Rock Creek Sustainability Initiative Research Findings

Portland State University Research Team

December 2008

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Acknowledgements

Funding to help enable this research project was provided through a U.S. Geological Survey Mini-Grant administered by the Institute for Water and Watersheds at Oregon State University.

We would also like to thank the following people for their help with this project.

From Parametrix, Inc.:

- Kevin Benck
- Cyrus Bullock
- Kevin Halsey
- Damon Hess
- Paul Manson

From Water Environment Services:

- Carol Murdock and Bob Storer

For taking their time to present to the research team:

- Steve Fancher, City of Gresham
- Phil Pommier, Pacific Water Resources
- Christina Skellenger, Gerding Edlen Development

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Overview

The Rock Creek basin in Clackamas County, western Oregon is poised for rapid urban growth. This has been shown in the work completed by Metro, Clackamas County, and the City of Happy Valley as part of the Damascus/Boring Concept Plan and by the Happy Valley Comprehensive Plan. The goal of the Rock Creek Sustainability Initiative (RCSI) is to protect the habitat and water quality values of Rock Creek and its tributary through coordinated planning for redevelopment from agriculture to employment uses.

The City of Happy Valley, Sunrise Water Authority, and Clackamas County Water Environment Services (WES) are collaborating to create a sustainable development test project that would provide an opportunity to create and measure a suite of sustainable development practices on a local level. The RCSI project area is approximately 400 acres in the City of Happy Valley. It was incorporated within the Urban Growth Boundary (UGB) in 2002 and designated as a regionally significant industrial area (RSIA) for medium to large scale campus industrial development. The RCSI desired end result is an economically vibrant core employment zone constructed in a manner that protects ecological function and provides the community with an equitable return on the investment of natural capital used in the development of the project area.

In order to help advance the project a grant was obtained through the U.S. Geological Survey mini-grant program administered by the Institute for Water and Watersheds at Oregon State University. This enabled the convening of a research team of graduate students from the Departments of Urban Studies and Planning and Environmental Sciences at Portland State University. The objectives of the research team were to provide the RCSI project team with a document that could inform interested stakeholders and decision makers on the benefits of applying Low Impact Development (LID) principles for stormwater management. The following report:

- Provides a more detailed description of the background to the RCSI project;
- Gives an overview of LID, including rationale, methods, obstacles, and benefits;
- Identifies and describes numerous LID projects (mostly in the Pacific Northwest) with relevance to RCSI including detailed descriptions of two projects, the *Kitsap Sustainable Energy and Economic Development Project* in Bremerton, WA, and the *Springwater Industrial Area* in Gresham, Oregon;
- Describes current conditions in the RCSI project area;
- Identifies ecosystem services currently provided in the area and describes appropriate valuation approaches;
- Recommends performance evaluation methods;

- Evaluates costs and values of LID and conventional approaches to stormwater management;
- Describes the utilization of the ecosystem services assessment tool EcoMetrix, and potential for expanded use of this tool in the project area; and,
- Gives possible approaches for implementing LID practices in the project area.

In addition to providing baseline information and identifying development scenario alternatives, the report concludes with potential next steps to fill information gaps and advance opportunities identified.

Many findings are contained within these pages, but four core principles rose to the surface. (1) The RCSI provides an opportunity to advance cutting edge technology to promote multiple ecosystem benefits. (2) An LID approach allows local jurisdictions the ability to proactively control their own destiny by avoiding numerous regulatory measures associated with declining environmental performance. (3) An increasing economic and performance benefit is generally observed with increasing scale. (4) Implementation is not straightforward, but opportunities exist to ease implementation burdens and help advance the goals of the RCSI project. Many steps are already underway.

I. Introduction

RCSI Project Background

The Rock Creek Sustainability Initiative (RCSI) began in November of 2005 as a collaborative effort of three parties: Water Environment Services (a department of Clackamas County); the City of Happy Valley; and Sunrise Water Authority. These parties are pooling their resources and efforts to create a test project in an industrial development area that features sustainable development principles and provides an opportunity to quantitatively and qualitatively measure the effectiveness of sustainable development practices on a local level.

Beginning in 2002, significant changes occurred regarding land use in the Portland Metropolitan area. Metro approved the single largest Urban Growth Boundary (UGB) expansion since the inception of the UGB, 18,000 acres, with the express intent of allowing for the formation of a totally new city. During 2004, the City of Damascus was incorporated, encompassing roughly 12,000 acres of the 2002 UGB expansion. Concurrently, Clackamas County and Metro co-funded a community-based design process that produced the Boring-Damascus Concept Plan, which was completed in 2005.

Sunrise Water Authority also finalized a water system master plan in 2004, which included components regarding the use of reclaimed water and water conservation. The East Happy Valley Comprehensive Plan process was initiated by the City of Happy Valley and the Stormwater Master Plan was begun by Water Environment Services (WES) in 2005. Clackamas County also convened their Green Ribbon Committee on sustainable agriculture and related industry during the same year.

Changes in land use planning for the Damascus and East Happy Valley area created an environment in which new ideas could be fostered. Each of the service providers in the affected areas (Happy Valley, WES, and Sunrise) were involved in independent planning processes that were to some degree linked to the actions taken by each other.

WES was grappling with the reality that existing stormwater practices were not meeting the needs of the area and increased development would only exacerbate the deficiency. Stormwater detention basins did not function as intended given the hydrogeology of the service area for which planning was taking place. The agency was considering how to implement new best management practices and mechanisms that would allow them to meet numeric discharge limitations likely to be developed in reaction to pending third party lawsuits. WES was also determining how to test and verify that any new stormwater management practices met the needs of the agency. It is also common knowledge that increases in impervious surfaces as a result of development decreases the amount of soil surface area available for stormwater detention and retention and groundwater infiltration. Stormwater quality and quantity both have a direct impact on water quality of surface water resources in the area. The same factors also significantly impact the biodiversity of the area and the vitality of the stream corridors that are central to terrestrial and aquatic fauna populations and migration patterns.

Sunrise Water Authority (Sunrise) was completing demand forecasts and water resource evaluations. From these investigations, Sunrise concluded that in order to meet future demands, water conservation and water reuse would be two of many factors in water resource management. Sunrise identified a need to take an active role in managing all of the water resources upon which they were reliant, especially the Clackamas River, its tributaries, and the recharge of groundwater aquifers. Tracking data on supply sources, including stream flows and groundwater levels, would become a pivotal element in water right permitting processes. Stormwater management in developing areas would impact the contaminant load of the surface water sources from which potable water is drawn and also affect the flow patterns within tributaries to the Clackamas.

The City of Happy Valley was simultaneously faced with determining how to meet Metro Title 13, Title 6, and Title 3 requirements. These requirements addressed safeguarding nature in neighborhoods, water quality, fish and wildlife conservation, and managing for flood control. The city also realized that when they develop a comprehensive plan for East Happy Valley, the area brought into the UGB in 1998, they will need to address these issues. Happy Valley contracts with WES for stormwater management functions, and the City is largely reliant on the stormwater management practices provided by WES to meet Metro requirements.

Service providers recognized the nexus of their interests when Providence Medical Centers purchased a portion of the industrial area land. Providence has a history of integrating green design practices into the construction of new facilities. The architectural firm, Zimmer, Gunsul, Frasca (ZGF), and the engineering firm, KPFF, also actively promote green design features in their work. These firms were retained by Providence to perform planning and design tasks for the recently acquired land. The firms came to each of the service providers with a conceptual level map of how the entire industrial area could be planned and developed in a manner that would be mutually beneficial to the Providence site and adjacent parcels. During the presentation to Sunrise Water Authority, Sunrise staff became involved with discussing how water conservation measures could be incorporated into the design process, along with the use of reclaimed water, and how they could work with developers to integrate these features if they were incorporated into the development code for the area. This discussion also led Sunrise staff to consider how development fit into the agency's new emphasis on watershed management in the Rock Creek Basin.

These discrete but related concepts coalesced into the concept of the Rock Creek Sustainability Initiative, an effort to advance sustainable development and integrated water management at a systems level. Each provider saw the value in looking beyond the individual structure level of development to the point at which the built environment and the environmental aspects of managing the Rock Creek Watershed intersected. Thus staff from the service providers agreed to cooperate in looking for a method to initiate sustainable development in the joint service territories, starting with the designated project area.

Description of Project Area

The project area is approximately 400 acres and was designated as a regionally significant industrial area (RSIA) as part of the aforementioned UGB expansion; it was subsequently included in the City of Happy Valley Comprehensive Plan. Refer to Figure 1.7 for a map of the project area. One of the most significant features of the project is that the project area is substantially undeveloped with minimal impervious surfaces or roadways. Significant portions are currently being used for agricultural purposes. It is also bounded on one side by Rock Creek, a significant tributary to the Clackamas River. Development has already occurred on the west side of Rock Creek, and the effects are being monitored by USGS and WES. The entire project area lies within the confines of the Rock Creek Watershed. The lower reaches of Rock Creek have been classified as a salmonid bearing stream, up to a waterfall that creates a natural fish passage barrier. The stream is categorized as moderately impaired.

The upper reaches of the watershed lie primarily within the city limits of the City of Damascus, with a smaller portion lying within the City of Happy Valley, including the project area. This is significant in that the City of Happy Valley is creating a comprehensive plan and development code for the portion lying within their boundaries, with the intent for development to occur within two to five years. The City of Damascus is in the process of developing a comprehensive plan for their city, and has not begun to create the development code, so significant development in the Damascus portion of the watershed is unlikely to begin for about eight years. These circumstances have created a situation in which any development that occurs within the watershed is going to be largely confined to the project area. Any significant change, or lack thereof, in water quality parameters or flows being monitored in Rock Creek will have an extremely strong correlation to the type of development that occurs within the project area. External factors influencing monitored parameters may still be present, but will be limited.

PSU Research Team Project Objectives

In order to move the project forward, a grant was obtained through the U.S. Geological Survey Mini-Grant program administered by the Institute for Water and Watersheds at Oregon State University. This grant helped provide process support and enabled the convening of a graduate level research opportunity through the School of Urban Studies and Planning at Portland State University during the Fall Term of 2008. Students had the opportunity to gather information regarding actions needed to move towards implementation of sustainable development in the project area. Early in the term, the research team determined that addressing all aspects of sustainable development within the framework of a ten-week course would not be possible. The determination was that the maximum benefit to the RCSI Project team would be derived from addressing one aspect of sustainable development individually. The class chose to focus on Low Impact Development (LID) principles for stormwater management. Water Environment Services has stormwater modeling efforts under way. The sentiments of the research team were that addressing stormwater was likely to yield the most useful information for the project team with immediate opportunities for application.

The objectives of the research team were to provide the RCSI project team with a document that could be used to advise and educate decision makers on the benefits of applying LID in the project area. It is intended that the document will address issues and questions that the policy makers have in regards to:

- Current Conditions in the project area
- Approaches to assigning value to the ecosystem services offered in the project area
- Analysis of different development scenarios
- Recommendations for performance evaluation methods
- Relative costs and value of LID and conventional approaches to stormwater management
- Recommendations for approaches to implementing LID practices in the project area.

The intent is to enable this document to be integrated into a larger effort to address the diverse aspects of sustainable development as it pertains to the RCSI Project area.

II. Low Impact Development

Overview of Low-Impact Development (LID)

Low Impact Development (LID) encompasses many ideas, but its basic definition, according to the U.S. Environmental Protection Agency (U.S. EPA) is "an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible" (U.S. Environmental Protection Agency [U.S. EPA], 2008).

Figure 1.1 illustrates that LID is an integrated approach and it does not involve merely one solution assigned to one problem, but rather many solutions applied to an entire project or site. This figure explains the five-step approach that is laid out in a manual written by the Department of Environmental Resources in Prince George's County, Maryland. The manual describes LID as a "comprehensive technology-based approach to managing urban stormwater". LID attempts to mimic the hydrology of the area as it existed before development occurred and attempts to manage stormwater onsite rather than being moved to larger facilities as is often the case in conventional stormwater management (Prince George's County, 1999).

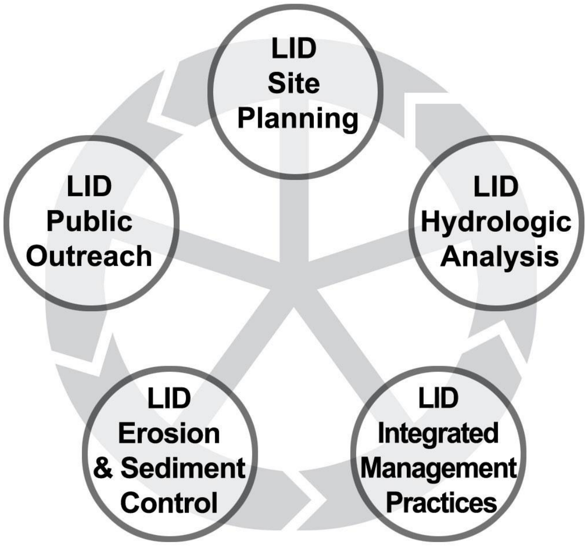


Figure 1.1. LID Integrated Approach

Source: Prince George's County, Maryland, 1999.

An important concept related to LID is "ecosystem services". Ecosystem services are a collection of life sustaining natural functions, conditions, or processes produced naturally by the ecosystem. Examples include water supply, fish habitat, and erosion control. When ecosystem services become damaged or degraded, negative consequences may occur such as a decline in water or air quality, soil stability, or biodiversity. These consequences have economic costs and could eventually lead to a lower quality of life for people in the affected communities. In places that have suffered degradation, people are trying to restore and protect watershed ecosystems. There are two approaches to dealing with stormwater: single-objective approaches and the ecosystem services approach. Single-objective approaches focus on one problem, such as preventing flood damages from a 10-year flood, whereas the ecosystem services approach involves crafting a solution that provides many ecosystem functions such as flood abatement, biodiversity maintenance, and water quality improvement (David Evans and Associates, Inc. [DEA, Inc.] & ECONorthwest, 2004).

The Lents Project Case Study provides an example of how the ecosystem services approach may be applied. In this case, the City of Portland attempted to quantify the value of ecosystem services in the Lents neighborhood of Portland. The project goal was to develop a tool that measured changes in ecosystem services that occurred after certain projects were implemented. After that, the researchers assigned values to these changes. This "valuation" tool is intended to help decision-makers evaluate different project alternatives. In the case of Lents, the specific water-related goal was flood abatement, so the city compared the return on investment of two approaches: a single-objective, flood storage approach and an ecosystem services-focused flood abatement approach (DEA, Inc. & ECONorthwest, 2004).

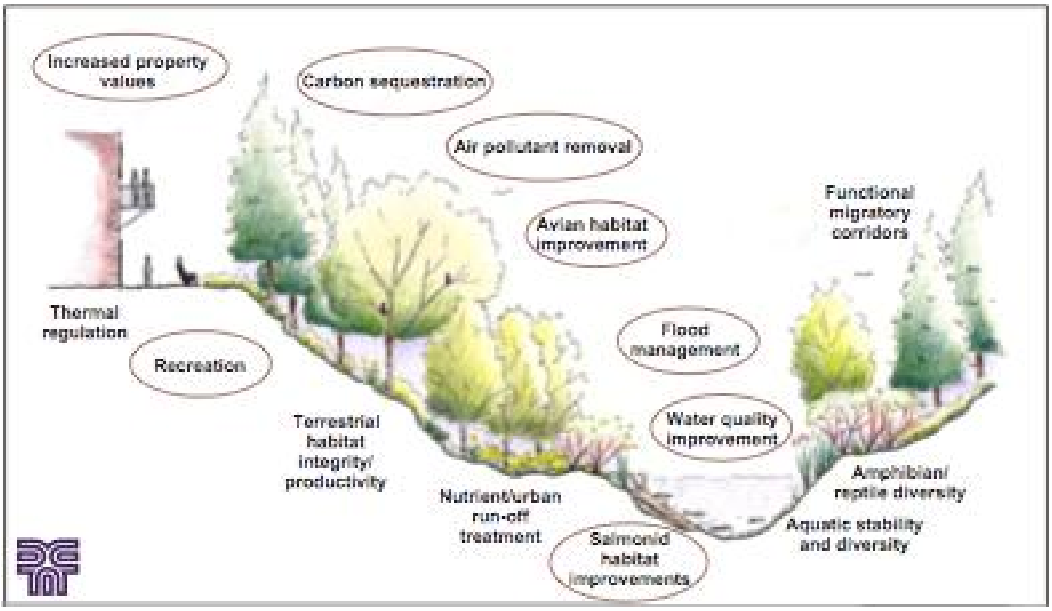
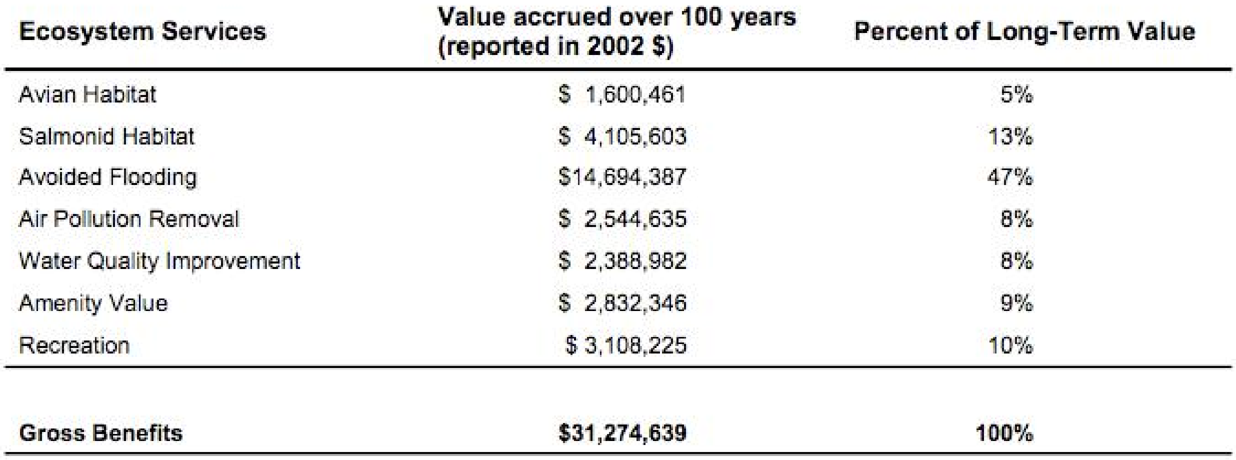


Figure 1.2. Ecosystem Services
Source: DEA, Inc. & ECONorthwest, 2004

Figure 1.2 shows the various ecosystem services in a riparian area. The ecosystem services circled in Figure 1.2 were quantified in the Lents analysis. Table 1.1 summarizes the long-term value of changed ecosystem services. Taking an ecosystem services approach can produce many benefits, both in economic and environmental terms. For example, if one were to look at "Avoided flooding", which was a major goal for the Lents neighborhood, the value accrued from changes in this specific ecosystem service over 100 years would be $14,694,387[1] (DEA, Inc. & ECONorthwest, 2004).

Table 1.1 Value of changed ecosystem services (long-term)



Ecosystem Services	Value accrued over 100 years (reported in 2002 $)	Percent of Long-Term Value
Avian Habitat	$ 1,600,461	5%
Salmonid Habitat	$ 4,105,603	13%
Avoided Flooding	$14,694,387	47%
Air Pollution Removal	$ 2,544,635	8%
Water Quality Improvement	$ 2,388,982	8%
Amenity Value	$ 2,832,346	9%
Recreation	$ 3,108,225	10%
Gross Benefits	**$31,274,639**	**100%**

Source: Source: DEA, Inc. & ECONorthwest, 2004

Rationale for Pursuing LID

There are a number of reasons to pursue LID ranging from environmental benefits to economic benefits to improved quality of life. LID can help protect a range of natural resources and associated ecosystem services, which benefit residents, businesses and municipalities. Information exists on the economic values of some of these benefits. Other benefits are more difficult to value. This report aims to highlight the costs and benefits of LID and make it easier to evaluate as an option for stormwater management policies and projects. A more detailed comparison of the costs and benefits of LID and conventional stormwater controls are included later in the report. This section aims to highlight some of the broader benefits of integrating LID techniques into projects.

Environmental Benefits

Pollution abatement is a major impetus for using LID techniques. Incorporating LID can reduce the amount of stormwater that runs into water sources such as streams and rivers. Pollution removal is another important function of LID and can be accomplished through certain practices such as filtration and uptake. With fewer pollutants reaching water sources, the habitats for wildlife are preserved along with the environment for recreational uses. Economic benefits related

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[1] In 2002 dollars

to the use of these techniques are the reduced costs of treating drinking water (Environmental Protection Agency [EPA], 2007).

Protecting downstream water resources is another benefit. Incorporating LID techniques can reduce stream channel degradation from erosion and sedimentation, improve water quality, and reduce illnesses related to being in contact with polluted water. Certain LID practices can infiltrate runoff, which in turn recharges ground water. This also increases stream baseflow, which is important in maintaining the health of aquatic life (EPA, 2007).

In many cases, the value of LID practices is that they are preventive measures. For example, it is generally less expensive to keep water clean than to clean polluted water. Using trees for stormwater management is also very valuable; the more forest cover a watershed has, the lower the water treatment costs. Using LID techniques can reduce the amount of water discharged from combined sewer systems into receiving waters during storm events as well. These practices also improve wildlife habitats and other natural resources, which can then increase land value and prevent mitigation costs (EPA, 2007).

Using LID techniques can reduce downstream flooding. This is achieved by reducing the peak flows and the total volume of runoff. This action reduces many costs including those incurred due to property damage from flooding as well as stormwater infrastructure costs – both capital costs and operation and maintenance costs. This has a "domino-effect" of cost reduction. Managing runoff onsite reduces erosion and the transportation of sediment. It also reduces flooding and downstream erosion. This, in effect, reduces cleanup and restoration costs. LID techniques can also protect floodplains (EPA, 2007).

One of the benefits of using LID is the reduced impact of a development on a wetland. This has regulatory implications and since often, projects using LID techniques have less of an impact on the environment than conventional projects, developers will pay lower impact fees for these "greener" projects. Additionally, some states offer incentives for using LID techniques including regulatory compliance credits and simpler permitting processes (EPA, 2007).

Land Value and Quality of Life Benefits

Another benefit of LID is its ability to increase property values and property tax revenue. In some cases, LID features can serve as visual amenities that add value to a property. Studies have shown that housing developed in clusters can sell for higher rates and appreciated at a higher rate than subdivisions with conventional designs and less open space. In addition to the real estate value of cluster housing, there is also environmental value because it allows for more open space in a development, helping with stormwater management. Additionally, the use of LID practices requires less land than conventional stormwater management practices such as ponds. Therefore, the land that would have been used for a pond can now be used for housing or another use (EPA, 2007).

