

PORTLAND PLAN

Watershed Health



PORTLAND PLAN BACKGROUND REPORT FALL 2009

**Planning and Sustainability Commission
Recommended Draft**

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ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers



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ABBREVIATIONS

BES – City of Portland Bureau of Environmental Services
BOP – City of Portland Bureau of Planning (Bureau of Planning merged with Office of Sustainability to form the Bureau of Planning and Sustainability)
BPS – City of Portland Bureau of Planning and Sustainability
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
cfs – cubic feet per second
COP – City of Portland
CSO – Combined sewer overflow
CWA – Clean Water Act
DDT – Dichloro-diphenyl-trichloroethane
DEQ – Oregon Department of Environmental Quality
DLCD – Oregon Department of Land Conservation and Development
EPA – U.S. Environmental Protection Agency
ESA – Endangered Species Act
FEMA – Federal Emergency Management Agency
LCDC – Oregon State Land Conservation and Development Commission
LEED – Leadership in Energy and Environmental Design
MS4 – Municipal Separate Storm Sewer System
NMFS – National Marine Fisheries Service
NRI – *Draft* Natural Resources Inventory
ORS – Oregon Revised Statutes
OWEB – Oregon Watershed Enhancement Board
OWQI – Oregon Water Quality Index
PCBs – Polychlorinated biphenyls
PDX – Portland
PWMP – *Portland Watershed Management Plan*
SDWA – Safe Drinking Water Act
TCE – Trichloroethylene
TEES – Terrestrial Ecology Enhancement Strategy
TEESAG - Terrestrial Ecology Enhancement Strategy Advisory Group
TMDL – Total Maximum Daily Load
TSS – Total Suspended Solids
UIC – Underground injection controls
USGS – U.S. Geological Survey
US EPA – U.S. Environmental Protection Agency

EXECUTIVE SUMMARY

DOCUMENT PURPOSE

The *Watershed Health Background Report* provides a factual basis to inform development of the Portland Plan and the Comprehensive Plan update. The information that follows constitutes a “snapshot” of existing conditions, opportunities and challenges, and policy issues identified by technical staff in 2009 and 2010. This version of the background report also incorporates changes made in response to public testimony to the Planning and Sustainability Commission in July 2011. In addition, it includes updates to incorporate new data and changed conditions that occurred between the initial drafting of the document and its completion in March 2012.

OVERVIEW

Portland’s location at the confluence of the Columbia and Willamette Rivers shapes the city’s ecology and economy. The rivers serve as corridors of commerce connecting the Columbia Basin and Willamette Valley to marine and rail-based commerce. The rivers are also critical corridors for salmon, birds and other migratory wildlife of significance for the Pacific Northwest.

According to Metro and City of Portland projections, Portland will grow by 105,000 to 136,000 households¹ and will experience a demand for 100,000 to 200,000 more jobs by the year 2035². Accommodating that growth will intensify many challenges for protecting watershed health. To address these challenges, the City will need to adopt new approaches for allocating growth, constructing buildings, designing streets and stormwater systems, and providing open space.

Portland has come a long way since the days when sewage and industrial waste were regularly dumped into the Willamette River and Columbia Slough and wetlands were routinely filled to accommodate growth. Once considered “wastelands”, today, wetlands and floodplains are recognized as critical for wildlife habitat, clean water and flood management. While urban trees were once appreciated primarily for their beauty, today we recognize that they provide critical “eco-system services” by stabilizing steep slopes, absorbing rainwater, and cleaning and cooling the air.

Even though the safety and health benefits of healthy natural systems are documented and recognized, natural ecological processes continue to weaken under the pressures of increasing impervious areas, spreading invasive species, loss of vegetation, hardening of riverbanks, and myriad other problems. Historic development patterns and practices – straightening or piping streams to make room for growth, dumping waste into rivers and streams, constructing levees and filling wetlands – have left their legacy on Portland’s environment. Without thoughtful interventions,

¹ City of Portland. Bureau of Planning and Sustainability. *Portland Plan Housing Demand and Supply Projections*. Fall 2009. <http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=283476>

² City of Portland. Bureau of Planning and Sustainability. *Economic Opportunities Analysis, Task 2/3 Report – Supply and Demand: Revised Draft*. October 2009. <http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=270872>

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native fish and wildlife populations will continue to decline, and Portlanders will increasingly suffer because of a polluted environment.

In 2005, the City of Portland's Bureau of Environmental Services (BES) completed the *Portland Watershed Management Plan* (PWMP) in order to focus efforts to protect and restore Portland's natural systems. The PWMP lays out an integrated, system-wide approach to improving watershed health. Since its adoption, the PWMP has helped City bureaus consider watershed health as they design and implement projects. The Plan recognizes the benefits of mimicking natural systems, wherever possible, to most efficiently and effectively prevent and reverse environmental decline. As Portland moves forward with planning for future growth, incorporating watershed health goals into the Portland Plan and Comprehensive Plan update will be critical to maximizing limited environmental and fiscal resources while also striving to meet other public interests.

The *Portland Watershed Management Plan* is organized around four goals that correspond to the four fundamental elements required for overall watershed health:

- **Hydrology** – “Move toward normative stream flow³ conditions to protect and improve watershed and stream health, channel functions, and public health and safety.”
- **Water quality** – “Protect and improve surface water and groundwater quality to protect public health and support native fish and wildlife populations and biological communities.”
- **Habitat** – “Protect, enhance, and restore aquatic and terrestrial habitat conditions and support key ecological functions and improved productivity, diversity, capacity, and distribution of native fish and wildlife populations and biological communities.”
- **Biological communities** – “Protect, enhance, manage, and restore native aquatic and terrestrial species and biological communities to improve and maintain biodiversity in Portland's watersheds.”

Decades ago, Portland became nationally renowned for linking land use and transportation planning to create more vital communities. Now, the Portland Plan offers the opportunity to add further depth and richness to our planning processes in order to create sustainable and more satisfying communities, even as we face the impacts of climate change. The PWMP goals provide a framework to inform choices about growth allocation, infrastructure investments, and urban design. Through critical analysis and creative thinking, City investments can enhance Portland neighborhoods in cost-effective ways and ensure that future residents can be accommodated while the health and resiliency of the natural environment is enhanced.

This background report is organized around the four watershed health goals. Given the importance of community action for restoring healthy watershed conditions, this document also includes a section on stewardship, education, and public involvement. Organizing and analyzing information using this framework can help evaluate progress in improving watershed health.

³ Normative flow has the magnitude, frequency, duration, and timing essential to support salmonids and other native species.

KEY FINDINGS

HYDROLOGY

Stream flow conditions in Portland do not meet the conditions needed to support salmonids and other native species during all their life cycles. Increased impervious areas, piped streams, and impoundments have affected the normal hydrological cycle, causing the following problems:

- Low summertime stream flows
- Flashy conditions, with streams rapidly rising and falling during rain storms
- Diminished surface water infiltration to meter water into streams and replenish groundwater aquifers
- Persistent and increased flooding and streambank erosion
- Sewage backing up into basements in parts of the city when stormwater fills the combined sewer system

Although hydrologic problems persist, multiple actions are being taken to move toward normalizing hydrology. These include the following:

- \$1.4 billion investment in the Big Pipe Project added capacity to the combined sewer system
- Adoption of green stormwater management strategies, such as green streets, rain gardens, and ecoroofs
- Construction of floodplain and stream restoration projects to reduce local flood damage and improve local hydrologic conditions
- Comprehensive programs to increase piped sewer capacity and reduce the amount of stormwater entering the combined system to reduce sewer backups

WATER QUALITY

Overall water quality in the Willamette River has improved considerably since citizens successfully lobbied for water quality regulations in the 1930s. Trend data for the last 5 to 15 years show slight improvements in water quality in Johnson, Fanno, and Tryon Creeks and significant improvement in the Columbia Slough and Willamette River. Investments in stormwater infrastructure have netted positive results for water quality. Yet problems persist, and all of Portland streams continue to be water quality limited.

The following projects have contributed to recent water quality improvements:

- **Columbia Slough:** Removal of cesspools and septic system sources in upgradient groundwater, cleanup efforts of legacy pollutants (pollutants that are a result of historical uses), and a 99 percent reduction in combined sewer overflows (CSOs).
- **Willamette River:** With completion of the Big Pipe project, the volume of combined sewage and stormwater overflowing to the Willamette River is reduced by more than 94%. A variety of additional projects include the Burlingame sewer repair and streambank restoration project.
- **Fanno Creek:** Streamside improvements and in-stream bank stabilization projects.

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A number of factors affect the water quality of local rivers and streams. Non-point source pollution – sediment, fertilizers and heavy metals carried by stormwater – poses a risk to local streams and potentially to rivers and even the ocean. In the Willamette River, the Portland Harbor (between Swan Island and Sauvie Island) was named a Superfund site by the U.S. Environmental Protection Agency due to contaminated sediment. An emerging area of concern locally and nationally is “Priority Persistent Pollutants” (including pharmaceuticals and personal care products) entering wastewater treatment plants. Fortunately, a recent local study finds that wastewater from treatment plants is not a significant source of the most persistent pollutants.⁴

Numerous efforts are underway to protect and improve water quality. The Oregon DEQ regulates many stormwater outfalls to streams to protect water quality. Spill prevention outreach and education, and with regulation as part of the Columbia South Shore Well Field Wellhead Protection Program, has been effective in reducing the risk of contamination to this groundwater source, which augments the City’s Bull Run drinking water.

Sustainable stormwater facilities, such as rain gardens and green streets, are increasingly being used to capture and break down pollutants before they enter the waterways. Riparian and floodplain protection and restoration projects also slow and filter runoff. In addition, local governments and nonprofits sponsor public education programs aimed at reducing non-point source pollution.

While overall water quality practices have improved, virtually all water bodies in the City of Portland continue to have problems with temperature and some continue to have problems with legacy pollutants, such as DDT, or bacteria levels.

*Unlike pollution from industrial and sewage treatment plants, **non-point source pollution (NPS)** comes from many diffuse sources. It is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water. Pollutants include:*

- *Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;*
- *Oil, grease, and toxic chemicals from urban runoff and energy production;*
- *Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;*
- *Salt from irrigation practices;*
- *Acid from abandoned mines;*
- *Bacteria and nutrients from livestock, pet wastes, and faulty septic systems; and*
- *Atmospheric deposition and hydromodification.*

State agencies report that NPS pollution is the leading remaining cause of water quality problems. The effects of NPS on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries, and wildlife.

Source: USA EPA:

<http://www.epa.gov/owow/NPS/qa.ht>

⁴ Oregon Department of Environmental Quality. *Fact Sheet: Implementing Senate Bill 737*. June 2011 Update. <http://www.deq.state.or/wq/pubs/factsheets/programinfo/09-WQ-25SB737FS.pdf>

BIOLOGICAL COMMUNITIES

A growing number of species are listed as threatened or endangered at the state and federal levels. In March 1998, Portland initiated its Endangered Species Act (ESA) program in response to the listing of steelhead trout in the lower Columbia River as a threatened species under the federal ESA. Since then, five additional salmonid species that use or migrate through Portland's waterways have joined the list.

Portland also sits along a migratory corridor for birds. In recognition of Portland's position on the Pacific flyway, in 2003 the City of Portland signed the Urban Conservation Treaty for Migratory Birds, committing to providing habitat for birds that pass through the region.

Despite the many threats of an urban environment, the Portland metropolitan area has a diverse array of wildlife species⁵ that live in or migrate through the city.

Birds

- 209 native species, 18 of which are listed as state or federal species of concern⁶

Mammals

- 54 native species
- Eight out of nine bat species are listed as state or federal species of concern
- Four native rodent species are listed as species of concern

Amphibians

- Two amphibian species are state-listed sensitive species

Reptiles

- 13 native species
- Western pond turtle and western painted turtle are listed as state species of concern

Fish

- Six salmonid species are listed as threatened under the ESA
- Salmonid species are found far up Johnson and Tryon creeks
- Cutthroat trout is the most abundant salmonid species in Portland streams
- Salmon are found in all accessible habitats in the Columbia Slough

As some species face decline, populations of invasive animals – such as the red-eared slider, common snapping turtle, nutria, bullfrog, and zebra mussel – continue to increase, competing for food and habitat and, in some cases, preying on native species.

⁵ These numbers are based on Metro's 2006 inventory for the region. The City of Portland's Bureau of Environmental Services (BES), as part of the Terrestrial Ecology Enhancement Strategy (TEES), has developed a list of special-status species that focuses on Portland.

⁶ Species whose conservation status is of concern to the U.S. Fish and Wildlife Service, but for which further information is still needed. Such species receive no legal protection and use of the term does not necessarily imply that a species will eventually be proposed for listing. (ODFW)

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For the past few years Environmental Services has led the inter-bureau Terrestrial Ecology Enhancement Strategy (TEES) coordinating team and its stakeholder group (TEESAG), which has called attention to the needs of terrestrial species. The groups suggest monitoring specific species and habitats as a way to assess ecological integrity for multiple species. These efforts are also highlighting opportunities to enhance wildlife corridors as a way of improving the viability of terrestrial species within the city.

PHYSICAL HABITAT

Portland's physical habitats face continued risk as a result of biological stressors, climate change, habitat change, degradation and loss, habitat fragmentation, human disturbance, and pollution (COP BES 2007). Most in-stream habitat is severely degraded and is rated as marginal to poor. Riparian areas (the vegetated zones along streams) continue to be heavily affected by streamside development and loss of vegetation. Upland habitats are extremely fragmented and lack wildlife corridors that would connect them to riparian areas, wetlands or other uplands. Invasive plants continue to threaten habitat and other watershed functions. Climate change is expected to significantly alter habitats as well.

The City of Portland has taken steps to address these conditions. For example, the draft Natural Resource Inventory (NRI) provides more accurate and complete information about the location and relative quality of important natural resources, and the Terrestrial Ecology Enhancement Strategy Advisory Group (TEESAG) identified and mapped areas of other terrestrial habitats that had not previously been identified. Because of this effort, essential terrestrial habitat information is now available and can be considered in the Portland Plan process.

The new information identifies diverse habitat types in the Portland area. Special attention is called to habitat areas that have been virtually eliminated from the city. For example, grasslands and oak woodlands, two habitat types that have been nearly lost within the city, have now been identified as focal areas for restoration. Increasing habitat diversity will help native species adapt to ecosystem changes, such as those likely to occur due to climate change.

Efforts by the City of Portland and community organizations such as Friends of Trees have expanded the urban forest. These efforts will become even more important as the City works to reduce the effects of climate change. The City's Grey-to-Green program supports Friends of Trees in planting 33,000 yard trees and 50,000 street trees by July 2013, towards the long-term Urban Forestry Action Plan goal of achieving 33 percent tree canopy coverage citywide.

The Grey-to-Green program will further increase habitat for birds, fish, pollinators and other wildlife by reducing the spread of invasive species, adding ecoroofs and green street facilities, and removing stream culverts that are barriers to fish passage. It is unclear how long-term challenges like the threat of invasive species will be addressed after the program ends in 2013. Ongoing funding is needed to manage natural areas, care for street trees and maintain green streets, to continue the public's continued support and stewardship of these efforts.

STEWARDSHIP, EDUCATION, AND PUBLIC INVOLVEMENT

Moving toward watershed health requires the shared efforts of public agencies, nonprofits, community groups, and individual Portlanders. City bureaus promote education, involvement, and stewardship through a number of programs. The following provides a sampling of efforts in 2008:

- More than 26,000 students learned about watershed health
- About 3,600 property owners attended onsite stormwater management workshops
- About 500 people attended a free ecoroof training series
- A total of 13 stewardship grants and 20 mini-grants totaling about \$68,000 were awarded to neighbors, schools, and organizations to implement their own projects
- Parks volunteers logged more than 450,000 hours removing invasive plants, planting native vegetation, building trails, and picking up litter
- \$425,000 in grants was made available to realize exemplary, comprehensive green building projects

A number of nonprofits and informal stewardship groups work to improve watershed conditions. Among these, watershed councils play an especially pivotal role. Working across political boundaries with neighbors, local jurisdictions, business people, and other nonprofit organizations, the watershed councils foster stewardship, inform watershed residents, and sponsor projects to improve water quality and habitat. Nonprofit organizations such as Friends of Trees and SOLV conduct tree plantings and stewardship projects throughout the city. Also, “Friends” groups, such as the newly formed Stephens Creek Stewards, work to improve conditions in many of Portland’s watersheds and sub-watersheds.

Public comments from *visionPDX* and Portland Plan workshops reveal that Portlanders are knowledgeable and concerned about urban hydrology. They want to see more sustainable stormwater projects, such as green streets, ecoroofs and rain gardens. Most people support restoration projects that increase habitat, improve recreational opportunities, and improve watershed health. However, they are concerned about the costs associated with these projects. Portland Plan participants ranked watershed health in the top five priority issues, of over 20 identified. They emphasized the need for clear information about the impacts of individual actions on the natural environment, desire clean-up of the Willamette River, and the importance that all Portland residents have access to nature.

