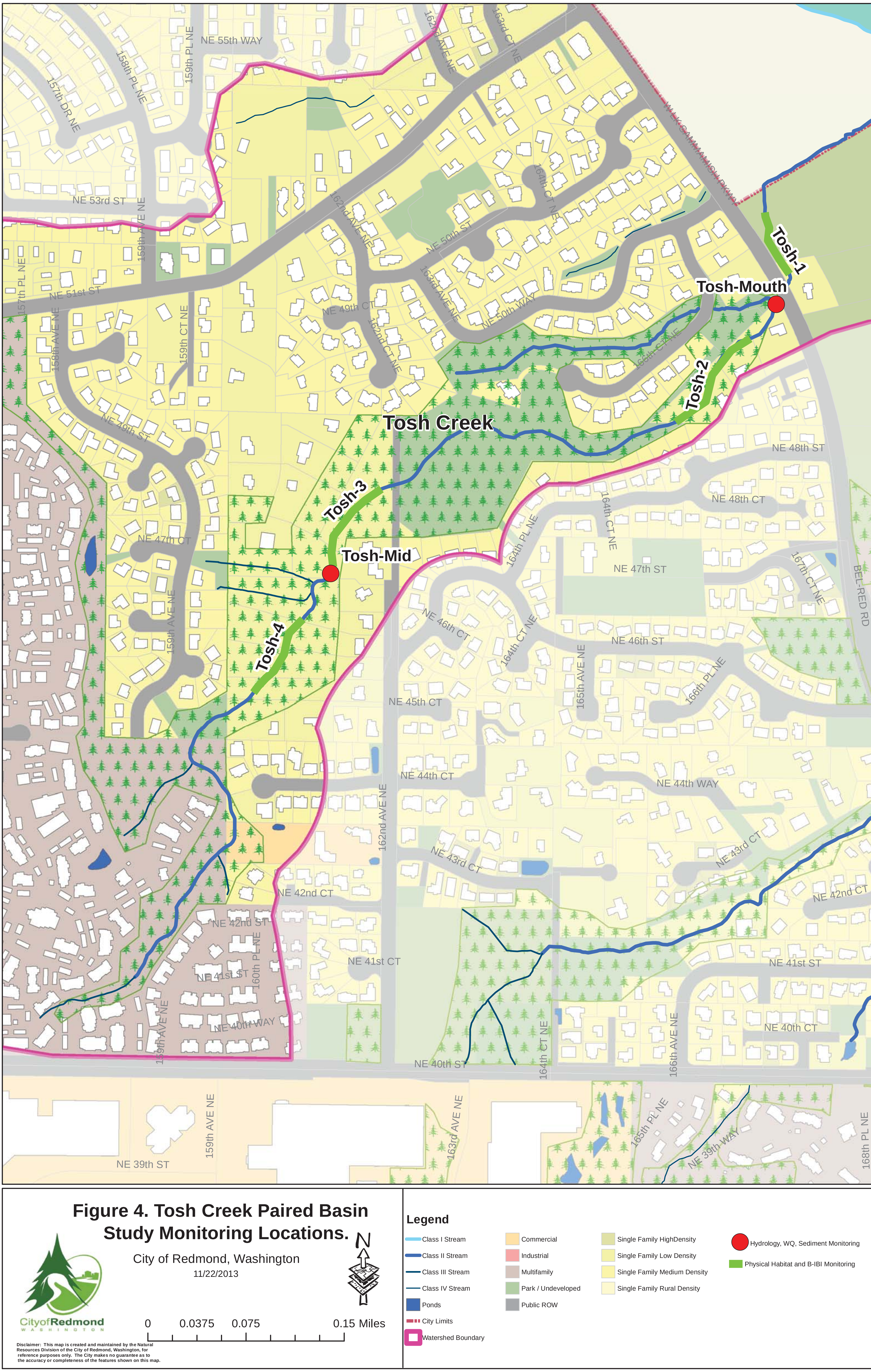

Figure 4. Tosh Creek Paired Basin Study Monitoring Locations.

City of Redmond, Washington

11/22/2013

City of Redmond WASHINGTON

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3.1.2.1. Colin Creek Watershed

Colin Creek has its headwaters in the City-owned Redmond Watershed Preserve Park (Figure 1). The Redmond Watershed Preserve Park was purchased in 1926 for a domestic water supply (City of Redmond 2011). It occupies an 800-acre parcel of land that is outside the city's contiguous limits but within the City's jurisdiction. In addition to Colin Creek, two other creeks within the city (Mackey Creek and Seidel Creek) also have their headwaters in the park. Because the City has prohibited development within the Redmond Watershed Preserve Park, it is considered one of the most pristine lowland forests in King County (Luchetti, personal communication, 2011). Colin Creek flows north out of a large wetland through the Redmond Watershed Preserve Park, enters Welcome Lake, exits the lake over a spillway with a fishway of questionable function, and then enters a steep ravine. Colin Creek then joins Struve Creek, a left bank tributary of Bear Creek. Only 2,260 linear feet, out of a total of 29,265 linear feet, are located within city boundaries. The entire stream within the city is designated as a Class II stream. No stormwater outfalls exist along the creek.

The watershed within the city limits is 90 acres, and is 100 percent comprised of parks and undeveloped land (see Figure 5). It consists of dense stands of mature conifer forest, which provide good cover for the stream. The channel has substantial amounts of large woody debris that contribute to a diverse instream habitat.

Colin Creek is not listed on the 2008 Section 303(d) list of threatened and impaired water bodies (Ecology 2012). B-IBI sampling was not performed by the City on Colin Creek; however, King County conducted sampling in this watershed from 1997 through 2010. The median B-IBI score for Colin Creek is 28; indicating "fair" conditions (PSSB 2011).

Dense stands of second generation forest flank both sides of Colin creek as it meanders through the Redmond Watershed Preserve Park, north into unincorporated King County. The riparian zone is one of the most pristine in Redmond with 97 percent forest cover. The system is complex with thick vegetation providing shade for the majority of the channel. Very few invasive species are found within Colin Creek's buffers, or within the portion of its watershed located in Redmond. A large wetland complex is present in the headwaters that feed both Colin and Seidel Creek.