There are also quality of life benefits. Many LID techniques incorporate landscaping with trees and flowering plants, which can complement existing landscaping features. Creating a quality design can increase property values. Because LID techniques can be used on individual lots, homeowners are often involved in these projects and thus learn about water quality issues and take part in the stormwater management process. The more people that are personally involved with stormwater management, the greater the public awareness, which furthers the cause (EPA, 2007).

Economic Benefits

As noted in many cases above, using LID techniques has economic benefits as well, including flood control, improved water quality, reduced expenditure on stormwater infrastructure, reduced energy use, improved air quality, and increased property value (ECONorthwest, 2007). While few studies of LID implementation have fully quantified the economic benefits, a 2007 literature review by ECONorthwest cites several studies which attribute quantifiable economic benefits to LID implementation, such as a 2-to-5% property value increase for properties in a floodplain with onsite management (ECONorthwest, 2007). The Lents case study echoes this notion, assessing that the value of services provided by using the ecosystem-oriented approach would have been twice as great as the value provided by the conventional approach (DEA, Inc. & ECONorthwest, 2004). These initial studies suggest that further quantifiable analysis of the economic benefits of LID is necessary. The Valuation section of this paper (VII) aims to quantify the economic benefits of LID in the RCSI project area.

Specific LID Techniques

The sections above discuss the benefits of using LID techniques. Table 1.2 describes specific LID techniques and their impact on specific ecosystem services.

Table 1.2. LID Methods Matrix

Method	Description	Primary Ecosystem Services Supported	Project Examples
Bioretention areas/Rain gardens	A shallow landscape feature designed to capture, filter and infiltrate stormwater runoff using vegetation and soils.	Erosion & sediment control Hazard Mitigation Water Quantity	Green Cove Basin High Point Kitsap SEED Portland Convention Center Springwater Industrial Area Villebois
Bioswales	A sloped landscape feature designed to direct, slow and filter stormwater runoff using vegetation and soil.	Erosion & sediment control Hazard Mitigation Water Quantity	Gateway Green Streets Master Plan High Point South Waterfront, OHSU Springwater Industrial Area Tabor to the River Villebois Zhangjiang New Columbia Clinton Beach Park
Constructed Wetlands	A substantial landscape feature designed to capture, filter and infiltrate stormwater runoff using vegetation and soils.	Erosion & sediment control Habitat Function Hazard Mitigation Water Quantity	Kresge Foundation Headquarter Springwater Industrial Area
Cisterns/rain barrels	A storage basin for stormwater capture and onsite greywater reuse, such as flushing toilets and watering plant.	Erosion & sediment control Hazard Mitigation	Kitsap SEED Kresge Foundation Headquarter South Waterfront, OHSU Zhangjiang
Drought resistant native landscaping	Low maintenance, low-water native vegetation.	Erosion & sediment control Habitat Function Hazard Mitigation Water Quantity	Clinton Beach Park Kitsap SEED Kresge Foundation Headquarter Springwater Industrial Area
Increased Tree Density	Planting trees to increase stormwater diversion and infiltration.	Erosion & sediment control Habitat Function Hazard Mitigation Water Quantity	Green Cover Basin Springwater Industrial Area Tabor to the River
Green roofs/ vegetated roofs/ eco-roofs	A thin layer of soil and plants constructed on rooftops to filter, slow rainwater, and serve as building insulation.	Erosion & sediment control Water Quantity	Clinton Beach Park Kresge Foundation Headquarter South Waterfront, OHSU
Minimized building footprint	Building upward rather than outward, limiting impervious roof surface, and maintaining the maximum possible natural vegetated greenspace on a site.	Erosion & sediment control Habitat Function Hazard Mitigation	Kitsap SEED Kresge Foundation Headquarter

Method	**Description**	**Primary Ecosystem Services Supported**	**Project Examples**
Porous paving	Pavement or pavers that allow water infiltration and reduced runoff; Replacing/minimizing impervious surfaces.	Erosion & sediment control Hazard Mitigation	Clinton Beach Park Green Cover Basin High Point Kitsap SEED Kresge Foundation Headquarter Pringle Creek Springwater Industrial Area
Soil amendments	Additives made to soil to restore its infiltration capacity and chemical characteristics.	Erosion & sediment control Habitat Function Hazard Mitigation Water Quantity	Kitsap SEED

LID Implementation Examples and Status

Table 1.3 below summarizes projects that use LID techniques. Most projects are located in the Pacific Northwest, but there are a few projects from other regions as well. Some of the projects are in the planning stages, while others are in the construction stage or have already been built.

Table 1.3 Project Matrix

Project	**Location**	**Rationale for Project Development**	**Major Project Sponsors**	**LID Methods Utilized**	**Web Site**	Current Status
Clinton Beach Park	Whidbey Island, WA	Providing beach access without damaging ecology	Port District of South Whidbey Island	Porous pavers Bioswales Green roof Drought resistant native landscaping	www.sustainablesites.org/cases/show.php?id=8	2 years old
Damascus Stormwater management plan	Damascus, OR	Pilot Stormwater Master Planning with Ecosystem Services Approach; city has no existing man-made stormwater infrastructure; protect watershed health	City of Damascus Metro Clackamas River Basin Council Clackamas Water Environment Services Johnson Creek Watershed Council Oregon Homebuilders Association City of Portland BES	Specifics unknown	www.ci.damascus.or.us/HotTopicsDraftCompPlanMap.aspx	Applied for grant Proposed start date: May 15, 2009
Gateway Green Streets Master Plan	Portland, OR	Sustainable urbanism pilot project; Address infrastructure and walkability needs	City of Portland	Landscape swales and planters	www.portlandonline.com/shared/cfm/image.cfm?id=185817	Policy

Project	**Location**	**Rationale for Project Development**	**Major Project Sponsors**	**LID Methods Utilized**	**Web Site**	Current Status
Green Cove Basin	Olympia, WA	Protecting sensitive watershed habitat	City of Olympia	Pervious pavement requirements Infiltrating gallery requirements Tree density requirements Maximum impervious surface limits	www.psparchives.com/publications/our_work/stormwater/lid/ordinances/Green_Cove.pdf	
High Point	Seattle, WA	HOPE VI affordable housing redevelopment project	HUD Seattle Housing Authority	Raingardens Bioswales Pervious pavement	www.thehighpoint.com	Policy Phase 1: built 2 years Phase 2: in construction
Kitsap SEED	Bremerton, WA	Economic development: attracting clean-tech business cluster to Kitsap County	Port of Bremerton Kitsap County Kitsap Economic Development Alliance Washington Clean Technology Alliance State of Washington	Cisterns for stormwater capture and onsite reuse Drought tolerant plantings Porous paving Bioretention: 10" topsoil + 4' fill Swale, Rain gardens	www.kitsapseed.com	Design
Kresge Foundation Headquarters	Troy, MI	To demonstrate Foundation's environmental mission	Kresge Foundation	Minimizing building footprint Green roof Stormwater capture and reuse Native landscaping Constructed wetland Porous paving Bioswales	www.sustainablesites.org/cases/show.php?id=14	3 years completed
New Columbia	Portland, OR	HOPE VI affordable housing redevelopment project	HUD Housing Authority of Portland	Bioswales Retains 98% of stormwater on-site	www.hapdx.org/newcolumbia/awards.html	Built
Portland Convention Center	Portland, OR	Achieve higher LEED-EB status; promote sustainable practices	Metro	Rain garden	www.mercvenues.org/venues/oregonConventionCenter.aspx	Built

Project	**Location**	**Rationale for Project Development**	**Major Project Sponsors**	**LID Methods Utilized**	**Web Site**	Current Status
Pringle Creek	Salem, OR	Sustainable mixed-use community project, economic development		Porous pavement	www.pringlecreek.com/	Built
South Waterfront – OHSU Center for Health and Healing	Portland, OR	Health Services, Economic development: Keep and expand valuable institution and employer in Portland	OHSU	Bioswales leading to Willamette River Green roof Rainwater harvesting and reuse in toilets and for landscaping	www.gerdingedlen.com/project.php?id=62	Phase 1: built Future phases pending
South Waterfront - Greenway	Portland, OR	Provide recreation area and protect habitat	City of Portland	Design guidelines include: "Utilize riverbank stabilization strategies that enhance the river and riverbank ecosystems" and "Integrate a variety of vegetation, above and below ordinary high water (OHW), that supports the river and riverbank habitats" (City of Portland, 2002).	www.portlandonline.com/planning/index.cfm?c=34291	Policy
Springwater Industrial Area	Gresham, OR	Economic development: Bring high-quality, family-wage jobs to East County, especially in high-tech research and development sector.	City of Gresham Metro	Rain gardens Bioswales Constructed wetlands Stormwater planters Porous paving Increased tree density	greshamoregon.gov/city/city-departments/planning-services/comprehensive-planning/template.aspx?id=7370&terms=springwater	Policy
Tabor to the River	Portland, OR	Eliminate flooding, fix system, prevent CSOs, improve watershed health	City of Portland	Hundreds of projects in 35 project areas including: Bioswales Tree plantings	www.portlandonline.com/Bes/index.cfm?a=199738&c=47591	Policy Early phases Will continue for next 10-20 years

Project	**Location**	**Rationale for Project Development**	**Major Project Sponsors**	**LID Methods Utilized**	**Web Site**	Current Status
Villebois	Wilsonville, OR		Costa Pacific Homes	“Greenways” Bioretention (ponds) Bioswales Planter boxes	www.villebois.net	Built
Zhangjiang, China	Shanghai, China	Trying to be one of first developments in China to achieve LEED Platinum status	Shanghai Municipal Committee and Municipal Government	Bioswales Infiltration facility Irrigation Geo-lake plate for heating and cooling exchange	www.lrsarchitects.com/EE/index.php/site/project_detail/aa	Planning

Other Related Sustainable Development Efforts

Several development frameworks provide guidelines to facilitate LID implementation. Within their broader suite of sustainable development resources, these frameworks offer tools, reference libraries and guidance on proven and cost-effective LID implementation methods. U.S. Green Building Council's LEED certification has developed an understood market value; achieving LEED certification can increase sale/rental price and marketability of development (Spivey and Miller, 2008). The Sustainable Site Initiative and the Living Building Challenge, which are currently under development to compliment and support the goals of LEED certification, provide a view into the resources that will be available to support sustainable development in the near future.

Leadership in Energy and Environmental Design (LEED)

U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) certification process is comprised of a collection of rating systems designed to provide attainable benchmarks and recommended methodologies for sustainable development. LEED for New Construction (LEED-NC) and LEED for Neighborhoods (LEED-ND, which is currently testing pilot sites) both include elements which support Low Impact Development.

Source: http://www.usgbc.org/

LEED for New Construction

LEED-NC, the most established of USGBC's suite of rating systems, was designed to "guide and distinguish high-performance commercial and institutional projects" (http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220). Focused on the impact of new buildings on their environment, LEED-NC's rating system includes prerequisites and credits in a range of building elements. Prerequisites are required for certification. Achieving credits earns points, which accumulate to earn 4 levels accreditation: certified (26-32 points) silver (33-38 points), gold (39-51 points), and platinum (52-69 points). Credits including stormwater design: quality control and stormwater design: quantity control, as well as water use reduction, water efficient landscaping, and protecting and restoring habitat.

To earn a point, a building must meet credit requirements. For example, to achieve the Stormwater Management: Quality Control point, the requirement is to "Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs).” (USGBC, 2005) To assist in attainment of this point, the USGBC provides BMP recommendations and calculation tools.[2] For many credits, more than one method is offered for meeting the requirement. In addition, applicants have the option of documenting an alternative method used, and applying for a “credit interpretation ruling” on whether that method is applicable to the credit. The recommendations, tools and flexibility can be useful assistance in the implementation of Low Impact Development, and certification offers a known value to potential property investors and tenants.

LEED for Neighborhood Development

Still in its pilot phase, LEED for Neighborhood Development (LEED-ND) approaches sustainable development on larger scale than LEED-NC, moving focus from the individual building to the site design and neighborhood levels. LEED-ND addresses Low Impact Development through several credits, including Stormwater Management, Site Design for Habitat and Wetlands Conservation, Restoration of Habitat or Wetlands, and Conservation Management for Habitat or Wetlands.[3] Like LEED-NC, LEED-ND offers guidelines and tools, and evaluates projects according to their ability to accomplish a set of prerequisites and credits, the achievement of which lead to “certified”, silver, gold, or platinum LEED certification.

The Living Building Challenge

The Living Building Challenge, put forth by the Cascadia Green Building Council, was created to compliment LEED-NC while encouraging innovation in sustainable development. The Challenge offers a simplified accreditation process, with only 16 criteria, but sets the bar for success higher by specifying stricter standards and making them all required.[4] It also requires that a building be operational for a year before accreditation, to ensure that the operating building meets its predicted goals. With fewer completed projects, the Living Building Challenge is not

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[2] A complete list of current points and their requirements is available in the LEED for New Construction Rating System v2.2. Calculation tool are available in the LEED for New Construction Reference Guide or to registered users in the tools section of the USGBC web site (www.usgbc.org).

[3] A complete list of current points and their requirements is available in the Pilot Version: LEED for New Construction Rating System. Calculation tool will be available to registered users the USGBC web site (www.usgbc.org) when LEED-NC has completed the pilot phase of the program.

[4] Criteria are available on Cascade Green Building Council’s Living Building Challenge web site: http://www.cascadiagbc.org/lbc.

as established as LEED. However, it offers a Users Guide that provides technical information and support. Also, because it is designed to encourage the generation of new resources, tools and building methods for implementing sustainable development in a range of situations and environments, the Living Building Challenge will instigate the expansion of sustainable development options in the not-too-distant future.

The Sustainable Sites Initiative

The Sustainable Sites Initiative approaches sustainable development by looking at the site with or without the building. Slated by USGBC to be incorporated into a future version of LEED, Sustainable Sites' evaluation is based on "ecosystem services". Ecosystem services are "goods and services of direct or indirect benefit to humans that are produced by ecosystem processes involving the interaction of living elements, such as vegetation and soil organisms, and non-living elements, such as bedrock, water, and air." (Lady Bird Johnson Wildflower Center, 13) These include global climate regulation, air and water cleansing, water supply and regulation, erosion and sediment control, hazard mitigation, pollination, habitat functions, water decomposition and treatment, human health and well-being benefits, food and renewable non-food production, and cultural benefits. Sustainable Sites works to evaluate development and management practices by their success in maintaining ecosystem services as close as possible to their natural state, thereby extracting the most benefit from ecosystem services' natural functions and avoiding costly replacement techniques.

Not yet in its pilot phase, the Sustainable Sites Initiative plans to release its complete Standards and Guidelines mid-2009 and its rating system in 2011. It will then release a Reference Guide in 2012, to provide assistance in developing practices and achieving successful implementation.

THE SUSTAINABLE SITES INITIATIVE™

Source: http://www.sustainablesites.org/

III. Case Study Examples

LID has not yet been implemented at a site that perfectly matches the economic and environmental requirements of the RCSI project site. However, there were some projects which shared important characteristics. Similar to the RCSI site, both the Kitsap SEED project in Bremerton, Washington, and the Springwater Industrial area are slated for industrial development. Both are also located in the Pacific Northwest, in ecologically sensitive sites. Springwater and RCSI are located in neighboring communities and both are currently undeveloped. The following analyses will describe further similarities and differences between these projects with the goal of identifying how other jurisdictions are planning for this type of development and why.

A. Kitsap Sustainable Energy and Economic Development Project (Kitsap SEED)

The Kitsap SEED Project site is located in Port Orchard, WA, which is in Kitsap County on the Olympic Peninsula west of Seattle. Like RCSI, the project's goal is to foster economic development without producing negative environmental impact. SEED will reach this goal by building a sustainable business park that attracts and retains clean technology business while demonstrating sustainable development practices. The area is known locally for military employment more than sustainability. However, it is directly connected to downtown Seattle by ferry, giving it convenient access to supportive political leadership and builders and designers knowledgeable in sustainable development.

Motivation for the Project

The original impetus for the project was economic development. Championed by the Port of Bremerton, Kitsap Economic Development Alliance and the Washington Clean Technology Alliance, the project was conceived as a way to attract businesses that would provide a solid base for economic development and local employment opportunities to a community whose economy is heavily dependent on the U.S. Navy and related industries (City of Bremerton, ED Appendix 5 and Kitsap County, 5-1). Attracting clean technology offered the possibility of getting in early on emerging technologies in a growing field with a strong and well paid workforce. Potential connection with local educational institutions offered training opportunities for local residents.

Figure 1.3 Kitsap SEED location

Source: Google maps

In assessing the steps necessary to attract clean technology, it became apparent that clean technology businesses would be drawn to developments that followed a guiding principle of their business model: sustainability. The project team therefore approached Mithūn of Seattle to develop preliminary designs for a sustainable project (Interview with Chris Saleeba at Mithūn, November 7, 2008).

Developing a sustainable project that would house clean technology employers opened to door to funding opportunities, including partnerships with the Federal Economic Development Administration, the State of Washington, Kitsap County, and West Sound Utility District.

The Project Site

The initial 75-acre site, owned by the Port of Bremerton, is a former naval storage facility that recently underwent significant environmental remediation and is currently undeveloped. The site is zoned industrial, and has nearby airport, ferry and rail access. However, it is also surrounded by forest and sensitive habitats.

Achieving Sustainable Development

To achieve sustainable development, Kitsap SEED managers and site designers chose to begin with a Phase 1 building on 7.5 acres of the site that would serve as a pilot project, implement a 65/10/0 stormwater management strategy and set a goal of LEED-NC Platinum Certification for the Phase 1 building.

The initial driver for phased implementation was economic. The pilot Phase 1 building, the SEED Clean Tech Commercialization Center (CTCC), is designed as a business incubator site for start-up companies. Phase 2, the SEED Sustainable Practices Collaborative (SPC), will expand out from Phase 1 to fill the educational role of the site, providing shared facilities for incubator businesses, as well as a clean technologies educational and promotional site. The remaining acreage of the site will be available for future phases of development to be led by incubator firms who require additional space as they outgrow their startup facility.

From a Low Impact Development standpoint, beginning with a pilot project that used only a subsection of the site allowed designers to evaluate the specific environmental needs of the site, assess opportunities and challenges, and create best practices that set an example for future development.

The 65/10/0 stormwater management model called for a minimum of 65% vegetative surfaces, a maximum of 10% impervious surfaces and 0% effective impervious surfaces. To achieve this goal, the project will include the following methods:

- Cisterns for stormwater capture and onsite reuse
- Drought tolerant native plantings
- Porous paving
- 10" topsoil and 4' fill additions
- Bioswales
- Rain gardens
- Minimized building footprint
- Siting and clustering development to minimize impact

During an iterative design process, designers decided against using a green roof on the CTCC, choosing instead to use the roof space for photovoltaics to meet other energy conservation goals. However, this decision was only made after ensuring that the 65/10/0 requirements were met through other methods.

It is important to note that in planning the site's development, analysis of potential development scenarios found that increasing open space on the site and decreasing the building footprint did not negatively impact the amount of building area that would be developed in comparison to local industry standards. (See Figure 1.4.)

Setting a goal of LEED-NC Platinum for the CTCC placed the project's sustainability objectives within an established context. This meant that the building would have benchmarks and guidance for meeting sustainability objectives. In addition, LEED certification offered an understood valuation system, which would attract prospective funding sources and future tenants.[5]

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[5] The Port of Bremerton received a $2.58 million grant from the Department of Commerce's Economic Development Administration (EDA), which includes funding from the Global Climate Change Mitigation Incentive Fund. According to the Kitsap Development Alliance, the inclusion of LEED features in the planned building was important in the award. (www.kitsapeda.org/news.asp?ID=712)

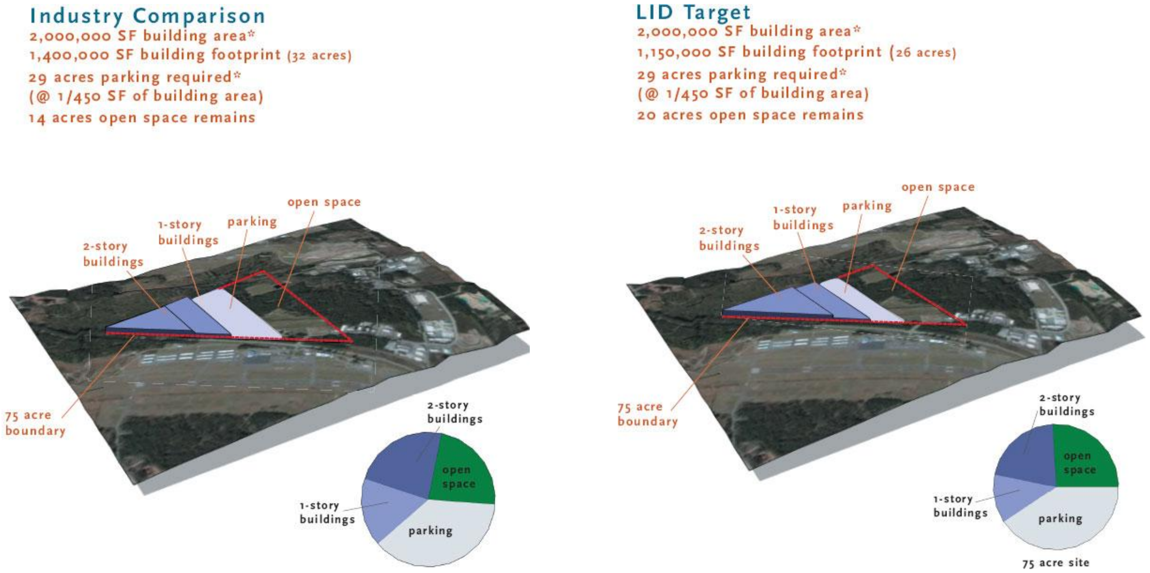

Figure 1.4. Comparison of LID Development to and Industry Standard
Source: Mithūn

Challenges

While the Kitsap SEED project has found considerable support and funding from a range of sources, it has yet to break ground. Success of the project will depend on its ability to attract a range of small businesses that will then support the project in the long term, and grow enough to expand beyond the pilot building. This will also hinge on the commitment of those businesses to continue developing at a high standard of sustainability.

B. Springwater Industrial Area

Project Overview

The Springwater Community is a 1272-acre area of unincorporated Multnomah County located to the southeast of Gresham. This area was added to the urban growth boundary in 2002 and designated as a regionally significant industrial area, which served the purpose of adding more industrial land both to the city of Gresham and the region. Although it is currently unincorporated, Gresham plans to annex the area (City of Gresham, Springwater Community Plan Summary [SCPS], 2005).