CHALLENGES AND OPPORTUNITIES

When development intensity increases, it often contributes to declining water quality, altered hydrology (such as erosion and flooding), declining wildlife populations, and degraded habitat. Assessments of local conditions confirm that Portland watersheds are challenged in all of these areas. Although it would be easy to assume that further growth will inevitably lead to worsening watershed conditions, Portlanders have said that they expect more — that they envision⁷ communities that are greener and healthier than they are today. Policies that address natural resource protection and habitat restoration along with innovative strategies starting with green buildings, green streets, and ecoroofs, can be applied more broadly and strategically to protect and enhance watershed health while accommodating residential and job growth. The following challenges and opportunities should be considered as Portlanders plan for the future.

● INTEGRATING WATERSHED HEALTH AND LAND USE PLANNING

The PWMP presents important policies and strategies for improving watershed health, yet these policies and strategies have not been well integrated into land use planning. Existing land use tools do not sufficiently protect existing natural resources. In much of the city, zoning regulations governing the type, density and standards for development have been applied with limited consideration for natural conditions such as soil infiltration rates, groundwater levels, and natural hazards. In some areas, redevelopment could improve watershed health by replacing or retrofitting paving and roofs with greener stormwater management and site improvements.

Environmental overlay zoning is the key land use tool to protect high-value natural resources, and guide environmentally-sensitive development on other natural resource areas. A recent draft inventory of natural resources shows that 23 percent of highly-ranked resources, about 430 acres, are outside of environmental overlay zones and over 2,500 acres are on private property (COP, BPS 2009). In addition, the City lacks incentives to promote restoration of natural resources on private property. Without changes to zoning provisions or the creation of other tools, Portland watersheds will continue to lose natural resources and their ecological functions.

The effectiveness of the City's Stormwater Management Manual is also hampered by the lack of integration between planning and watershed health. The manual regulates how stormwater is handled on a property to minimize the hydrologic impacts of development. Yet in some areas natural conditions, such as depth to the perched water table, make it challenging to implement the manual's requirements at the allowed zoning densities. As a result, there remains the potential for offsite problems related to stormwater runoff even when the manual's requirements are followed.

● NATURAL RESOURCES AS INFRASTRUCTURE

Healthy natural systems are vital not only for native plants and animals, but also for human health and safety. Trees clean and cool the air and stabilize the slopes to reduce the risk of landslides. Functioning floodplains store water during storms and gradually release it downstream afterwards. Wetlands filter pollutants and recharge aquifers. Unfortunately, development and impervious surfaces have degraded natural systems; invasive species also threaten them. Further degradation

⁷ visionPDX, 2007.

and loss of natural functions would be costly and increase risks to human health and safety (ECONorthwest 2009). Although predevelopment conditions cannot be recreated, trees, green streets, and ecoroofs can serve as green infrastructure, mimicking natural functions and supplementing the services provided by human-made infrastructure. As the City evolves in its understanding of the important public benefits of natural resources, thought must be given to how to plan for, manage, and finance green infrastructure, to ensure its long-term effectiveness and continue public acceptance and stewardship of green infrastructure projects.

● CUMULATIVE IMPACTS

When an environmental system fails, rarely is one factor or one action to blame; most often it is the accumulation of various impacts over time. For example, streams are polluted by runoff from hundreds of lawns and streets, slumps and slides occur because many homes are built on steep slopes. Flood damage occurs as pavement replaces vegetation within floodplains. When development proposals are reviewed by the City, there is little opportunity to acknowledge or prevent the cumulative impacts of individual choices. Yet the outcomes of these cumulative actions affect tax payers, ratepayers, downstream property owners and future generations. Neighborhood advocates and environmental activists can relate experiences of communitywide problems that resulted from site-specific decision making. Strategies are needed to better consider cumulative impacts in long-range planning processes and when development proposals are reviewed, so that the costs of individual actions are not unfairly passed on to others.

● ACCESS TO NATURE

Parks and natural areas, urban forest canopy, and backyard habitats not only provide watershed health benefits, but also contribute to human health. They provide opportunities for recreation and exercise, as well as mental health benefits.⁸ Having access to nature also allows people to understand how natural systems work. If younger generations have a chance to experience nature, they are more likely to be good stewards of Portland's streams, forests, and other natural systems. Yet many Portlanders cannot easily get to nature. The Portland Plan is an opportunity to consider how to ensure that all Portlanders have the opportunity to benefit from being close to nature.

● GREENING THE CENTERS

The Portland Plan process will include the development of Central City 2035, and the opportunity to further integrate nature and natural systems even in Portland's urban core. The Portland Plan will also re-examine how growth can be accommodated in town centers, main streets and transit corridors. For too long, "urban" and "green" have been considered mutually exclusive concepts. Yet downtown Portland boasts the verdant Park Blocks, ecoroofs, street trees, numerous LEED-certified buildings, and some of the most productive peregrine falcon habitat in the state. The rain garden at the Oregon Convention Center shows how smart urban design can integrate water and natural beauty into an urban context. Other areas, like Gateway, represent significant opportunities for replacing paved surfaces with landscaped areas for stormwater infiltration. More work is needed by urban designers, architects, planners, and landscape architects to explore ways to create

⁸ See City of Portland – Bureau of Planning and Sustainability. *Portland Plan Human Health and Safety*. Fall 2009. <http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=346241>

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compelling buildings, streets, and public spaces that maximize natural benefits in Portland's most urban areas.

RECOMMENDATIONS

The PWMP frames an approach that considers the natural and built landscape in a holistic manner. It calls for creation of a vigorous and connected green infrastructure system of ecoroofs, green streets and restoration projects that improve water quality, increase habitat and reduce risks from natural hazards, while also supporting economic development, urban design, recreation, transportation and a host of other public objectives. The Portland Plan provides an opportunity to further consider and promote these kinds of multi-objective approaches to make more effective use of taxpayer and ratepayer funds and ensure greater environmental resiliency.

● INTEGRATING WATERSHED HEALTH AND LAND USE PLANNING

The Portland Plan can use science-based analyses of natural systems to inform decisions about where and how future development should occur. Information about slopes, soils, habitat and hydrologic conditions can provide valuable information where to concentrate growth and where to prioritize preservation and restoration of natural resources. The watershed health goals can guide the planning process to reduce impervious surfaces, prevent pollution in local streams, and provide high-quality habitat for native wildlife communities.

● NATURAL RESOURCES AS INFRASTRUCTURE

The Portland Plan provides an opportunity to think about the important public benefits of natural resources functions and explore ways to more effectively plan for, manage, and finance green infrastructure to sustain, replicate and enhance these functions. Currently, BES funds the Grey-to-Green initiative, which is increasing tree canopy, ecoroofs, and natural areas through 2013. Capital funds also support floodplain restoration projects that improve habitat and water quality. The Portland Plan should acknowledge the important public benefits provided by trees, swales, green streets, and natural areas; examining long-term strategies to finance, provide, and manage green infrastructure facilities to expand their use and to ensure their long-term viability.

● CUMULATIVE IMPACTS

Strategies are needed to better consider the cumulative impacts in long-range planning and in development review processes, so that individual actions do not increase public costs or have a detrimental effect on watershed health, or public health and safety. The Portland Plan offers an opportunity to re-examine existing policies and zoning, look at how they are implemented through permitting processes, and determine how to reduce and prevent unintended consequences of multiple actions taken throughout a neighborhood or the city.

● ACCESS TO NATURE

The Portland Plan is a chance to determine how to rectify current inequities in Portlanders' ability to experience nature by prioritizing areas for additional parks, open spaces, and street trees. As the Portland Plan looks at how to accommodate growth, thought is needed about how to ensure that all Portlanders can enjoy a lush tree canopy, places to view wildlife, natural areas to explore, and opportunities to garden. Special thought should be given to children's access to nature to stimulate

their thinking, support their emotional wellbeing, help them feel grounded in their physical community - and instill a respect for the natural world so they will be good stewards in the future. Consideration should also be given to ways to create new greenspaces – such as pocket parks, roof gardens, trails, and parkways that meld with the urban environment.

- **GREENING THE CENTERS**

The Willamette River and the Park Blocks are central Portland’s visually most prominent north/south corridors. From the backdrop of the West Hills to Salmon Springs Fountain, water and trees are fundamental elements of Portland’s downtown identity. Also, the character of Gateway Regional Center is shaped in part its proximity to Rocky Butte, groves of Douglas fir trees and views of Mt. St. Helens and Mt. Hood. The Portland Plan should examine ways to further green the Central City and Metro 2040 centers to provide more attractive cityscapes and roofscapes, more energy-efficient buildings, lower infrastructure costs, and a diversity of bird and fish species in unique urban districts.

CHAPTER 1: OVERVIEW

In order to plan for the future, we must first look at the present. What is the environmental landscape on which we depend? Are people living in areas safe from floods, fires and wildfires? Is there adequate safe drinking water? Are there places where we can be close to nature as a counterpoint to urban life? Is biodiversity present to protect species from being decimated by disease? Is the urban forest healthy enough to clean the air and capture stormwater? Is the environment in good health? Where are the problems? What is improving?

This document begins to consider these questions and is a starting point for discussions to inform the Portland Plan, Periodic Review and the update to Portland's Comprehensive Plan. It summarizes the current conditions in the City's five watersheds – Columbia Slough, Fanno Creek, Tryon Creek, Johnson Creek and the Willamette River, by describing the hydrology, water quality, physical habitat and biological communities within Portland's boundaries. In addition, this document explores the implications of this information. The purpose of this report is to describe current conditions – what exists, rather than what could or ought to be. It explores implications of these conditions for Portland's future and suggests ideas for consideration for the Portland Plan and Comprehensive Plan update. However, it does not provide solutions or propose new policies.

Portland adopted its first Comprehensive Plan in 1980, laying out goals and policies for Portland's future growth and development. Since then, several sections of the original Comprehensive Plan have been revised, but the document has not had a full update. Currently, Portland is in the process of updating the original Comprehensive Plan, as well as the 1988 *Central City Plan*⁹. The update will begin with development of the "Portland Plan", a strategic plan that will identify priority objectives and near-term actions to most effectively move the City of Portland, other local government and nonprofit partners toward achieving long-term aspirations, while addressing long-term and emerging challenges. Building upon that framework, the City of Portland will update the Comprehensive Plan to provide a broad-ranging guide for the physical, economic, social, cultural and environmental development of the City over the next 25 years.

RELEVANT CHANGES AND DEVELOPMENTS

The Comprehensive Plan's Goal 8 - Environment directs the City of Portland to: "Maintain and improve the quality of Portland's air, water and land resources and protect neighborhoods and business centers from detrimental noise pollution" (COP BOP 1980).

Although the City is still striving to meet this goal and its associated policies and objectives, a number of factors have changed significantly since the Comprehensive Plan was originally adopted. For example, the near extinction of native salmon and the impacts from climate change are two critical issues that were not considered in 1980. In addition, over the years many new plans and

⁹ The *Central City Plan* broadened the scope of the 1972 *Downtown Plan*, by including the east side of the Willamette River. It contains policies, objectives and actions for eight sub-districts in the City core. The Plan is also being updated under the project name – Central City 2035 – to meet state requirements.

policies have been developed by various City bureaus to address environmental issues. As these plans were developed and implemented, a more holistic understanding of environmental challenges and solutions began to occur. An update to the Comprehensive Plan's environmental goal and policies is now needed to incorporate new environmental plans and policies and prepare for future decision-making that protects and restores vital natural systems.

This report highlights Key Findings drawn from data collection and analysis provided in a number of reports, including:

- *Clean River Plan*, 2000
- *2005 State of the River Report*
- *2005 Portland Watershed Management Plan*
- *Lower Willamette Sub-basin: Natural Systems Workshop Summary Report* (on climate change), 2010.
- *Metro State of the Watersheds* report, 2006
- *Natural Resource Inventory Update – Portland Plan Background Report*, 2009
- *Terrestrial Ecology Enhancement Strategy*, 2010

ORGANIZATION OF THIS REPORT

The document is organized in the following sections:

- **Overview/Planning Overview/Watershed Approach** – These sections describe the relationship between comprehensive planning, environmental regulations and watershed health. They also describe the *Portland Watershed Management Plan (PWMP)*, which provides the analytical, policy and strategic foundation for the City of Portland's efforts to improve local watershed health.
- **Citywide Characterization** – This section summarizes key issues and conditions throughout Portland's watersheds.
- **Hydrology, Water Quality, Habitat and Biological Communities** – These four sections correspond to the four primary goals of the PWMP. Each section describes conditions overall and highlights some of the key issues particular to each Portland watershed.
- **Stewardship, Education and Public Involvement** – This section describes some of the City's efforts around environmental education and the key role that watershed councils, nonprofits and friends groups play in improving watershed health conditions. A brief summary of public attitudes on the environment is also included.
- **Implications** – This section summarizes some of the issues raised in the report and identifies a set of questions regarding their potential implications for planning.
- **References** – This section lists key documents that served as resources for this report. It includes hyperlinks for readers wanting more detailed descriptions of the data and findings summarized here.

Watershed Health

While this report does not provide solutions or propose new policies it is hoped that this information, when considered with information about other issues such as transportation, urban form and economic development, can suggest new directions and opportunities for Portland's continued evolution as one of the greenest and most livable cities in the nation.

CHAPTER 2: ENVIRONMENTAL PLANNING AND CITY PROGRAMS

STATEWIDE AND REGIONAL LAND USE REGULATIONS

The City of Portland’s environmental planning has evolved over the past three decades in response to a series of land use regulations established at the state and regional levels. The following outlines these primary land use laws.

SENATE BILL 100

Senate Bill 100 requires all Oregon cities and counties to adopt comprehensive plans to guide land use, transportation and infrastructure decisions. The bill is intended to make efficient use of public investments in infrastructure and protect valuable farm and forest land by concentrating development within urban areas. Focusing development in urban areas also limits sprawl, which reduces impacts on natural resources outside of urban growth boundaries. Jurisdictions must demonstrate that local comprehensive plans are consistent with the 19 Statewide Planning Goals established by Senate Bill 100. Of these, the following goals relate directly to natural resources in Portland:

- **Goal 5: Open Spaces, Scenic and Historic Areas, and Natural Resources.** Goal 5 sets out a process for inventorying and evaluating 12 types of resources, including wildlife habitats, mineral resources, groundwater, wetlands and waterways. If a resource or site is found to be important, the local government can: preserve the resource, allow the proposed uses that conflict with it or establish a balance between the resource and those uses that would conflict with it.
- **Goal 6: Air, Water and Land Resources Quality.** Goal 6 requires local comprehensive plans and implementing measures to be consistent with state and federal regulations on matters such as stream quality and groundwater pollution.
- **Goal 7: Areas Subject to Natural Disasters and Hazards.** Goal 7 requires that jurisdictions apply “appropriate safeguards” when planning for development in places subject to natural hazards such as floods or landslides.
- **Goal 15: Willamette Greenway.** Goal 15 sets forth procedures for local and state government to conserve, enhance and maintain a greenway for the 300 miles of land along the Willamette River.

METRO URBAN GROWTH MANAGEMENT FUNCTIONAL PLAN TITLES 3 AND 13

Metro’s *Urban Growth Management Functional Plan* (Metro Code Section 3.07,) provides tools for local governments to help meet goals in the 2040 Growth Concept, Metro’s long-range growth management plan. Title 3 (Metro Code Sections 3.07.310 - 3.07.370) of the *Urban Growth Management Functional Plan* addresses regional water quality, floodplain management, and fish and wildlife conservation issues through performance standards intended to protect streams, rivers, wetlands and floodplains. Title 3 implements Oregon Statewide Planning Goals 6 and 7 by limiting encroachment into vegetated “water quality resource areas,” and by requiring special provisions to prevent erosion and impacts on flood hazards. In addition to adopting performance standards,

Watershed Health

Metro adopted a model ordinance that local governments can use to comply with the Title 3 standards.

Metro also adopted the Nature in Neighborhoods Program to implement *Title 13 of the Urban Growth Management Functional Plan* aimed at protecting, conserving and restoring the region's fish and wildlife habitat. Metro's program was developed in three basic steps:

- An inventory was completed of regionally significant fish and wildlife habitat.
- Economic, social, environmental and energy (ESEE) impacts were analyzed to identify the consequences and tradeoffs of protecting or not protecting inventoried natural resources.
- Metro developed, adopted, and is implementing a program to achieve the goals of the planning effort. It calls for balancing resource protections and economic goals, and focuses on protecting, conserving and restoring high-value riparian resources.

Portland and other Metro area cities and counties are required to demonstrate substantial compliance with Title 13 requirements.

CITY PROGRAMS

PORTLAND COMPREHENSIVE PLAN GOAL 8

When Portland developed its Comprehensive Plan, it addressed the environmentally-related statewide planning goals in Comprehensive Plan Goal 8: Environment. This section of the Comprehensive Plan sets policies and objectives for air quality, water quality, land resources, noise, aggregate resources and radio frequency emissions.

THE CITY'S RESPONSE TO LAND USE/ENVIRONMENTAL REGULATIONS

In response to Statewide Planning Goal 5, in 1981 the City developed a stream map that included setbacks and land use restrictions in riparian areas. In 1986, the City established an "interim protection resource zone" and then prepared a series of eight detailed natural resource inventories that informed the design of the current environmental protection and conservation overlay zones. The City responded to Statewide Planning Goal 15 by adopting the *Greenway Plan*, which includes policies and regulations specific to the Willamette River and riverfront.