Neither Washington Trout or City crews officially surveyed Colin Creek for fish presence, but there are anecdotal reports of numerous cutthroat trout present. WDFW maps show coho spawning in the reach below Welcome Lake (WDFW 2011). There is one fish passage barrier within the watershed preserve.

3.1.2.2. Seidel Creek Watershed

Seidel Creek has its headwaters in the Redmond Watershed Preserve Park (Figure 1). The East Fork of Seidel Creek joins the main stem within the park. The topography at the headwaters is relatively flat with numerous wetlands, beaver dams, and ponds. The headwaters for Seidel Creek are connected with the same large wetland that is the headwater for Colin Creek. The stream flows through rural King County pasture and wood lots before it enters the left bank of Bear Creek just east of the city limits. The entire stream length is 31,121 linear feet (of which 22,220 linear feet are located within the city and 8,901 linear feet are outside the city). Approximately 13,260 linear feet of Seidel Creek within the city is designated as a Class II stream. There are no stormwater outfalls mapped along the creek.

The Seidel Creek watershed comprises 615 acres and land use is considered 100 percent parks and undeveloped land. Land cover is mostly forest (see Figure 6), and the watershed is generally undisturbed. The eastern two-thirds of the watershed was logged in the 1930s, and the western third was logged during World War II. The forest has naturally regenerated since then, being protected initially as a municipal water supply, and more recently as a natural park, with a focus on protecting its wide variety of habitats, including ponds and wetlands.

In general, water quality in Seidel Creek is good due to the low level of development. However, Ecology included the lowest 0.1 mile, in unincorporated King County, on the 2012 Section 303(d) list as a Category 5 water body due to high temperature (Ecology 2012). This reach is also listed as Category 2 for dissolved oxygen. B-IBI sampling was not performed by the City on Seidel Creek; however, King County conducted B-IBI sampling in the watershed from 2002 through 2010. Their median B-IBI score for Seidel Creek was 32; indicating "fair" conditions (PSSB 2011).

All reaches of Seidel Creek are flanked with densely wooded second growth forest. Its headwater is a large wetland complex that feeds both Seidel and Colin Creek. The upper reaches contribute to a manmade water impoundment that is flanked by wetlands and dense forest. Below the dam is also heavily wooded with some prairie within the buffer. The entire portion of Seidel Creek's Watershed within Redmond is within the Redmond Watershed Preserve and is characterized by 83 percent tree cover in the riparian zone.

A low dam backs up water below the confluence with the East Fork of Seidel Creek to create a reservoir. The reservoir was originally used as a municipal water supply but due to water quality issues was abandoned in 1953. However, this dam now represents a complete fish passage barrier. There are two other barriers upstream on the East Fork, and one partial barrier (a concrete flume) upstream on the main stem. There are large numbers of resident salmonids that use Seidel Creek, but no anadromous fish due to the fish passage barriers. This issue is being addressed with a fish passage project. No surveys of Seidel Creek were done by Washington Trout.

3.1.3. Control Watersheds

The watersheds for Country Creek and Tyler's Creek were selected as Control watersheds for the RPWS. Conditions within each of these watersheds are described in the following subsections.

3.1.3.1. Country Creek Watershed

Country Creek is located in the southwest portion of the city (Figure 1). Country Creek enters the Sammamish River near the outlet of Lake Sammamish approximately 1,500 feet upstream of the weir. The lower reach of Country Creek on the valley floor flows through a seasonally flooded and wooded wetland complex that is backwatered from the lake. Closer to WLSP, the stream flows through stands of dense blackberry and reed canarygrass with little native vegetation. Upstream of the valley floor, the channel runs through residential neighborhoods. The headwaters of Country Creek are located in Cascade View Neighborhood Park where several springs feed the modest flow in the upper reach. A right bank tributary enters the stream just upstream of WLSP. The total stream length is 7,210 feet of which 5,000 feet are designated as a Class II stream. An average of 1.6 stormwater outfalls can be found per 1,000 feet along the creek.