Presently, much of the project area is undeveloped agricultural land. The existing development consists of single-family housing and is characterized as rural. Springwater is located along Oregon State Highway 26 in the upper area of the Johnson Creek Watershed. Route 26 bisects the area and runs from the northwest to the southeast of the project site. Johnson Creek is the major drainage feature of the area and runs northwesterly through the project site for two miles. The following tributaries convey runoff to Johnson Creek's mainstem: Sunshine Creek, Hogan Creek, Badger Creek, and the North Fork of Johnson Creek (City of Gresham, Springwater Stormwater Master Plan [SSMP], 2005).

Motivations

The major goal of this project is to bring high-quality jobs to East Multnomah County, with an emphasis on those in the high-tech research and development sectors. A second goal is to create a project that provides leadership in sustainable development through green construction techniques, through the lifestyle it creates, and through the types of industries it attracts (City of Gresham, SCPS, 2005).

Development Attraction

As mentioned above, the Springwater Community Plan's goal is to bring many high-quality jobs to the area. The Springwater Community Plan estimates that this area could create over 15,000 jobs. The area will be divided into sub-districts with different attributes and uses. The sub-districts and the specific types of development the area aims to attract are summarized below:

- Industrial sub-district 1: 384-acre industrial area that contains the following industries: specialized software applications, recreational equipment and technology, corporate headquarters, specialty food processing, and renewable energy technologies;
- Industrial sub-district 2: 106-acre industrial area dedicated to research and development (R&D) that contains corporate headquarters, graphic communication and creative services, R&D and testing, computer services, accounting, legal services, and medical services;
- Mixed-use village: 23-acres; contains a grocery store as an anchor tenant;
- Moderate density residential: 43-acres; moderate density residential (townhouses);
- Low density residential: 99 acres; 1 house/6,000 sq. feet;
- Very low density residential: 97 acres; 1 house/12,000 sq. feet;
- Parks: 3 new parks to provide recreational opportunities to employees and residents; a trails system will connect to the existing regional trails system and provide bicycle and pedestrian access between the various sub-areas of Springwater;

- Roads and Transit: new arterials and collectors will be built; route 26 will be improved in phases; there will be a new interchange on a new southern arterial and a new grade-separated bridge-crossing at a new northern collector street; and transit service will operate in Springwater (City of Gresham, SCPS, 2005).

Stormwater Management Plan

The City of Gresham produced the Springwater Community Plan in 2005 in partnership with Multnomah County and in coordination with Metro and Clackamas County among others. The Springwater Community Plan sets the policy and code for the area and plans for Springwater's urbanization as required by the state of Oregon (City of Gresham, Springwater Stormwater Master Plan [SSMP], 2005).

To move forward with this project and the eventual annexation of this area by the City of Gresham, the City created a Stormwater Master Plan with the major goal of managing stormwater "to protect water quality and aquatic habitat and to minimize impacts of localized and downstream flooding" (City of Gresham, SSMP, p. 9, 2005). In order to achieve this goal, the plan aims to state what infrastructure is needed to collect, convey, and treat stormwater runoff from this area. The use of green and low impact development techniques is included among the plan's objectives (City of Gresham, SSMP, 2005).

Figure 1.5. Map of Springwater project area
Source: City of Gresham

Figure 1.5 shows a map of the Springwater project area. The first step in developing a stormwater master plan was creating a hydrologic and hydraulic model of the watershed and stormwater system, which includes natural and man-made features. The goal of this model is to estimate water quantity in the area, represent and evaluate the area's existing stormwater system, predict flood risk, and design stormwater management facilities. It also aims to evaluate different stormwater management strategies including low impact development and best management practices. After that, a water quality model was developed. This was done to analyze the water quality in the area's current stormwater system, identify the water quality and pollutants associated with various land uses and figure out which techniques could best control for issues, and to study different alternatives for reducing pollutant levels. The goal is to make sure there is no net increase in pollutant loads or levels due to urbanization. The results of these analyses show that it will be important to build regional stormwater facilities and utilize LID techniques (City of Gresham, SSMP, 2005).

The following section includes the Stormwater Management Facilities. The techniques chosen for this area attempt to mimic the natural hydrology of the area (pre-development). In order to do this, the city had to select techniques that would reduce stormwater volume and reduce peak flow rates. The techniques best suited to do this were low-impact techniques including rain gardens, porous pavement, and tree planting. Springwater has shallow groundwater so techniques that involve deep injection of stormwater were not an option. Additionally, new drywells were a challenge because the permitting process is difficult. The city wanted to minimize conveyance piping as well, so drainage channels (also known as swales) were a good option. It is important to note that the certain techniques work better depending on the primary land use. For example, drainage channels work well in industrial areas because there are large lots and few driveways. "Pocket swales" or rain gardens work better in residential areas because they are contained in specific areas at the end of a street or in the middle of a block (S. Fancher, personal communication, November 12, 2008).

The following list includes stormwater management techniques to be used in the project area, organized by category.

- Regional stormwater management facilities – The purpose of these facilities are to control stormwater quality and quantity. They will control runoff from the development and protect natural resources.
- Swale culvert crossings – This refers to locations where proposed swales will cross a road.
- Stream crossings – This refers to locations where streams cross roads. Bridges will be built over Johnson Creek to allow fish to pass through the area.
- Stormwater collection/conveyance system – This refers to green street swales and drainage channels that aim to collect runoff and convey it between subbasins rather than have it drain directly to the stream system.
- Natural resources improvement projects – This refers to projects that deal with water quality, reconnection of the floodplain, and temperature management (City of Gresham, 2007).

In addition to these techniques, the city of Gresham adopted “Green Development Practices” and compiled this information in an implementation guide for the Pleasant Valley and Springwater Plan Districts called *Green Development Practices for Stormwater Management*, published in July 2007. In these two districts, private property owners are required to manage 100% of the stormwater runoff from their property using “Green Development Practices”, before it is discharged into the streets or open spaces, where it will flow to regional facilities including ponds or wetlands created for this purpose. “Green Development Practices” include rain gardens (also known as swales, bioswales, or biofiltration), stormwater planters, porous pavement, or planting trees. In addition, all new streets in these areas must use “Green Street” elements to manage stormwater before discharging it. The “Green Street” techniques are specific to streetscapes and are used in the public right-of-way. Figure 1.6 illustrates stormwater management techniques used in Springwater and Pleasant Valley, minus tree planting (City of Gresham, 2007).

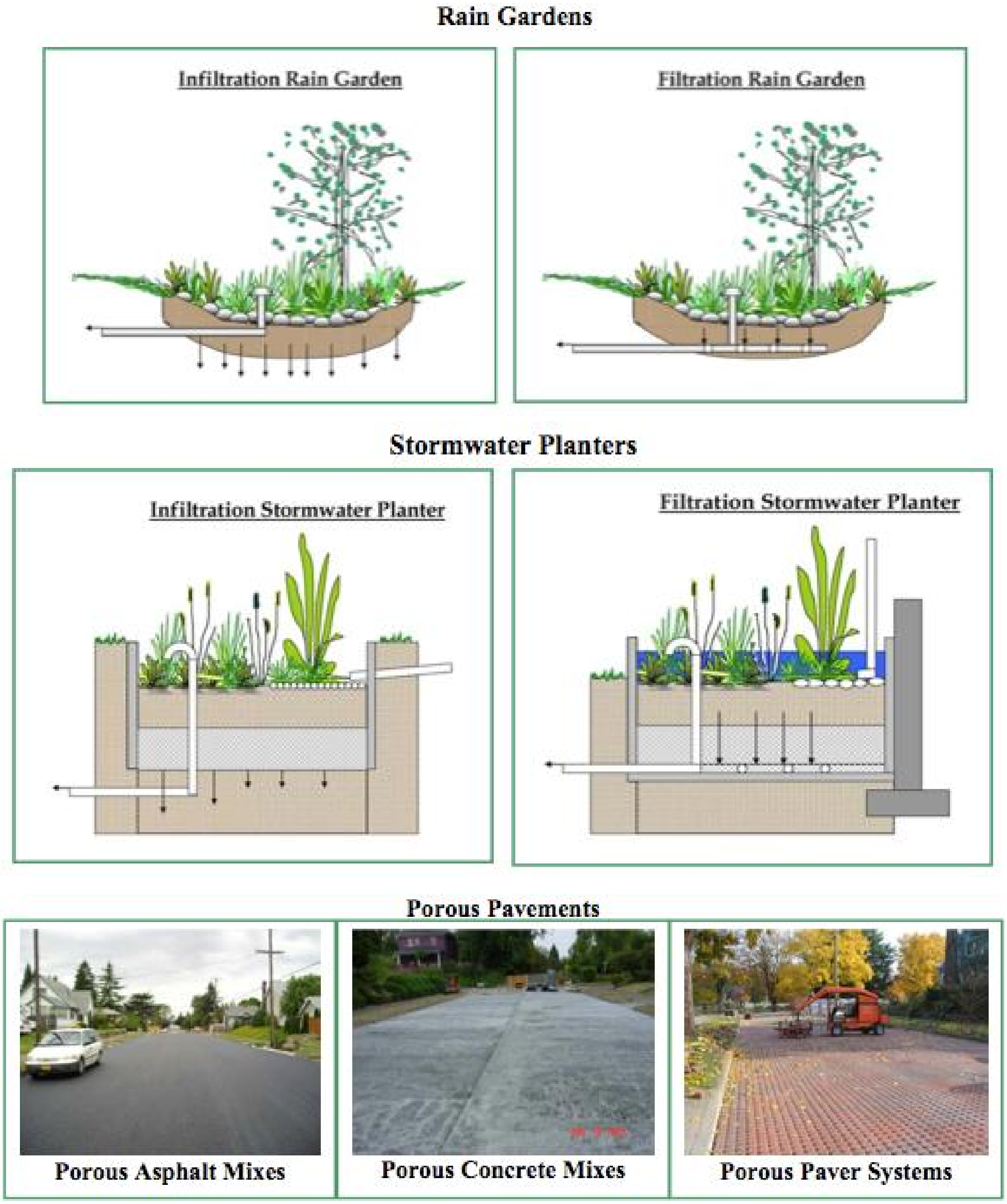

Figure 1.6. Stormwater Management Techniques used in Pleasant Valley and Springwater areas of Gresham, OR

Source: City of Gresham, 2007.

IV. Existing RCSI Conditions

RCSI Project Area Description

While researching this information concerning other relevant projects, the research team set about specifically delineating the project area and documenting existing conditions. This physical description of the approximately 400-acre RCSI project area is intended to place the site into its general environmental context. This was done using aerial photographs and ArcGIS software and by reviewing current literature. For an in-depth assessment of the lower Rock Creek watershed, see the Rock and Richardson Watershed Assessment (Ecotrust, 2000) and the Draft Willamette Subbasin Plan for the lower Clackamas River (Willamette Restoration Initiative, 2004).

The delineation of the RCSI project area in this section (Figure 1.7) is an approximation based on rough map sketches and personal communication. While it is relatively accurate, it does not necessarily represent the true boundary (particularly the northern edge). The RCSI project area lies within the lower Rock Creek watershed. The site is adjacent to more than one mile of lower Rock Creek and is approximately 1/3 mile northeast of Rock Creek's convergence with the Clackamas River.

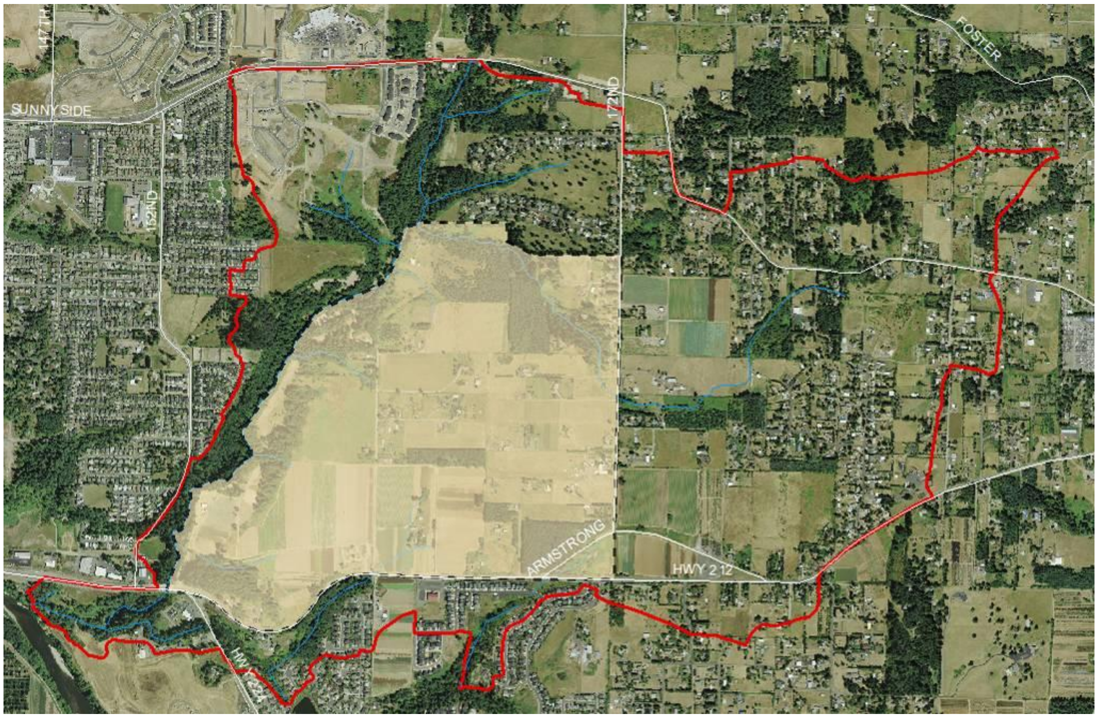

Figure 1.7 RCSI Project Area and Surrounding Watershed

Landscape Analysis and the Ecosystem Services Approach

Two approaches were used to determine the existing conditions of the RCSI project area. The first was a basic landscape analysis to identify and describe some of the key features and opportunities of the site: soils, infiltration, hydrology, land use/land cover, water quality and fish presence. The second approach explored a tool called EcoMetrix, which roughly assessed the ability of the landscape to provide certain ecosystem services.

Landscape Analysis Approach

Soils

Figure 1.8 shows delineations of soil types from the Natural Resource Conservation Service (NRCS). Note: at this enlarged scale, the soil line placement may not be accurate, and any details herein need to be field-verified. The soil types are also listed in Appendix B, along with their slopes, properties and typical profiles. Soil data were obtained from the NRCS web soil survey (2008).

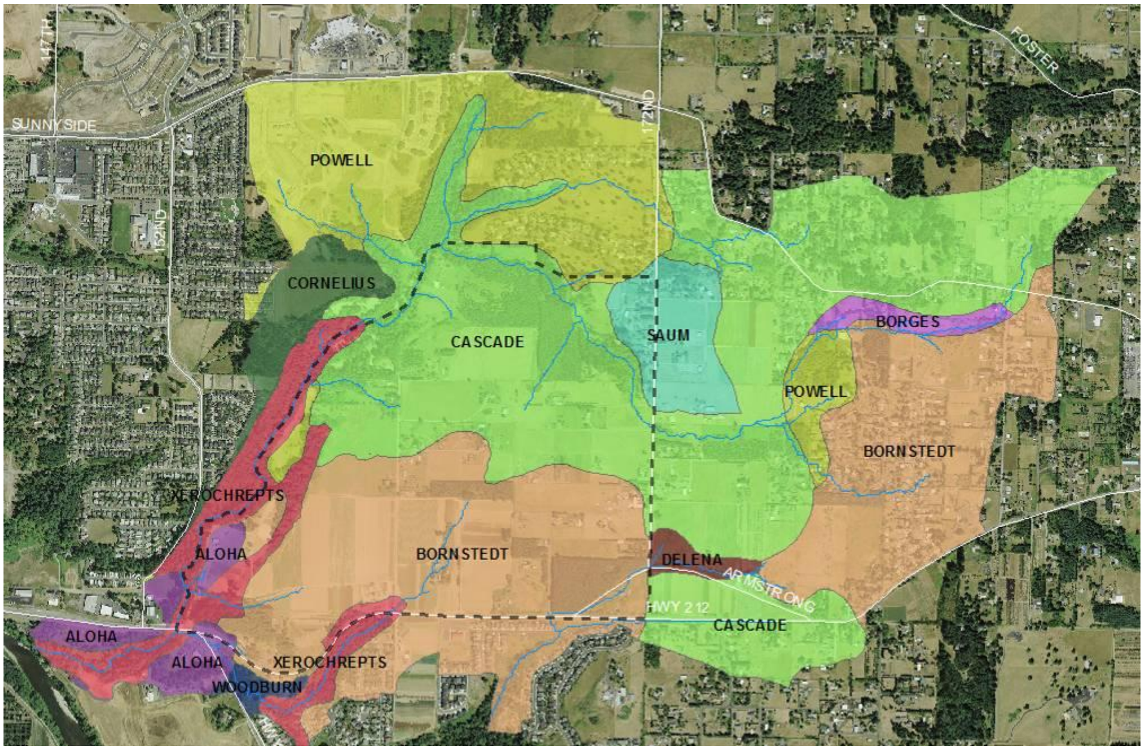

Figure 1.8 Soil Types - RCSI and Surrounding Watershed

Source: Natural Resource Conservation Service, 2008.

Snyder (2008) estimated the depth to ground water to be approximately 100 - 160 ft below land surface for much of the project area, and is at its deepest near the center-east edge. The depth to ground water tapers to zero where it discharges to Rock Creek and the Clackamas River (Snyder, 2008). However, the NRCS values listed in Appendix B show a depth to the water table between 1.5 and 6 feet below land surface. This suggests that there may be a perched water table sitting on a shallow restrictive layer/hardpan/ fragipan. Further research revealed that only a very small percentage of the soils on site are classified as hydric. Thus, more research is needed to determine the depth and extent of a hardpan layer and any associated perched water table.

Infiltration

Different locations within the RCSI project area have varying capacities to infiltrate water. The soil type data were overlaid with slope data and were qualitatively classified into four groups according to their ability to infiltrate water (Best, Feasible, Marginal and Infeasible – B, F, M and I, respectively). The results are shown in Figure 1.9.

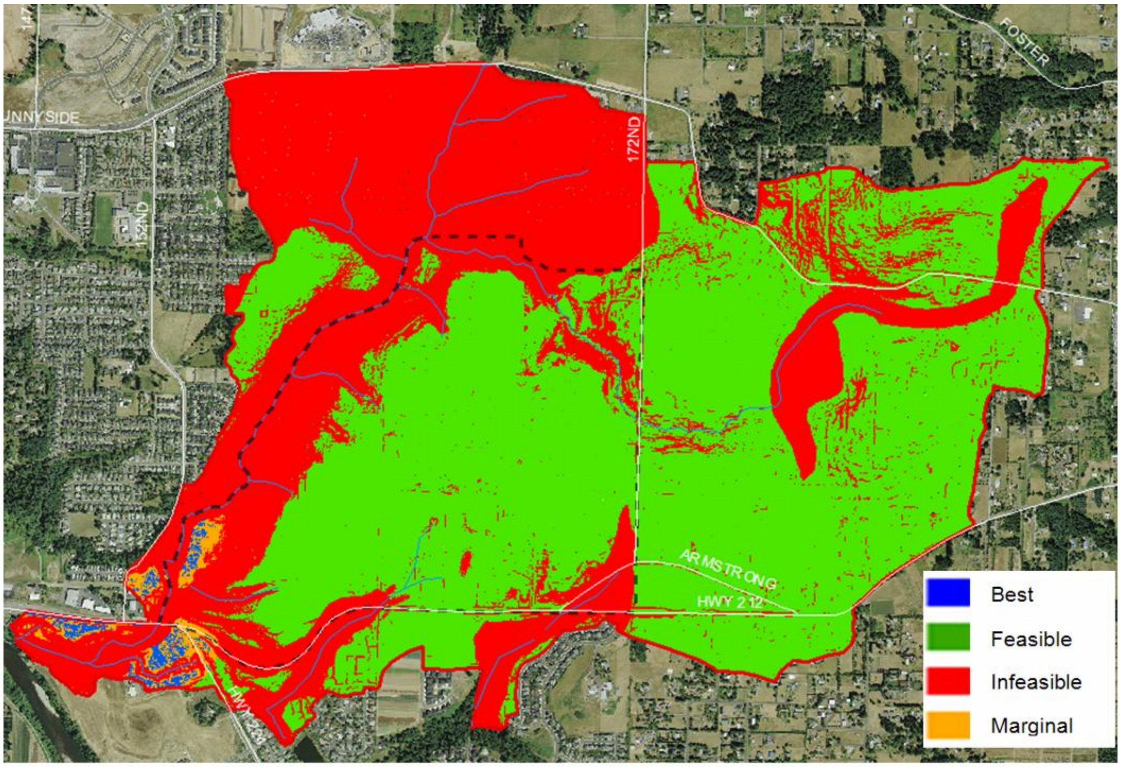

Figure 1.9 Infiltration Classification
Source: Water Environment Services, 2008.

The majority of the RCSI project area, 65%, is classified as Feasible to infiltrate water and nearly 34% as Infeasible. Less than one half of one percent (0.3%) is considered Best with the remaining 0.9% as Marginal. The Infeasible zones for infiltration tend to be near the steeper drainage areas and Feasible zones are in the flatter, upland agricultural areas. This will be an important consideration when exploring LID and best management practices for on-site stormwater management.

Hydrology

Lower Rock Creek flows NNE to SSW and makes up the entire western edge of the RCSI project area, then continues another 0.3 mi to its confluence with the Clackamas River. The topography of the site dictates surface water and local ground water flow directions. The RCSI has its highest elevation in the center-east with drainages flowing north, west and south (Figure 1.10). Precipitation and surface and ground water withdrawals are the main sources of water into the project area. Surface water withdrawals from lower Rock Creek are predominately used for agriculture with some used for domestic/municipal uses (ODEQ, 2006). Deep ground water withdrawals appear to be mostly used for domestic purposes (Oregon Water Resources Department, 2008). Some of the deeper, regional ground water that originates in the Boring Hills to the north may bypass Rock Creek and the RCSI project area to discharge directly to the Clackamas River (Snyder, 2008).