PORTLAND ENVIRONMENTAL OVERLAY ZONE REGULATIONS

The City's environmental zoning program is intended to protect significant natural resources or mitigate impacts to them. It is the primary tool for complying with Statewide Planning Goal 5 and supports compliance with Goals 6 and 7. It is also a significant component of the City's compliance with Metro Title 3, upcoming compliance with Title 13, and is a component of the City's *Stormwater Plan* and MS4 permit (described, below).

Chapter 33.430 of Portland's Zoning Code governs proposed development in sensitive natural resource areas by applying two classifications of environmental overlay zones. The Environmental Protection Zone (p-zone) prohibits most development to protect the highest value natural resources. The Environmental Conservation Zone (c-zone) allows development that limits impacts on natural

resources. Greenway Overlay Zones, which apply along the Willamette River, also protect natural resources and help meet Metro's Title 3 water quality requirements. Environmental overlay zones apply to almost 20,000 acres of significant natural resources in Portland and urbanizing Multnomah County.

Over the past several years, the City has been updating its Natural Resource Inventory (NRI). This effort builds upon Metro's recent inventory of regionally-significant riparian corridors and wildlife habitat for the Title 13 Nature in Neighborhoods Program. Portland's draft NRI incorporates new data about the location of streams, wetlands and other natural resources. The mapping methodology draws from the latest available science and reflects the City's commitment to recovery of salmonids species listed under the Endangered Species Action. Through the process of developing the NRI, the City has identified more than 20 miles of open waterways and over 100 acres of wetland in Portland that lack protections from environmental or other resource overlay zones. About one-third of inventoried natural resources outside of the major river channels have no regulatory protections.

The City also initiated the *River Plan* to update the *Greenway Plan*. The planning effort is intended to promote a number of river-related goals, including environmental protection and restoration, economic development, and public access. The *River Plan/North Reach*, adopted by City Council in 2010, includes proposed environmental and greenway zoning code updates and identifies proposed restoration and mitigation sites ("pearls") within the river corridor. Currently, the Plan is under appeal to the Oregon Supreme Court. Planning the central reach of the riverfront is being conducted as part of the Central City 2035, an update to the *Central City Plan*.

OTHER CITY PROGRAMS

In addition to the zoning regulations described above, the City is complying with state and federal environmental regulations through the Stormwater Management Program, completion of the Big Pipe, which nearly eliminates combined sewer overflows (CSOs) into the Willamette River and Columbia Slough, revegetation of degraded areas with native trees and plants, and funding of community stewardship projects.

Stormwater Management Program

The Stormwater Management Program is administered by Bureau of Environmental Services (BES) in order to manage water quality impacts of development in Title 3 Water Quality Resource Areas. A key implementation of this program is the Stormwater Management Manual. Adopted by City Council in 1999, the manual requires that all new and redevelopment projects manage stormwater on site, to the maximum extent possible. The manual focuses on vegetated facilities, including green streets, vegetated planters, rain gardens and ecoroofs – and encourages retention and enhancement of tree canopy through established "best management practices" and stormwater management credit for trees on properties and parking strips. These approaches reduce the amount of stormwater entering engineered or "grey" stormwater facilities, mimic natural functions and provide numerous benefits for watershed health, often at less cost than traditional "grey" or engineered solutions. They provide the following benefits:

Watershed Health

- Absorb and infiltrate runoff
- Replenish groundwater
- Filter and biodegrade pollutants from street runoff
- Provide wildlife habitat
- Help cool the urban environment
- Improve air quality and absorb carbon

The Stormwater Management Program includes a number of other efforts to promote to increase stormwater infiltration:

- **Green Streets Policy** – The 2007 policy clarifies that all City-funded development must meet stormwater management requirements with green streets facilities.
- **1% for Green Fund** – This fund supports construction of green street facilities that manage runoff from public rights-of-way and addresses watershed or infrastructure needs.
- **Innovative Wet Weather Program** – Grants from the federal government help fund the City's program to construct and test innovative stormwater management projects.
- **Sustainable Stormwater Program** – The City's Sustainable Stormwater Program uses funding, education and technical assistance to promotes the use of green streets, rain gardens, ecoroofs and other green infrastructure approaches.
- **Grey to Green Initiative** – In 2008, the City initiated the Grey to Green Initiative, a 5-year program to invest \$50 million in "green infrastructure", in order to accelerate efforts to achieve the goals of the *Portland Watershed Management Plan*. Grey to Green funding is provided to:
 - Add 43 acres of ecoroofs
 - Construct 920 new Green Street facilities
 - Plant 33,000 yard trees and 50,000 street trees
 - Control the spread of invasive weeds
 - Replace 8 culverts that block fish passage
 - Purchase 419 acres of high priority natural areas



Green Street: SE 55th & SE Belmont St.



Grey-to-Green has expanded public awareness and the use of sustainable stormwater or green infrastructure approaches. Yet sources of ongoing funding are needed to maintain public facilities, such as green streets, and to hold the line or make progress in controlling the spread of invasive species after the 5-year initiative ends.

Columbia South Shore Water Quality Protection

The City's backup drinking water wells are located in the Columbia South Shore. To protect groundwater and surface water quality, and prevent spills that could contaminate the wells, the City of Portland regulates businesses in this area that handle hazardous materials. These regulations also help meet Title 3 standards for protecting Water Quality Resource Areas. The Columbia South Shore Well Field Wellhead Protection Program has been certified by the DEQ and is considered a statewide significant resource under Goal 5.

CSO Reduction and Portland Harbor Cleanup

The City's investment in the Big Pipe to reduce Combined Sewer Overflows (CSO) into the Willamette River also helps prevent pollutants from entering the river. Portland's participation in the Portland Harbor cleanup helps identify and control sources of pollution being conveyed to the Willamette River in the Superfund site.

Additional Programs

Several additional voluntary programs relate to the City's management of its watersheds. For example, Watershed Revegetation, Community Stewardship, and Naturescaping for Clean Rivers programs, managed by BES, support Title 3 standards that call for restoring degraded Water Quality Resource Areas.

EMERGING EFFORTS

Analysis of Ecosystem Services

Since its inception, Portland's environmental planning program recognized the value of protecting some environmentally-sensitive lands for the variety of services they provide. More recently, the field of economics has begun to systematically acknowledge and quantify the benefits received from natural resources and ecosystem processes provided. These evaluations can inform planning efforts for land use, hazard mitigation, infrastructure and parks. These studies identify services in five categories:

- *Provisioning* such as the production of food and water
- *Regulating*, such as the control of climate and disease
- *Supporting*, such as nutrient cycles and crop pollination
- *Cultural*, such as spiritual and recreational benefits
- *Preserving*, which includes guarding against uncertainty through the maintenance of diversity

Watershed Health

The following are examples of studies of ecosystem services conducted in the Pacific Northwest:

- *Comparative Valuation of Ecosystem Services: Lents Project Case Study (2004)* – This study assessed the value of the Lent’s Flood Abatement Project by quantifying and valuing the ecosystem services provided by project including flood abatement, biodiversity maintenance, air quality improvement, water quality improvement and cultural services.
- *Economic Benefits of Large Patches of Tree Canopy: A Second-Stage Hedonic Price Analysis (2005)* – This study assessed the value of increasing tree canopy on property values in Portland.
- *A New View of the Puget Sound Economy: The Economic Value of Nature’s Services in the Puget Sound Basin (2008)* – This study assessed the value of Puget Sound Basin ecosystems including flood protection, water supply and filtration, food, habitat, waste treatment, climate regulation, recreation and other benefits. A partial valuation of these services shows a range of economic benefits between \$7.4 billion to \$61.7 billion/year.

Local Planning for Climate Change

A number of local efforts are emerging to identify, reduce and prepare for the anticipated effects of climate change. These are two notable examples that should inform planning for Portland’s future:

Climate Action Plan 2009 – This City of Portland Plan sets targets, policies and strategies aimed at reducing carbon emissions by 80 percent by 2050. The Plan acknowledges the role of the urban forest and natural system in addressing climate change by sequestering carbon, cooling and shading buildings in the summer, and lessening heat loss in the winter. The Plan calls for increasing tree canopy to cover one-third of the City. It also calls for reducing stream temperatures as an indicator of overall watershed health.

Climate Leadership Initiative, Lower Willamette Sub-basin –The Climate Change Initiative at University of Oregon brought together local scientific experts to examine how climate change is likely to impact habitats and species within the lower Willamette River areas. They expect the following changes within the area:

- Increase of invasive species
- Loss of existing habitat and species diversity
- Change in migration patterns and habitat range
- Loss of culturally-important species and landscapes
- Increased flooding
- Reduced water quality

Portland Plan

Their analysis included the following recommendations that relate to the Portland area:

- Protect existing high-quality habitats and floodplains
- Increase the complexity of streams
- Protect genetic diversity and species recovery opportunities
- Reconsider species management, including threatened and invasive species, understanding that species' territories with shift
- Identify low-impact development principles and policies
- Promote water and energy conservation
- Accommodate human population increases
- Build ecological literacy

Bird-friendly Development

Awareness is growing about the dangers that birds face in urban environments. Because birds are unable to perceive glass, they experience risks due to nighttime lighting, reflective surfaces, and transparent glass structures. To reduce these risks, some cities are instituting nighttime lights-out programs for office buildings. Chicago and Toronto are leading efforts to create bird-safe cities by adopting bird-friendly development guidelines. These issues are relevant in Portland, which has key nesting and feeding areas, such as Oaks Bottom and Smith and Bybee Lakes, located near highly-developed areas - and a variety of raptors, including peregrine falcons, bald eagles, osprey and hawks living in or near downtown.

Urban Conservation Treaty for Migratory Birds

Portland provides critical habitat for over 200 species of birds that live in or pass through the area and is one of five U.S. cities participating in the Urban Conservation Treaty for Migratory Birds, which protects migratory birds and enhances their habitats. The U.S. Fish & Wildlife selected Portland as a pilot project city, due to its location in the Pacific Flyway.

CHAPTER 3: THE WATERSHED APPROACH

WHAT IS A WATERSHED?

A watershed is the area that catches rain and snow and drains into a corresponding river, stream or other waterbody. It is a geographic area that begins at ridge tops (highest elevations) and ends at a river, lake or wetland (lowest elevation). Within a watershed, there can also be sub-watersheds. These drainage areas are smaller and are defined by their tributaries (COP BES 2004).

The *Framework for Integrated Management of Watershed Health* defines a watershed as: “A topographically discrete unit or stream basin that includes the headwaters, main channel, slopes leading to the channel, tributaries and mouth area” (COP BES 2005a).

Portland contains five watersheds representing its largest urban waterbodies (Figure 3). These are the Columbia Slough, Willamette River, Johnson Creek, Fanno Creek and Tryon Creek. There are also many sub-watersheds that have been identified and are used for planning purposes. For example, Portland’s share of the Willamette River watershed consists of 27 sub-watersheds (such as Stephens Creek), with drainage areas of a few square miles or less.

Another watershed of great importance to the residents of Portland is the Bull Run watershed. The City owns approximately 5% of the watershed with the rest being primarily US Forest Service land. Because the watershed has been managed in a way that maintains its exceptional conditions, Portlanders benefit from consistently high-quality drinking water. Because of its importance, management activities in the Bull Run watershed and the surrounding management unit are restricted. All commercial logging, including thinning and salvage cutting has been prohibited in the watershed since 1996, and 76% of the 102 square-mile watershed has never been logged. The watershed is closed to public access and the area is required by federal law to be managed jointly by the City and the US Forest Service for the purpose of protecting the Portland drinking water supply. Although anadromous fish have been impacted by the Bull Run dams built to store water supply, the Water Bureau was granted an Incidental Take Permit in 2009 from the National Marine Fisheries, based on the Bureau's 50-year habitat conservation plan to address these habitat impacts.

THE PORTLAND WATERSHED MANAGEMENT PLAN

The Bureau of Environmental Services (BES) completed the *Portland Watershed Management Plan* (PWMP) in 2005 in order to focus efforts to protect and restore the natural systems within the City's boundaries. The PWMP lays out an integrated, system-wide approach to improve watershed health by identifying goals, objectives, strategies and actions to protect natural resources and improve ecosystem functions citywide. Since its adoption, the PWMP has been instrumental in assisting bureaus' consideration of watershed health as projects are designed and implemented. (COP BES 2005).

THE WATERSHED APPROACH

In the past, City planning efforts often focused either on land uses or on water quality. The PWMP's "watershed approach" offers an alternative – it considers the links between what happens on the land and the conditions of streams, rivers and other waterways. The Plan builds on the technical analyses found in the *Framework for Integrated Management of Watershed Health* (December 2005), individual watershed characterizations, existing watershed plans and technical memorandums. The PWMP also provides a holistic approach for meeting numerous state and federal regulations for water quality, species recovery, pollution prevention and natural resources, including those listed in Table 1, below. It does this by focusing on four goals that are fundamental to watershed health:

- **Hydrology:** Move toward normative stream flow conditions to protect and improve watershed and stream health, channel functions, and public health and safety.
- **Physical habitat:** Protect, enhance, and restore aquatic and terrestrial habitat conditions and support key ecological functions and improved productivity, diversity, capacity, and distribution of native fish and wildlife populations and biological communities.
- **Water Quality:** Protect and improve surface water and groundwater quality to protect public health and support native fish and wildlife populations and biological communities.
- **Biological Communities:** Protect, enhance, manage and restore native aquatic and terrestrial species and biological communities to improve and maintain biodiversity in Portland's watersheds (COP BES 2005).

Because of the comprehensive nature of the PWMP, this background report draws from its descriptions of watershed conditions, with supplemental information provided where conditions have changed.

Table 1: Regulatory Drivers

International	
Migratory Bird Treaty Act	This act is a treaty between the U.S., Canada, Japan, Mexico and Russia that makes it illegal to take, kill or possess migratory birds.
Federal	
Clean Water Act (CWA)	This law focuses on surface water pollution in order to restore and maintain the chemical, physical and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." The law is implemented by regulating discharges into water bodies and working to ensure that surface waters meet standards.
Safe Drinking Water Act (SDWA)	This is the primary federal law protecting drinking water quality. This is carried out by setting drinking-water standards, protecting water sources, funding water system improvements and supporting public education.
Endangered Species Act (ESA)	The purpose of this law is to protect critically imperiled species from extinction. Any action that may jeopardize the existence of threatened or endangered fish, wildlife and plant species or their critical habitat is considered unlawful.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund	This law was developed to clean up abandoned or uncontrolled hazardous waste sites. It provides the authority to respond to releases or threatened releases of hazardous substances that may endanger public health or the environment.
State	
State Land Use Planning Goals and Requirements	Oregon has a program for land use planning based on 19 Statewide Planning Goals. The state's policies on land use, citizen involvement, housing, natural resources, etc. are expressed through these goals. Goals are achieved through local comprehensive plans.

Another driver for developing the PWMP was the stormwater management needs across Portland. A large amount of money has been invested in water infrastructure – not only to transport water to homes for usage, but also to transport wastewater away from homes to treatment plants and discharge to rivers. Storm systems collect excess water that runs off street and building surfaces and moves it away in order to minimize problems associated with too much rainwater (i.e. street or property flooding). In the past, increases in stormwater volumes were handled by increasing the capacity of pipes, however the costs associated with that work can be significant (COP BES 2005). With the watershed health approach, the preferred method to handle stormwater is to mimic natural systems and infiltrate it as close to its source as possible, whenever practicable. Trees, ecoroofs, green streets and swales capture and filter precipitation that would otherwise have to be directed through pipes into rivers or streams.

Although the PWMP was spurred by these drivers, it has broader benefits – its ecological principles set a holistic direction for achieving watershed health within an urban setting. The PWMP goals can focus attention on the source of environmental problems (how we build, develop and expand), rather than the symptoms of the environmental problems (what happens when we build, develop or expand poorly). By incorporating the PWMP into the Portland Plan, the City can more strategically address its environmental challenges.

CHAPTER 4: CITYWIDE CHARACTERIZATION

LOCATION

Portland is situated midway between the Coast Range and the Cascade Mountains – about 30 miles from each. The City is located about 65 miles inland from the Pacific Ocean, at the confluence of the Columbia and Willamette Rivers, which are influenced by tidal activity, as is the Columbia Slough. Elevations range from 20' along the Willamette River to 1040' at Council Crest in the West Hills, and 1050' at Mt. Scott in the southeastern portion of the City (COP BES 2005).

Portland encompasses 130 square miles, but its streams and tributaries are part of the 11,478 square-mile Willamette River Basin, which is shared with many upstream cities and counties. The Willamette River Basin is the largest river basin in Oregon. Thirteen major tributaries join the Willamette as it stretches 187 miles from its headwaters to its confluence with the Columbia River at Kelley Point. Along its course, the river passes through forests, farmland, small towns, and large cities (COP BES 2005).



Figure 1: Columbia and Willamette Rivers Watersheds

Portland is bound on the north by the Columbia River. Its basin – the sixth largest drainage basin in the U.S. – covers nearly all of Idaho, large portions of Washington, Oregon, and British Columbia and small portions of Montana, Wyoming, Utah and Nevada. Although Portland occupies only about 1/16 of one percent of the 219,000 square-mile Columbia Basin, the City sits at an important ecological crossroads – namely the confluence of the Willamette and Columbia Rivers (COP BES 2005). Portland's small corner of both of these large systems is important to the region's economy, culture, and the fish and wildlife that live and migrate through the area.