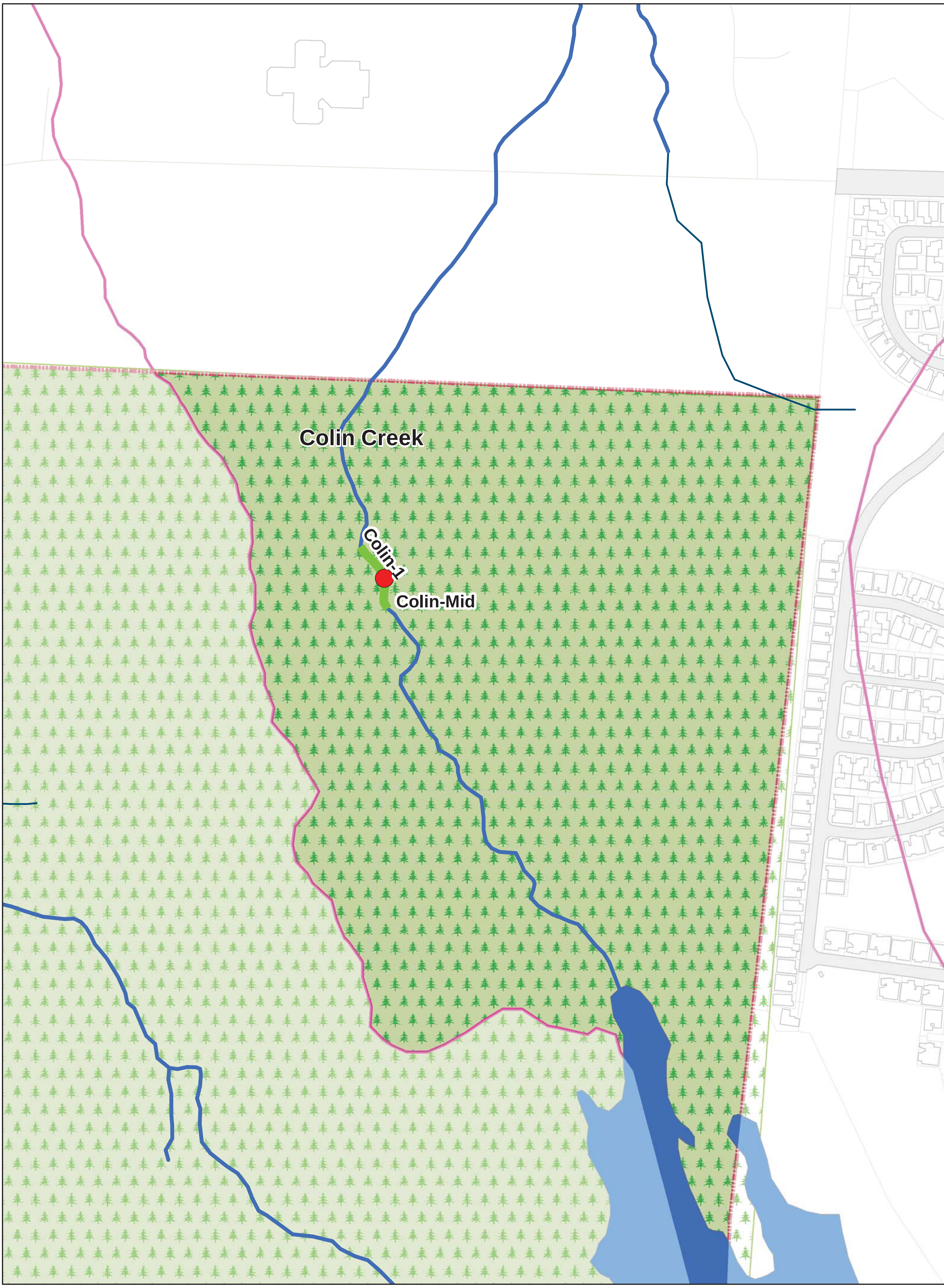

Figure 5 - Colin Creek Paired Basin Study Monitoring Locations.

City of Redmond, Washington

6/25/2015

N

0 0.0325 0.065 0.13 Miles

Legend

- Class I Stream
- Class II Stream
- Class III Stream
- Class IV Stream
- Ponds
- City Limits
- Watershed Boundary
- Commercial
- Industrial
- Multifamily
- Park / Undeveloped
- Public ROW
- Single Family HighDensity
- Single Family Low Density
- Single Family Medium Density
- Single Family Rural Density
- Flow, WQ, Sediment Monitoring
- Habitat and Biological Monitoring

City of Redmond WASHINGTON

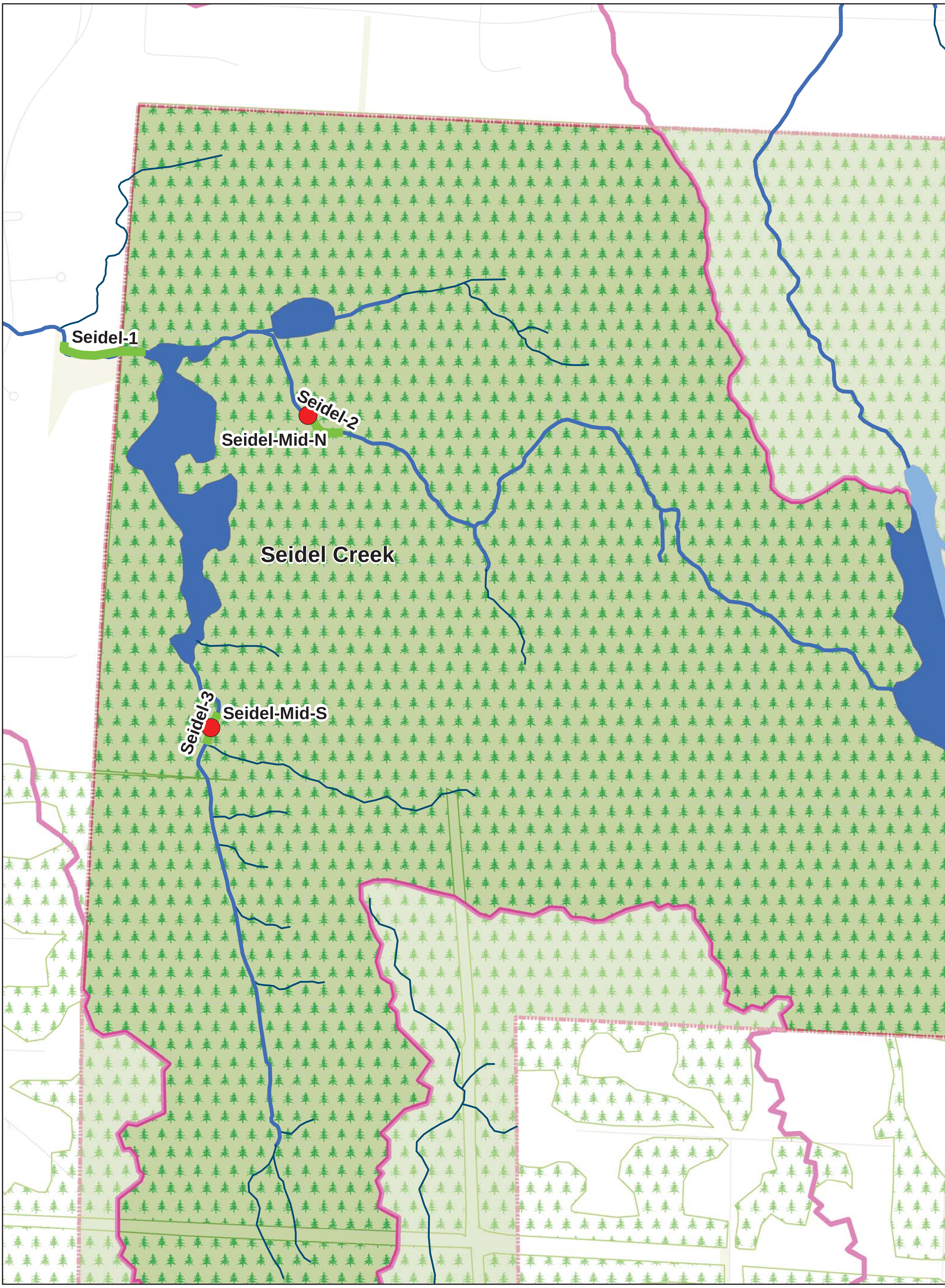

Figure 6 - Seidel Creek Paired Basin Study Monitoring Locations.