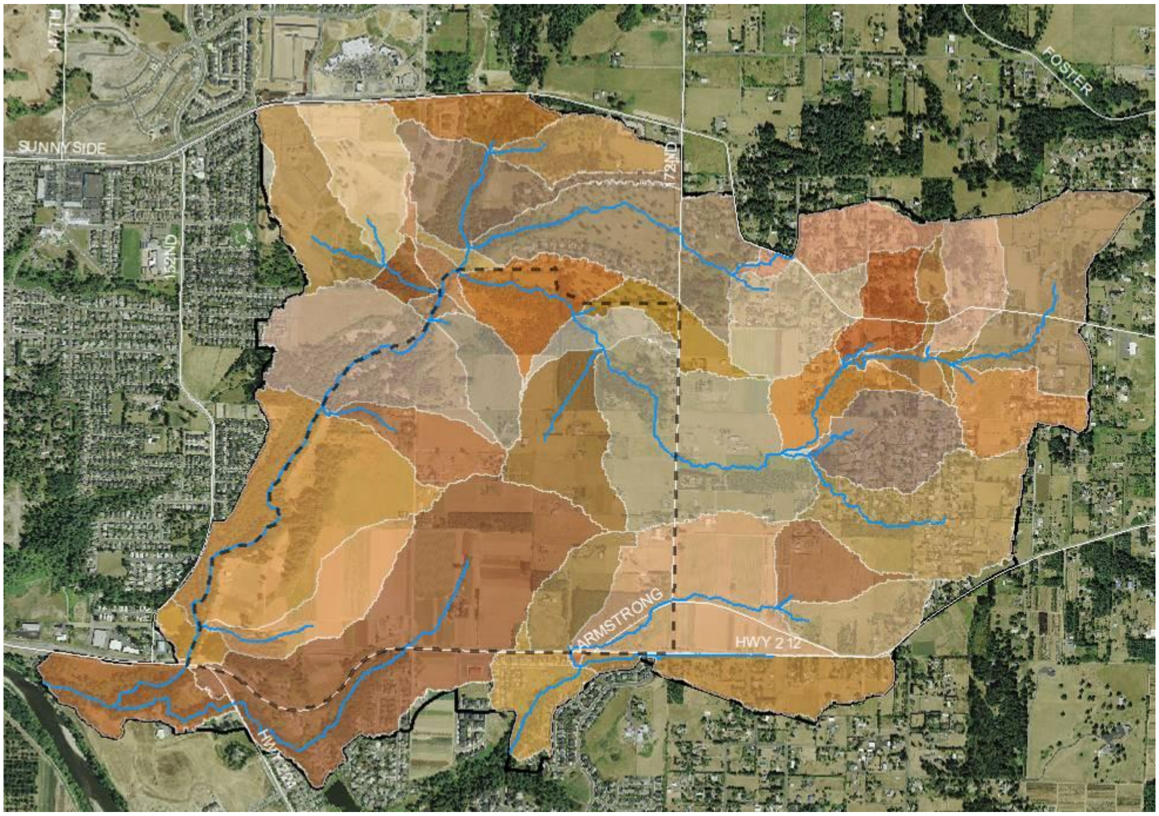

Figure 1.10 Drainage Patterns and Catchment Areas
(RCSI project area and surrounding watershed)

The 2-year storm event for this location is 2.4 inches in a 24-hour period. A storm of this intensity is expected to occur every other year, or has a 50% chance of occurring in any given year. A rain event of 2.4 inches over the 400-acre project area amounts to almost 3.5 million cubic feet, or 26 million gallons, in one day. Other storm intensities that may be planned for are the 5-year event (3.0 in/24hr), the 10-year event (3.4 in/24hr), the 25-year event (4.0 in/24hr), the 50-year event (4.5 in/24hr), and the 100-year storm event (5.0 in/24hr). A 2-5 year flow event can cause flows of 350 cfs in lower Rock Creek (Water Environment Services, 2007).

Land Use/Land Cover

A very large portion of the RCSI project area has been used for agriculture. There are also some noticeably intact forested riparian corridors along lower Rock Creek and its tributaries. Figure 1.11 shows approximately 45 acres (11.2 %) of relatively high quality riparian wildlife habitat and 27 acres (6.7%) of high quality upland wildlife habitat. These numbers somewhat underestimate the actual riparian areas of the corridor because the Rock Creek riparian zone extends beyond the western edge of the project area, as can be seen in Figure 1.11.

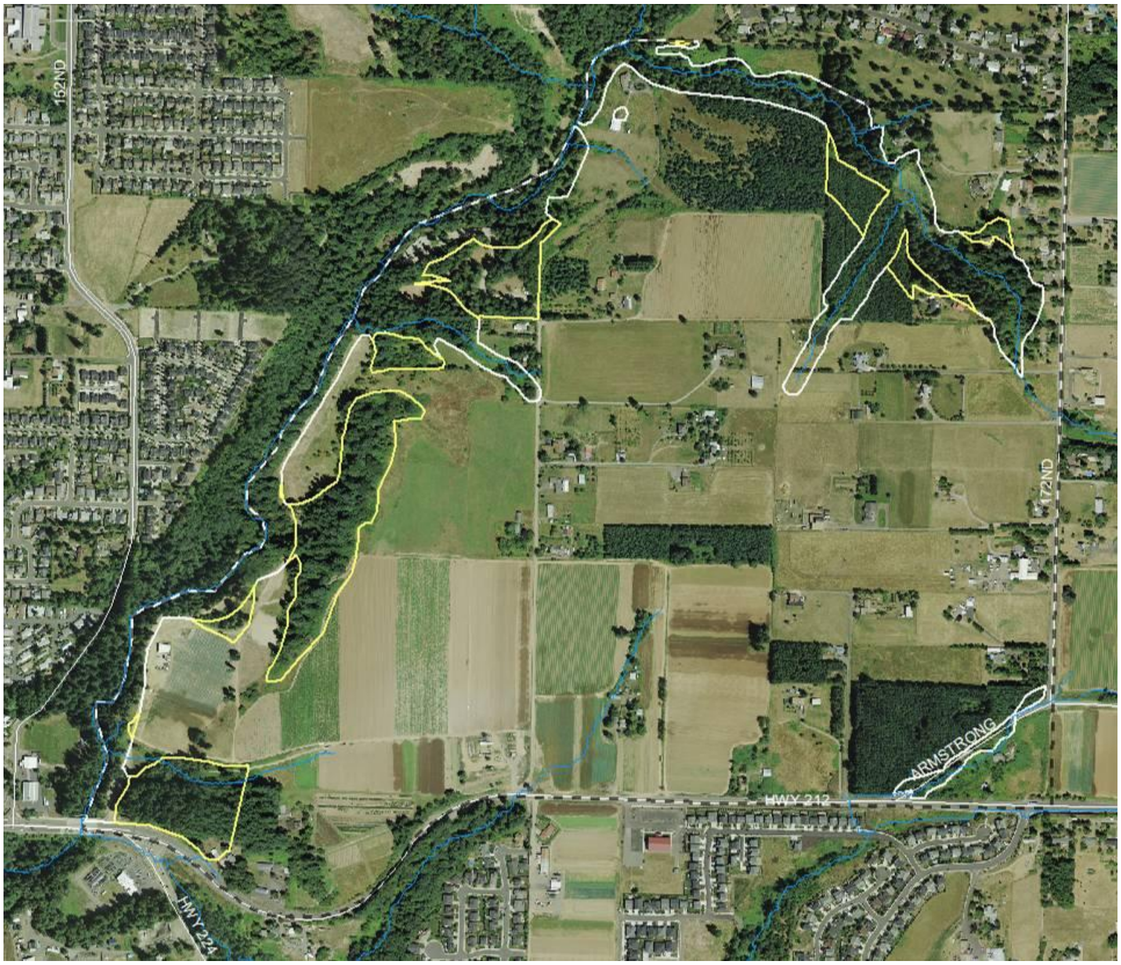

Figure 1.11 Land Use / Land Cover

High quality wildlife riparian corridor habitat (white) / Uplands (yellow)

Source: Metro, 2008.

Generally, the riparian areas in the lower canyons of Rock Creek are forested and include fairly mature (and some individual old growth) conifers, cottonwood, alder, maple and oak (Ecotrust, 2000). These areas are particularly valuable for the many ecosystem services they provide, and their protection will help maintain water quality standards and continued fish presence. With the exception of some rooftops, parking and storage areas and highly compacted dirt roads, there are essentially no impervious surfaces, which should be considered a significant asset of the site.

Water Quality

Lower Rock Creek appears to be within most water quality regulatory standards with some exceptions. Oregon Department of Environmental Quality (ODEQ) data from 2004 show that E.Coli bacteria levels during fall, winter and spring put Rock Creek on the Clean Water Act's 303(d) list of impaired streams—a Total Maximum Daily Load (TMDL) is required. Summer

E.Coli levels are “attaining some criteria,” and the substances chlorpyrifos and dieldrin, both toxic to aquatic life and human health, are a “potential concern” (ODEQ, 2004).

Oregon DEQ stream data from 2002 show lower Rock Creek to be “attaining” temperature standards for salmonid fish spawning (not warmer than 12.8 °C from October 1 – May 31) and rearing (not warmer than 17.8 °C during summer). However, some water quality “snapshot” monitoring results on July 16, 2005 and July 28, 2007 show stream temperatures of 18.67 °C and 19.0 °C, respectively—both above the 17.8 °C limit for salmonid fish rearing in summer (Clackamas River Basin Council 2005, 2007). While these snapshot results should raise some red flags, stream temperatures should be calculated using a consecutive seven-day rolling average of maximum temperatures (ODEQ, 2006). The Clackamas River, however, does exceed temperature standards, requiring a TMDL, so maintaining low temperatures in Rock Creek is crucial.

Pesticides are another major concern for Rock Creek. The Pesticide Toxicity Index for benthic invertebrates (based on pesticide concentrations in water samples) resulted in lower Rock Creek receiving one of the highest ratings in October 2000 (Bauer and Salminen, 2005). The high pesticide levels are most likely from agricultural and residential landscaping practices within the watershed. Other water quality limitations are presented in Table 1.4.

Table 1.4 Water Quality Limitations
Source: Bauer, Salmien and Rynyon 2005

Pesticides	Bacteria	Nitrates	Phosphorus
Highest	Very High	High	High

Lastly, data exist for many other potential water quality problems, such as dissolved oxygen levels, turbidity levels and chlorine concentrations, but do not appear to be of immediate concern.

Fish Presence

Rock Creek is biologically important. Oregon Department of Fish and Wildlife surveys in 2002-2003 collected 246 Cutthroat trout, 93 Rainbow and Steelhead trout, and 60 Coho salmon (Tinus, Koloszar, & Ward, 2003). The Rock and Richardson Watershed Assessment (Ecotrust, 2000) clearly summarized lower and middle Rock Creek as “salmonid hot spots” in the following manner; “These areas all have confirmed salmonid populations and offer good potential for habitat restoration and species recovery…[These] areas should receive special attention in terms of monitoring, protection, and restoration. If salmon cannot be retained in these sections, then they cannot continue to exist in these watersheds" (Ecotrust, 2000).

Table 1.5 shows native and introduced fish species found in lower Rock Creek while Table 1.6 presents a summary of selected fish in the Clackamas River Basin with their federal and state status. Of these fish, Rock Creek is known to be used by Chinook and Coho salmon, Rainbow and Steelhead trout, and with Cutthroat trout being the most common salmonid (Water Environment Services, 2007).

Table 1.5 Fish Species in Lower Rock Creek

(In addition to salmon and trout species)

Sources: Runyon and Salminen, 2005; Ecotrust, 2000.

Native Fish Species Common (Scientific) Name	**Introduced Fish Species** Common Name
Largescale Sucker *(Catostomus macrocheilus)*	Pumpkinseed
Red Side Shiner *(Richardsonius balteatus)*	Bluegill
Reticulate Sculpin *(Cottus perplexus)*	Largemouth Bass
Longnose Dace *(Rhinicthys cataractae)*	Brown Bullhead
W. Brook Lamprey (*Lampetra richardson)*	
Northern Pikeminnow (*Esox Lucieus*)	
Torrent Sculpin *(Cottus rhotheus)*	

Table 1.6 Selected Fish in Clackamas River Basin

(Fish names in ***boldface*** *also found in Rock Creek)*

Source: Runyon and Salminen, 2005.

Common Name **(Population Segment)**	**Scientific Name**	**Life-History Forms**	**Federal / State Endangered Species Status**
Chinook Salmon (L. Columbia R.)	*Oncorhynchus tschawytscha*	Anadromous (fall and spring runs)	Threatened / Threatened

Coho Salmon (L. Columbia R.)	*Oncorhynchus kisutch*	Anadromous	Candidate / Endangered
Steelhead / Rainbow Trout (L. Columbia River)	*Oncorhynchus mykiss*	Anadromous (winter steelhead), resident (rainbow)	Threatened / Critical (Steelhead)
Cutthroat Trout (L. Columbia R.)	*Oncorhynchus clarki*	Anadromous, fluvial, adfluvial, resident	Proposed / Critical (Anadromous Form)
Bull Trout	*Salvelinus confluentus*	Fluvial, resident	Threatened / Critical
Pacific Lamprey	*Lampetra tridentanta*	Anadromous	No status / Vulnerable

Note to Table: Fish-life history forms are as follows: Anadromous populations migrate from the ocean / Columbia estuary with spawning and juvenile rearing in the basin; Fluvial populations undergo within-basin migrations between small spawning tributaries and Clackamas / lower Willamette Rivers; Adfluvial populations migrate between spawning tributaries and lakes; Resident populations usually occur in small headwater streams and exhibit minimal instream movement.

Runyon and Salminen (2005) identified several factors in Rock Creek that are limiting fish populations: Modified channel function, Modified flow, Habitat diversity impacts, Sediment load impacts, Temperature impacts, Impaired key habitat quantity. The same report identified the following fish passage barriers:

Fish Passage Barriers

- A 20-foot waterfall lies about six-tenths of a mile upstream of Rock Creek's mouth. Anadromous fish make use of the area below the falls for spawning and rearing. In-stream barriers in lower Rock Creek may inhibit movement during low flow periods.
- Two small tributaries below the falls in Rock Creek also provide some limited habitat, although culverts just upstream block these.
- In middle Rock Creek, resident cutthroat trout have been found in a stretch of the mainstem between Foster Road and SE 172nd Avenues. These fish may be hemmed in by culvert blockages both upstream and down.

Bauer, Salminen and Runyon (2005) state that fish habitat is impaired in Rock Creek and is mostly due to changes in riparian vegetation and function, limited large wood and complexity in stream channels, and increased sediment loads. While invasive weeds are affecting riparian and upland habitats, there are some high quality riparian habitats present in the watershed, particularly in the canyons of lower Rock Creek (Bauer, Salminen and Runyon, 2005). Thus, these areas should be a focus of habitat restoration and protection efforts.

Results

There are some key features and opportunities of the RCSI project area that should be recognized. Infiltration rates are likely feasible but may be a limiting factor for Low Impact Development and on-site stormwater management. Infiltration may be infeasible near Rock Creek and its tributaries due to steep slopes. More research is needed to determine infiltration rates of different soil types as well as the extent and depth of perched ground water levels. There currently exists a well-functioning riparian corridor with some high quality riparian and upland wildlife habitat. The fact that the project area has very little impervious surfaces should be recognized as an asset and an opportunity. Maintaining minimal imperviousness will help ensure healthy riparian habitat, attain water quality standards, and provide cool, summer baseflows to Rock Creek. Bacteria (E.Coli), pesticides, high temperatures and nutrients are the main water quality concerns. Lastly, lower Rock Creek has populations of federally or state listed salmonid species and should be a focus of restoration and protection efforts.

Ecosystem Services Approach and EcoMetrix

The second approach for assessing the project area was an attempt to quantify the ecosystem services of the area. The powerful uses of this approach are to 1) quantify existing conditions, 2) compare development alternatives, and 3) predict impacts over time. There are some currently accepted methods to quantify landscape components that this analysis did not explore—a few are listed below:

- The Habitat Evaluation Procedure (HEP) uses limiting variables to determine habitat suitability index (HSI) values.
- The Habitat Evaluation System (HES) for streams and lakes and certain terrestrial systems, uses key weighted variables to derive Habitat Quality Index (HQI) scores.
- Hydrogeomorphic (HGM) analysis and Wetland Evaluation Technique (WET) for wetlands. Scores are derived for each wetland function.

The research team utilized a tool called EcoMetrix, developed by Parametrix, Inc. to assess the ecosystem services the landscape currently provides. The analysis tool aims to quantify how well the natural systems within the project area are providing those services, such as water purification (quality), water regulation (quantity and timing), biological support, erosion and landslide control, soil formation, pollination, air quality and climate regulation, to name a few. It essentially puts a score on the ability of nature to provide those tangible, beneficial functions. Intangible services (e.g. aesthetic value, psychological well-being, historic natural character, etc.) are not quantified.

For EcoMetrix to quantify ecosystem services, it is first necessary to identify beneficial functions, identify the habitat structures and components that are most pertinent to performing that function, and then collect data about those habitat components. Multiple habitat components can help perform the same function, and one habitat component can perform multiple functions. In the end, the aggregation of functions comprises the ecosystem services the site is providing.

The basic EcoMetrix methodology is to divide the project area into small map units (a grouping of similar/homogeneous landscape features). Then, datasheets are completed in the field for every map unit. The results from the datasheets are run through the EcoMetrix calculator, which assigns values to certain combinations of habitat components. The output is a measure of how well the landscape is providing each individual service or function; or, how well the landscape is performing the suite of ecosystem services.

Evaluation of EcoMetrix

EcoMetrix is designed so that very small map units can be delineated and datasheets filled out in the field. Due to time and resources constraints, this analysis did not fill out the datasheets in the field and did not look at the entire 400-acre RCSI project area. Instead, map units and datasheets were completed entirely using ½-foot aerial photographs and ArcGIS 9.2. For analysis, the research team focused on the Providence medical site and its immediate subwatershed (Figure 1.12). This condensed, course-scale methodology had not been performed before, and certain limitations became apparent. These limitations are described below.

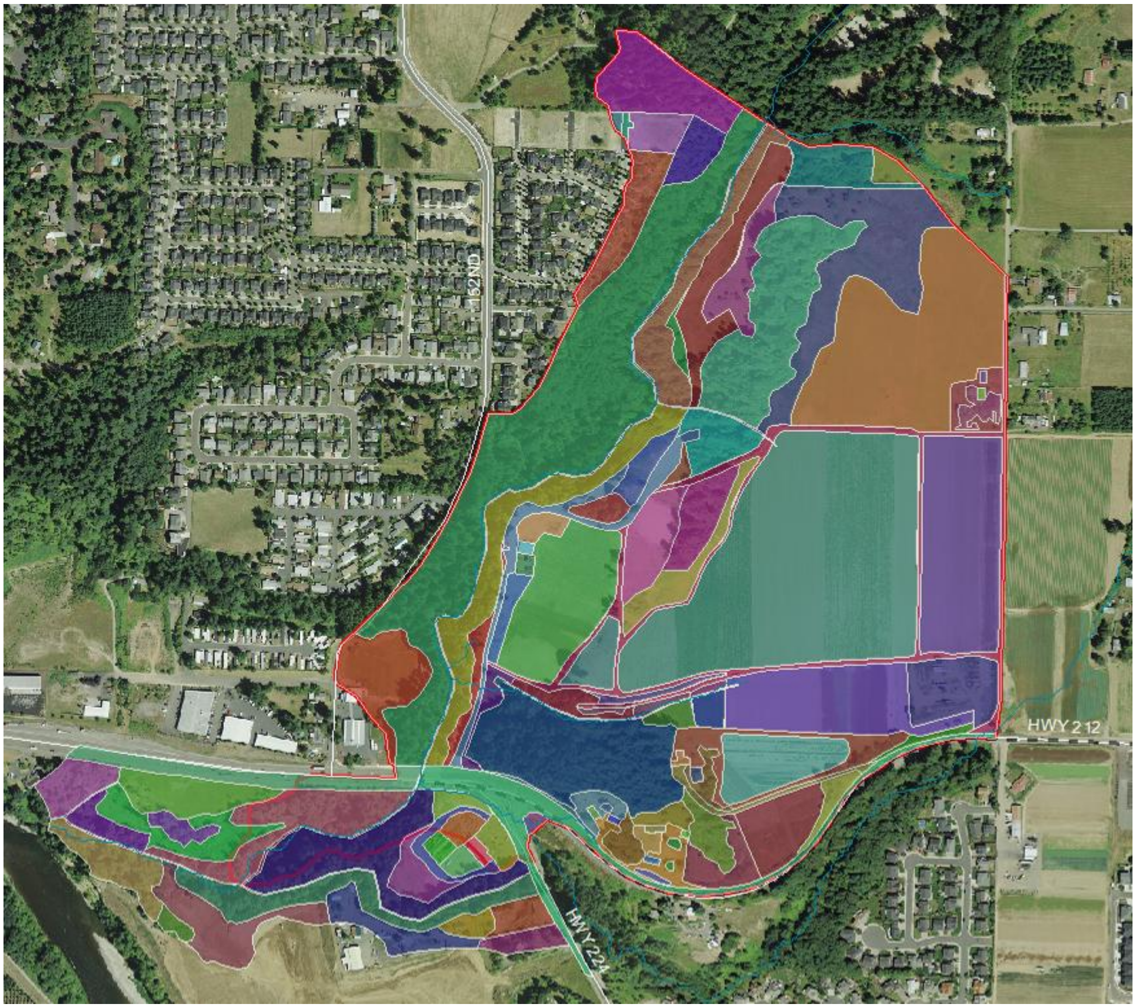

Figure 1.12 EcoMetrix Map Units - Providence Medical Site & Immediate Subwatershed
(A map unit is a grouping of similar/homogeneous landscape features)

Using aerial photos, 115 map units were drawn at a scale of 1:1000. At this scale, only very general landscape types could be delineated: forests, mixed stands, agriculture, grass, shrubs, bare ground, dirt roads, buildings and industrial. Stream survey data by the Oregon Department Fish & Wildlife provided the only on-the-ground details for certain stream and riparian map units—wetted width and depth, pools, riffles and runs, bankfull width, channel shape, stream substrate, bank status, large wood sizes and numbers, as well as adjacent riparian vegetation structure. Beyond that, all other map units were at too coarse a scale to ascertain the details asked of the datasheets. The only details that could be consistently determined were the general habitat type (map unit), proximity to water features, soil type, percent slope, and percent canopy cover. Occasionally, details such as downed wood, overhanging vegetation, and percent ground cover could be estimated. In total, datasheets were filled out for 45 map units. The analysis was run by Parametrix and the results are shown in Appendix C.