TOPOGRAPHY

Portland's topography is significantly different on the east and west sides of the Willamette River. It is generally flatter on the east side of the Willamette River and along the south shore of the Columbia River. Steep slopes exist on the outer west (Tualatin Mountains – West Hills) and southeast areas of the city, where several lava domes, including Mt. Tabor, Rocky Butte, Powell Butte, Kelley Butte, Clatsop Butte, and Mt. Scott are prominent features. The current geological character of the basin was defined thousands of years ago when the Missoula Floods, a series of catastrophic floods, inundated the area. Floodwaters carried and deposited large quantities of silt, sand, gravel, cobbles and boulders, while erosion or deposition activity during that time influenced or created the ridges, terraces, channels and depressions seen throughout the basin today (Snyder 2008).

SOILS

Soils on the west side of the Willamette River vary from clay loam, with low permeability and relatively high erosion potential, to gravelly loams, which are relatively well drained and moderately permeable¹⁰. The flat areas along the west bank of the Willamette River are urban and highly disturbed, consisting mostly of fill. On the east side of the Willamette River, soils are also highly variable, highly disturbed and generally urban (i.e. with impermeable surfaces). Much of the area along the Columbia River has been filled with dredged sand, which drains very well. In undisturbed areas along the Columbia River, percolation rates are very slow. Areas south of Columbia Boulevard have soils that drain well. In the southeast areas of the city, soils vary from moderate to low permeability (COP BES 2004).

CLIMATE

Portland's current climate is described as mild throughout the year. Cool wet winters lead to warm, drier summers. Average annual precipitation is 37 inches (measured at the airport), but is somewhat variable throughout the basin with precipitation increasing eastward to the foothills of the Cascades. Half of the annual precipitation falls during the months of December, January and February with less in the spring and autumn, and very little in July and August (Snyder 2008).

HYDROLOGIC CYCLE

Understanding the hydrologic cycle is key to understanding watershed health. As rain falls to Earth, it eventually fills the rivers, which flow back to the sea. How those rain drops travel differs greatly in developed and undeveloped areas. Where there is little development, the water is absorbed into the ground, used by vegetation and trees, and/or flows into streams or rivers.

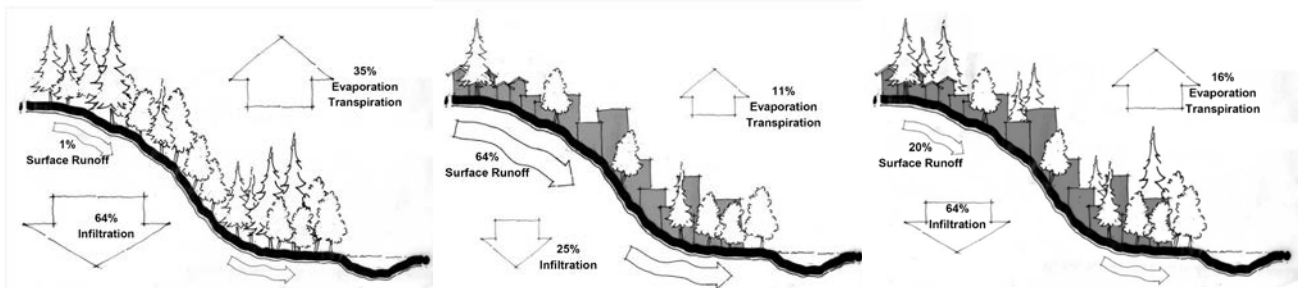


Figure 2: Hydrologic cycle scenarios relative to impervious surface cover

In developed portions of the city, rain travels in multiple ways. It can be absorbed into the ground in landscaped areas or it can also hit impervious surfaces, flow over solid ground, and then into stormwater collection systems. From there, how and where it travels depends on the area's stormwater facilities. It may percolate into the ground or groundwater via sumps. It could enter the

¹⁰ Permeability is a measure of the grain size, grain sorting, cementation and fracturing of the aquifer matrix. When the material is coarser, the permeability is greater, meaning the water (or other fluids) move through quicker.

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sewer system and be sent to treatment facilities. It might be channeled into surface streams. Or it could infiltrate into the ground via on-site stormwater facilities, such as swales or green streets. As rainwater travels these various pathways, it can pick up and carry pollutants and gain velocity until it pours into local streams. Alterations to the natural hydrologic cycle can contribute to localized problems such as flooding, water quality problems, contaminated fish, basement sewer back-ups and a need for substantial investments in infrastructure to redirect the water (COP BES 2004).

As can be seen in Figure 2, some impacts associated with development can be mitigated by incorporating vegetation and stormwater infiltration.

PORTLAND'S WATERSHEDS

In order to develop solutions to problems that affect watershed health, it is essential to understand a watershed's unique characteristics. Table 2, below, provides a general overview of the size, stream length, general topography and jurisdictions of Portland's watersheds: Columbia Slough, Willamette River, Johnson Creek, Fanno Creek, Tryon Creek and the Columbia River. The Johnson Creek watershed has the largest drainage area and the longest stream length within the City's boundaries. However, the Willamette River watershed is much larger, when its entire length and drainage area is considered. The Tryon Creek watershed has the smallest drainage area and stream length in Portland.

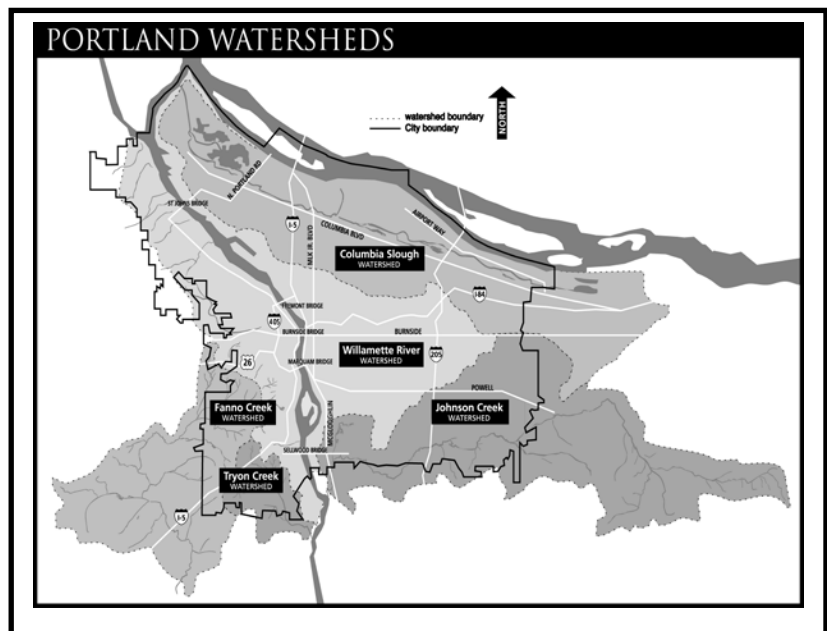


Figure 3: Portland's five watersheds

TABLE 2. GENERAL OVERVIEW OF PORTLAND'S WATERSHEDS				
Watershed	Drainage area (square miles)	Stream length (miles)	General topography	Jurisdictions (other than Portland)
<i>Columbia Slough</i>	51 (42 in PDX)	19	Managed ¹¹ floodplains	Troutdale, Fairview, Gresham, Maywood Park, Wood Village; Multnomah County
<i>Fanno Creek</i>	32 (7 in PDX)	15	Steep slopes	Durham, Tigard, Beaverton; Washington County
<i>Tryon Creek</i>	6 (5 in PDX)	7	Steep slopes	Lake Oswego; Multnomah and Clackamas Counties
<i>Johnson Creek</i>	54 (20 in PDX)	25	Managed floodplains and steep terrain	Milwaukie, Gresham, Happy Valley; Multnomah and Clackamas Counties
<i>Willamette River</i>	11,478 (69 in PDX)	187 (17 in PDX)	Managed floodplains and steep slopes	Many jurisdictions; major population centers include Salem, Eugene, and Springfield.
<i>Columbia River</i>	260,000	1,200 (16 in PDX)	Dike along riverfront and managed floodplains	Many jurisdictions, including 7 U.S. states, 1 Canadian province, and 13 federally-recognized Native American reservations.

By considering each watershed's specific characteristics and issues along with the PWMP goals it is possible to identify effective actions to improve conditions overall.

¹¹ A floodplain is flat or nearly flat land adjacent to a stream/ river that experiences occasional or periodic flooding. It includes the floodway, which is the stream channel and the adjacent areas that carry flood flows, and the flood fringe, which are considered to be the areas covered by the flood, but which do not experience a strong current.

CHAPTER 5: HYDROLOGY

GOAL: *“Move toward normative stream flow¹² conditions to protect and improve watershed and stream health, channel functions, and public health and safety.”*

IMPORTANCE OF HYDROLOGY

Hydrology focuses on the properties, distribution, and effects of water on the earth’s surface, in the soil and underlying geology, and in the atmosphere. Flooding and precipitation are hydrologic conditions.

Hydraulics focuses on the practical applications of water—the act of operating, moving, or employing water in motion. A levee is a hydraulic mechanism.

Historically, cities were commonly built along river corridors where people could fish, farm fertile floodplains, and build businesses near shipping and distribution networks. However, river systems are dynamic – constantly changing. As cities grew, people often filled the floodplains and controlled river flows with reservoirs and dams. Dams along the Willamette and Columbia Rivers were built to generate electricity, reduce flooding, support irrigation and aid in river transport. By regulating river flows the dams allowed riverfront and floodplain development, which enabled river-related and port-related businesses to flourish, but also affected hydrology and other natural functions.

These changes contributed to degraded river conditions, not only because of pollution, but because of development on its edges. When waterways are disconnected from floodplains, the size and complexity of the riparian fringe between water and uplands is reduced. This has a negative impact on the important links between

aquatic and terrestrial ecosystems (COP BES 2005a). Stream flow changes affect water temperature, which can be detrimental to the survival of many aquatic species (COP BES 2004). River productivity can be significantly affected if groundwater recharge/discharge, which normally occurs in floodplains, is reduced. When floodplains are developed and banks are hardened, water isn’t able to infiltrate during high flows, which can lead to flooding and associated property damage and threatens human safety. And when the landscape cannot absorb and filter rain naturally, dealing with stormwater becomes an enormous and costly challenge.

Hydrology is considered one of the most basic and critical forces shaping the structure, dynamics and function of river ecosystems. Flow dynamics affect nearly every ecosystem function, including habitat formation and maintenance, the flow of energy and materials, temperature, the transport of nutrients and contaminants, and the composition of biological communities (COP BES 2005a). Because of the critical importance of hydrology, restoration of other watershed components may have limited benefits unless significant elements of normative flow are restored (COP BES 2005a). For these reasons, hydrology is the first PWMP goal.

¹² Normative flow has the magnitude, frequency, duration, and timing essential to support salmonids and other native species.

PRECIPITATION AND HYDROLOGY

Rainfall and groundwater recharge (water that has infiltrated from the surface into groundwater) are the primary sources that feed local streams. While mountain snow melt also feeds rivers and streams, within Portland, only the Willamette River and Columbia River gain significant water volumes from snow melt.

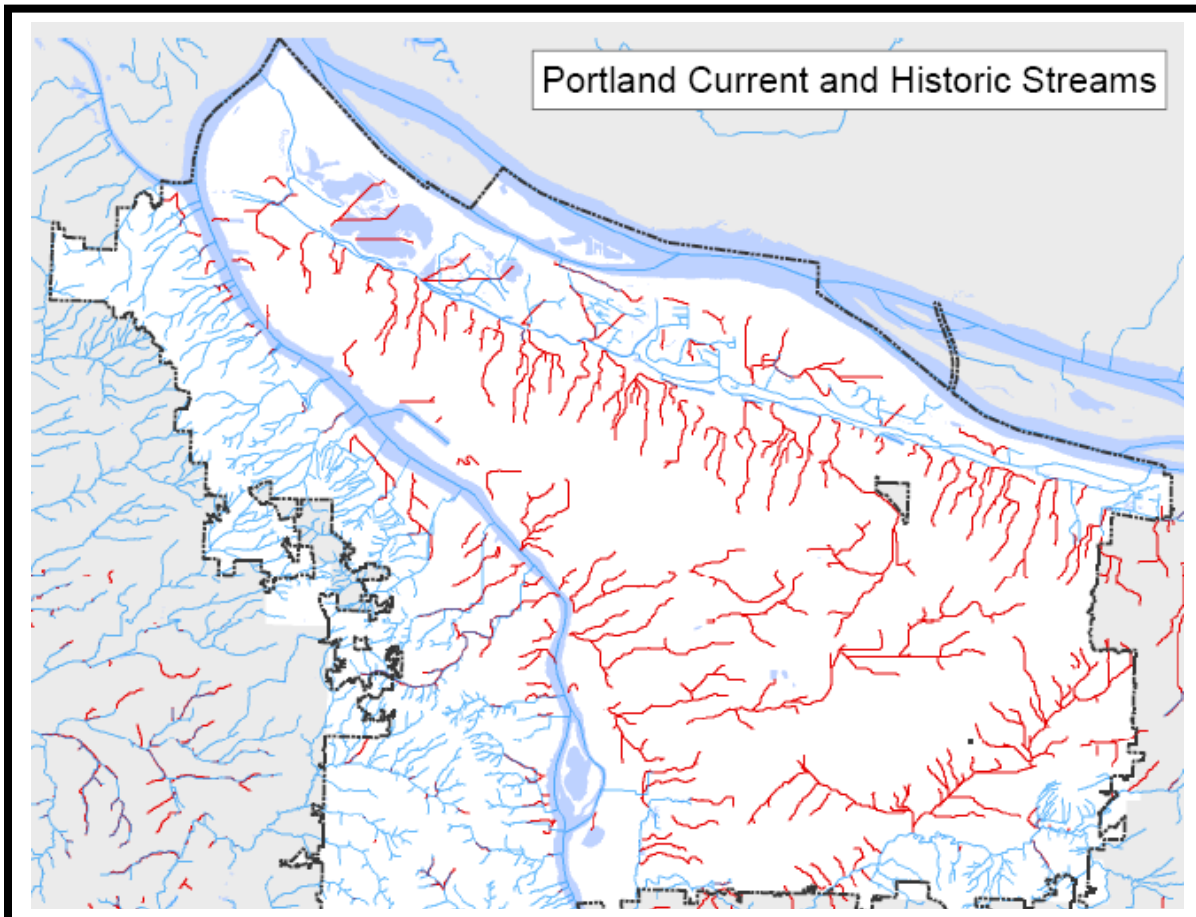


Figure 4: Portland's current and historic streams (Source: BOP June 2007).

While rainfall patterns have been relatively consistent over time, the stream systems have undergone significant changes. Prior to development, the Columbia Slough consisted of a system of side channels, lakes and wetlands that covered the entire Columbia River floodplain between the mouths of the Willamette and Sandy Rivers. Johnson Creek and the Willamette River also contained numerous wetlands and broader floodplains (COP BES 2005a).

Across the city, there once was a greater variety of streams (see red streams in Figure 4). As development occurred, many of these streams were filled or routed to underground pipes. The riparian areas along these small streams were lost along with the important habitat and water filtration/detention functions associated with them. Levees and dams were built, wetlands and floodplains were filled, and vegetation was removed. Even when streams remained, portions were straightened, piped, forced into culverts, or disconnected from their floodplains. In addition, streets,

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buildings and parking lots prevented rainwater from soaking into the soil or being taken up by trees or other vegetation. As a result, hydrologic conditions in the watersheds have been significantly altered. Increased quantity and velocity of runoff causes streams to rise and fall more quickly, which in turn, contributes to stream bank erosion and flood damage, destroys natural habitat, and pollutes area streams.

STORMWATER

Because the natural processes for absorbing and filtering rainwater have been altered, large quantities of stormwater need to be managed by local jurisdictions. Portland's annual precipitation translates to about ten billion gallons of stormwater runoff per year (COP BES 2007-2008). Managing stormwater at its source has been a City priority for two decades, in part due to the high cost of large infrastructure such as the Big Pipe.

HOW STORMWATER IS HANDLED

The City of Portland manages stormwater in several ways. Older Portland neighborhoods have a combined sewer system, which collects stormwater runoff from streets and sewage from buildings in the same pipes. Until recently, most of this mixture flowed to the treatment plant, but when it rained some combined sewage overflowed to the Willamette River.

In Fall 2011, the City completed work on the CSO Control Program, which began in 1991. As a result of these efforts, CSOs to the Columbia Slough have been reduced by 99%. With completion of the Big Pipe project, the volume of combined sewage and stormwater overflowing to the Willamette River is reduced by more than 94%. Instead of an average of 50 combined sewer overflows to the river each year, they will now occur an average of four times each winter and once every three summers instead of every time it rains. The City met all of its required CSO program milestones within the required timeframe. (COP BES 2011).