City of Redmond, Washington

11/22/2013

N

0 0.05 0.1 0.2 Miles

City of Redmond WASHINGTON

Disclaimer: This map is created and maintained by the Natural Resources Division of the City of Redmond, Washington, for reference purposes only. The City makes no guarantee as to the accuracy or completeness of the features shown on this map.

Legend

- Class I Stream
- Class II Stream
- Class III Stream
- Class IV Stream
- Ponds
- City Limits
- Watershed Boundary
- Commercial
- Industrial
- Multifamily
- Park / Undeveloped
- Public ROW
- Single Family HighDensity
- Single Family Low Density
- Single Family Medium Density
- Single Family Rural Density
- Flow, WQ, Sediment Monitoring
- Habitat and Biological Monitoring

The Country Creek watershed consists of 212 acres located entirely within city boundaries. The lower 800 feet of the stream channel flows through King County-owned open space property. Land use is predominantly single-family dwellings (see Figure 7). The EIS area in the watershed is 22 percent. Land cover is predominantly landscaped yards.

Country Creek is listed as a Category 5 water body on Ecology's 2012 Section 303(d) list due to impairment from fecal coliform bacteria (Ecology 2012). The median B-IBI score for Country Creek is 20, indicating "poor" conditions (PSSB 2011).

Riparian buffers are narrow in the middle reaches near WLSP, but broad in the upper reach with thick vegetation and mature conifers. On average, development encroaches on 17 percent of the 30-foot riparian buffer.

There are 10 fish passage barriers on Country Creek and the right bank tributary; six are complete barriers and four are partial barriers. The undersized culvert under WLSP is a partial barrier. The first complete barrier is on the main stem upstream of the right bank tributary. There has been no observed salmonid use in Country Creek based on surveys by Washington Trout crews (Washington Trout 2005), likely due to these multiple barriers.

3.1.3.2. Tyler's Creek Watershed

Tyler's Creek is a right bank tributary of Bear Creek. It originates west of Avondale Road Northeast in the northeast portion of the city and flows south and east, joining Bear Creek just east of the city limits (Figure 1). Sediment loads from the steep channel on the hillside and thick vegetation combine to create a braided channel through the wetland at the base of the valley wall. The total stream length is 3,417 linear feet; 2,990 linear feet are within the city, of which 2,020 linear feet are designated as a Class II stream. An average of three stormwater outfalls can be found per 1,000 feet along the creek.

The Tyler's Creek watershed is 168 acres, and 167 acres are located in the city. Land use is predominantly single-family residential (Figure 8). There are large tracts of undeveloped land in the headwaters. Land cover is primarily landscaping (43 percent) and impervious surface (35 percent). There are a relatively high number of stormwater outfalls along Tyler's Creek (three outfalls per 1,000 linear feet).

Ecology included all of Tyler's Creek on the 2008 Section 303(d) list as a Category 5 water body due to high temperature (Ecology 2012). The median B IBI score for Tyler's Creek based on data collected by the City as part of the Annual Benthic Monitoring study (2005, 2006, and 2007) is 20, indicating poor conditions (PSSB 2011). These samples were collected from two sites west of Avondale Road Northeast.

Riparian buffers are in fair condition, with only 10 percent encroachment within 30 feet of the stream and well-established riparian plantings. Most of the buffers are protected within Native Growth Protection Easements (NGPEs) or tracts within the city limits. However, the protected easements are much narrower than present standards. Some upper reaches of the stream channel were rehabilitated and several fish barriers corrected, but the habitat is poor quality having uniformly sized rock, plastic fabric, and large riprap weirs.

There are two partial fish passage barriers on Tyler's Creek: a baffled culvert under Avondale Road Northeast and a second barrier upstream. There are two other potential barriers, one at the mouth and one near the headwaters. No significant salmonid use has been documented in Tyler's Creek, although Washington Trout crews did document salmonids upstream of Avondale Road Northeast (Washington Trout 2005).

3.2. Status and Trends Monitoring

This section describes the monitoring stations, measurement frequency, indicators, and data analysis methods that will be used for the Status and Trends Monitoring component of the RPWS. This information is organized under separate subsections for the following monitoring categories: hydrologic, water quality, sediment quality, physical habitat, and biological. The specific indicators of stream health that will be evaluated in categories are also summarized in Table 2 (following Figures 7 and 8) with their associated measurement frequency.

3.2.1. Hydrologic Monitoring

A total of 14 fixed monitoring stations will be established to facilitate hydrologic monitoring in each of the study watersheds. Per the recommendations from the literature review (see *Background* section), monitoring stations were established at the mouth and a mid-point location within each watershed where feasible given the watershed's size. The specific monitoring stations established based on this goal are as follows:

Application Watersheds

- Evans Creek Tributary 108: two stations designated Lower Stream Station and Midstream Station, respectively (see locations in Figure 2).
- Monticello Creek: one station at the mouth designated Mont-Mouth; one station at the approximate midpoint of the watershed on north tributary designated Mont–Mid-N, and one station at the approximate midpoint of the watershed on south tributary designated Mont–Mid-S (see locations in Figure 3).
- Tosh Creek: one station at the mouth designated Tosh-Mouth, and one station at the approximate midpoint of the watershed designated Tosh-Mid (see locations in Figure 4).

Reference Watersheds

- Colin Creek: one station at the approximate midpoint of the watershed designated Colin-Mid (see locations in Figure 5).
- Seidel Creek: one station at the approximate midpoint of the watershed on north tributary designated Seidel-Mid-N, and one station at the approximate midpoint of the watershed on south tributary designated Seidel-Mid-S (see locations in Figure 6).

Control Watersheds

- Country Creek: one station at the mouth designated Country-Mouth, and one station at the approximate midpoint of the watershed designated Country-Mid (see locations in Figure 7).
- Tyler's Creek: one station at the mouth designated Tylers-Mouth, and one station at the approximate midpoint of the watershed designated Tylers-Mid (see locations in Figure 8).