The research team was unable to use EcoMetrix to its full potential with the aerial photograph method. It was incapable of deciphering on-the-ground details that are asked of the map unit datasheets, and so many of the indicators needed to measure certain functions were not available. Thus, this analysis was limited to seven total functions (Temperature Regulation, Habitat Formation, Bank Stability, Filtration, Soil Stability, Streambed Stability and Anadromous Fish Habitat) and on many map units only two or three functions could be measured. With additional data collection and analysis, Phosphorous, Nitrogen, Infiltration, and further habitat functions can also be included. These results are mostly limited to canopy cover and proximity to streams. An important point is that the main limitations of this approach were not in the methodology, but in the lack of available data, as well as time and resources. The benefit of this approach was the course scale rapid assessment with expenditure of limited resources, but findings should be considered preliminary.

One compelling conclusion evident from use of this tool is that if ecosystem services are removed from a site, they will need to be replaced—often requiring expertise and engineering at significant cost. If used to its full potential, EcoMetrix can help to quantify the current levels of ecosystem services of the landscape, compare loss of service between different development scenarios, and help predict impacts to these ecosystem services over time.

V. Development Scenario Analysis

In addition to taking an inventory of the ecosystem services provided by the current land use, the research team used EcoMetrix to determine levels of ecosystem services generated by a hypothetical LID alternative. The idea was to see if a reputedly more ‘sustainable’ scenario, such as those described in the case studies, would generate more ecological benefits than a conventional development scenario. The utility of the EcoMetrix tool in this regard stems from its sophistication and comprehensiveness for capturing ecological flows, its flexibility in application, and its capacity for normalizing the evaluation criteria across ecological functions. The southern 40 acres of the proposed hospital site was chosen for this analysis because of its location and features (slope, drainage patterns), ‘campus’ style development (an oft-used approach in Employment zones), timeliness, and its spatial concurrence with map units developed in the preceding inventory.

We initially examined three hypothetical development scenarios. The scenarios each begin with the same hospital buildout plan, (based on an earlier feasibility analysis completed by its engineering consultants), then varying degrees of low impact development practices were incorporated. Scenerio A is an ‘existing code’ option that allows for major site modifications to accommodate a spatially extensive development pattern. Scenario B modifies the same development pattern to include bioswales in lieu of storm sewers. Scenario C is a highly clustered option that incorporates the site’s natural drainage patterns, significant vegetation and infiltration to approximate the original hydrology. These are described in detail below. No analysis was completed for either of the first two scenarios due to constraints on data availability.

Scenario A: Conventional Development

The first scenario looks at the conventional approach to development. This approach emphasizes low-rise construction and surface parking lots to reduce construction costs, broad rights-of-way allowing for separation of transportation modes, and stormwater management via an underground collection network, large centralized surface or sub-surface detention facilities, and export off-site. It would most likely require extensive grading of the site due to the presence of moderate slopes (3-5%) throughout the site.

Scenario B: Conventional Development with LID Features

The second scenario modifies the conventional scenario, primarily by replacing most underground stormwater facilities (pipes) with surface facilities (bioswales and green roofs). These surface stormwater facilities typically replace other landscaping elements, resulting in little if any net decrease in the development's hardscape footprint. Where landscaped areas have been graded, however, soils may need significantly more amendment to achieve target infiltration rates. In addition to conveyance, bioswales and greenroofs attenuate runoff and filter particulates from stormwater. Attenuation of runoff prevents stormwater from peaking at abnormally high levels, where it can erode stream channels, and encourages infiltration that contributes to summer base flows and reduced stream temperatures. Filtering of particulates from stormwater removes hydrocarbons (oils and grease from roads and parking areas), as well as nutrients and pesticides (from landscaped areas) that adversely affect aquatic habitat (by increasing turbidity and concentrations of toxins while reducing available oxygen). This approach attempts to replace some of the ecological functionality of the pre-development site. By handling stormwater management on-site, bioswales and green roofs can also lead to reduced size of local and regional collection and detention facilities, as well as stormwater treatment plants. Analysis of this alternative was not attempted due to data constraints.

Scenario C: LID-Intensive Development

The third scenario is an even lower-impact, and consequently more sustainable approach that is less a modification of the conventional approach and more of a different approach altogether. In contrast to scenarios A and B, this scenario begins by preserving what is possible of the existing ecological infrastructure of the site, and designing the development project's footprint for the balance of the site. This can often be accomplished if density bonuses are provided as compensation if an unusually high percentage of land is set aside for habitat conservation (such as in Portland's experimental stormwater marketplace). The resulting development is often more compact, taking the form of taller mixed-use structures that include parking and narrower multi-purpose rights-of-way for access. Ecological functions such as stormwater detention and filtration that cannot be preserved are incorporated into the landscape design, so that the entire site in effect serves as the stormwater facility. LID components may include bioswales, raingardens, stormwater infiltration planters, green roofs, pervious pavements, open space, street trees and native vegetation with a multistory canopy. The aim of this alternative is to manage stormwater at the source (i.e. where it falls), and thus attain a level of ecological function closer to that of the original pre-development site. If this can be accomplished effectively, local and regional collection and treatment facilities may be altogether unnecessary.

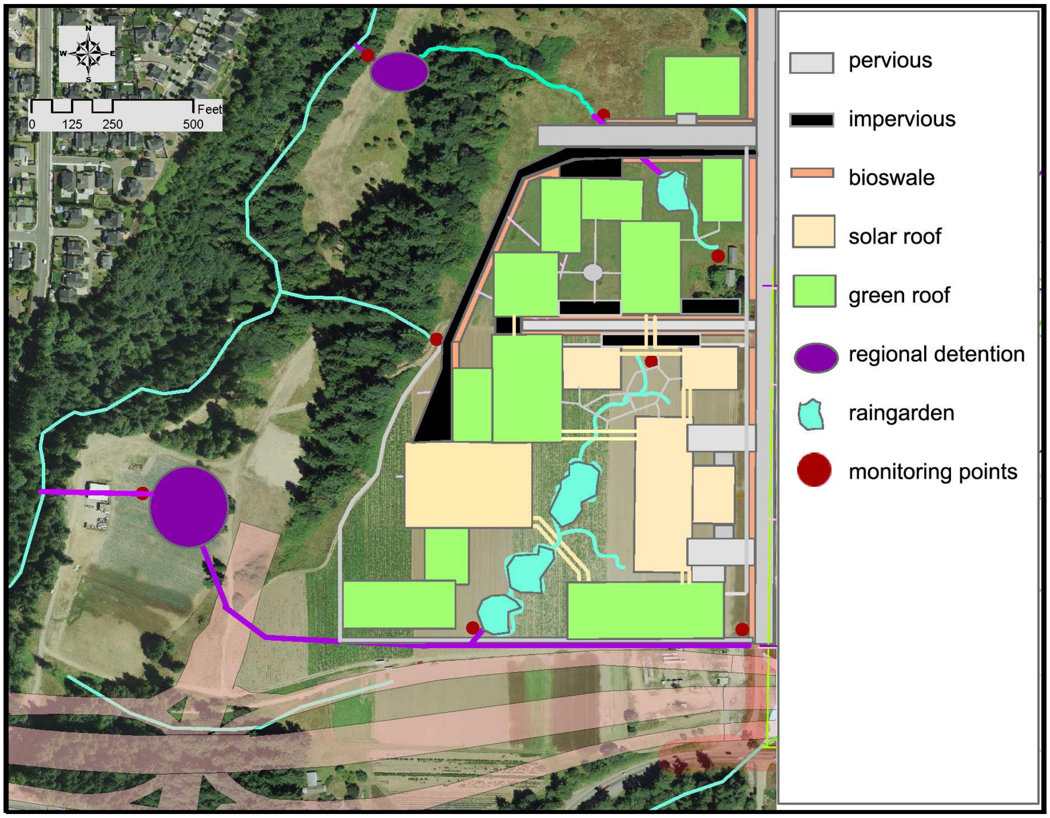

Figure 1.13 Scenario C: LID Intensive Development

Methods

As with the inventory of the existing site, we applied the EcoMetrix tool to development Scenario C at a slightly larger scale of analysis than was it was originally designed for—map units averaged just under one acre in size. While this approach may be inadequate for determining actual ecosystem credits, it should be fairly representative of the ecological function of the overall site. [6]

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[6] This can be postulated because map units are nested hierarchically—meaning properties at one scale are proportional to those at another scale. The main difference is that at larger scales the output will be more generalized while at smaller scales it will be more explicit. The linearity of this relationship as it pertains to the map unit methodology should be validated before affirming the results of our analysis.) Specifically, one should look for evidence of emergent system properties at higher scales that invalidate the hypothesis of a linear relationship along hierarchies of map units (Ahl and Allen, 2000). Such a test was beyond the scope of the present analysis, although the landscape ecology literature is likely to have something to say on the matter.

Each map unit was assigned to one of the following nine land cover *classes*: conventional roof, green roof, pervious pavement, impervious pavement, bioswale, ornamental landscaping, native landscaping, raingarden, man-made stream, and natural open space (see Appendix A). Datasheets were completed for each land cover class. Due to time constraints, it was assumed that individual map units had the same characteristics (including adjacencies) as all the others in their class and no attempt was made to distinguish among them except for size. While this is a simplification of reality (for in actuality no two map units would be exactly alike), we decided there was no reason that a fundamental difference among map units would occur within any given class, and that it was plausible that one *could* build them identically without compromising function or form. As a means to at least partially address this issue, however, map units were depicted in the datasheets as being fairly complex and multifaceted (as opposed to homogenous) entities. That is, we addressed the likelihood of differentiation *among* map units by allowing for spatial heterogeneity *within* map units. Completed datasheets were then sent to Parametrix staff for calculation and summarization.

Results of Alternatives Comparison

Results were unavailable at the time of publication, due to resource constraints. Parametrix staff have also advised the research team that more detail on specific map units will likely be necessary in order to satisfy the requirements of the EcoMetrix model.

VI. Performance Evaluation

LID facilities are readily monitored and managed for compliance with water quality standards because the facilities are typically quite accessible. This makes it easier to find and address the effects of contaminants near the source, helping to prevent downstream impacts. For example, the magnitude of oil and grease pollution will be apparent through the discoloration and die-back of vegetation in a raingarden at the end of a parking lot swale or loading dock ramp, whereas it will not be apparent inside a catch basin. It is a well-established principle that eliminating or otherwise mitigating contaminants at the source is often simpler and more cost-effective than providing additional treatment capacity downstream (Callan and Thomas, 2007). The visibility of LID facilities also aids in early detection or verification of potential problems, so that the duration of a spill event may be reduced. This is significant because time-of-exposure is often a critical variable in toxicity calculations (Hemond and Fechner-Levy, 2000). In addition to this direct observation, regular (semi-annual or annual) evaluation of the LID facility with the EcoMetrix tool could reveal less obvious pollution such as heavy metals that bio-accumulate, resulting in diminished local species diversity which adversely impacts both the hydroecology (i.e. stream channel stability) and the overall food web (biological stability).

Maintenance of LID facilities presents both problems and opportunities. On the one hand, facilities must be maintained on a more regular basis so that function as well as form (aesthetics) is not diminished. Maintenance tasks, similar to landscape maintenance and construction, are labor intensive and likely to translate into higher costs per unit of stormwater managed than are automated treatment facilities. However, by incorporating stormwater facility maintenance into routine landscape maintenance, maintenance becomes both more proactive and less obtrusive. Also, stormwater facility maintenance and repair costs can be shifted largely to the private sector, where they become part of the building’s operating budget. This could be achieved either through formal maintenance agreements between property owners and the utility (such as with conservation easements), or by establishment of a self-managing special district that assesses patrons annually for operations and maintenance (O&M) as well as periodic capital costs. The latter approach may be the most efficient way to address maintenance if viewed from the big-picture, long-term perspective, because economies of scale can keep costs relatively low, ecosystem services are improved substantially, and local control ensures greater responsiveness to problems. For more discussion on institutional structures to facilitate adaptive O&M, see Appendix B.

EcoMetrix may also aid in the assessment of LID facilities' performance over time. In particular, it could prove a useful component of adaptive watershed management where external factors such as re-development of the site, cumulative effects of adjacent development, or climate change alter the local hydrology. In contrast to conventional monitoring, EcoMetrix permits evaluation of ecosystem conditions, which can be followed up by redesign of facilities to address specific functional deficiencies. For example, if stormwater regulation was insufficient due to increased overland flows, additional raingardens could be added, or existing ones deepened to provide more storage capacity at key locations in the storm system. This is cost-prohibitive with buried assets such as catch basins, stormwater mains or detention pipes.

Because of the cost-prohibitive nature of retrofitting buried assets such as conveyance and detention pipes, very conservative assumptions must be used in their design, often resulting in over-built facilities. LID facilities by contrast are readily reconfigured to add capacity where needed. This can be especially cost-effective when coupled with regular maintenance work. For example, when substrates are dug up for cleaning, vegetation might be replaced with deeper-rooted species to improve infiltration and/or soil replaced with cobbles to improve storage. If filtration was an issue, soils could be further amended, retention times increased by lengthening the drainage path, and/or vegetation modified to include a larger component of wetland-type plants.

This section has shown that monitoring of LID systems is straightforward, maintenance is proactive, and facilities are readily reconfigured and/or enlarged as external inputs change. Thus it may be implemented in a more flexible and experimental way than buried systems, saving costs.

VII. Valuation

The task in this section of the report is to develop a preliminary estimate of the costs and benefits of an LID stormwater management scenario for the RCSI study area in comparison to a conventional stormwater management scenario for the area. A comparative cost analysis was recently completed by Phil Pommier, PE of Pacific Water Resources (PWR), a consultant for the RCSI project. This analysis uses the PWR work as a starting point, and expands the LID scenario in order to consider additional LID tools, and their costs, that could be employed to further improve the area's ability to manage stormwater in a productive manner.

The analysis is considered "preliminary" in the sense that it identifies the range of affected costs and benefits, and provides a mix of quantitative and qualitative measures, but it does not calculate a net economic benefit of all benefits minus all costs. While such an analysis would help inform decision-making, but it was beyond the scope of the present study, for reasons outlined below. Nonetheless, the preliminary approach adopted here can help inform decision-makers and stakeholder by identifying the relevant costs and benefits of two different stormwater management strategies. Comparing those costs and benefits can be done given the information currently available. This work also serves as a starting point for a more formal analysis, if such a product were deemed necessary.

This section consists of four main components. The first considers of some of the main issues involved in projecting the potential costs and benefits of conventional and LID practices for a particular site or area. The second describes the development scenario and alternative stormwater management strategies, including their associated costs, which have recently been calculated by PWR. Third, using the PWR LID scenario as a basis, a suite of additional LID practices will be considered in terms of their impact on the costs and performance level of the LID stormwater management strategy. These additional practices include landscaping requirements that call for the use of drought-tolerant native vegetation and the addition of 200 trees to the area, and the creation of biodetention cells, or "rain gardens," on each site. This augmented LID scenario will serve as the basis of the concluding section that details the benefits that can reasonably be associated to using a variety of LID practices to manage all stormwater on-site in the RCSI study area.

Assessing the Costs and Benefits of LID Practices

There are four closely related issues that affect any attempt to valuate LID practices: the newness of LID projects and practices; the site-specific nature of the design and effectiveness of various LID techniques; the multi-faceted nature of most LID projects; and the fact that some of the benefits associated with LID are non-market goods and services. Each one of these issues will be looked at in turn before discussing the unique LID-related costs and benefits of the RCSI study area.

The use of LID practices is still less than 20 years old. They were first implemented in the early 1990s in Prince George's County, Maryland, in an attempt to meet the multiple goals of lowering stormwater management costs, improving water quality, and preserving the integrity, functionality, and services of the surrounding ecosystems (Prince George's County, Maryland, 1999). The effectiveness of these early endeavors has since led many other jurisdictions to begin to follow suit, with additional support coming from the EPA and a variety of newly developed LID-focused trade and environmental groups (for a partial list of these groups, see the "Other Related Sustainable Development Efforts" section of this report). As a result, a multitude of pilot and demonstration projects have either recently been constructed, or are in the process of being constructed, and are just beginning to supply researchers with some information regarding their costs and potential benefits.

These projects have succeeded in demonstrating that in many cases, and LID stormwater management system can be more effective, less costly, and more socially and environmentally beneficial. They have also helped identify many of the variables which not only should be considered when assessing an area's potential for LID, and when choosing which LID techniques to employ, but also when beginning to consider an LID project's potential costs and benefits. Regarding the cost information supplied by these projects, pilot and inaugural projects can cost more than subsequent routinized projects. Part of this is because such projects often have additional goals such as education or public involvement, but also because cost savings from improved efficiency and economies of scale have yet to be realized. As Denise Andrews, the manager of Seattle's surface water program pointed out when discussing the recently completed "Street Edge Alternative" pilot project, "You could take $200,000 off the price just from what we didn't know…. The pilot phases that we are currently in are more expensive, but as the project becomes institutionalized, all the costs will come down" (Foss, 2005, p. 7). Although costs for some practices in some jurisdictions have begun to decrease[7], there are still likely to be further decreases in the near future, and there is also a great deal of variation between areas due to the relative levels of experience of the designers, engineers, permitters, and workers who all have to learn about how to implement the various LID practices.

Regarding information about some of the benefits of LID techniques, the newness of LID may limit the development of a more complete body of information about LID benefits. Newly planted trees, for example, can take up to ten years before they are mature enough to start making measurable economic contributions to stormwater management, air purification, cooler water, a cooler microclimate, and a property's amenity value. Although each of these benefits produced by a single tree in a single year is individually small, they quickly begin to add up over a larger area with more trees, and over the course of a project's lifecycle, often producing sizeable benefits.[8]

The second issue affecting LID evaluation that has already been touched upon is the site-specific nature of each project. The ability of any site to help manage stormwater depends on a number of factors, particularly soil type and condition, slope, type and amount of vegetation, depth of the water table, and amount of impervious surfaces. Each of these variables helps determine the feasibility, design, cost, performance, and benefits of different LID practices. As a result, a swale in one location can look, cost, and perform differently than a swale in another project. As the EPA has recently noted, "One of the chief impediments to getting useful economic data to promote more widespread use of LID techniques is the lack of a uniform baseline with which to compare the costs and benefits of LID practices" (U.S. EPA, 2007).

The third issue affecting LID valuation is that many stormwater management projects employ multiple LID practices, making it difficult to accurately pinpoint the extent of each component's contribution to the project's resulting benefits. In an analysis of 17 LID projects of varying scale, all but three of the projects used multiple LID techniques, averaging between three and four techniques per project (USEPA 2007. p. 11). While analyses of many of these projects were

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[7] The City of Portland, for example, now estimates their installation costs for permeable pavers to be $5.00/sf, down from the $10.50/sf rate they paid as part of their initial permeable paver pilot projects (City of Portland, 2003; City of Portland, ND).

[8] The City of Portland's 1.4 million street and park trees, for example, are estimated to provide nearly $27 million worth of environmental and property-value related aesthetic benefits every year (Portland Parks and Recreation [PPR], 2007)

able to isolate the costs of their various components, they did not attempt to isolate their individual contributions to stormwater management of other related benefits. Thus, while we know that Seattle's "Street Edge Alternative" project was able to reduce total surface run-off by 99% through the use of swales, narrower streets, and additional trees and shrubs, we do not know the extent of each of these component's contributions to the end result (USEPA 2007, pp 12-13).

The final issue affecting LID evaluation is that some of the benefits of LID are ecosystem-based non-market goods and services that are, by definition, not traded in established markets and so are more difficult to measure. Economists and other researchers interested in quantifying LID-related ecosystems-based economic benefits have developed alternative valuation strategies.[9]

Applying LID to Rock Creek

A thorough assessment of the RCSI area's potential for LID was recently performed by Phil Pommier, PE, of Pacific Water Resources for the RCSI project team.[10] To perform this assessment, Mr. Pommier developed a hydrologic model of the area based on its soil types, water tables, slopes, and an amount of future impervious surfaces that was based on the future development scenario depicted in Figure 1.14 that is based on current zoning codes and building practices. It should be noted at the outset that the RCSI area analyzed by Mr. Pommier is actually a bit larger than the RCSI study area delineated by the project team for the PSU students. This discussion of his work pertains only to those portions of his analysis that are within the smaller PSU RCSI study area that is outlined in yellow.

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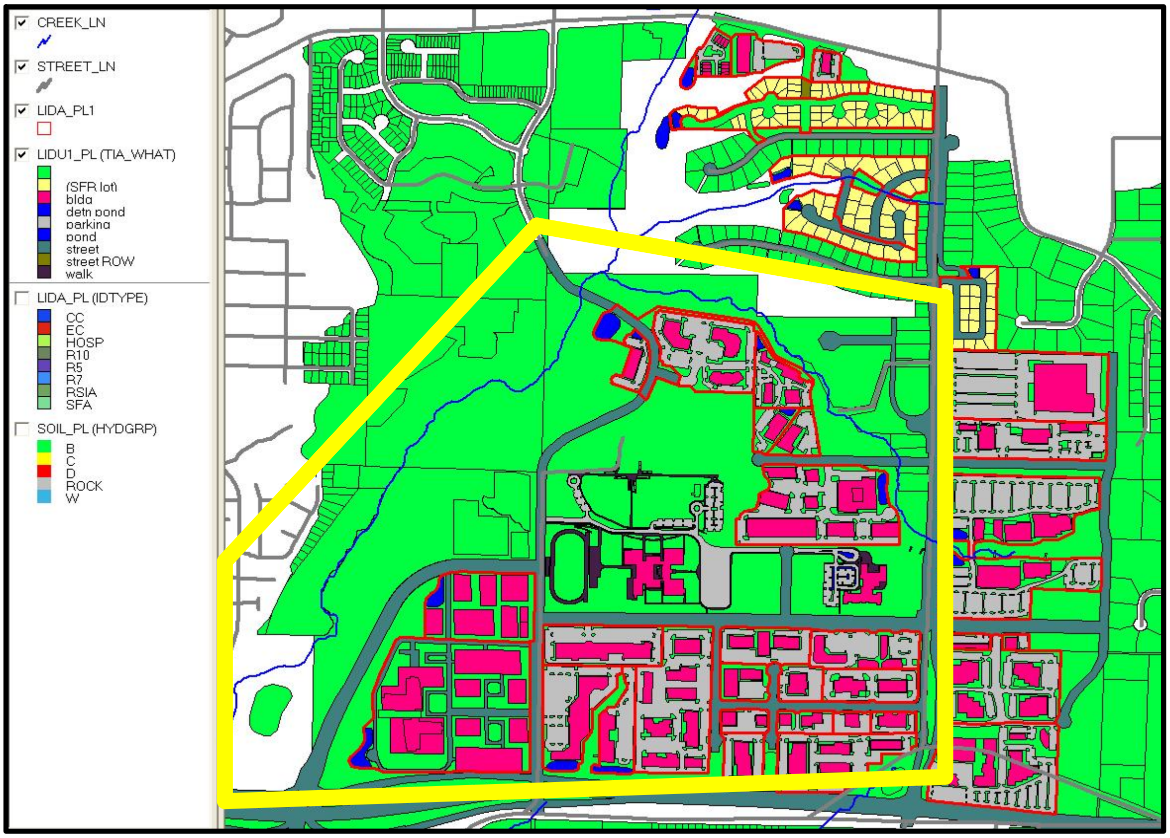
[9] See MacMullan (2007) for descriptions of these methods.