In much of Portland, either east of 52nd Avenue or north of Fremont Street, stormwater runoff flows into the ground via sumps, also known as underground injection control (UIC) facilities. Sumps are perforated, vertical pipes usually connected to sedimentation manholes, which help remove pollutants. Sedimentation manholes collect stormwater, allowing solids to settle to the bottom and

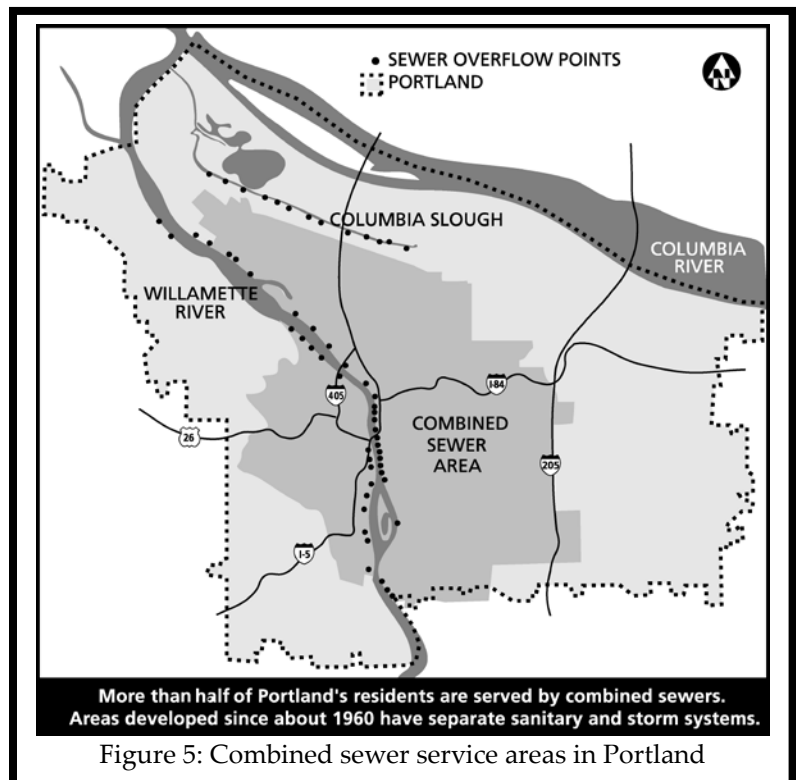


Figure 5: Combined sewer service areas in Portland

trapping oils and greases in the manhole before the treated stormwater flows to the sump and percolates into the ground.

The rest of Portland has a separate storm sewer system. Sanitary sewers carry sewage from buildings to the treatment plant, and stormwater runoff flows to streams through public and private pipes, drainages, swales and other stormwater conveyances. Stormwater runoff that is not properly managed can cause stream bank erosion, landslides and flooding, and harm water quality.

LOOKING FORWARD

Outside of the combined sewer area (in the separated system) in areas where groundwater is high, the City is redesigning some UICs and replacing others with swales and other green stormwater management facilities to increase the distance between the bottom of the UIC and groundwater. These types of facilities replenish groundwater supplies that feed cool, clean water to rivers and streams.



Glencoe Elementary School rain garden

Because of the high costs associated with capital projects such as the Big Pipe project, there has been a shift in focus over the last ten years to managing stormwater closer to its source. An important tool for doing this is the *Stormwater Management Manual*. Adopted in 2004, the manual outlines requirements for development and redevelopment projects on both private and public property, emphasizing the use of vegetated surface facilities, such as rain gardens, stormwater planters or other landscaped stormwater facilities. This relieves the burden on Portland's sewer system and mimics the natural way water is absorbed into the ground.

The urban forest – street and trees in park and private property – also provides important stormwater management benefits along with many other benefits. Currently, trees in parks and along streets save the City over \$11 million in stormwater management annually costs by intercepting nearly half a billion gallons of stormwater. If the benefits of other vegetation are included (i.e. shrubs and grasses), the interception of stormwater increases to 1.3 billion gallons annually – saving almost \$36 million in processing costs (COP PP&R 2007). Further detailed information on the stormwater management infrastructure and urban forest can be found in the Infrastructure Condition and Capacity and Urban Forest background reports.

HYDROLOGIC INFLUENCES

The hydrology of Portland watersheds differs depending on an area's natural and built characteristics. Table 3 describes some of the natural landscape influences on hydrology and seasonal streamflows and helps explain the differences in hydrology within each watershed. For example, in Tryon Creek, the soils are slow to infiltrate and the natural topography is steep. This means that when it rains, the water runs off the land surface quickly, and flows into local streams

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where flow velocities increase rapidly leading to a high frequency of landslides, bank erosion and channel incision.

Topography and soil drainage also have an impact on flood conditions. Columbia Slough has flat topography and flooding is controlled by levees. Johnson Creek has mixed topography, but is flatter in the middle sections of the watershed. Because of watershed conditions, past filling of the floodplain and channelization of the creek, Johnson Creek floods about every other year.

TABLE 3. LANDSCAPE INFLUENCES ON HYDROLOGY WITHIN THE CITY OF PORTLAND				
WATERSHED	TOPOGRAPHY	SOIL DRAINAGE	AVERAGE GAGED FLOWS – WINTER	AVERAGE GAGED FLOWS – SUMMER
<i>Columbia Slough</i>	Flat	Poorly draining to well draining	Lower Slough (9 miles) is tidally influenced. Middle and Upper Slough flow controlled by pumping and managing gravity gates.	Lower Slough (9 miles) is tidally influenced. Middle and Upper Slough, flow controlled by pumping and managing gravity gates.
<i>Fanno Creek</i>	Moderate to steep slopes	Mostly poorly draining soil	5 cfs ¹³	< 1 cfs
<i>Tryon Creek</i>	Steep slopes – up to 60-75% ¹⁴	Slow to very slow infiltration rates Low soil permeability	10 cfs	< 1 cfs
<i>Johnson Creek</i>	Varies – Floodplains and steep slopes (from 1-25%, 1-30%, and >50%)	Varies – Very low in clay areas to high permeability	54 cfs	< 5 cfs
<i>Willamette River</i>	Varies Westside – steep slopes Eastside – relatively flat	Westside – low to moderately high permeability Eastside – mostly moderately high permeability	20,000 cfs Tidally influenced; dams affect flow	5,000 cfs Tidally influenced; dams affect flow
<i>Columbia River</i>	Relatively flat in the Portland/Vancouver area	Well draining to water table (at river level)	Lower basin is tidally influenced; dams affect flow	Lower basin is tidally influenced; dams affect flow

The City of Portland takes an active approach to restoring environmentally-sensitive land to more natural conditions. For example, through the Johnson Creek Willing Seller Program, the City

¹³ Cubic feet per second

¹⁴ Severe landslide potential is considered to be 30%.

purchases targeted properties for creek and floodplain restoration projects to improve water quality, enhance habitat and reduce the frequency of damaging floods. As of October 2010, 276 acres of property have been purchased through this program.

Table 4 describes the development factors that influence the hydrology of a particular watershed. When development occurs in a previously undeveloped area, the storage and flow of water can be significantly altered. Residential and commercial development compacts soils and creates impervious areas, decreasing infiltration and increasing surface runoff (US EPA no date).

Development varies by watershed. Fanno Creek is zoned predominately for single-family housing (83%) in contrast to the Columbia Slough, which has 32% of land zoned for single-family. While higher density areas generally contribute higher pollutant loads to water systems on an acre-for-acre basis, because of the extent of disturbed land and human activity, recent research suggests that higher density development has less overall impact on regional water quality because it reduces the amount of impervious surface and runoff per unit, as compared with a low-density development pattern (US EPA no date).

Research continues to show a strong connection between the percent of total impervious area and watershed health. As the percentage of impervious surfaces within a watershed increases, there is less groundwater recharge, increased surface water runoff after storms, and higher pollutant delivery to streams (COP BES 2005a). Several studies have shown that a watershed with 10% impervious surface coverage is likely to become impaired (US EPA no date) and at 25%, severe impairment occurs. All of Portland's watersheds exceed this level. Fortunately, restoration projects have shown that it is possible to improve the biological diversity in urban streams through stormwater retrofits and physical habitat improvements (Schueler 2000).

Climate change is also likely to influence local hydrology. While it is certain that temperatures will increase globally, analysis is just emerging regarding the anticipated local impacts. Though the extent and specifics of those impacts cannot yet be predicted with a high level of certainty, it is reasonable to expect that rising sea levels and changing weather patterns will affect and likely increase the extent of local floodplains.

Preserving open space areas, natural resource areas, parks and some rural lands is one strategy to offset develop-related impacts in a watershed. A variety of tools are used to protect natural areas. Properties can be acquired by public agencies or nonprofits and preserved as open space. Planned developments can cluster housing on less-sensitive areas and set aside communally owned open space. Conservation easements have also been used to protect significant resources on private property.

One tool the City uses to protect and conserve natural resources and to comply with State Land Use Planning Goal 5 is zoning – specifically environmental overlay zones (as described in Chapter 2). Table 4 shows that the Willamette River watershed has the largest acreage in environmental protection overlay zoning (5,087 acres), while the Columbia River watershed has the least (23

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acres). Because the Columbia River watershed within Portland consists primarily of riverbank and open water, it has the largest overall percentage in combined conservation and protection environmental overlay zones (75%). While the Tryon Creek watershed (31%) has the fewest acres within the city, it has the second highest percentage of combined conservation and protection environmental overlay zones (31%). Fanno Creek and Columbia Slough have the least proportion (14%).

AREA (ACRES WITHIN PORTLAND)	CURRENT ZONING – ACRES (% OF WATERSHED)	ENVIRONMENTAL ZONES – ACRES (% OF WATERSHED)	IMPERVIOUS AREA – ACRES (% OF WATERSHED)
<i>Columbia Slough</i> (27,156)	Industrial – 11,658 (43%) Single family – 9,147 (34%) Multifamily – 1,745 (6%) Parks/Open space – 3,668 (14%) Commercial - 938 (3%)	Conservation – 1,624 (6%) Protection – 2,128 (8%)	9,727 (36%)
<i>Fanno Creek</i> (4,660)	Single family – 3,813 (82%) Multifamily – 409 (9%) Parks/Open space – 254 (5%) Commercial - 177 (4%)	Conservation – 440 (9%) Protection – 253 (5%)	1,164 (25%)
<i>Tryon Creek</i> (3,044)	Single family – 2,122 (70%) Parks/ Open space – 586 (19%) Multifamily – 188 (6%) Commercial – 147 (5%)	Conservation – 430 (14%) Protection – 527 (17%)	666 (22%)
<i>Johnson Creek</i> (13,139)	Single family – 8,126 (62%) Multifamily – 2,094 (16%) Parks/Open space – 1,757 (13%) Commercial – 617 (5%) Industrial – 539 (4%)	Conservation – 1,344 (10%) Protection –1,040 (8%)	3,702 (28%)
<i>Willamette River</i> (38,211)	Industrial – 8,260 (22%) Single family – 13,487 (35%) Multifamily – 4,291 (11%) Parks/Open space – 8,592 (22%) Commercial – 3,580 (9%)	Conservation – 2,244 (6%) Protection – 5,087 (13%)	13,397 (35%)
<i>Columbia River</i> (3,928)	Industrial – 1,093 (28%) Single family – 419 (11%) Multifamily – 259 (7%) Parks/Open space – 1,405 (36%) Commercial – 752 (19%)	Conservation – 2,889 (74%) Protection – 23 (1%)	522 (13%)

**Information in this table is based on GIS spatial analysis. Zoning data was last updated in May 2008. Environmental zone data is current as of April 2009. Columbia River data added January 2012.*

GROUNDWATER

Groundwater is water located in the soil pore spaces and fractures beneath the ground surface. If a geologic unit is saturated, permeable, and has the ability to transmit usable quantities of water, then it is called an aquifer. The depth from the ground surface to where the rock becomes completely saturated with water is called the water table (USGS 2009). Groundwater is recharged from water infiltrating into the soil. In turn, groundwater flows to the surface through seeps, springs, and streams.

In 2008, the U.S. Geological Survey (USGS) published a report characterizing the estimated depth to groundwater in the Portland area. The greatest depth to groundwater (greater than 300 feet) is found in parts of the Tualatin Mountains, the foothills of the Cascade Range and much of the Boring Hills. The areas where shallow depths to groundwater are found include the low-lying areas along major streams and rivers specifically the following:

- Former stream channels extending from the confluence of Johnson Creek and Crystal Springs Creek northward to the Willamette River and southward to the Clackamas River
- Much of the area adjacent to Johnson Creek
- Area extending from Beggars Tick Marsh eastward to Holgate Lake at the west end of Powell Butte
- Area around Fairview Creek
- West end of Lake Oswego

These areas of shallow depths to water are important to recognize due to concerns for stormwater management and the systems that are designed to allow for the infiltration of stormwater (Snyder 2008). Careful consideration of drainage patterns is needed to ensure that development in these areas does not create additional problems.

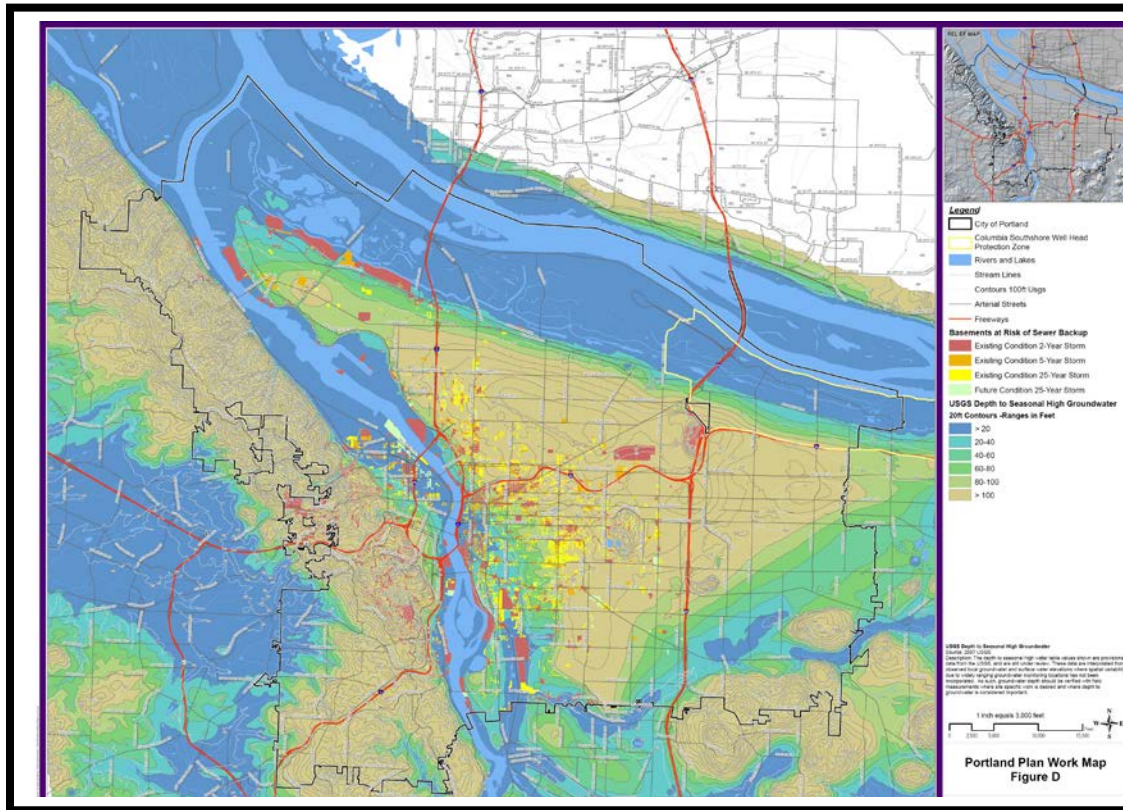


Figure 6: Portland’s depth to groundwater and sewer backup risk

HYDROLOGY – SUMMARY AND A LOOK AHEAD

Stream flow conditions in Portland do not meet the normative conditions as defined in the PWMP. Significant alterations, such as increased impervious areas, piped streams, and impoundments have impacted the normal hydrological cycle. Summertime flows in urban streams are low, yet during rain storms, streams continue to be “flashy,” meaning that rainwater moves quickly from the land to streams, causing stream elevations to rapidly rise and fall. When water moves too quickly across surfaces, little water infiltrates to replenish groundwater and recharge aquifers and can cut into banks, reducing riparian habitats.

During heavy rains, stormwater running off impervious areas flows into the combined sewer system, causing sewage to back up into basements in parts of the city. Some sewer pipes are nearly 100 years old and can no longer function as designed. In addition, many pipes are too small to handle large volumes of combined sewage and storm runoff. The City continues to work to improve hydrologic conditions in its urban streams and rivers, because rivers that are connected to their floodplains and subject to natural hydrological dynamics maintain a wider variety of species and food webs (COP BES 2005a). For example, the Tabor-to-the-River Project is replacing sewer pipes, planting thousands of trees, and adding green streets. Using a combination of pipe improvements and green infrastructure will eliminate or significantly reduce basement back-ups in this area.

Flooding persists and the frequency is increasing in parts of Portland. In the Johnson Creek watershed, recent floodplain restoration projects have enhanced natural floodplain functions on

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public property to reduce the frequency of local flood damage to private property. Through the Johnson Creek Willing Seller Program, BES continues to acquire floodplain property as part of a comprehensive program to reduce flood impacts, improve water quality and enhance wildlife habitat.