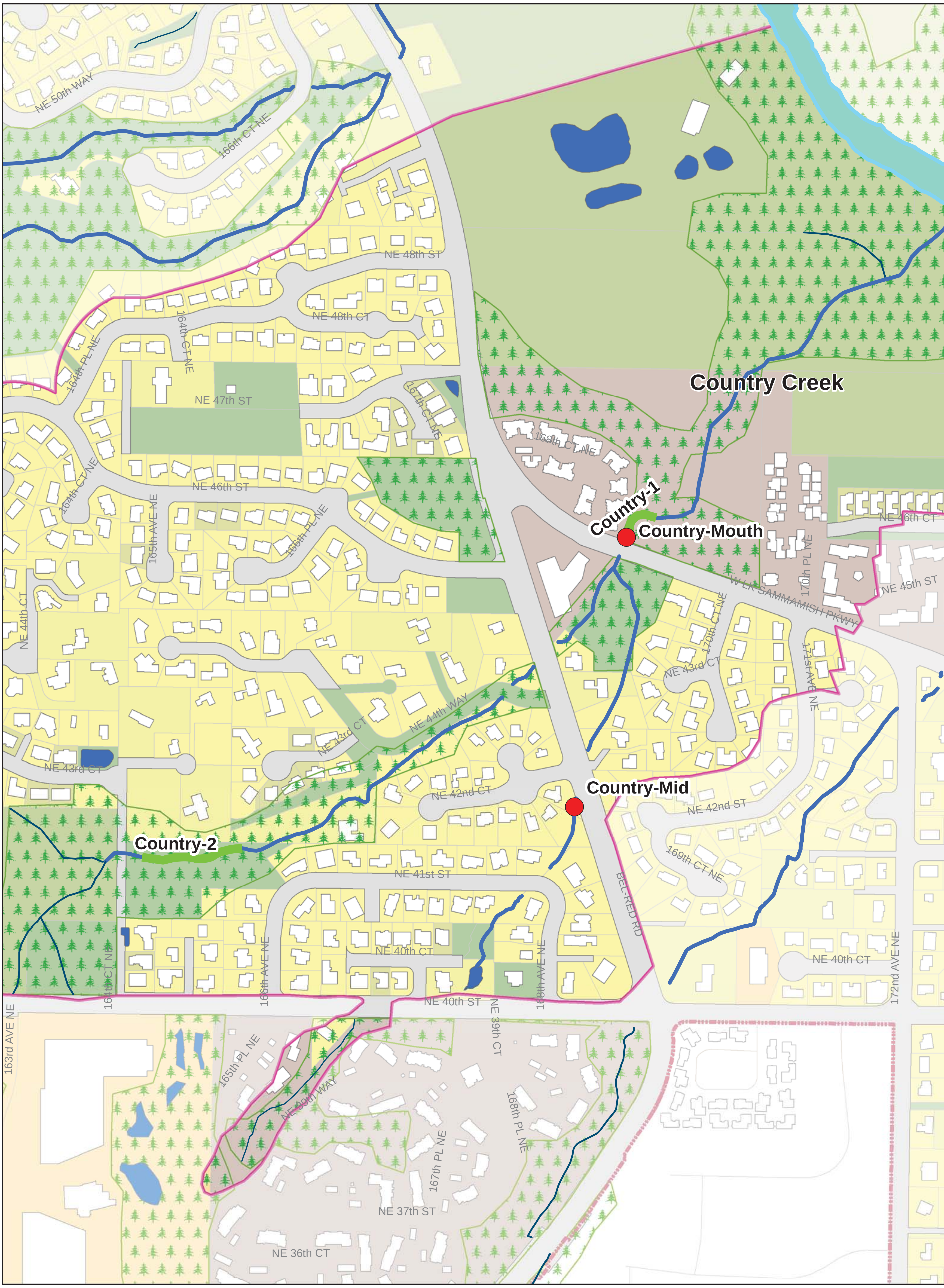

Figure 7 - Country Creek Paired Basin Study Monitoring Locations.

City of Redmond, Washington

6/25/2015

N

0 0.0325 0.065 0.13 Miles

City of Redmond WASHINGTON

Legend

- Class I Stream
- Class II Stream
- Class III Stream
- Class IV Stream
- Ponds
- City Limits
- Watershed Boundary
- Commercial
- Industrial
- Multifamily
- Park / Undeveloped
- Public ROW
- Single Family HighDensity
- Single Family Low Density
- Single Family Medium Density
- Single Family Rural Density
- Flow, WQ, Sediment Monitoring
- Physical Habitat