[10] The ensuing discussion of Mr. Pommier's work refers to the two draft technical memorandums he produced for the RCSI project team, Pommier 2008a, and Pommier 2008b. the copies made available for the present study were still in draft form, but should soon be finalized and be made available through Clackamas County's department of Water and Environmental Services.

Figure 1.14 Proposed Development Scenario for the Greater RCSI Study Area
(PSU Study Area Outlined in Yellow)



This hydrologic model allowed Mr. Pommier to predict the amount of stormwater run-off generated by storms of various magnitudes, and then consider a variety of conventional and LID stormwater management infrastructure scenarios and their ability to manage the different amounts of run-off. The conventional stormwater management scenario relied on a network of catch basins, man holes, and pipes to capture run-off and transport it to a series of detention facilities—both above ground ponds and underground boxes—that were placed around the perimeter of the development where the water would be held for pollution settlement and then slowly released into the nearby Rock Creek tributaries. The LID scenario Mr. Pommier developed employed two LID techniques, soil amendments for the 23 sites' remaining pervious areas, and a network of connected low-slope bioswales. The primary purpose of both of these techniques is to infiltrate some of the stormwater, then convey the remainder via the swales to somewhat smaller detention facilities for controlled release into the nearby waterways. The need for detention facilities in the LID scenario arises from the fact that the area's high water tables and slowly draining clay soils prevent the remaining post-development pervious area (about 26%

of the area of each site, on average) from immediately absorbing all of the stormwater from storms equal to or greater in magnitude than a 2-year storm event.

In both the LID and conventional scenarios, the only modification necessary to handle different magnitude storm events was a resizing of the detention facilities.

For the purposes of developing cost estimates for each of these scenarios, Mr. Pommier estimated detention facilities dimensions capable of handling 2-year and 10-year storm events. The 2-year standard is the current minimum level of performance allowed by county standards, while the 10-year standard is a much higher level of performance that would likely better meet the county's stormwater management goals by further minimizing negative impacts on the area's water quality and biodiversity. Again, it should be noted that the RCSI study area analyzed by Mr. Pommier is somewhat larger than the PSU RCSI study area. The costs reported below represent an estimate of the costs of those components of Mr. Pommier's scenario for the 2-year standard that lie within the PSU study area, thus excluding the costs associated with the residential area to the north, and those associated with the portion of the Regionally Significant Industrial Area (RSIA) east of SE 172nd Avenue. The latter costs were estimated by the author to represent one third of the costs of the stormwater management infrastructure for the larger area's RCSI sites.

Table 1.7 Costs of Conventional SWM Infrastructure

Components	*Hospital Site*	*RSIA Sites*	*Total*
Pipes	$242,500	$70,023	$312,523
Catch Basins	$80,000	$23,310	$103,310
Manholes	$55,250	$16,317	$71,567
Water Quality Devices — MSDs or steam filters	$50,000	$13,320	$63,330
Detention Facilities	$65,813	$215,851	$281,664
TOTAL	**$493,563**	**$338,821**	**$832,384**

Table 1.8 Costs of LID SWM Infrastructure			
Components	***Hospital Site***	***RSIA Sites***	***Total***
Swales	$471,080	$78,441	$549,521
Drop structures	$80,470	$10,310	$90,780
Amended Soils	$392,194	$39,487	$431,681
Culverts	$19,500	$7,493	$26,993
Detention Ponds	$40,658	$169,231	$209,889
TOTAL	**$1,003,902**	**$304,962**	**$1,308,864**

It should be noted that all additional costs of the LID scenario can be attributed to the greater slopes present on the two hospital sites in the southwest corner of the study area which make the conventional infrastructure cheaper by enabling the use of smaller pipes, and the LID infrastructure more expensive because of the additional engineering requirements for constructing the sites' low-slope swales (Pommier 2008b). In fact, if the hospital site is excluded from the analysis, then the LID infrastructure is actually $33,859, or 10%, cheaper than the conventional infrastructure.

It is also important to note that, although both scenarios handle the same amount of stormwater, they produce different levels of other hydrologic-related services, specifically ground water recharge and water purification, two primary issues of concern for the RCSI project team. Since the LID scenario provides increased levels of ground water and water purification, the increased costs are accompanied by increased levels of service that, as Mr. Pommier notes, have "the potential for reducing adverse impacts on downstream receiving waters, thereby improving water quality and aquatic biota related to these systems" (Pommier 2008a, p. 1).

Despite the apparent level of hydrologic service advantages of Mr. Pommier's LID scenario over his conventional scenario, it is still limited by its need to convey a majority of each site's stormwater run-off off site and then discharge it, unfiltered, into the nearest waterway whence it is carried off down stream. Discharging water this way negatively impacts fish habitat not only by allowing it to pass unfiltered into Rock Creek (although some pollutants do settle out in the detention facilities), but also by allowing it to warm up as it sits in the detention pond. As previously noted in this report, Rock Creek is tenuously close to exceeding allowable temperatures which, if exceeded, would trigger the imposition of a temperature TDML by the Oregon DEQ, and potentially require expensive mitigation efforts. The use of detention ponds also can affect stream temperatures by reducing the amount of ground water recharge that is necessary for maintaining dry-season stream flows. If these flows get too low, then the water's temperature will increase. The curtailed groundwater recharge also reduces the amount of drinking water available for Sunrise Water Authority's (SWA) wells. Since there are not more additional groundwater or river water rights available in the area, reduced groundwater amounts would force SWA to import additional water from outside sources at increased rates.

A More Complete LID Scenario

Despite the area's slope, soil, and water table constraints noted by Mr. Pommier, it appears likely that additional LID techniques perhaps not considered by Mr. Pommier could allow each site to completely manage its own stormwater through increased infiltration and transevaporation, thus improving the area's overall hydrologic performance by making sure that all stormwater is filtered through the soil, and that groundwater is recharged to the greatest extent possible. The purpose of this sub-section is to describe the components of this more complete LID scenario, how it works, and how much it would cost. For the purposes of distinguishing this LID scenario from Mr. Pommier's LID scenario, this one will be referred to as the "LID-complete" scenario, and Mr. Pommier's will be referred to as the "LID-lite" scenario.

The LID-complete scenario builds on Mr. Pommier's LID-lite scenario of swales and amended soils by adding 250 large trees to the site, requiring all landscaping to be done with native drought-tolerant plants and shrubs, and using rain gardens to detain water on-site for controlled, delayed discharge into each site's swale system. The trees would help manage stormwater in two ways. First, mature large trees uptake close to 600 gallons of water per year (PPR, 2007). The addition of 250 trees to the area would process close to 150,000 gallons of water per year, thus lessening the burden on the soil for infiltration. Second, tree roots help improve the soil's infiltration capacity by loosening the clay and providing pathways for stormwater to infiltrate the soil. For the purposes of this study, the cost of purchasing and establishing each tree is estimated to be $100[11] (See Table 1.9 for a summary of the costs of this LID scenario).

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[11] This estimate was made by the author, based on a personal conversation with Paul Reinhart of the non-profit tree advocacy group, *Friends of Trees.*

Native, drought-tolerant landscaping would improve the area's hydrology by removing the need for pesticide use, and by eliminating the need for dry weather irrigation once the plants are established. Lack of pesticides would lead to cleaner water going into the ground, and lack of irrigation requirements would lead to decreased demands for the area's limited supplies of drinking water. Since the use of native plants can cost more or less than conventional landscaping depending on design and plant choices, it is assumed that this requirement would add no additional costs to the project.

The purpose of the rain gardens would be to detain run-off during a storm, then slowly discharge it into the swales afterwards while at the same time allowing for additional infiltration though the rain gardens themselves. The design of these rain gardens would be quite similar to the vegetated swales, but a bit deeper and wider (although the actual shape could vary quite a lot) and capable of holding an average of 1.5 cubic feet of water for every square foot (sf) of rain garden surface area. Assuming that the total rain garden storage volume needed would be the same volume needed for Mr. Pommier's modeled 10-year detention requirements, the total square feet of rain gardens needed for the area's 23 building sites would total 272,309 sf, or about 17.2% of these sites' combined 36.3 acres of pervious surfaces. Since these rain gardens are quite similar in construction to wide swales, their costs per sf are assumed to be equal to the costs of the 14' wide swales listed by Mr. Pommier as costing \$7.50/sf (Pommier 2008b, p. 9), producing a total area-wide cost of \$2.04 million. Additional costs for this scenario also include \$7,500 for LID information and education to help developers and designers understand the on-site stormwater management requirements and opportunities.

While these costs are higher than the LID-lite scenario, it should be pointed out that this scenario also provides the highest possible level of post-development hydrologic services by maximizing the area's potential for groundwater recharge and eater purification via soil infiltration. It also provides numerous additional economic benefits described in the next subsection.

Table 1.9a. Initial Costs of LID-complete SWM Infrastructure	
Swales	$549,521
Drop structures	$90,780
Amended Soils	$431,681
Culverts	$26,993
Trees (250ea)	$25,000
LID Information & Education	$7,500
Rain Gardens	$2,042,318
TOTAL	**$3,173,793**

Table 1.9b. Immediate Benefits of LID-complete for Developers			
Item	*Area (sf)*	*Price/sf*	*Savings*
More developable land	56,400	$3-6-	$169,200-338,400
Avoided Landscaping costs	338,799	$3-5	$1,016,397 – 1,693,995
TOTAL			**$1,185,597 – 2,032,395**

Table 1.9c. Initial Costs Minus Calculated Immediate Benefits	
Initial Costs	$3,173,793
Immediate Benefits	$1,185,597 – 2,032,395
Net Initial Costs of LID-complete	**$1,141,398 – 1,988,196**

Potential Benefits of the "LID-complete" Scenario

There are three main types of benefits resulting from using the suite of LID practices outlined above in order to manage all stormwater run-off on-site: avoided costs; retained and enhanced related ecosystem services; and economic development opportunities.

The primary avoided costs resulting from this scenario include avoided landscaping costs, avoided salmonid loss and restoration costs, avoided water filtration costs, and avoided increased drinking water costs. The available data allow us to quantify the landscaping-cost savings specific to the LID scenario. The available data, however, do not allow us to quantify the other cost savings. For these avoided costs we report information on related economic values at issue that the LID scenario help protect. Regarding avoided landscaping costs, in the scenario described above, swales and rain gardens occupy 338,799 sf of the 23 site's combined area, land that would no longer need to be landscaped as a result of placing swales and gardens there. Assuming that this area would otherwise be landscaped at $3-5/sf, this would produce an avoided cost of $1.0-1.7 million. Additional avoided landscape-related costs include not having to pay for irrigation, mowing, and pesticide use. Not having to irrigate would alone save each site owner at least $1,400 per year[12] or $32,200 annually for the entire area.

The LID scenario will help protect salmon and salmon habitat. One study (ODFW, 2003) calculated the value of the 400 salmonids that pass through the Rock Creek area at $872 apiece[13]. Based on this information, the LID scenario will help protect a salmon population valued at $174,000. The LID scenario also helps protect salmon habitat and avoids future restoration costs.[14]

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[12] Personal Communication from Kim Anderson of SWA. This avoided cost would begin to be seen in year 3 since the native drought-tolerant landscaping would still need to be irrigated with a temporary system for the first two years to help get the plants and trees established.

[13] This value is the one calculated by Goodstein and Matsen (2004) for non-Chinook salmon such as the Coho found in Rock Creek. The estimated 400 salmonids in Rock Creek also include cutthroat and steelhead trout—both anadromous fish—which were not valued by Goodstein and Matsen. Since these trout are, like the Coho, anadromous and wild, it is being assumed by the author that they have the same $872 value to the Oregon and Washington households studied by Goodstein and Matsen.

[14] Water chiller units for sufficiently cooling the Chehalis (WA) River and the Tualitan River to meet TMDL requirements were estimated to cost $35M and $104-225M, respectively (Nieme, et al, 2006).

Additional avoided costs savings come from not having to pay to clean up the polluted stormwater entering the waterways from the detention facilities, as well as from not having to purchase additional drinking water from external providers such as the City of Portland whose rates are currently about triple the amount SWA pays for locally provided water.[15] Cost-savings would also be realized from the area's extra trees, which, by processing stormwater, help avoid the costs of expanded stormwater management infrastructure. The City of Portland recently estimated that each publicly owned tree saved the City $7.54[16] in stormwater costs, adding up to $11.5M for the entire City (PPR 2007, p. 27). Additionally, American Forests (2001) estimated the avoided stormwater construction costs from trees for the entire Willamette/Lower Columbia River Region to be $20.2B.

The second main category of benefits stemming from the LID-complete scenario are the goods and services produced by the maintained functionality of those ecosystem services most directly related to the area's hydrology. These ecosystem services include biodiversity, air purification, and soil health. Biodiversity not only has a high level of intrinsic value for many Oregonians, but also produces economic value through supporting such activities as fishing, bird-watching, and outdoor exploration. Air purification is enhanced by the presence of the scenario's additional trees which, as already noted, produce economic value by reducing healthcare costs. Soil health is maintained and improved by the root systems of the area's trees and perennial plants and shrubs which loosen the soil and improve the area's overall natural stormwater management capacity by improving the soil's infiltration rates.

The third main type of benefits produced by the LID-complete scenario comes from the economic development opportunities created by the scenario. The most obvious such benefit is the additional developable land gained by removing the nine detention ponds from the area. Together, these ponds in Mr. Pommier's LID-lite scenario occupied 56,400 sf. Assuming that industrial land values will be in the range of $3-6/sf[17], an additional $169,200-338,400 of value would be created for the site owners. Additional economic development values stem from the landscape amenities and branding/marketing potential created by the presence of the various LID

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[15] Personal communication from Kim Anderson of SWA.

[16] The City of Portland produced two sets of numbers, one for street trees, and one for park trees, which are smaller in size, on average. This figure is an average for all the trees in Portland calculated by the author.

[17] This range is based on the author's observed values of a random sampling of currently occupied industrial sites along Hwy 212 in Clackamas, which were currently assessed on Portlandmaps.com at about $3-6/sf.

components. Studies have found that lots in new LID residential developments can have higher sales prices, quicker absorption rates, and higher appreciation rates than comparable developments (MacMullan 2007, pp. 24-25).

Another probable source of economic development value likely to be created by the LID-complete scenario is the increased likelihood of attracting LEED development. The requisite LID components contribute to a project's LEED score. LEED buildings are desirable because of their higher value which stems from the higher rents they command--$11.33/sf more on average nationally—and their higher occupancy rates—92% vs. 87.9% nationally (Spivey and Miller, 2008).

Yet another economic development related benefit comes from staying ahead of the development curve. Sustainable site development is increasingly becoming the norm due to higher market demand and changing regulations, particularly those that are designed to protect water quality and ecosystem health. The City of Portland, for example, now requires all new developments to manage all stormwater on-site whenever possible, and many other local jurisdictions will doubtless soon follow suit. Implementing such practices now will help ensure that these sites remain at the forefront of the growing market for building on sustainable sites.

Findings

The lower price of the conventional scenario is accompanied by a low level of related hydrologic services and a high likelihood of incurring higher costs from higher landscaping, salmon habitat restoration, and higher water purification and drinking water acquisition costs. The moderately higher price of the LID-lite scenario is accompanied by a somewhat reduced likelihood of incurring these additional costs, as well as a moderately higher level of hydrologic services stemming from its increased filtration rates. The LID-complete scenario has the highest costs, but the possibility of avoiding the additional costs outlined above is greatly reduced in large part due to the resulting high level of hydrologic services, but also because of the lower future landscaping costs that also accompany the scenario. In addition, the LID-complete scenario has the potential to create additional value stemming from the maintained related ecosystem services, and from its potential to enhance the area's economic development possibilities.

Next Steps

There are two next steps that would help refine and improve this current analysis. First, a formal risk assessment of the possibility of violating either Endangered Species Act or Federal Water Quality laws should be performed for each of these scenarios since violations of these laws could increase compliance. This would likely require a more formal modeling analysis such as the one capable of being provided by the EcoMetrix tool, as well as the solicitation of some formal scientific opinions.

Second, the LID-complete scenario should be subjected to Mr. Pommier's hydrologic model to make sure that it is feasible. If not, then other LID tools could be considered. Extensive use of permeable pavers, for example, could reduce the area's impervious surface amount by over 50%, thus greatly reducing the amount of stormwater that needs to be detained in rain gardens and infiltrated in bioswales and amended soils. If it is determined that the conventional and LID-lite strategies have a high risk of incurring significant environmental restoration, mitigation, and clean-up costs, then these additional tools could ultimately be cost-effective despite their potentially higher price tags.

VIII. LID Code Incorporation

In order to more fully understand the opportunities and barriers to implementation of LID practices, it is first necessary to identify the regulatory drivers that would cause an entity to consider adoption of LID practices, and the barriers and opportunities that are present within the existing regulations. There are a multitude of regulations that have implications for LID applications.

Regulations at all levels are evolving to provide allowances for their use and application in meeting permit or regulatory compliance points. This evolution can occur either in the form of modified code or regulation language, or in the management directives for application of those codes or regulations. In general, the more removed a regulation is from on-the-ground application, the less likely it is to prescribe particular mechanisms to be used in meeting the regulation. The majority of high level regulation pertains to the establishment of standards and programs that implementing agencies have the ability to satisfy through any means that are effective. Unless it is a code or regulation created or modified within the last five years, local and county level code and regulation is less likely to contain specific language permitting or encouraging LID application.

The following is a survey of the major regulations, ordinances, or guidance documents pertaining to the RCSI project area.

Federal Regulations

The Clean Water Act, the Safe Drinking Water Act, and the Endangered Species Act are the bases for almost all regulation regarding water quality protection. These three federal level acts create a waterfall effect on regulations amongst implementing agencies all the way to the local level. The linkages between and the concomitant objectives of these legislative acts result in overlaps that are being recognized by agencies at all levels and are resulting in efforts to redefine actions needed for compliance efforts to include LID practices, either at regulation level or in implementation guidance.

Clean Water Act

The Water Pollution Control Act of 1972, more commonly known as the Clean Water Act, is the driving force behind the majority of regulations pertaining to water quality. In Section 101 (a) of the act it is clearly stated that restoration and maintenance of the chemical, physical and biological integrity of the nation's waters is the objective for the legislation. Implementation of the legislation is passed to the States for action. The Oregon Department of Environmental Quality is the agency responsible for implementation and compliance enforcement in Oregon.

Verbiage in various sections of the Act demonstrate a consciousness that traditional constructed stormwater management actions are not the only possible solution to water quality issues. Section 105(a)(1), directs the Administrator to make grants to assist in development of new and improved methods for reducing or eliminating pollution discharges. Further, Section 121(a)(1) and (2), specifically directs pilot project funding to projects that seek to manage stormwater on a watershed or subwatershed basis and that will demonstrate and determine best management practices for the reduction of pollutant discharges that are cost effective and innovative. Section 201(i) also encourages the Administrator to encourage those methods and processes of pollution control that minimize energy requirements. Taken in total, this language regarding the direction and focus of research funding under the Act would clearly tend to encompass LID actions.

The language under Section 212(2)(B) doesn't specifically recognize LID practices as being a treatment works for the purposes of the Act, but it can be construed liberally to be included as they are a method for preventing, reducing or treating stormwater. This definition becomes important as subsequent sections delineating projects eligible for grant funding rely on the definition in this section.

Section 303 of the Act defers to the States the right to determine water quality standards in compliance with federal regulation. Section 303(d)(1)(A) of the Act creates the need for States to inventory those waters that do not meet the adopted water quality standards. Section 303(d)(1)(C) and (D) dictate the establishment of TMDLS's and Thermal loads for listed waters. This listing, as documented by Oregon DEQ, becomes the compulsory factor for stormwater management activities at the state, county and local level.

Section 306(a)(1) defines standards of performance for controlling discharge which reflect the greatest degree of effluent reduction achievable "through application of the best available demonstrated control technology, processes, operating methods, or other alternatives…". LID applications suffer under this language as the restriction to demonstrated control technology creates a barrier for what is a relatively new mechanism for addressing stormwater management.

The Clean Water Act also mandates that States undertake implementation of a nonpoint source management program. Section 319 of the Act sets out the requirements for the States in regards to these programs and provides a funding mechanism, in the form of grant funds, to complete the required program plan. The specific best management practices that will be implemented as part of the plan must be defined under Section 319(b)(2)(A), although the verbiage does not dictate to the states what constitutes a BMP as it applies to this section. The language also recognizes the connection between stormwater management actions and the associated impact on groundwater quality. The silence of the language regarding what constitutes a BMP for this section of the act leaves the state free to define those and creates an opportunity for the inclusion of LID as a BMP at the state regulatory level.

The National Pollution Discharge Elimination System (NPDES) is organized and defined under Section 402 of the Clean Water Act. This is the section of the Act that creates the NPDES permit system and defines the requirements for the states as the administrators of the permit program. Section 402(p)(3)(B)(iii) creates the requirement for municipal discharges that are covered under NPDES permits to require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques, and system design and engineering methods, and such other provisions as the Administrator or State determines appropriate for the control of such pollutants.

While not specifically identified as a viable alternative to constructed stormwater management treatment works in the text of the Clean Water Act, Administrator directives for implementation and interpretation of the language within the Act are very specific. On March 5, 2007, the EPA Regional Administrators received a memorandum from Assistant Administrator, Benjamin Grumbles, that endorsed green infrastructure as “a cost effective and environmentally preferable approach to reduce stormwater and other excess flows entering combined or separate sewer systems in combination with, or in lieu of, centralized hard infrastructure solutions”. This document was followed by a memorandum from Linda Boornazian, the Director of the Water Permits Division, and Mark Pollins, the Director of the Water Enforcement Division, to all Water Division Directors in Regions 1-10, Regional Counselors and Enforcement Coordinators in Regions 1-10, and all state NPDES Directors, clarifying that permitting authorities for NPDES permits are to encourage permitees to utilize green infrastructure approaches in their stormwater plans. These directives to the implementing agencies and administrators clearly articulate a new preference from the EPA for liberally construing existing language in the Act where possible and appropriate to allow for incorporation of LID strategies in meeting regulatory requirements.