Although hydrologic problems persist, multiple strategies and actions are being implemented to move toward normalizing hydrology. The City has invested significantly in the Big Pipe Project, which collects stormwater and directs it to the treatment plant, as well as “green” stormwater management strategies. Monitoring of green streets, ecoroofs and other green infrastructure has demonstrated that these approaches are very effective at reducing flows into storm drains.

CHAPTER 6: WATER QUALITY

GOAL: “Protect and improve surface water and groundwater quality to protect public health and support native fish and wildlife populations and biological communities.”

IMPORTANCE OF WATER QUALITY

Before construction of Portland's main sewage treatment plant in 1951, Portland's waterways were badly polluted. The sewers dumped raw sewage directly into the Willamette River and Columbia Slough. Industrial waste from canneries, paper mills, and slaughterhouses added to water quality problems. A 1927 Portland City Club report described the Willamette River as "ugly and filthy," and told how workers refused to handle logs taken from the Columbia Slough.

In the 1930s, after a few failed efforts from the legislature to end the pollution, citizens took the matter into their own hands. Using the State's pioneering initiative and referendum process, they put a measure on the 1938 ballot to establish a state sanitary authority charged with cleaning up the Willamette River, which passed and Oregon's first environmental agency came into existence later becoming the [Department of Environmental Quality](#).

Protecting the quality of Portland's rivers, streams and groundwater keeps them safe for a multitude of beneficial uses such as drinking water, fish and wildlife habitat, recreation and irrigation. The vast majority of the water found on Earth is not available for human consumption – meaning that what is available should be managed very thoughtfully. Although raw sewage is not flowing directly into streams, other pollutants such as toxic substances, pesticides, herbicides, stormwater, nutrients, and pharmaceuticals, as well as high temperatures, can affect the quality of Portland streams.

WATER QUALITY ISSUES

A number of factors affect water quality in local rivers and streams. Stormwater pollutants can include sedimentation, fertilizers, pesticides, vehicle-related runoff such as petroleum by-products, and heavy metals. Runoff can also carry fecal contaminants from leaking septic systems, livestock, pets and tame waterfowl, contributing to elevated bacterial levels. The potential risks extend beyond those to local water bodies – excessive nutrients from these sources are associated with risks to fisheries in streams, rivers and even oceans (including ocean “dead zones” in 150 areas of the world, including Oregon).

While water quality practices have improved overall, virtually all water bodies in the City of Portland have problems with temperature. In the Columbia Slough and Johnson Creek, legacy pollutants such as DDT are identified as water quality problems. Fanno and Tryon Creeks both have problems with bacteria levels.

In the Willamette River, the U.S. Environmental Protection Agency named the Portland Harbor (the area of the Willamette River between Swan Island and Sauvie Island) a Superfund site, due to contaminated sediment. Stormwater monitoring in the Portland Harbor shows that the majority of pollutants came from industrial land uses (LWG, 2011). A cleanup program is being led by the federal government; Bureau of Environmental Services (BES) represents City concerns in this effort.

There are numerous efforts underway to protect and improve water quality. In order to prevent pollution, the Oregon DEQ regulates many stormwater outfalls to streams, including those managed by the City of Portland, Multnomah County, the Port of Portland and a number of private entities.

Public and private investments in sustainable stormwater practices, such as rain gardens and green street facilities are being implemented to capture and break down pollutants before they enter the waterways. Riparian and floodplain protection and restoration projects also help improve water quality by slowing and filtering surface runoff before it enters streams, wetlands and rivers. In addition, the City of Portland, Metro, soil and water conservation districts, and local watershed councils sponsor education programs for youth, home gardeners and pet owners aimed at changing practices to improve water quality by reducing non-point source pollution.

In terms of treatment plant discharges, the DEQ is monitoring an emerging area of concern locally and nationally – “Priority Persistent Pollutants” (including pharmaceuticals and personal care products). Fortunately, a recent study of over 50 large wastewater treatment plants showed that most of persistent pollutants are not entering Oregon’s municipal wastewater systems, and that wastewater from treatment plants is not a significant source of most persistent pollutants (Oregon DEQ 2011).

ASSESSING WATER QUALITY

The State of Oregon is required to assess the quality of its waters and report results to the U.S. Environmental Protection Agency (EPA). The regulation and management of water quality to federal and state standards in Portland’s streams occurs through the following process:

- Waters that do not meet standards are placed on a list – referred to as the 303(d) list of impaired waters (referring to Section 303(d) of the Federal Clean Water Act).
- Once a water body has been “listed,” a plan to improve water quality needs to be developed. This is done by establishing Total Maximum Daily Loads (TMDLs) – written plans with analyses that establish how waterbodies will meet and maintain water quality standards. TMDLs identify the maximum amount of a pollutant the water body can assimilate without violating standards, sets load capacities and divides the load capacity among each source (DEQ 2006).

Since the early to mid-1990s, the City has conducted a comprehensive monitoring program of its waterways. Sites have been monitored in dry and wet weather conditions. The data have been used to establish TMDLs, to meet permit requirements and to help inform management priorities.

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All of Portland's major waterways – Columbia Slough, Fanno Creek, Tryon Creek, Johnson Creek, the Willamette River and the Columbia River – have been placed on the 303(d) list and have established TMDLs to improve water quality (See Table 5).

One water quality limiting factor that all streams share is temperature. Temperature can affect the amount of dissolved oxygen in a waterbody and influence bacteria levels. If temperatures are too high, many aquatic species cannot survive. Oregon's stream temperature standard is set to protect specific salmonid life stages. For example, the numeric temperature criterion for salmon and steelhead spawning is 13° C. For their migration corridors, the criterion is 20° C. Johnson Creek's 7-day average daily maximum stream temperatures in the summer range from a low of 15° C (in Kelley Creek) to a high of 26 ° C where the creek intersects SE 92nd Avenue (DEQ 2006). Improving temperature conditions requires restoring riparian vegetation, increasing cooler in-stream flows, and occasionally, narrowing stream channel widths (DEQ 2006).

In March 2008, Portland submitted a comprehensive citywide TMDL implementation plan that outlines strategies for managing pollutant loads entering the listed water bodies for which Portland was named a designated management agency (COP BES 2008).

The Oregon Water Quality Index (OWQI) is a different way of describing water quality conditions in waterways. It is a defined set of water quality variables that are analyzed and combined to produce a score describing general water quality. Scores range from 10 (worst case) to 100 (ideal water quality), though any score below 80 is in the poor or very poor category. The water quality variables included in the OWQI are temperature, dissolved oxygen (percent saturation and concentration), biochemical oxygen demand, pH, total solids, ammonia and nitrate/nitrogen, total phosphorus, and bacteria¹⁵. The OWQI is a useful tool for showing general trends; however, it should not be used as the sole measurement of conditions in streams (COP BES 2008).

The following table (Table 5) summarizes water quality measures for each waterbody:

¹⁵ The bacterial indicator for the OWQI changed from fecal coliform to E. coli in 2002.

TABLE 5. WATER QUALITY MEASURES

Waterway	TMDL Pollutants – Year TMDL Set	Oregon Water Quality Index (2006)
<i>Columbia Slough</i>	DDT/DDE, dieldrin, dioxin, PCBs, lead, phosphorus, bacteria (E. coli), dissolved oxygen, pH, chlorophyll <i>a</i> ¹⁶ - 1998 Temperature– 2006	Very poor
<i>Fanno Creek</i>	Bacteria (E. coli), temperature, phosphorus, dissolved oxygen – 2001	Poor
<i>Tryon Creek</i>	Bacteria (E. coli), temperature – 2006	Poor
<i>Johnson Creek</i>	DDT, dieldrin, bacteria (E. coli), temperature – 2006	Very poor
<i>Willamette River</i>	Dioxin – 1991 Mercury ¹⁷ , bacteria (E. coli), temperature – 2006	Fair to good
<i>Lower Columbia River Basin</i>	Dioxin – 1991 Dissolved gas - 2002	Good

WATER QUALITY TRENDS

The main implementation process to address pollutants that have waste load allocations identified in a TMDL is the *Stormwater Management Plan* (SWMP). The SWMP is a requirement from the City's NPDES Municipal Separate Storm Sewer System (MS4) permit. Annual reports are submitted to DEQ that describe the best management practices used to control stormwater pollutants and protect water quality. The annual report also provides information on water quality trends in the rivers and streams within Portland's jurisdictions. The trends described below are based on a review of data records, with some streams having longer periods of record leading to more conclusive results. The following overall water quality trends are for the 2007–2008/2008-2009, and 2009-2010 reporting years in the MS4 annual compliance reports¹⁸:

Columbia Slough – Water quality shows significant improvement trends, many of which result from a combination of removal of cesspools and septic system sources in upgradient groundwater, cleanup efforts of legacy pollutants and virtual elimination of combined sewer overflows. The increase in chlorophyll *a*, due to algal growth throughout the Slough, is of potential concern for aesthetic reasons and because it can result in the reduction in oxygen levels.

¹⁶ Chlorophyll *a* is the predominant type of chlorophyll found in algae. High values are a primary indicator of nutrient pollution.

¹⁷ The mercury TMDL is a phased TMDL for which no load allocations and waste load allocations have been set of yet. Only reduction targets were set in 2006.

¹⁸ <http://www.portlandonline.com/bes/index.cfm?c=50289&>

Watershed Health

Fanno Creek – The water quality trends observed during the wet season are indicative of improving water quality. A combination of riparian improvements, in-stream bank stabilization, and upland stormwater management facilities may be responsible for these improvements.

Tryon Creek – Few significantly increasing temporal trends were found, most of them occurring during the dry season. In the wet season, the trend has been that temperature in the creek is decreasing and dissolved oxygen is increasing.

Johnson Creek – The water quality trends show some improvement, for nutrients and dissolved oxygen. With the exception of dissolved zinc, no significantly increasing trends for any constituents of concern were observed. While these trends are encouraging, it is not possible to draw any conclusions as to their cause. The sparseness of significant trends may be due to the relatively small data set (about seven years of continuous data collection).

Willamette River – The water quality trends are very positive during both the wet and dry seasons and may be related to the multiple efforts taking place in the watershed, including the reduction of stormwater discharges through combined sewer overflows. (Completion of the East Side CSO Tunnel in fall 2011 will reduce combined sewer overflows to an average of four times each winter and once every three summers.) It is also significant that water quality entering the city has greatly improved, probably as a result of the multi-faceted efforts throughout the entire Willamette River basin.

Lower Columbia River Basin – The Columbia River water quality in the Portland/Vancouver area shows no trends.

GROUNDWATER QUALITY

The City of Portland has an interest in ensuring the quality of groundwater in local aquifers for several reasons. In the summer, the City often uses the 27 municipal supply wells in the Columbia South Shore Well Field to augment the drinking water supply with groundwater. These wells are also an important source of water for emergency use, allowing the City to supply drinking water when the Bull Run watershed is unavailable and continue to operate the Bull Run system as an unfiltered source. Groundwater discharges also provide low temperature, high-quality baseflow to local streams. Also, with the climate changes anticipated in the next few decades, groundwater may play an increasingly important role in both water supply and streamflow.

Supply wells in the Columbia South Shore Well Field tap three different aquifers and are capable of producing approximately 100 million gallons of drinking water per day. Well depths vary from 120' to 670'. The supply wells are sampled at least once a year, more frequently when actively being used for municipal supply. Water from the supply wells meets all federal and state primary drinking water standards.

An extensive monitoring well network provides additional groundwater quality data and an early warning of potential water quality issues. Isolated areas of contamination have been identified in the proximity of the City's well field. These areas are relatively shallow and are a result of pollutants released in the past. DEQ oversees the investigation, monitoring and cleanup of these sites to eliminate or reduce risk to the aquifers used for drinking water. The City's supply wells are also protected from the impacts of this near-surface contamination by one or more low permeability aquitards¹⁹ that prevent or limit the migration of pollutants into the primary drinking water aquifers. A state-certified groundwater water protection program regulates businesses that handle, store, or transport high-risk chemicals within the groundwater protection area.

WATER QUALITY – SUMMARY AND A LOOK AHEAD

Regulations controlling industrial discharges to rivers, streams and sewer systems have significantly reduced the pollution from these sources since historic times. The EPA is beginning the process of cleaning up decades of pollution at the Portland Harbor. City regulations continue to prevent pollution of groundwater and drinking water. Nonpoint source pollution is an ongoing issue, being addressed through sustainable stormwater approaches and public education efforts.

Investments in stormwater infrastructure have netted very positive results. Since 1990, Portland has reduced average annual CSOs from six billion gallons to about two billion gallons. CSO discharges to the Columbia Slough have been reduced by over 99 percent. With completion of the East Side CSO Tunnel, the "Big Pipe", in Fall 2011, combined sewers will overflow an average of four times each winter and once every three summers instead of every time it rains.

BES reports on the progress made toward improving water quality in the PWMP annual reports. Trending data in these reports show improvements in the Columbia Slough, Willamette River and Fanno Creek, yet despite the progress made, problems still exist. All of Portland's streams are water quality limited, and Johnson and Tryon Creeks do not show significant trends either towards improvement or degradation.

¹⁹ An aquitard is a relatively impermeable layer between aquifers that limits the flow of water between aquifers. Also called a confining layer, it offers protection to the aquifer below by inhibiting not only groundwater, but contaminants from getting into the aquifer.

CHAPTER 7: BIOLOGICAL COMMUNITIES

GOAL: “Protect, enhance, manage and restore native aquatic and terrestrial species and biological communities to improve and maintain biodiversity in Portland’s watersheds.”

IMPORTANCE OF BIOLOGICAL COMMUNITIES

A healthy watershed consists of physical and biological components that are linked together and are dependant on each other. Soil, vegetation and animals “self-organize” into systems that capture and process energy resulting in diverse, abundant and productive plant and animal species, including humans. Each species has an ecological function that another species may rely on for habitat or food supply. For example, plants convert the sun’s energy into food for herbivores that eventually become food for carnivores. The character and abundance of individual species reflects the health of the environment upon which they depend (COP BES 2005a).

When one component of the system is weakened, other parts become increasingly vulnerable. For example, small patches of fragmented habitat are less likely than large habitat patches to sustain biological communities. The species that live in fragmented patches have less food and shelter available, leaving them vulnerable to predators. As one link is destroyed, other dependant parts begin to break apart as well. Because of this interconnection between all species, it is important to ensure the survival of all native terrestrial plant and wildlife communities (COP BES 2005a).

Over the last several years, a significant effort has been made to develop a broader body of information about the presence and life-cycle needs of native terrestrial plant and wildlife communities, and to use this information to set priorities for conserving and restoring of their habitat. These efforts include the draft watershed characterizations, the information documented by the Terrestrial Ecology Enhancement Strategy Advisory Group (TEESAG) and Portland’s draft Natural Resource Inventory (NRI).

SPECIES PRESENCE

The confluence of the Willamette and Columbia Rivers is a regional nexus on the Pacific and Columbia River Flyways and provides critical resting and feeding locations for migratory birds. Birds represent the majority of vertebrate diversity in the Portland Metro region with about 210 native resident and migratory bird species frequent the area. Migrants pass through the region in large numbers, moving along both flyways, utilizing habitats along the Willamette and Columbia Rivers²⁰.



Western Meadowlark

²⁰ COP, BPS, Hayden Island Natural Resources Inventory, Public Review Draft, 2011.
<http://www.portlandonline.com/bps/index.cfm?a=355337&c=55273>

Portland Plan

About 50% of these native bird species depend on riparian habitats for their daily needs, while 94% use riparian habitats at various times during their lives (Metro 2006). Eighteen bird species are listed as state or federal species of concern, including the olive-sided flycatcher, streaked horned lark, and the vesper sparrow (Table 5). The streaked horned lark is also a federal candidate for listing under the Endangered Species Act.

The Audubon Society's Christmas Bird Count, performed by hundreds of volunteers, can provide an indication of the presence of particular bird species. For example, bald eagles appear to be re-establishing themselves with the highest count of 34 birds observed in 2008, compared to previous lows of 3 in earlier years. In contrast, the streaked horned lark had a high count of 96 in 1940, but none were spotted in 2008, and only 5 were spotted in 2007 (Audubon 2009).

Fifty-four native species of mammals inhabit the Metro area. Eight species of mammals, or 13% of total species, are non-native. Of the native species, 28% percent are closely associated with water-based habitats, and another 64% use these habitats at various points during their lives. Eight out of nine bat species, such as the hoary bat, and four native rodent species, such as the red-tree vole, are listed as state or federal species of concern (Metro 2006).

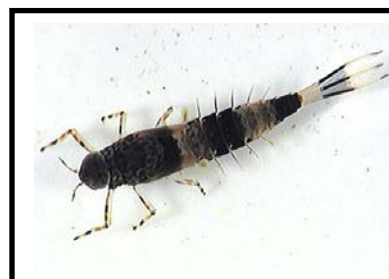


Western Painted Turtle

due to competition from introduced species. Two non-native turtle species, the common snapping turtle and red-eared slider, have established breeding populations in Portland and compete with native turtle species (Metro 2006).

A number of amphibian species (salamanders, toads, and frogs) inhabit the Portland area; however their existence is threatened by the non-native bullfrog, which preys on native amphibians. Of the native amphibian species, 69% rely exclusively on riparian habitat. Another 25% use these habitats during their life cycle. Two amphibian species are state-listed sensitive species; one is considered of concern at the federal level (Metro 2006).