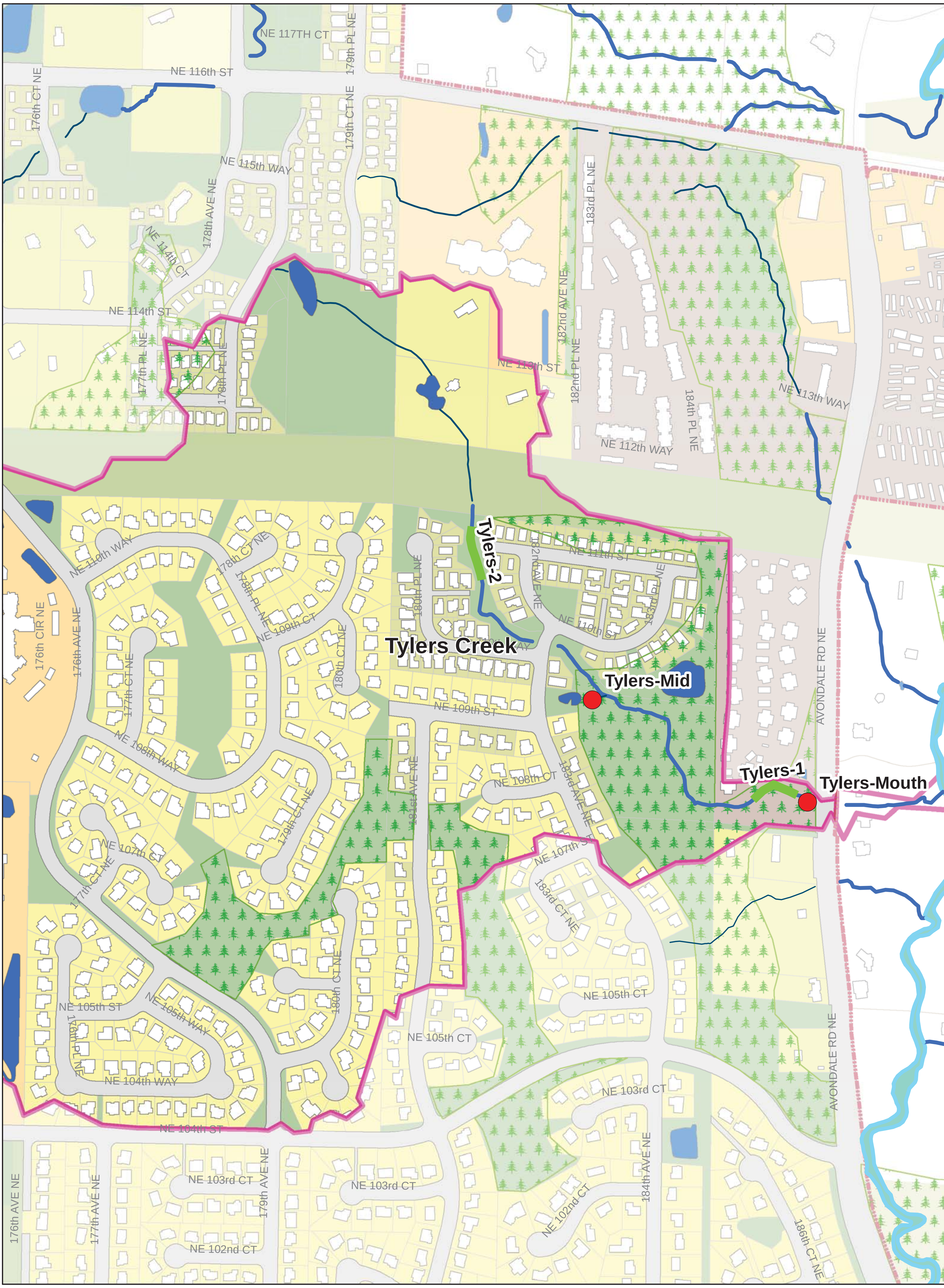

Figure 8 - Tylers Creek Paired Basin Study Monitoring Locations.

City of Redmond, Washington

6/25/2015

N

0 0.0375 0.075 0.15 Miles

Legend

- Class I Stream
- Class II Stream
- Class III Stream
- Class IV Stream
- Ponds
- City Limits
- Watershed Boundary
- Commercial
- Industrial
- Multifamily
- Park / Undeveloped
- Public ROW
- Single Family HighDensity
- Single Family Low Density
- Single Family Medium Density
- Single Family Rural Density
- Flow, WQ,Sediment Monitoring
- Habitat and Biological Monitoring

CityofRedmond WASHINGTON

Table 2. Indicators of Stream Health for the Redmond Paired Watershed Study.

Indicator	Measurement Frequency
Hydrology Monitoring	
• Flow	• Continuous
• High pulse count • High pulse frequency • High pulse count duration • High pulse count range • Low pulse count • Low pulse count frequency • Low pulse count duration • Low pulse count range • Richards-Baker (RB) flashiness index • TQ Mean • Storm volume • Base volume • Total flow volume	• Post-processed from continuous flow measurements
Water Quality Monitoring	
• Total suspended solids • Turbidity • Conductivity • Hardness • Dissolved organic carbon • Fecal coliform bacteria • Temperature • Total phosphorus • Total nitrogen • Copper, total and dissolved • Zinc, total and dissolved	• Twelve grab samples collected annually during storm events (three each quarter) • Four grab samples collected annually during base flow (one each quarter)
• Temperature • Conductivity • Turbidity	• Continuous
Sediment Quality Monitoring	
• Total organic carbon • Copper • Zinc • Polycyclic aromatic hydrocarbons • Phthalates	• Annually

Table 2 (continued). Indicators of Stream Health for the Redmond Paired Watershed Study.

Indicator	Measurement Frequency
Physical Habitat Monitoring	
• Bankfull width • Wetted width • Cumulative bar width • Bankfull depth • Wetted depth • Substrate class • Substrate embeddedness • Fish cover • Thalweg depth • Presence of bars • Presence of edge pools • Main channel slope and bearing • Large woody debris tally, including notation of diameter, length, category, zone, and key-pieces • Evidence of vegetation colonization below OHWM that persists more than 1 year • Slopes vegetated over the crown of the bank • Presence of desirable native plant species • Presence of invasive plant species • Presence of good-habitat indicator liverwort species • Channel incision or aggradation • Channel widening, narrowing, or migration • Changes in channel slope, sinuosity, and/or bedform type	• Annually
Biological Monitoring	
• Benthic macroinvertebrates	• Annually
• Benthic Index of Biotic Integrity • Taxa Richness • Ephemeroptera Richness • Plecoptera Richness • Trichoptera Richness • Clinger Percent • Long-Lived Richness • Intolerant Richness • Percent Dominant • Predator Percent • Tolerant Percent	• Post-processed from benthic macroinvertebrate data

OHWM: ordinary high water mark.