Endangered Species Act

The Endangered Species Act of 1973 is the second primary piece of federal legislation that created mandates affecting water quality issues at all levels of government. Section 2(b) of the Act states, in part, that the purpose of the Act is to provide a means to conserve the habitat upon which endangered species rely. Section 2(c)(2) declares that it is, "the policy of Congress that Federal agencies shall cooperate with State and local agencies to resolve water resources issues in concert with conservation of endangered species. The administration of this Act at lower levels of government will be heavily reliant on State actions and regulation development. The State of Oregon has developed the Oregon Plan for Salmon Restoration which is the basis for State level compliance with ESA mandates and will be addressed later in this document.

Section 4(d) of this Act dictates that any listed species─including salmonid species present in the Willamette and its tributaries─must be conserved. Pivotal to these regulations is the prohibition of "take" of any listed species. Take is broadly construed in this context to include any action that will harass, harm, pursue, hunt, wound, trap, capture, or collect, or to attempt to engage in such conduct. Degradation of critical habitat is construed as a take for the purposes of the ESA. In Section 3(5)(A)(i) and (ii) this legislation introduces the need to conserve critical habitat areas essential to the conservation of the species and that may require may require special management considerations or protections.

LID is not implicitly supported by the verbiage of the Act, however; the extensive commentary contained in the Federal Register, Vol. 65, No. 132, of July 10, 2000, after the adoption of the final 4(d) rules, supports LID. On page 42431, NOAA comments that, "It is widely recognized that urbanization alters the hydrologic behavior of once unpaved, undeveloped lands. Within this context, common goals for management of urban landscapes include controlling stormwater runoff and protecting water quality. An urban watershed can become properly functioning if the ecological functions essential for listed salmonids within the watershed-such as storage, attenuation of peak flows and water quality mitigation-can be restored…". On page 42461, NOAA comments on how using the best available technologies to achieve properly functioning conditions can be accomplished "by guiding land use practices on the watershed scale in order to reduce impervious surfaces, maintain forest cover and natural soils. These conditions will, in turn, maintain essential habitat processes such as natural water infiltration rates, transpiration rates, stormwater runoff rates, sediment filtering, and provide hydrographic conditions that maintain and sustain listed salmonids." NOAA states on page 42548, that "Conserving and restoring functional habitats depends largely on allowing natural processes to increase their ecological function, while at the same time removing impacts from current practices. Those functional requirements apply regardless of where or how development takes place".

These comments and others of a similar vein all speak to the goal and intent of LID applications and premise upon which they function.

Safe Drinking Water Act

The primary purpose of the Safe Drinking Water Act is to provide regulation of the safety of treated drinking water in the United States. However, the legislation does recognize the link between the quality of drinking water and the quality of the water sources from which it is drawn. In fact, many of the contaminants that are regulated and monitored subject to this Act are also on the list of contaminants that are implicated in impacts on salmon species and addressed in the 303(d) listings and or NPDES permits, such as turbidity, copper, TDS and nitrates.

United States Code Title 42, Chapter 6A, Subchapter XII, Part C, Section 300h-7(a) establishes the requirement for States to develop ground water quality programs and well head protection programs. Section 300j-13(a) dictates that States conduct source water assessments, with Section 300j-13(a)(6) allowing the states to utilize programs developed in compliance with other regulations as a basis for compliance with this requirement. The requirement for State Underground Injection Control programs is established by Section 300h-1(a).

Completion of the development of programs as required by this Act is left to State agencies. At this level the regulation is silent as to implementation measures to achieve source water, well head and groundwater protection, and thus specific reference to LID practices is absent as well. The important factor to note here is that there is a recognition of the connection between stormwater inputs to the source waters of the nation. Monitoring programs under the SDWA have similar objectives with monitoring efforts under CWA. Unfortunately, the SDWA specifically prohibits the use of SDWA appropriated funds for grant applications already supported by Clean Water Act funding.

State Regulations, Programs and Plans

Oregon Revised Statute 468b

ORS 468B assigns the Oregon Department of Environmental Quality responsibility for monitoring and regulating water quality in Oregon. 468B.015 determines that it is the policy of the state to: conserve waters of the state; protect, maintain or improve the quality of waters of the state for public water supply, propagation of wildlife, fish, and aquatic life and for domestic and other uses; provide for necessary treatment or corrective action to waste prior to discharge to waters of the state; provide for abatement, prevention, or control of new or existing water pollution; and cooperate with other agencies of the state and federal government in carrying out these objectives. The Environmental Quality Commission is the body responsible for setting policy for the DEQ.

Within ORS 468B, DEQ is tasked with implementation of the Clean Water Act, including the establishment of effluent limitations per section 303(d) for waters of the state. It also establishes parameters for the discharge permits at 468B.050, strategy for groundwater resource protection at 468B.167, and Underground Injection Control at 468B.195.

The administrative rules developed by EQC and DEQ to guide implementation and regulation of the various state programs are where specific practices begin to be mandated, recommended, or allowed. This organizing statute defines the goals and objectives of programs administered by DEQ. Objectives of the Safe Drinking Water Act and the Clean Water Act are represented in the statute.

ORS 468 contained a provision allowing for the issuance of a Green Permit to entities. This permit was intended to reward entities that go the extra mile in efforts to protect the environment. Inclusion of LID practices at the development level would likely have qualified for attaining the first tier of Green Permits for stormwater. The permit would modify regulatory requirements after a facility has demonstrated that it could achieve the performance claimed in the application. This option was not renewed by the legislature and expired in January 2008.

Oregon Administrative Rule Chapter 340, Division 16

The provisions of this administrative rule allowed entities to receive a tax credit for construction of eligible facilities that reduce air, water, or noise pollution or the releases of wastes. The verbiage of the rule would need to be liberally construed in order for LID applications to be considered an eligible facility. The conflict would occur in that the principle function of the facility must be for the reduction or control of pollution. Many of the LID practices that could be applied, for example pervious paving have a primary function of providing hard surface parking or transportation facilities, although the nature of the material makes the overall facility a functional stormwater runoff control device.

The need to take issue with the language in the rule has been nullified by the fact that the rule is expiring. No new applications for the program will be accepted by DEQ as of December 2008.

Oregon Administrative Rule Chapter 340, Division 40

The groundwater protection program recognizes the interaction of groundwater with surface waters of the state at 340-040-0020(1), by recognizing its contributions to base flows in rivers, lakes, streams, and wetlands. The relationship is acknowledged again at 340-040(4)(c)(J),(K), and (L). According to 340-040-0110(2)(b) and (c), the regulations and numeric limits established in these rules are designed to regulate those substances that have the potential to enter groundwater, at least partially, from one or more nonpoint sources and that may adversely impact public health or the environment. No specific actions, activities or practices are discussed, recommended or required. Several of the contaminants of concern that are addressed in the groundwater protection or wellhead protection plans are similar in nature to those addressed in the SWA and the CWA. LID practices are a form of control for non-point sources of pollution that are a contributing factor in groundwater contamination.

Oregon Administrative Rule Chapter 340, Division 41

This administrative rule is the primary vehicle for the implementation of the NPDES permit process. Section 340-041-0004(1) states that the purpose of the antidegradation policy for Oregon is to: 1) guide decisions that affect water quality such that unnecessary further degradation from new or increased point or nonpoint sources of pollution is prevented; and 2) protect, maintain and enhance existing surface water quality to ensure the full protection of all existing beneficial uses. Subsection (2) states that the policy of the Commission is to require that growth and development be accommodated by increased efficiency and effectiveness of waste treatment and control.

The “Three Basin Rule” is presented in Section 340-041-0350. The rule essentially states that no new permitted discharges will be allowed on the Clackamas, McKenzie, or North Santiam Rivers. Considering the level of development that is planned for subwatersheds along the north side of the Clackamas River, meeting this rule may be challenging.

Control of nonpoint sources of pollution is at least as important as controlling point sources. Section 340-041-0007(9) indicates that federal, state, and local resource management agencies will be encouraged and assisted to coordinate planning and implementation of programs to regulate or control runoff, erosion, turbidity, stream temperature, stream flow, and the withdrawal and use of irrigation water on a basin-wide approach so as to protect the quality and beneficial uses of water and related resources. Such programs may include, but are not limited to: development of projects for storage and release of suitable quality waters to augment low stream flow; urban runoff control to reduce erosion; possible modification of irrigation practices to reduce or minimize adverse impacts from irrigation return flows; stream bank erosion reduction projects; and federal water quality restoration plans.

LID practices can address many of these programmatic themes. Reductions in runoff from sites through on site infiltration or other mechanisms will assist in maintaining groundwater storage for stream bank recharge and maintenance of base flows, reducing erosion at upland sites and at stormwater discharge points, maintenance of streambank stability through reducing or maintaining the flashiness of the streams, improvements in water quality of discharged waters. The chapter identifies the TMDL’s and constituents for which 303(d) listed streams must be monitored. LID practices have been successfully used by other organizations around the nation, and in the local area to minimize discharges of particular pollutants or water quality impairments.

Permit requirements are performance based, rather than technique based, allowing the permit applicant to define the mechanisms, practices, or techniques that will be used to meet the applicable standards. This provides an opportunity for organizations to incorporate LID practices as a permitted stormwater management mechanism.

Oregon Administrative Rule Chapter 340, Division 44

The Oregon Underground Injection Control (UIC) Program is implemented per OAR 340-044. The primary issue with LID and the UIC program is the possibility of some of the LID mechanisms, depending on design and construction, being defined as UIC's based on provisions in the program.

Another issue that is likely to create resistance to LID practices under the UIC is that urban stormwater is unlikely to meet precisely the background water quality of the existing groundwater, as required by 340-044-0018(1)(c). Although there is an allowance in the rule for injection of stormwater under 340-044-0018(3), subsection (C) mandates that no other method of storm water disposal is appropriate. It would be at the discretion of the reviewer to determine if a proposed LID mechanism met the test for an appropriate method. In determining if a method is appropriate, consideration is given to protection of groundwater quality, management of surface water quality and watershed health issues. Thus, depending on the interpretation of the reviewer, the proposed LID technique and design, and the site specific conditions at the location of the proposed technique, the rule could serve as a barrier or an aid to implementation.

Oregon Statewide Planning Goals

The Land Conservation Department (LCD) is responsible for setting statewide land use planning goals and developing guidance for assisting local and regional governments with compliance. Aspects of LID use can assist in moving towards compliance with several of the goals, or could at least be given consideration as a possible mechanism for developing a compliance program for achieving a goal.

The OAR's governance of the statewide planning goals allows Metro to develop a functional plan to be applied to all entities within their jurisdiction. Metro is in the final stages of producing such a plan and enabling ordinances, and those plans will be discussed later. The goals are worth discussing here separately, as there are differences between Metro's interpretation and the goals as presented.

Goal 5 dictates protection of natural resources based on the premise that preservation of these resources promotes a healthy environment. This goal is mainly concerned with land use planning and the preservation of open spaces; however, the application of LID practices can assist in meeting certain aspects of the goal. OAR 660-023-0140 deals with groundwater resources in Subsections 3 through 6. Application of LID practices as part of land use planning and development processes can assist local agencies with preserving groundwater quantities, especially in limited groundwater areas such as the RCSI project area, and can help minimize the pollution of groundwater from nonpoint sources. Incorporation of LID techniques to meet the statewide goal would occur at the level of the municipal or county comprehensive plan that is submitted to LCD for review and approval.

Goal 6 addresses air, water, and land resources quality. The goal seeks to ensure that discharges as a result of development do not threaten to violate or violate applicable state or federal environmental quality statutes. The goal further states that the carrying capacity of the air, water, and land resources should be a consideration in the formulation of plans. Plans for development that do not include LID will have difficulty meeting the objective of this goal if the receiving stream is already water quality limited prior to implementation of the development under the proposed plan. Conventional piped stormwater systems with point source discharge do not assist in achieving compliance with this goal. LID practices can be a mechanism in plans that seek to comply with this goal. The reduction of stormwater discharges is a significant objective of LID practices, as is achieving levels of treatment through natural processes.

Goal 7 deals with natural hazard areas. In the context of LID practices, wetlands and floodplains are part of the stormwater management system and would be incorporated into any stormwater management plan as such. LID practices for the particular area that is incorporated into the RCSI project area are unlikely to be significantly influenced by proximity to flood zones. However, stormwater planning carried out on a watershed or subwatershed scale would seek to conserve, protect, and enhance natural flood plains and wetlands to assist in stormwater management during heavy storm events.

The Oregon Plan

The Oregon Plan represents the State of Oregon’s integrated approach to addressing the requirements of the Endangered Species Act. The plan does not institute new regulatory compliance mandates, instead relying on improved enforcement of existing measures such as Goal 5 habitat protections, NPDES permitting, and enforcement of TMDL and other 303(d) listed stream monitoring and recovery requirements. The premise of the plan is that many of the actions already mandated by regulation will have a net result of improving water quality, habitat health and ecological function to the point that anadromous salmonid populations will recover concurrent with the improvements.

LID has a significant place in this process. LID practices are known to reduce sediment loads that can detrimentally impact spawning and rearing habitat, produce cooler temperatures in stormwater discharges, preserve hydrologic function and stream morphology, and decrease contaminant loads that harm fish and other aquatic organisms. LID practices have also been associated with the preservation of groundwater quantities and contribute to preservation of base flows in streams. Language directly endorsing LID is not present in the current iteration of the Oregon Plan, however it is likely that it will soon, as one hallmark of the plan is the use of adaptive management and frequent revisions of the plan to accommodate new innovations and techniques as they become known or are developed.

Oregon Nonpoint Source Control Program

The State of Oregon has taken a similar approach to satisfying requirements for a nonpoint source control plan to satisfy section 319 of the Clean Water Act. The Nonpoint Source Plan contains nine key elements, all of which are linked to efforts of various departments of the State and other local entities. Again, the actual activities undertaken pursuant to the plan are administered by existing programs with similar or linked objectives. For instance, the numeric water quality criteria are gathered from programs such as the 303(d) requirements or NPDES permit requirements.

LID practices contribute to retention of biological integrity of receiving streams and improved management of nonpoint source pollutants. The ability of LID practices to assist in meeting TMDL and water quality requirements and in complying with limitations prescribed in NPDES permits are significant in contributing to Oregon's implementation of the NSCP. The document is deliberately vague in defining how water quality parameters might be met in order to allow for the greatest flexibility at the local or watershed level for selection of site specific solutions.

Metro Functional Plan

Metro was tasked by LCD with developing a functional plan for its subject jurisdictions to meet statewide planning goals. Metro has developed the plan and several title sections pertain to natural resource protection and water quality issues. Title 3 addresses water quality and flood management, Title 9, performance standards, and Title 13 regulates the Nature in Neighborhoods efforts.

The intent of Title 3, per section 3.07.310, is to protect the beneficial uses of water and the functions and values of resources within the Water Quality and Flood Management Areas. The title would indicate that there would be applicability for LID in this section. The title language is primarily focused on the conservation of riparian and water quality resource areas. The focus on preservation of specific land areas does not provide a ready connection to the implementation of stormwater management practices in developed areas, although stormwater management is essential to long term function and viability of those areas protected in this title. This title offers no support for implementation of LID in its language.

Title 9, delineates the performance measures by which progress of the implementation of the Urban Growth Management Functional Plan gauged. This title concludes that a primary goal of the plan is to protect and restore the natural environment through actions such as protecting wetlands, improving surface and groundwater quality, and reducing air emissions. Within the section regarding what performance measures will be utilized to gauge progress on the stated goals, only one item, the amount of land that is environmentally sensitive that is permanently protected, even marginally addresses the original goal. These performance measures are inadequate to provide an impetus for communities to embrace LID.

Title 13 governing habitat friendly development is more useful in promoting LID practices. At 3.07.1330.B.3.b.iv, habitat friendly development practices, which promotes substantially the same principles as LID, is an option that cities may incorporate into their own implementing ordinances if they choose not to adopt the model ordinance as provided by Metro. The remainder of the language in the title advocates the use of habitat friendly development in Habitat Conservation Areas as a mechanism to reduce or mitigate the impacts of development within those areas when development cannot be avoided.

The influence of development practices on water quality does not persist throughout the document. Section 3.07.1360, Program Objectives, Monitoring and Reporting, focuses entirely on habitat and does not list a single water quality related objective. Additional verbiage could be included to further promote the use of habitat friendly development in all developing and redeveloping areas of Metro's jurisdiction, as appropriate. As it stands, the language directs local agencies to remove barriers in comprehensive plan and implementing ordinances for the use of habitat friendly development in where applicable in regionally significant fish and wildlife habitat. Again, the application is limited to specific areas within the Metro jurisdiction.

Clackamas County

The Rules and Regulations of 2002 for the Surface Water Management Agency of Clackamas County do not promote LID practices. Language is included that requires on site infiltration, but the context of the comment does not indicate that LID measures were specifically intended.

Clackamas County is currently engaged in the process of developing watershed action plans. Based on early involvement and comment at the Stakeholders meetings, it is clear that the guidance for the county is trending towards incorporation of more LID practices where possible in order to capture water quality and quantity benefits, as well as capturing ecosystem functions and making contributions to riparian area health.

Clackamas County surface water management does provide for a property owner to apply for a service charge credit for on-site storm water management. A property owner can receive a credit for up to 66% of the relevant fee based on the effectiveness of on-site measures in controlling both water quality and quantity. On site detention or retention facilities per current design standards are allowed measures to qualify for this credit. The design standards of Clackamas County would be the determining factor in whether the application of LID practices would be an approved measure to qualify for this credit.

IX. LID Implementation

This section is intended to provide a general guide for decision-makers and staff to incorporate low impact development into the City of Happy Valley's operations. This section describes other Oregon cities' LID implementation lessons, the three primary implementation options and opportunities to ease implementation.

LID Implementation Lessons from Other Oregon Cities

In 2006, Oregon State University's Sea Grant Extension Program conducted needs-assessment workshops with local decision makers and residents in three Oregon communities of vastly different populations—Portland/Metro, Grants Pass, and Brookings (Godwin et al., 2008).

Although there were many differences between these communities including geographic and demographic differences, the following three themes were consistent across these workshops, as noted in "Barriers and Opportunities for Low Impact Development: Case Studies from Three Oregon Communities":

- Lack of basic understanding of planning and the impacts of growth: The workshops' most significant theme was a lack of basic understanding of the connection between today's land use and development decisions and tomorrow's consequences, in terms of both costs and resource quality. Neither the public nor local officials grasp the effects that individual planning decisions will have on infrastructure capacity, stormwater management, and water quality (p. 3).
- Need for active leadership: Participants expressed a need for strong administrative support and direction to incorporate LID practices into codes or to encourage developers to try LID projects. It is unreasonable to expect a local government staff person to deviate from normal practices without significant support from superiors. Leadership also needs to play a role in coordinating education and outreach between government (for example, public safety, planning, and health) and industry (developers, contractors, real estate pros, landscapers, suppliers, etc.), and across jurisdictions (such as departments and governments) (p. 4).

- Need for technical information and assistance: Technical impediments to instituting LID practices included a basic unfamiliarity with low impact techniques and designs, and a difficulty in shepherding these designs through the local government approval processes (p. 5). (A common solution was for publicly-sponsored pilot projects to "test" any new permitting process, codes, standards etc.)

The City of Happy Valley can take away from this study's findings that information sharing and projects are important to gain more understanding of development impacts. Currently, the City benefits from having a stormwater and drinking water provider which has compiled much information. Secondly, there is a need for continuous political will. This is necessary for staff to be supported in their work, and to create continuity for multi-year and multi-term programs that may last longer than election terms and commission appointments. Lastly, technical knowledge and relevant existing projects (such as those detailed in Section II) can provide much information for the East Happy Valley Comprehensive Plan Area.

Implementation Options

In this case, there are three primary LID implementation options:

1. Enter into an Intergovernmental Agreement with the stormwater provider, Water Environment Services to manage stormwater.
2. Create policies, codes, standards, permitting processes and programs at the City level.
3. A hybrid of the above.

The first option would be simpler than the second from a city perspective. WES is currently the stormwater provider. This IGA would expand WES' role to create management policies, review (portions of) development applications, and demonstrate compliance with local, state and federal policies and other duties. However, this would also assume that WES has the desire and capacity to perform these duties. It also removes some community development control from local decision-makers.

The second option is more onerous to the city both at the front end and to maintain. It does then rest community development control at the city level. Some of this work has been initiated and local models exist (discussed below).

Regardless of option, there are three primary considerations that need to be addressed:

1. Determining the jurisdictional boundaries for stormwater facilities;
2. If there is a hybrid, how the two approaches, standards, codes and policies would be reconciled; and
3. Which entity (City, WES or private owner) would maintain LID facilities.

The first consideration is common through all implementation options and considerations. This consideration must be addressed for any stormwater management in the project area. Currently, WES manages regional stormwater systems. As LID has positive effects to these systems, WES's operations must be considered and reconciled with the LID facilities' performance. Secondly, LID would include stormwater facilities outside of WES's traditional jurisdictional area; which is the city right-of-way (ROW). LID in the city ROW could be under the jurisdiction of the City or WES; but either would require an IGA. Jurisdiction would include duties such as: facility performance and overall goals, policies, implementation codes and standards, construction details satisfying the policies and standards and reconciliation between City and WES existing regional system capacity.

Maintenance is a pervasive question in the entire process from considering LID incorporation through the construction phases. Maintenance is discussed here because there is an additional entity that can perform maintenance, but is not part of the jurisdictional considerations above: private property owners. Adjacent and proximate property owners can perform LID facility maintenance. An adjacent property owner could, as part of a condition of approval, development agreement or other mechanism, be required to maintain a stormwater facility within adjacent ROW. Additionally, proximate private owners could form a Local Improvement District and consolidate resources to maintain facilities within a specified area.

Opportunities to Ease Implementation

This section discusses items that satisfy some of the case studies' lessons and the implementation option considerations. It also identifies and describes existing tools, resources and opportunities that are available to the City for LID implementation.

The Sea Grant case studies found there is a common lack of basic understanding of planning and the impacts of growth. The City of Happy Valley has a benefit in that it is not a sole entity attempting to educate its community. There are regional examples such as the Cities of Gresham and Portland, which have successfully created complete LID programs. Additionally, WES has already commenced this information-gathering activity. Lastly, Metro has created handbooks and resources for LID appropriate for a cityscape such as Happy Valley. These resources demonstrate that the City would not have to conduct this educational program on its own, nor are it "out in front" of other regional jurisdictions.

The Sea Grant case studies also found that there is a need for active leadership and technical information and assistance. Again, there is stormwater leadership from WES, Metro and adjacent jurisdictions. Should the City of Happy Valley decide to include LID, it could do so using the momentum from these other jurisdictions and WES programs such as the RCSI.