Thirteen native reptile species inhabit the Portland area. The western pond turtle and western painted turtle are state and/or federal species of concern, largely due to loss of wetlands, nesting habitat (upland) and backwater habitats, and

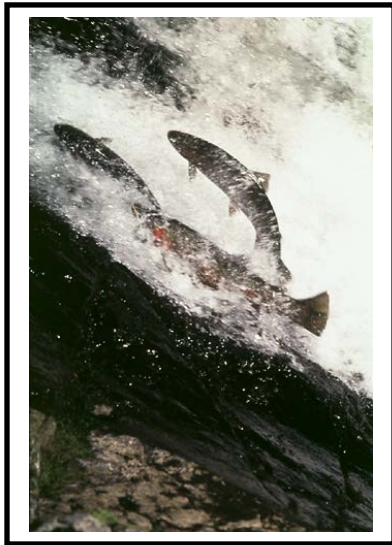


Ameletid Minnow Mayfly

Benthic (bottom-dwelling) macroinvertebrates are the base of the food chain for fish and other aquatic life. Throughout Portland, the diversity and numbers of benthic macroinvertebrates are low because of a lack of suitable habitat, degraded water quality, and altered hydrologic conditions (COP BES 2004).

Watershed Health

Both native and introduced species of cool-water and warm-water fish inhabit the Lower Willamette River. Common native species include sucker, reticulate sculpin, and various minnows including northern pikeminnow. Introduced species include smallmouth bass, black crappie, white crappie, and mosquito fish. Reticulate sculpin and redbreast shiner are the most predominant aquatic species in Portland's streams (COP BES 2004).



Steelhead Trout

Salmonid populations are much less abundant and diverse than previously existed in the area. However, thousands of anadromous salmonids, including steelhead, Chinook salmon, and Coho salmon continue to swim through Portland on their way to spawning beds upstream, and juveniles return as they migrate to the Pacific Ocean. Sub-yearling salmon are present in the Lower Willamette River and Columbia Slough year-round. Two populations of salmonids are found in Johnson and Tryon Creeks. Cutthroat trout are the most abundant salmonid species in Portland streams (COP BES 2004).

SPECIAL STATUS SPECIES

As part of terrestrial species enhancement work, the City of Portland has developed a comprehensive wildlife species list of vertebrate wildlife species known to occur, or that could occur in Portland, given their natural ranges and habitat requirements. A subset of those species is a list of Special Status Species – those

wildlife species whose range includes Portland, which are officially listed or identified by various entities because they are in decline, rare, or have some other special concern:

- U.S. Fish and Wildlife Service: Candidate, Listed Threatened or Endangered, Species of Concern
- Oregon Department of Fish and Wildlife: Listed Threatened or Endangered, State Sensitive, State Strategy
- Oregon Natural Heritage Information Center: Ranked or Listed
- Oregon Watershed Enhancement Board: Priority
- Partners In Flight: Focal Species
- Northwest Power and Conservation Council *Willamette Basin Sub-basin Plan*: Focal Species
- National Audubon Society: Watch List

Special status species have ranges known to include Portland and are officially listed or identified by a state or federal entity, or wildlife organization as being in decline, rare or have some other special concern.

The Special Status Species list (see Table 6) is intended to help land managers and planners identify actions that will help protect, restore, and enhance the survival of identified wildlife species.

The City of Portland has identified a combination of species and habitats to monitor to provide feedback on the effectiveness of efforts to improve habitat and biological communities over time. One of these species is the streaked horned lark. Portland could play an important role in improving

the status of the species, as some of the last remaining habitat and breeding populations between Puget Sound and the Upper Willamette Valley are found in Portland.²¹

The City is also monitoring the western painted turtle and the western pond turtle. The species' range in Oregon is relatively small and many areas where the species occurs in abundance are within or adjacent to urban areas, including in Portland. Surveys have been conducted in the Columbia Slough and Johnson Creek watersheds and site-specific management recommendations have been made regarding preserving native turtle populations.

TABLE 6. SPECIAL STATUS WILDLIFE SPECIES IN PORTLAND AND THREATENED FISH

Birds		Fish	Amphibians	Reptiles	Mammals
American Bittern	Pacific-slope Flycatcher	Chinook Salmon	Clouded Salamander	Western Pond Turtle	American Beaver
American Kestrel	Peregrine Falcon	Salmon	Northern red-legged Frog	Western Painted Turtle	California Myotis (bat)
American White Pelican	Pileated Woodpecker	Chum Salmon			Camas Pocket Gopher
Bald Eagle	Purple Finch	Coho Salmon			Fringed Myotis (bat)
Band-tailed Pigeon	Purple Martin	Oregon Chub			Hoary Bat
Black-throated Gray Warbler	Red Crossbill	Pacific Lamprey			Long-eared Myotis (bat)
Brown Creeper	Red-eyed Vireo	River Lamprey			Long-legged Myotis (bat)
Bufflehead	Red-necked Grebe	Sockeye Salmon			Northern River Otter
Bullock's Oriole	Rufous Hummingbird	Steelhead			Red Tree Vole
Bushtit	Short-eared Owl				Silver-haired Bat
Chipping Sparrow	Sora				Townsend's Big-eared Bat
Common Nighthawk	Streaked Horned Lark				Western Gray Squirrel
Common Yellowthroat	Swainson's Hawk				White-footed Vole
Downy Woodpecker	Swainson's Thrush				Yuma Myotis (bat)
Dunlin	Thayer's Gull				
Great Blue Heron ²²	Varied Thrush				
Green Heron	Vaux's Swift				
Hammond's Flycatcher	Vesper Sparrow				
Hermit Warbler	Western Meadowlark				
Hooded Merganser	Western Sandpiper				
House Wren	Western Wood-Pewee				
Hutton's Vireo	White-breasted Nuthatch				
Loggerhead Shrike	White-tailed Kite				
Long-billed Curlew	Willow Flycatcher				
Merlin	Wilson's Warbler				
Nashville Warbler	Winter Wren				
Northern Harrier	Wood Duck				
Olive-sided Flycatcher	Yellow Warbler				
Orange-crowned Warbler	Yellow-breasted Chat				

²¹ COP. *Terrestrial Ecology Enhancement Strategy: Summary and Update*. June 2010.

<http://www.portlandonline.com/bes/index.cfm?a=354986&c=51052>

²² The great blue heron is a special status species, not because of declining numbers, but because it is an Oregon Watershed Enhancement Board (OWEB) priority species of cultural significance. For example, it is Portland's City bird.

Watershed Health

A list of special status plant species was completed and documented in the *Terrestrial Ecology Enhancement Strategy Summary and Update* (See Table 7). These plants, known to occur in Portland, are officially listed as threatened or endangered. They contribute to the ecological integrity of Portland's ecosystem and provide important functions for other plants and animals.

TABLE 7. SPECIAL STATUS PLANT SPECIES IN PORTLAND	
Common name	Botanical name
Bristly sedge	<i>Carex comosa</i>
Columbia water-meal	<i>Wolffia Columbiana</i>
Columbian white-top aster	<i>Sericocarpus rigidus (syn Aster curtus)</i>
Columbian yellowcress, Columbia cress	<i>Rorippa columbiae</i>
Dotted smartweed	<i>Polygonum punctatum</i>
Golden Alexanders	<i>Zizia aptera</i>
Golden Indian-paintbrush	<i>Castilleja levisecta</i>
Grand redstem (loosestrife family)	<i>Ammannia robusta</i>
Holy grass	<i>Hierochloe odorata</i>
Howell's bentgrass	<i>Agrostis howellii</i>
Howell's montia	<i>Montia howellii</i>
Indian rice/black lily	<i>Fritillaria camschatcensis</i>
Long-bracted knotsheath retrorse sedge	<i>Carex retrorsa</i>
Loose-flowered bluegrass	<i>Poa laxiflora</i>
Meadow checker-mallow	<i>Sidalcea campestris</i>
Mountain lady's slipper	<i>Cypripedium montanum</i>
Northern wormwood	<i>Artemisia campestris var. wormskioldii</i>
Nuttall's waterweed	<i>Elodea nuttallii</i>
Oregon bolandra	<i>Bolandra organa</i>
Oregon sullivantia (coolwort)	<i>Sullivantia oregana</i>
Pale bulrush	<i>Scirpus pallidus</i>
Peacock larkspur	<i>Delphinium pavonaceum</i>
Salt heliotrope	<i>Heliotropium curassavicum</i>
Sierra mock-stonecrop	<i>Sedella pumila</i>
Tall bugbane	<i>Cimicifuga elata var. elata</i>
Texas bergia	<i>Bergia texana</i>
Toothcup	<i>Rotala ramosior</i>
Upland Nuttall's larkspur	<i>Delphinium nuttallii</i>
Water howellia	<i>Howellia aquatilis</i>
Weak bluegrass	<i>Poa marcida</i>
Western wahoo	<i>Euonymus occidentalis</i>
White rock larkspur	<i>Delphinium leucophaeum</i>

WATERSHED-SPECIFIC TERRESTRIAL COMMUNITIES

Although the TEES and draft NRI work is comprehensive on a citywide scale, little information is available about the species present within specific watersheds.

Provided below is more specific information drawn from the 2004 *Draft Watershed Characterization Summary*, developed by BES to provide part of the background information for the *Portland Watershed Management Plan* (PWMP).

Columbia Slough – A large number of bird, mammal, reptile and amphibian species use the watershed at various points in their life cycles. The slough serves as a travel corridor along the Lower Columbia River and also sits along the Pacific Flyway and other migratory bird pathways. More than a dozen species of ducks, geese, and swans winter in the area, and neotropical migratory shorebirds and songbirds stop over in the slough during spring and fall or nest there in summer. Several great blue heron rookeries are present in black cottonwood groves along the slough. In 2002, it was estimated that the watershed hosted over 160 migratory, breeding, and wintering species of birds. In 2003, a bald eagle pair began nesting in the watershed. Several amphibian species, including red-legged frogs live in the area. Western painted turtles also live in the watershed. The mainstem and secondary channels and lakes are home to beaver, muskrat, and northern river otter, as well as several species of bats. Coyote, black-tailed deer, and red fox live in the upland and riparian habitats.

Fanno Creek – At least 100 bird species are thought to use the watershed. Amphibians that may be present include the northwestern salamander, long-toed salamander, ensatina, and Pacific chorus frogs. Garter snakes are common. Mammals typical of the watershed, include raccoons, opossums, skunks, muskrats and non-native fox squirrels. Several species of mice, shrews, moles, and voles also live in the watershed.

Tryon Creek – More than 60 species of birds reside within the watershed for at least a portion of the year. The watershed also supports a number of amphibians and reptiles, including frogs, salamanders, snakes, toads and turtles. The most common mammals are bats, beavers, black-tailed deer, chipmunks, coyotes, flying squirrels, mice, moles, opossums, rabbits, raccoons, red foxes, shrews, skunks and squirrels.

Johnson Creek – The Johnson Creek Watershed hosts several habitat types (e.g., wetland, lowland conifer forest, mixed forest, riparian) and a corresponding variety of reptile, amphibian, bird and mammal species. Resident species, include Pacific chorus frogs, garter snakes, Douglas squirrels, beaver, winter wrens, great horned and western screech owls, and several species of bats. The watershed also hosts many neotropical migratory birds such as warblers, flycatchers and swallows. Some "Special Status" species known to occur in the watershed's riparian areas, include bald eagle, pileated and downy woodpeckers, olive-sided flycatcher, Swainson's thrush, brown creeper, northern red-legged frog, and western painted turtle (in the upper watershed). Black-tailed deer and coyotes are likely the only large mammals that can still be found in or near the remaining forested areas. This could be due to their adaptability to developed areas and their requirements for larger territories than small mammals.

Willamette River – The West Hills (especially Forest Park) support 11 species of reptiles, 112 species of birds, and 62 species of mammals. Several large mammals including bear, cougar and elk have been known to migrate through Forest Park. Oaks Bottom Wildlife Refuge and Ross Island provide valuable habitat for waterfowl, wading birds (herons, egrets), bald eagles, amphibians and beaver. Although the southeast is mostly developed, Mt. Tabor, Kelly Butte and Rocky Butte provide valuable anchor habitats.

Watershed Health

Lower Columbia River – The Lower Columbia River Basin provides habitat for other wildlife such as the endangered Columbian white-tailed deer, State of Oregon species of concern, or species being considered for listing under the Endangered Species Act, including the streaked horned lark, northern red-legged frog, and western painted turtles. Wetland and riparian habitats adjacent to the river are used by a variety of amphibians, including Larch Mountain salamander, Cope's giant salamander, Oregon spotted frog, western gray squirrels, river otter, fisher, bushy-tailed woodrat, and several bat species. Species such as the American beaver, red fox, coyote, opossum and raccoons have adapted well to urban environments.

WATERSHED-SPECIFIC—AQUATIC COMMUNITIES

Salmonids, defined as Pacific salmon and steelhead of the salmon family *Salmonidae*, have long been the primary indicator species representing the health of all biological communities in Portland (NOAA NMFS 2009). Salmonids are used as indicators for a variety of reasons including their ESA listing status (discussed below), the wealth of information about their life cycle, their large habitat ranges (from oceans to headwaters) and because their survival depends on healthy watershed conditions (COP BES 2004).

In 2008 and 2009, the Oregon Department of Fish and Wildlife (ODFW) studied Portland streams that flow into the Willamette River in order to expand on existing knowledge regarding fish populations in Portland streams, by identifying and evaluating the relative abundance, distribution and use of stream segments by fish species. The data collected should enhance coordination between jurisdictions involved in the protection of ESA listed and Oregon sensitive species, and provide insight for restoring stream condition throughout the area.

The following describes the fish found in Portland's portion of the following streams:

Lower Columbia Slough – Almost 5,000 aquatic animals were collected, comprising 26 aquatic species and 12 families, nine of which were fish. Non-native aquatic fish made up almost 78% of the 23 species collected. These included fish indicative of warm water, including bluegill, smallmouth bass, carp, bullhead, perch and crappie. Native minnows and sculpin were also collected, as were juvenile Chinook salmon and Coho salmon.²³

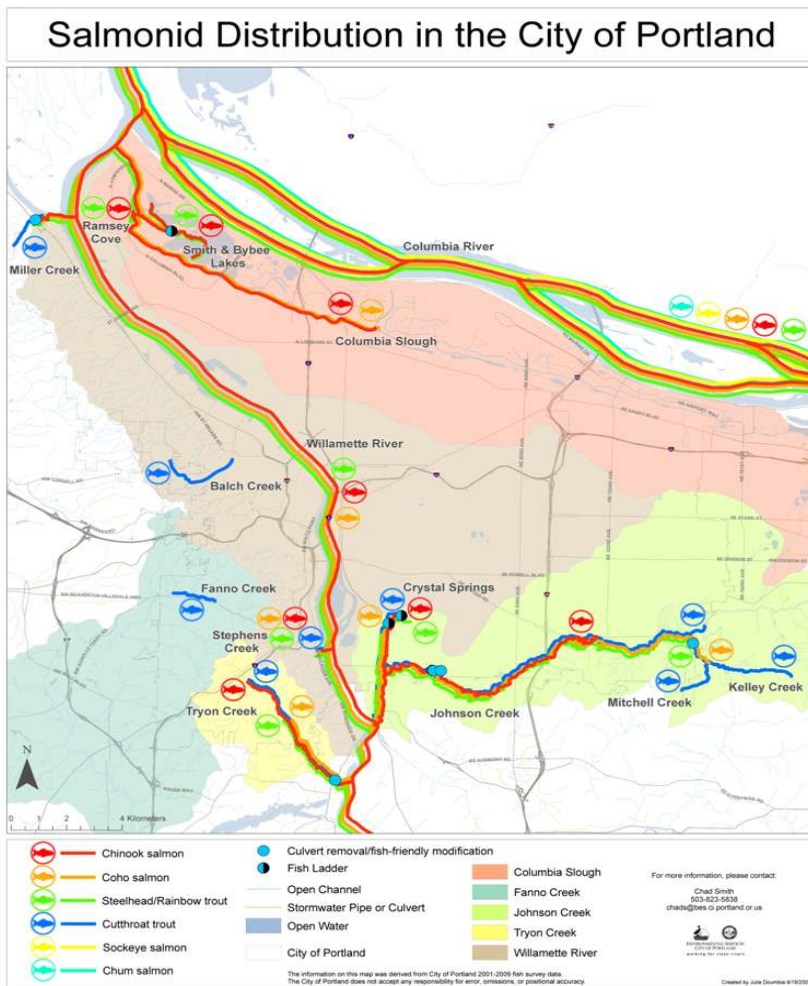
Fanno Creek – Four families of fish were captured during the course of the ODFW investigation: sculpin, minnows, salmonids, and lamprey. Sculpins were the most common species, representing 93% of the fish captured. Minnows represented 4% of the fish captured. Cutthroat trout made up 2% of the catch; no other salmonids were found in Fanno Creek. Western brook lamprey and Pacific lamprey made up 1% of fish captured. All but one fish (western mosquitofish) identified in Fanno Creek drainage were native species.²⁴

²³ ODFW. *Seasonal Comparison and Distribution of Fish Species in the Lower Columbia Slough: Completion Report 2009*. <http://www.portlandonline.com/bes/index.cfm?a=291276&c=51049>

²⁴ ODFW. – *Abundance and Distribution of Fish Species in City of Portland Streams: Completion Report 2009*. <http://www.portlandonline.com/bes/fish/index.cfm?c=51048&a=280352>

Portland Plan

Tryon Creek – Currently fish passage in Tryon Creek is hindered or blocked by a 400-foot long culvert with a 4.6% grade that runs under Hwy 43. A two-phase project to improve this condition is currently underway through a cooperative effort between the cities of Portland and Lake Oswego, ODFW, USFWS, Tryon Creek Watershed Council, and several other nonprofit and government agencies. In 2008, the U.S. Fish and Wildlife Service (USFWS) conducted a baseline survey of salmonids in Tryon Creek as part of an ongoing study will monitor the effectiveness of the project's improvements for lamprey, salmon, steelhead and native trout. During a fall survey, USFWS captured 571 trout species, 2 Coho, and 3 Chinook salmon above the culvert. Below the culvert, 45 cutthroat, 2 hatchery steelhead, 15 trout hybrids, 36 Coho (1 hatchery) and 24 Chinook salmon were captured. Based on this survey, the USFWS estimates Tryon Creek supports a trout population of about 1055 above the Hwy 43 culvert. In addition, fish tagging and monitoring showed that 19% of cutthroat trout, 20% of hybrid trout, and 1 of the 2 steelhead identified passed through the culvert.²⁵



²⁵ USFWS. *Tryon Creek Restoration Monitoring Project: FY2008 Progress Report*. February 2009. <http://tcwc.tryonfriends.org/pics/Tryon%20Creek%20Restoration%20Monitoring%20Project%202008%20Progress%20Report%20Final.pdf>

Figure 7: Salmonid distribution in the City of Portland

Watershed Health

Johnson Creek and its tributaries –

ODFW identified eleven families of fish in Johnson Creek and its tributaries during the course of their investigation. Native species represented 99.7% of the identified species. Sculpins comprised 51% of those captured, minnows, 43%, and salmonids (salmon and trout) 3%. Suckers and lamprey comprised less than 1%.