Continuous flow monitoring will occur at all 14 monitoring stations for the duration of the RPWS. Data from the continuous flow monitoring will be processed to calculate the following indicators for evaluating hydrologic impacts from urban development as described in DeGasperi et al. (2009):

- **High pulse count:** occurrence of daily average flows that are equal to or greater than a threshold set at twice (two times) the long-term daily average flow rate.
- **High pulse frequency:** number of days each water year that discrete high flow pulses occur.
- **High pulse count duration:** annual average duration of high flow pulses during a water year.
- **High pulse count range:** range in days between the start of the first high flow pulse and the end of the last high flow pulse during a water year
- **Low pulse count:** occurrence of daily average flows that are equal to or less than a threshold set at 50 percent of the long-term daily average flow rate
- **Low pulse count frequency:** number of times each calendar year that discrete low flow pulses occurred.
- **Low pulse count duration:** annual average duration of low flow pulses during a calendar year.
- **Low pulse count range:** range in days between the start of the first low flow pulse and the end of the last low flow pulse during a calendar year
- **Richards-Baker (RB) flashiness index:** a dimensionless index of flow oscillations relative to total flow based on daily average discharge measured during a water year.
- **TQ Mean:** the fraction of a year that mean daily discharge exceeds annual mean discharge
- **Storm volume:** total discharge volume during storm events over a water year.
- **Base volume:** total discharge volume during base flow over a water year
- **Total flow volume:** total discharge volume over a water year

Trends over time at each monitoring station will be evaluated using parametric (Pearson's r) and nonparametric (Kendall's tau or Spearman's rho) tests of correlation between these indicators and time. Statistical significance of the correlation coefficients will be evaluated based on an α-level of 0.05. The trend of interest will be evidence that receiving water conditions are improving based on one or more of these indicators in the Application watersheds while conditions in the Reference and Control watersheds remain relatively static.

In addition to the correlation analyses, separate analyses will be performed to compare measured flows in Tosh Creek and Monticello Creek to modeled flows for forested and existing conditions (i.e., conditions when the models were developed) that were derived from existing hydrologic models that have been developed for these watersheds using Hydrological Simulation Program—Fortran (HSPF). For these analyses, the measured and modeled flows will be post-processed to delineate individual periods of base and storm flow, respectively, across the entire time series for a given water year. Separate statistical analyses (Wilcoxon signed rank tests) will then be performed to determine if measured peak flows and flow volumes, respectively, during storm flow are significantly different from modeled flows for either the forested and existing conditions. Statistical significance in these tests will be evaluated based on an α-level of 0.05. These analyses will be performed every 2 years. If watershed rehabilitation efforts are effective, measured peak flows and flow volumes should depart from the modeled equivalent for existing conditions and more closely resemble those for forested conditions.

More detailed information on the procedures that will be used for data collection, quality assurance/quality control (QA/QC), management, and analysis for this component of the RPWS will be provided in the formal QAPP to be developed later.

3.2.2. Water Quality Monitoring

A total of 14 fixed monitoring stations will be established to facilitate water quality monitoring in each of the study watersheds. These stations will be co-located with the monitoring stations described above for hydrologic monitoring (see Figures 2 through 7). Twelve grabs samples will be collected annually during storm events (three each quarter) at all 14 monitoring stations for the duration of the RPWS. In addition, four grabs samples will also be collected annually during base flow (one each quarter) at these stations. Each sample will be analyzed for the following indicators for evaluating water quality impacts from urban development:

- Total suspended solids
- Turbidity
- Conductivity
- Hardness
- Dissolved organic carbon
- Fecal coliform bacteria
- Temperature
- Total phosphorus
- Total nitrogen
- Copper, total and dissolved
- Zinc, total and dissolved

In addition, the following indicators will be measured continuously at each station using probes:

- Temperature
- Conductivity
- Turbidity

Trends over time at each monitoring station will be evaluated using parametric (Pearson's r) and nonparametric (Kendall's tau or Spearman's rho) tests of correlation between these indicators and time. Where possible, variation in the indicator data related to changes in stream flow will be removed prior to performing the correlation analyses using methods described in Helsel and Hirsch (2002). Use of these methods is generally applicable for indicators that tend to increase (or decrease) as a function of flow (e.g., total suspended solids). By removing this variation, trends in the indicator data can be more readily detected in the correlation analyses. In all cases, statistical significance of the correlation coefficients will be evaluated based on an α-level of 0.05.

Annual mass load estimates will also be derived for the following subset of indicators using the nonparametric "smearing" approach described in Helsel and Hirsch (2002): total suspended solids, total phosphorus, total nitrogen, total copper, and total zinc. Trends over time at each monitoring station will again be evaluated using parametric (Pearson's r) and nonparametric (Kendall's tau or Spearman's rho) tests of correlation between these mass load estimates and time. Statistical significance of the correlation coefficients will be evaluated based on an α-level of 0.05. These analyses will be used to detect potential improvement in receiving water conditions from the combined effects of improved water quality and reduced stormwater runoff.

In all cases, the trend of interest will be evidence that receiving water conditions are improving based on one or more of these indicators in the Application watersheds while conditions in the Reference and Control watersheds remain relatively static.

More detailed information on the procedures that will be used for data collection, QA/QC, management, and analysis for this component of the RPWS will be provided in the formal QAPP to be developed later.

3.2.3. Sediment Quality Monitoring

A total of 14 fixed monitoring stations will be established to facilitate sediment quality monitoring in each of the study watersheds. These stations will be co-located with the monitoring stations described above for hydrologic monitoring (see Figures 2 through 7). Sediment samples will be collected annually at all 14 monitoring stations for the duration of the RPWS. Each sample will be analyzed for the following indicators for evaluating sediment quality impacts from urban development:

- Total organic carbon
- Copper
- Zinc
- Polycyclic aromatic hydrocarbons
- Phthalates

Trends over time at each monitoring station will be evaluated using parametric (Pearson's r) and nonparametric (Kendall's tau or Spearman's rho) tests of correlation between these indicators and time. Statistical significance of the correlation coefficients will be evaluated based on an α-level of 0.05. The trend of interest will be evidence that receiving water conditions are improving based on one or more of these indicators in the Application watersheds while conditions in the Reference and Control watersheds remain relatively static.

More detailed information on the procedures that will be used for data collection, QA/QC, management, and analysis for this component of the RPWS will be provided in the formal QAPP to be developed later.

3.2.4. Physical Habitat

A total of 19 fixed monitoring stations will be established to facilitate physical habitat monitoring in each of the study watersheds as follows:

Application Watersheds

- Evans Creek Tributary 108: two stations designated Lower Stream Station and Midstream Station, respectively (see locations in Figure 2).
- Monticello Creek: five stations designated Mont-1, Mont-2, Mont-3, Mont-4, and Mont-5, respectively (see locations in Figure 3).
- Tosh Creek: four stations designated Tosh-1, Tosh-2, Tosh-3, and Tosh-4, respectively (see locations in Figure 4).