Existing Tools, Resources and Opportunities

The Gresham model could supply many of the elements needed to implement LID into the City of Happy Valley's programs including:

- Comprehensive Plan policies
- Development codes, standards and construction details
- Outreach and education materials
- Programmatic tools and lessons learned
- System Development Charge fee structure

An implementation tool that could be used – and has been used successfully in other areas is an Overlay Zone. This zone could enact LID design standards, techniques or differing performance measures for the RCSI area.

One solution from the Sea Grant case studies is to create a "pilot project". These pilot projects are often municipal projects. They are intended to test the newly-enacted policies, codes, standards, permitting and construction processes through the land use review process. Processing these applications can be lengthy as the city staff and contractors often make refinements during the process, which creates a lengthy timeline and may not be profitable if it were a private project; and thus avoided. Sometimes these pilot projects are privately-sponsored projects that can adjust their timeline with a development agreement and/or assume some cost increases while testing the new process. The City of Happy Valley has an opportunity with the Providence site as an LID pilot project. For this, the City would have its LID procedures completed prior to the Providence land use application and then could test the procedures on this site.

The City has a significant resource in the Angelo Planning Group report from August 2008, Nature*-friendly Development Practices: City of Happy Valley Policies, Code, and Procedures Audit*. This report is an audit of the city's policies, code, and procedures regarding the promotion of low impact development planning practices. It identifies implementation barriers and recommendations to incorporate more nature-friendly development standards into city regulations. The Happy Valley audit includes an evaluation of sections of the Comprehensive Plan, Development Code, and Engineering Design and Standard Details Manual, in terms of their ability to adequately address natural resources protection and stormwater management and to encourage nature-friendly development practices as required by Metro’s Title 13. This audit could be combined with an effort to create guidance similar to the green development practices manual developed for the Springwater Industrial Area in Gresham.

X. Potential Next Steps and Additional Research

The PSU research team goal was to provide the RCSI project team with a document that could inform interested stakeholders and decision makers on the possibilities, consequences and benefits of applying LID principles for stormwater management. This research revealed several potential next steps that could fill information gaps and help advance the objectives of the RCSI project team.

Highlighted Steps

The PSU research team made a presentation of their work from a fall term project at a joint City of Happy Valley Planning Commission and City Council workshop on December 12, 2008. The research team developed eleven key findings and potential next steps (described below). Of these findings the team highlighted the following thee: (1) conducting additional economic analysis; (2) establishing monitoring plans and protocols (potentially utilizing the Parametrix's EcoMetrix tool); and (3) creating a development practices manual. Each next step has resources available for assistance. First, ECONorthwest is already conducting additional economic analysis for the RCSI project team, with support provided by the USGS-IWW grant, which will quantify avoided costs experienced in different locations through LID practices. Second, regarding monitoring plans and protocols, two graduate students from this PSU research team expressed interest in continuing work on this project for their advanced degrees (MS and PhD of Environmental Science and Management). Additionally, it may be possible to continue work with Parametrix to further utilize the EcoMetrix tool as part of these protocols. Third, the Masters of Urban and Regional Planning degree program at Portland State University culminates in a two term group workshop project. The creation of a development practices manual, such as the manual created for the Pleasant Valley and Springwater Area Districts in the City of Gresham, is a viable workshop project. The project could include detailed recommendations for funding sources and incentive programs to assist implementation as well as include a robust public involvement component.

Eleven Key Findings and Potential Next Steps

Key findings of the PSU research team include the following:

1. LID Potential: Expanded LID practices have strong potential for success and economic return on the RCSI project area despite concerns regarding steep slopes and questions about soil permeability. Generally, it is also expected that increasing the scale from a site specific location to the entire project area will help decrease net initial costs and increase net returns. It is also recognized that a mixture of conventional and LID practices will likely be needed.

2. Ecosystem Services as an Organizing Principle: The PSU research team report identified ecosystem services as a critical organizing principle of LID that is well suited as an organizing principle for the RCSI project. Ecosystem services are described in further detail in the report but generally related to the collection of life sustaining natural functions, conditions, or processes produced naturally by the ecosystem. This focus is well suited to greenfield development where it is possible to start with and enhance the natural services already provided on the landscape rather than attempt to mimic those services through the construction of hard infrastructure. The ecosystem services approach is also relevant for RCSI because it is being utilized in nearby locations such as the Springwater Industrial Area in Gresham, planning for the City of Damascus, the Lents Flood Abatement Project in the Johnson Creek Watershed, and the Tabor to River or Brooklyn Creek Basin Program in the City of Portland.

3. Staying Ahead of the Curve: Sustainability is a commonly used term with imprecise definition and is a constantly moving target with the learning of new information. The LID focus of the PSU research team report is one part of a potential sustainable development approach for the RCSI project area. Numerous implementation examples detailed in the report (Table 1.3) utilize LID as one component of a sustainable development approach being pursued to provide cost effective infrastructure provision with additional ecosystem benefits and simultaneously attract progressive, ecologically responsible companies to invigorate business development plans. While pursuing a sustainable development approach does not ensure a competitive advantage in attracting development of higher economic return, it is postulated. The continuation and enhancement of the RCSI project has the potential to achieve these results, keep from losing a potential competitive advantage to neighboring areas, enhance the ability to leverage sustainability grant funding research and development monies, and potentially enable participation with regional sustainable development efforts that could develop to provide information, resource, and coordination assistance.

4. Expanded Hydrologic Modeling: The initial work by Pacific Water Resources to compare a conventional development scenario with a limited LID scenario provides valuable information for the RCSI project team concerning the cost and performance of the respective infrastructure development options. Modeling of a more expanded LID scenario, as outlined by the PSU research team report, is recommended.

5. Expanded Economic Analysis: There were numerous questions about the economic implications of potential LID scenarios at the December 12, 2008 RCSI Update and PSU research team Presentation to the joint City of Happy Valley Planning Commission and City Council Workshop. Two foci of continued economic analysis are recommended: (1) a formal report of avoided costs demonstrated and ecosystem services provided by LID and sustainable development projects similar to RCSI, and (2) a more detailed cost/benefit analysis comparison of the LID scenarios developed through expanded hydrologic modeling.

6. Local Control and a Development Practices Manual: Extensive review of federal and state legislation reveals no significant barrier to LID implementation. Many directives are performance based objectives addressed well by a LID approach. The legislation does not provide specific implement directives, but failure to reach the performance objectives can lead to potentially costly lawsuit and mandated environmental review and cleanup costs. The lack of implementation language provides local jurisdictions, in this case the City of Happy Valley, to exert local control in a proactive manner regarding the development and direction of the RCSI project area. One tangible next step would be creating a development practices manual similar to the "Green Development Practices Manual" developed by the City of Gresham for the Springwater Industrial Area.

7. LID Pilot Project: A successful approach used in other locations is a pilot project to implement, test, monitor, and demonstrate LID practices. This approach should be considered for the RCSI project area. Due to planning processes area already underway in the area (e.g., hospital, school, and park), planning for the larger RCSI project area should develop continuously.

8. Monitoring and Adaptive Management: Partnership with Parametrix to further utilize the EcoMetrix tool has multiple benefits. A rapid assessment overview approach has the potential to help identify planning options that provide high levels of ecosystem services on a landscape level, both in terms of preserving currently high functioning areas and

prioritizing prime areas for restoration potential. This has a direct economic benefit by avoiding the cost of engineering the replacement for a previously functioning natural system benefit. The field level data collection process also provides detailed information about the performance of a full range of ecosystem benefits. This data can be utilized as a current baseline for the project area and ongoing monitoring with the tool can provide information about the performance of different LID and sustainable development measures to enable adaptation. This tool enables adaptive management by providing the local jurisdiction with an ability to tailor practices encouraged or incentives based on monitored data. The postulated result would be the ability to provide a higher level of ecosystem benefit at a lower cost.

9. Available Resources: The PSU research team report provided information on the goals and status of other projects relevant to RCSI, including two detailed case studies on the Springwater Industrial Area in Gresham, Oregon and the Kitsap SEED project in Bremerton, Washington. The report also provided information on the Sustainable Sites Initiative and LEED Neighborhood Design programs that could be valuable resources for providing a template for local jurisdictions with limited funds for creating policy guidance and code development to further sustainable development. The report did not, however, detail potential funding sources and partnership opportunities to leverage resources. Additional work to identify these resources is recommended.

10. Public Involvement: The PSU research team report did not address the question of public involvement or analyze public involvement efforts associated with related planning efforts such as the Damascus/Boring Concept Plan (DBCP) or the East Happy Valley Comprehensive Plan (EHVCP). An April 2008 draft report by Oregon Consensus, part of the Hatfield School of Government at Portland State University, however, did analyze the public involvement processes utilized in the 2004-2006 DBCP development. The report found that challenges experienced in the process were, among other reasons, related to the lack of identification and involvement of all affected stakeholder groups. Such a detailed identification of stakeholder group interested and affected by the RCSI project is recommended. It is recommended in order to be consistent with lessons learned from the consensus building literature of theory and practice, and to avoid the problems detailed in the DBCP public involvement analysis. A relevant starting point could be a comparative analysis of the DBCP and EHVCP public involvement processes to identify and convene an appropriate representative stakeholder advisory group for the RCSI project.

11. Coordination and Regional Discussions: The RCSI project team reported staff, time and resource challenges associated with the desire to advance the project. Indeed, the PSU research team was assembled with assistance from the USGS-Institute for Water and Watersheds mini-grant to help provide the project team with a document that could inform interested stakeholders and decision makers on the possibilities, consequences and benefits of applying LID principles for stormwater management to the project area as one component of a sustainable development approach. Due to RCSI project team resource limitations and the continued emergence of LID and sustainable development projects in the Portland Metro regional area (including Clackamas, Multnomah, and Washington counties), coordinated discussions about ways to coordinate land use and water management planning processes is recommended. One potential starting focus for a regional discussion convented by Metro could be the development of a guidance template for sustainable development within a Regionally Significant Industrial Area (RISA) since both RCSI and the Springwater Industrial Area were given this land use designation by Metro. This type of coordinated discussion could greatly assist local jurisdiction creation of sustainable development practices manuals.

Additional Information Regarding Potential Next Steps

When considering the opportunities presented by the RCSI project, it is important to remember a holistic picture that extends beyond LID. As described earlier, LID itself is an integrated approach that does not involve merely one solution assigned to one problem, rather many solutions applied to an entire project or site. Projects seeking to advance sustainable practices, such as RCSI, would be well advised to consider multiple ways to provide the most complete range of ecosystem benefits, including cultural benefits or social sustainability objectives. It is likely through this pursuit of the most complete suite of sustainability objectives that the RCSI project team members would be able to leverage the greatest set of partnerships and funding sources opportunities. This pursuit would also likely provide the greatest benefit to the residents, investors, and communities within and nearby the project area.

XI. Appendices

Appendix A: An Institutional Structure for Localized Stormwater Management

This section will articulate one framework for facilitating implementation of low-impact development practices at the 'district' or multi-site scale. The framework is based on principles of Integrated Water Resources Management (IWRM), an emerging international best practice for regional governance, including large-scale industrial parks (Geng Y. and J. Yi, 2006). IWRM in turn relies on the concept of a Regional Environmental Management System (REMS) that integrates the capacities of local jurisdictions and private sector entities to manage resources of mutual concern (see www.vrems.org and www.bartowga.org/Envms for public-sector examples in the USA). At the core of the REMS concept is an environmental information network (EIN) that feeds data on the performance of the stormwater management system into a centralized site operations and management (O&M) unit. The role of the EIN is to significantly reduce delays and discontinuities of information feedback within the system, so that apparent problems can be recognized, agreed upon and trouble-shot in a timely, adaptive fashion. The EIN data collection protocol is multi-scalar in both time and space. Data would be collected at both the LID facility and watershed spatial scales, as well as instantaneously, periodically, and through casual observation. Data collection methods include distributed sensor networks and manual water quality testing. Data are assembled into a multi-user geographic information system (GIS) database and coupled with water quantity and quality models for analysis. The ArcHydro data model was recently developed to facilitate this approach, allowing for inclusion of time-series monitoring data into the geodatabase.

Monitoring programs would be specific to the watershed in question. In the lower tributaries of the Clackamas River, limiting factors for endangered fish species include low flows, sedimentation, high temperatures, insufficient quantity and quality of habitat, and presence of toxics (Willamette Subbasin Plan, 2004). For typical campus-style commercial and industrial districts in these watersheds, a monitoring protocol might look similar to what is shown in Table 1.10 below.

Table 1.10. Suggested Monitoring Protocol for a Regional Low-Impact Stormwater System

Parameter	Collection method	Collection period	Collection point(s)
Discharge	Automated sensor (stage height)	Continuous	Storm system & Watershed
pH	Automated sensor	Continuous	Storm system
Temperature	Automated sensor	Continuous	Watershed
Turbidity	Visual observation	Weekly (all year)	Storm system
Erosion	Visual observation	Weekly (during rainy season)	Storm system
Bacteria	Manual testing	Semi-annually	Watershed
Phosphorous	Manual testing	Semi-annually	Watershed
Dissolved oxygen	Manual testing	Semi-annually	Watershed
Conductivity (metals)	Manual testing	Annually	Watershed
Pharmaceuticals	Manual testing	Annually	Watershed
Pesticides	Manual testing	Annually	Watershed
Macroinvertebrates	Manual testing	Annually	Watershed
Invasive species	Visual observation	Annually	Site
Canopy cover	Visual observation	Annually	Site

During the first few years, LID facilities should be monitored in a more regular and comprehensive fashion to ensure that they are performing properly with regard to design parameters such as detention period, infiltration rate, and erosion resilience. Where problems are encountered, whether at the facility, site or watershed scale, an environmental response team (consisting of designated experts among the collaborating entities) would assess potential impacts, possible sources and identify a range of appropriate responses. In keeping with watershed restoration best practices, corrective actions should be viewed as working hypotheses and monitored, modified and/or replaced until the problem is adequately addressed.

The Regional Environmental Management System could be organized as a special district (such as a ‘water control district’ authorized in ORS Chapter 553) governed cooperatively by local utilities and property owners. The district would be able to issue bonds to raise funds for capital improvements and make assessments to cover expenses, but would remain revenue-neutral. In addition to stormwater management, the district might also decide to undertake related operational responsibilities where it could achieve economies of scale and pass savings on to partners. This could include stormwater facilities maintenance, landscape maintenance, compost collection, district energy production (e.g. biomass, solar grid, ground-source heat pump, pumped-storage), or grey-water recycling for irrigation.

A special district could also be empowered to undertake any number of planning-related functions that advance regional sustainability, such as developing and implementing a master facilities plan, managing the extent of impervious surfaces, and acquiring easements on undeveloped sites to ensure efficient facilities planning or mitigation of unavoidable impacts. The district might also be able to generate and sell various ecosystem service credits in a local ecosystem marketplace to offset costs. The latter could conceivably be integrated into annual watershed monitoring activities that use the EcoMetrix tool, because that is the purpose for which EcoMetrix was developed. More localized watershed exchanges might also be developed to facilitate water quality, biodiversity, open space or density trading *within* the district as a means to improve flexibility and overall efficiencies for development.

Not least of all, the district should establish suitable watershed-wide performance benchmarks consistent with federal and state standards and regularly evaluate the effectiveness of the facilities plan in meeting them. The district might issue its own annual report that could simply be referenced in its members’ annual reports or compliance documents. In the event that water quality standards rise in the future, the district could identify a portfolio of investments likely to provide the most cost-effective means of meeting the standard across the watershed. As a means to help achieve performance targets, it might facilitate continual improvement among its members by incentivizing them to have a certified environmental management system and take actions to reduce their ecological footprint. Examples of the latter are joint alternative-transportation facilities, rainwater collection, landscaping with native plants, integrated pest management and use of non-toxic cleaning chemicals. Through these means the district could add value to members’ assets as well as improve their competitive position within their respective industries.

Appendix B: Soil Types, Slopes, Properties and Typical Profiles of the RCSI Project Area

Bornstedt silt loam, 0 to 8 percent slopes (123.5 ac, 30.4%)
8 to 15 percent slopes (39.5 ac, 9.7%)
15 to 30 percent slopes (19.6 ac, 4.8%)

Properties and qualities

- Depth to restrictive feature: More than 80 inches
- Drainage class: Moderately well drained
- Capacity of the most limiting layer to transmit water (Ksat):
  - Moderately low to moderately high (0.06 to 0.20 in/hr)
- Depth to water table: About 24 to 36 inches
- Available water capacity: Moderate (about 8.8 inches)

Typical profile

- 0 to 8 inches: Silt loam
- 8 to 33 inches: Silty clay loam
- 33 to 71 inches: Silty clay

Cascade silt loam, 3 to 8 percent slopes (78.7 ac, 19.4%)
8 to 15 percent slopes (55.3 ac, 13.6%)
15 to 30 percent slopes (35.7 ac, 8.8%)

Properties and qualities

- Depth to restrictive feature: 20 to 30 inches to fragipan
- Drainage class: Somewhat poorly drained
- Capacity of the most limiting layer to transmit water (Ksat):
  - Moderately low to moderately high (0.06 to 0.20 in/hr)
- Depth to water table: About 18 to 30 inches
- Available water capacity: Low (about 4.0 inches)

Typical profile

- 0 to 11 inches: Silt loam
- 11 to 21 inches: Silt loam
- 21 to 60 inches: Silty clay loam

Xerochrepts, very steep, 20 to 60 percent slopes (28.6 ac, 7.0%)

Properties and qualities

- Depth to restrictive feature: More than 80 inches
- Drainage class: Well drained
- Capacity of the most limiting layer to transmit water (Ksat):
    - Moderately high (0.20 to 0.57 in/hr)
- Depth to water table: About 36 to 72 inches
- Available water capacity: Moderate (about 8.0 inches)

Typical profile

- 0 to 8 inches: Silt loam
- 8 to 48 inches: Gravelly clay loam
- 48 to 60 inches: Very cobbly clay loam

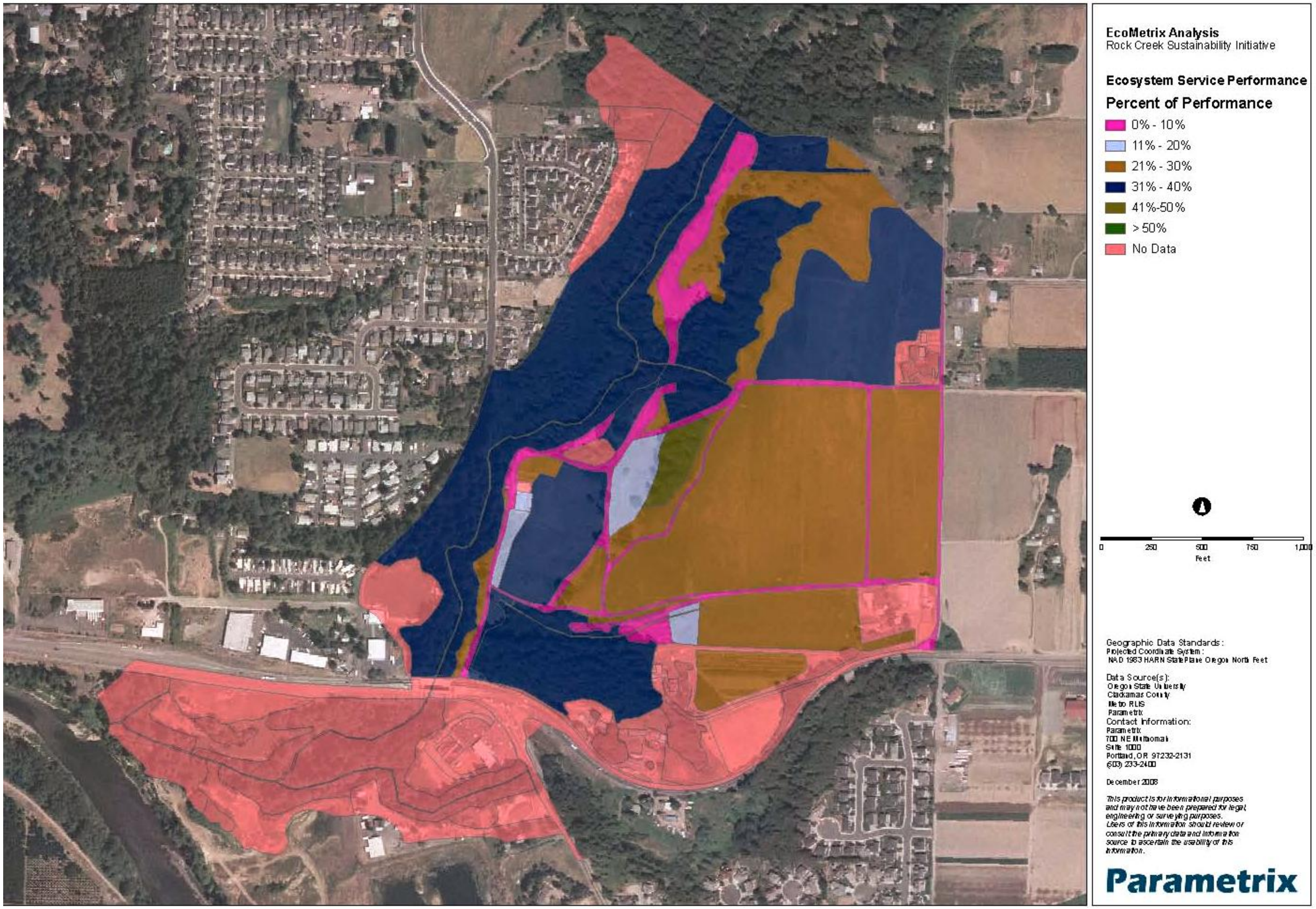
The following soil types are identified on the site but are a relatively minor percentage:

Aloha silt loam, 0 to 3 percent slopes (6.6 ac, 1.6%)
Cornelius silt loam, 8 to 15 percent slopes (0.1 ac, 0.0%)
Powell silt loam, 0 to 8 percent slopes (2.3 ac, 0.6%)
Powell silt loam, 8 to 15 percent slopes (4.8 ac, 1.2%)
Saum silt loam, 3 to 8 percent slopes (0.5 ac, 0.1%)
Saum silt loam, 8 to 15 percent slopes (10.6 ac, 2.6%)

Totals for Area of Interest, 405.7 ac (100.0%)

Source: Natural Resource Conservation Service, 2008

Appendix C: Preliminary EcoMetrix Analysis Results of the Providence Medical Site



Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN StatePlane Oregon North Feet

Data Source(s):
Oregon State University
Clackamas County
Metro RLIS
Parametrix
Contact Information:
Parametrix
700 NE Multnomah
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Portland, OR 97232-2131
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December 2008

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