Reference Watersheds

- Colin Creek: one designated Colin-1 (see locations in Figure 5).
- Seidel Creek: three stations designated Seidel-1, Seidel-2, and Seidel-3, respectively (see locations in Figure 6).

Control Watersheds

- Country Creek: two stations designated Country-1 and Country-2, respectively (see locations in Figure 7)
- Tyler's Creek: two stations designated Tylers-1 and Tylers-2, respectively (see locations in Figure 8).

Per the recommendations from the literature review (see *Background* section), monitoring stations were established in reaches that will be restored and in reaches where there will be no physical alterations to the channel. The following monitoring stations were specifically selected to capture reaches that have either been recently restored or are likely to be restored in the future:

- Mont-3
- Mont-4
- Mont-5
- Tosh-1
- Tosh-3
- Tosh-4

Physical habitat monitoring will be conducted annually at each monitoring station for the duration of the RPWS. Physical habitat monitoring will be based largely on indicators and methods laid out in Appendix C of the QAPP for Status and Trends Monitoring of Small Streams in the Puget Lowlands Ecoregion (Ecology 2014) and the TFW Monitoring Program Method Manual for the Large Woody Debris Survey (Shuett-Hames et al. 1999). The characteristic bedform type will be recorded for each habitat monitoring station as a whole, and physical habitat quality indicators will be measured at 11 cross-sections and one longitudinal (thalweg) profile for each habitat monitoring station (Ecology 2014: Appendix C-1).

The following indicators will be measured at each cross-section:

- Bankfull width, wetted width, and cumulative bar width (Ecology 2014: Appendix C-5)
- Bankfull depth, wetted depth, substrate class and embeddedness at 11 or more stations across the section (Ecology 2014: Appendix C-6)
- Fish cover (Ecology 2014: Appendix C-8)

The following indicators will be measured along the longitudinal (thalweg) profile:

- Thalweg depth and the presence of bars and/or edge pools (Ecology 2014: Appendix C-11)
- Main channel slope and bearing (Ecology 2014: Appendix C-16)
- Large woody debris tally (Ecology 2014: Appendix C-12), including notation of diameter, length, category, zone, and key-pieces, per TFW Level 1 survey procedure (Shuett-Hames et al. 1999, pp. 16–17).

Stream hydrology has very limited influence on overall riparian cover or tree cover (compared to other factors such as site history, vegetation management) so neither is likely to be responsive to watershed-level hydrologic restoration. In place of the methods and indicators proposed in Ecology (2014) Appendix C-10, an alternative monitoring method will be implemented that is calibrated to the range of conditions in Redmond and can differentiate between "good" and "impaired" vegetation states that are more likely to be responsive to watershed-level restoration activities. This method consists of recording at each cross-section:

- Evidence of vegetation colonization below the ordinary high water mark (OHWM) that persists more than 1 year
- Slopes vegetated over the crown of the bank
- Presence of desirable native plant species (e.g., cottonwood, willow)
- Presence of invasive plant species (e.g., reed-canarygrass)
- Presence of good-habitat indicator liverwort species

Post-processing of recorded physical habitat indicators will allow monitoring of:

- Channel incision or aggradation
- Channel widening, narrowing, or migration
- Changes in channel slope, sinuosity, and/or bedform type

More detailed information on the procedures that will be used for field data collection, QA/QC, management, and analysis for this component of the RPWS will be provided in the formal QAPP to be developed later.

3.2.5. *Biological Monitoring*

A total of 19 fixed monitoring stations will be established to facilitate biological monitoring in each of the study watersheds. These stations will be co-located with the monitoring stations described above for physical habitat monitoring (see Figures 2 through 7). Benthic macroinvertebrate samples will be collected annually at each monitoring station for the duration of the RPWS. Each sample will be processed to calculate the following indicators for use in evaluating stream health:

- Benthic Index of Biotic Integrity
- Taxa Richness
- Ephemeroptera Richness
- Plecoptera Richness
- Trichoptera Richness
- Clinger Percent
- Long-Lived Richness
- Intolerant Richness
- Percent Dominant
- Predator Percent
- Tolerant Percent

Trends over time at each monitoring station will be evaluated using parametric (Pearson's r) and nonparametric (Kendall's tau or Spearman's rho) tests of correlation between these indicators and time. Statistical significance of the correlation coefficients will be evaluated based on an α-level of 0.05. The trend of interest will be evidence that receiving water conditions are improving based on one or more of these indicators in the Application watersheds while conditions in the Reference and Control watersheds remain relatively static.

More detailed information on the procedures that will be used for data collection, QA/QC, management, and analysis for this component of the RPWS will be provided in the formal QAPP to be developed later.

3.3. Effectiveness Monitoring

As described above, roving stations will be established for the Effectiveness Monitoring component of the RPWS to verify that specific structural stormwater controls are constructed properly and performing as designed. The roving stations will be moved from one year to the next once a facility's effectiveness has been verified and new facilities come online. The specific types of monitoring to be performed at each roving station will depend on the type of structural stormwater control that is being evaluated. For example, it is anticipated that only hydrologic monitoring would be performed at roving stations for facilities that are only designed for flow control (e.g., vaults). In these cases, a facility's performance would be verified based on comparisons of measured flow from the roving station to the facility's predicted flow based on models used in its design. For facilities that are designed for runoff treatment, monitoring will follow guidelines from Ecology's Technology Assessment Protocol-Ecology (TAPE) (Ecology 2011) and include both hydrologic (e.g., influent and effluent flow) and water quality monitoring. In these cases, a facility's performance would be verified based on comparisons of its measured pollutant removal efficiency relative to targets that are identified in TAPE for specific treatment categories.

At present, no new structural stormwater controls have come online in an Application watershed that are suitable for Effectiveness Monitoring. For planning purposes, it is anticipated that two separate facilities will be completed and made available for monitoring in Years 2 and 3 of the study, respectively. For each facility, detailed information on the procedures that will be used for data collection, QA/QC, management, and analysis will be provided in separate addendums to the formal QAPP for the RSMP.

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