Johnson Creek main stem: Chinook and Coho salmon were identified. Cutthroat trout were found in higher percentages during the summer and lower percentages during the rest of the year. Steelhead populations were higher in Johnson Creek than in its tributaries.

Crystal Springs: Chinook salmon were identified; Coho salmon were found during the spring and winter. Steelhead trout were found in spring, fall and winter. A small proportion of cutthroat was identified during summer.

Kelley Creek: Coho salmon and cutthroat were identified year round. Steelhead were found only during the spring

Mitchell Creek: Cutthroat were identified.²⁶

Willamette River and its tributaries–

Miller Creek: ODFW identified ten families of fish during the course of their investigation; Sculpin represented an estimated 75% of fish captured, threespine stickleback made up 16%, salmon and trout accounted for 5% and 3% were minnows. Non-native fish represented less than 1%.

Stephens Creek: Eight families of fish were found in the only reach sampled during the course of the investigation; Minnows were the most abundant at an estimated 25%, salmon and trout made up about 3 percent, and sculpins comprised about 2%. Non-native fish made up most of the remaining fish identified. No non-native species were identified during summer.²⁷

Other studies verify that Chinook and Coho salmon use the Willamette River as a migratory corridor. Juvenile steelhead rest and rear in the Lower Willamette. The Willamette River also provides important habitat for lamprey, with adults observed at Willamette Falls in the spring and fall (Tinus, et. al. 2003).

Columbia River – The Columbia River is a migratory corridor and habitat for a number of salmonids and other native fish. In the Portland/Vancouver area, Hayden Island is designated critical habitat for Chinook, chum, Coho and sockeye salmon; steelhead and bull trout, euclachon (smelt), Pacific Lamprey and white sturgeon.

Chinook salmon were listed as threatened species under the ESA in March 1999, and Coho salmon in June 2005. In August 2005, the National Marine Fisheries Service (NMFS) announced designations of critical habitat areas in Portland for ESA listed salmon and steelhead. Critical habitat designations are important for species recovery. They are the areas that are considered essential for the existence of the species. If the critical habitat areas are not protected, then the

²⁶ ODFW. – Abundance and Distribution of Fish Species in City of Portland Streams: Completion Report 2009. <http://www.portlandonline.com/bes/index.cfm?a=280352&c=51049>

²⁷ Ibid.

species has no chance of survival. The critical habitat areas in Portland, include Johnson Creek (including Kelley Creek and Crystal Springs), Tryon Creek, the north part of the Columbia Slough (including Smith and Bybee Lakes), and the mainstem Willamette River (NOAA NMFS 2009).

Although fish have their own survival challenges in the Portland area, some pose threats to human health as well. High concentrations of chemicals such as polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethane (DDT) and chlordane are found in some fish tissue. This lead to fish consumption advisories for fish caught in the Columbia Slough and Portland Harbor. The Oregon Fish Consumption Guidelines recommend that people reduce their exposure to toxins found in fish from these water bodies by removing the skin and all fat, eggs, and internal organs before cooking. In the Portland Harbor area, consumption should be restricted to no more than eight ounces of fish per month, with additional restrictions for women of childbearing age, children and people with weak immune systems²⁸ (OR DHS 2009).

INVASIVE ANIMAL SPECIES

One of the many threats to biological communities is the presence of non-native animal species (defined as introduced species that have spread and cause harm to native species and/or habitats). These invasive species out-compete with native species for limited food, space and water (COP BES 2007). In the TEES Summary and Update: June 2010 identifies a list of 55 species of non-native animals that currently do or are expected to pose a risk to native species. Table 8 lists non-native species that are identified as management priorities based on the level of biological concern, documented or potential threat, and the ability to control their spread.

Present in Portland	Present, but not yet established	Likely to invade Portland in next 5-10 years
Bullfrog Red-eared slider (turtle) Common snapping turtle Domestic duck and goose species Feral cats and dogs Nutria Monk parakeet	European gypsy moth Mute swan Soft-shelled turtle Box turtle Eurasian collared dove	Zebra mussel Western quagga mussels Oak splendour beetle Oak ambrosia beetle Woodwasps Emerald ash borer Apple snails Chinese mystery snails Rusty crayfish Virile crayfish Ringed crayfish New Zealand mudsnails Spiny waterflea Fishhook waterflea

²⁸ It should be noted that these advisories are based on the national fish consumption rate of 17.5 g/day. In October 2008, the Oregon Environmental Quality Commission gave DEQ approval to revise Oregon’s toxic criteria for human health on a fish consumption rate of 175 g/day.

²⁹ TEES Summary and Update. June 2011.
<http://www.portlandonline.com/bes/index.cfm?c=51052&a=354986>

Watershed Health

The Oregon Invasive Species Council was formed in 2002 to conduct a coordinated and comprehensive effort to keep invasive species out of Oregon and to eliminate, reduce, or mitigate the impacts of invasive species already established in Oregon. Members include representatives of the Oregon Department of Agriculture, Oregon Department of Fish and Wildlife, Portland State University and the Sea Grant Program at Oregon State University. They provided recommendations to the City of Portland regarding the control of invasive animals, including the following:

- Develop performance measures to track progress in preventing the introduction, control of spread or eradication of these species.
- Conduct an awareness and engagement campaign targeted at specific audiences regarding prevent and control the spread of invasives.
- Expand the partnership created by the Audubon Society of Portland and the Feral Cat Coalition to enhance awareness about abandonment and feral pet issues.
- Consider local regulations to discourage the spread of animal invasives and promote incentives for people to act to reduce their spread.³⁰

Some native species can also become a nuisance, especially when humans modify their habitat, causing an increase their numbers. The TEESAG identified terrestrial wildlife “species of management concern”, because they have become problematic for one reason or another. Examples include cougar, because of concern over human-wildlife interactions, and Canadian geese, which sometimes congregate in high numbers causing water quality, health and property management issues.

URBAN HAZARDS TO BIOLOGICAL COMMUNITIES

All but the most adaptive wildlife species face a number of challenges in the city. In addition to the risk of habitat loss or fragmentation due to development (see Chapter 8 – Habitat), chemicals and nutrients (fertilizers) in landscaping, street runoff and waterways can affect animals’ health. Salmonids and other fish species are sensitive to sediments and chemical changes to water, especially in spawning and rearing areas. Insecticides can harm beneficial insects, such as bees and butterflies, essential for pollinating plants. Dogs can harass wildlife. Cats prey on birds and other small animals.³¹ Roads pose both a barrier and a danger to terrestrial species. Culverts under roads can block passage for migrating fish, while car and deer crashes threaten the safety of drivers as well. People may also fear or perceive threats from various wildlife, such as coyotes.

Some of these hazards can be avoided or offset by educating community members about landscaping with native plants, avoiding and making careful use of landscape chemicals, and thoughtfully managing pets. In addition, state highway departments and other transportation authorities are exploring new road designs that can reduce the risk of collisions with wildlife.

³⁰ Ibid.

³¹ The Audubon Society of Portland estimates that 40% of the wildlife taken into the Portland’s Wildlife Care Center are injured by cats, the top cause of injury.

<http://www.audubonportland.org/backyardwildlife/brochures/cats>

Awareness is growing about the particular dangers that birds face in urban environments. Because birds are unable to perceive glass, they experience risks due to nighttime lighting, reflective surfaces, and transparent glass structures. To reduce these risks, some cities are instituting nighttime lights-out programs for office buildings.

BIOLOGICAL COMMUNITIES – SUMMARY AND A LOOK AHEAD

Many native species continue to face challenges in the urban environment. The number of species in peril or species of concern continue to grow, while their habitats continue to shrink. In addition, a greater number of invasive animals have taken advantage of these disturbed areas and are gaining strongholds. Despite this, there have been significant positive signs over the last few years.

A focused effort on the needs of biological communities – especially terrestrial species and their habitats, has called attention to the opportunity of protecting and expanding anchor habitats and re-establishing wildlife corridors. The TEESAG also suggests monitoring specific focal species and their habitats as a way to assess ecological integrity for multiple species. By carefully selecting the right combination of species and habitat, the effectiveness of implemented actions could be monitored and adapted, and the health of our watershed could be assessed over time.

While salmonid species continue to struggle, it appears that they are taking advantage of habitat enhancements. For example, after a culvert was replaced and fish passage was enhanced in Miller Creek, salmon were documented far upstream. Salmon have been documented in all accessible habitats in the Columbia Slough, and Chinook have been found in the middle sections of Johnson Creek where they had not been seen for decades (PWMP Annual Report 2007 – 2008).

Recent investments in “green infrastructure”, including ecoroofs, tree planting, green streets, and streamside restoration will improve conditions for biological communities as well. For example, the Grey-to-Green initiative could significantly increase the extent and health of Portland’s urban forest. Not only will this improve hydrology and water quality, but can also provide habitat for a variety of native species found in urban areas, like Anna’s hummingbirds, Cooper’s hawks and Pacific chorus frogs. Ecoroofs can simulate grassland conditions and provide protected places for birds like kildeer to forage and nest. Green streets and ecoroofs can also provide food for native pollinators, such as the western bumblebee.

Issues about bird safety in urban environments is especially relevant in Portland, where key nesting and feeding areas for peregrine falcons, bald eagles, osprey and hawks are located in or near downtown. Cities like Chicago and Toronto can serve as examples for how to create bird-safe cities by adopting bird-friendly development guidelines.³²

³² The website “Birds and Buildings” provide resources including studies about urban hazards to birds and example design guidelines. <http://www.birdsandbuildings.org/index.html>.

CHAPTER 8: PHYSICAL HABITAT

GOAL: “Protect, enhance, and restore aquatic and terrestrial habitat conditions and support key ecological functions and improved productivity, diversity, capacity, and distribution of native fish and wildlife populations and biological communities.”

HISTORIC CONDITIONS

Prior to Portland’s development, the region was covered by extensive deciduous and coniferous forests on the hillsides; oak savannah and meadow habitats in the eastern portion of the city, forested buttes (lava domes) in the outer east, and floodplain wetlands and riparian areas in low-lying areas along the rivers and streams. With development, large areas were deforested. Some of these areas, such as Forest Park and Marquam Hill were replanted. However, virtually all of the high-quality meadow and oak savannah areas have been converted to urban uses.

The Willamette and Columbia Rivers included extensive and interconnected systems of river channels, open slack waters, various wetland types (including forested, emergent, and scrub-shrub wetlands), riparian forest, seasonally inundated wet prairie and upland forests. Connectivity of habitat was high both along the river and from the vegetated riverbanks to the upland forests (COP BES 2005a).

The 2005 *Framework for Integrated Management of Watershed Health* describes alternations to Willamette River habitats:

“Gradually, habitats along the Willamette River have been destroyed, degraded or disconnected through construction of dams throughout the Willamette and Columbia rivers and from fill and development along the Willamette River shoreline and floodplain areas. Large expanses of black cottonwood/Pacific willow forest and spirea/willow wetland have been filled and developed, leaving small strips of riparian forest, wetland and associated upland forests. These remnants are few or entirely lacking for large reaches through the downtown and industrial segments of the river. Most of the historical off-channel habitats (such as side channels, oxbow lakes and marshes) have long since been cut off from the channel and filled. Connectivity and maintenance of these habitats have been reduced or eliminated as a result of marked alteration of the seasonal hydrograph³³, particularly dramatic reduction of peak flows during wet weather months. Connection of many tributary habitats to the mainstem is eliminated or reduced by culverts (COP BES 2005a).”

³³ A hydrograph is the annual and seasonal trend in flow in a stream or river.

IMPORTANCE OF HABITAT

Healthy physical habitats are essential for the existence of biological communities, as well as the structure and function of river ecosystems. Riparian areas (vegetated areas next to streams) and wetlands are habitat zones where nutrients are cycled and stormwater runoff is filtered, protecting water quality in streams (COP BES 2005a). When physical habitats are restored, other watershed goals can often be met. For example, if channel structure is improved, it can improve hydrology and biological communities. Habitat restoration is essential for reversing the dominance of invasive species and allowing native biological communities to regain a foothold (COP BES 2005a).

HABITAT AREAS

Because of its location at the confluence of the Willamette and Columbia Rivers, Portland is an important regional ecological habitat “hub” for a myriad of species. Based on analysis captured in the City’s most recent draft NRI (February 2012), Portland contains almost 300 river and stream miles, about 2,520 wetland acres, and roughly 19,220 acres of forest and woodland areas one acre or larger. About a third of the land area is identified as having natural resource values, including valuable riparian and/or wildlife habitat. Most of these habitats are degraded at least somewhat by the effects of urbanization. About 24,945 acres of land within the city are ranked as having high relative natural resource value, about 3,750 acres are ranked as medium, and over 4,000 acres are ranked as low-value natural resources.

Over 300 species of native fish and wildlife species live in or migrate through the Portland basin, most of them using both riparian (93% of species) and upland habitats (89%), (Metro 2006) (COP BES 2010). For this reason, protection and restoration activities undertaken by the City are focused on three major habitat areas: in-stream habitat, riparian areas and upland areas. Wetland areas are found in both riparian and upland areas. The type, distribution and quantity of these habitats in Portland are highly variable due to a diversity of environmental factors (topography, soils, geomorphology, climate, vegetation, etc.) and human-related factors (land use activities, habitat disturbance, etc.) (COP BES 2005a).

Three additional habitat areas are described in this section. These are urban areas, special status habitats and critical habitat areas. Certain urban areas and features provide important habitat for species, such as bats and peregrine falcons, and also connect to higher quality habitat areas. Special-status habitats are those identified by the TEES to have particular importance in Portland and are severely declining. Critical habitat areas are those areas identified by NMFS to be essential for the conservation of salmon.

IN-STREAM HABITAT AREAS

In-stream habitats can be broadly defined as running-water or slack-water systems. Complex in-stream habitat provides food, large wood, riparian cover and habitat for native fish and wildlife life-cycle needs. Open water areas convey water, store water, and interact with groundwater. This area is essential for the survival of most fish and wildlife species (COP BES TEES 2007).

Watershed Health

In general, much of the city's in-stream habitat is severely degraded and rated as marginal to poor-quality, although higher quality in-stream habitat areas are found in natural areas, some parks, restored areas and other locations where development has not yet occurred (COP BES 2004). A few high-quality exceptions include Balch and Miller Creeks.

Specific in-stream habitat types in Portland include; open water (lakes, rivers, and streams), exposed mudflats, beach, riverine island, river delta, water column habitat, benthos habitat and off-channel open water. Ross Island, which was donated to the City of Portland in 2007, also contains important in-stream habitat.

RIPARIAN AREAS

Riparian areas are the environments adjacent to streams, rivers and wetlands that constitute a zone of direct interaction between terrestrial and aquatic ecosystems. An intact riparian area serves a multitude of functions vital to aquatic ecosystem health, including reducing flood peak, regulating stream flow, providing food for aquatic species, stabilizing banks and replenishing groundwater (Johnson & O'Neil 2001). Vegetation in riparian areas provides streams with structure, shade, microclimate, nutrients and habitat for fish and wildlife (COP BES TEES 2007), and helps improve water quality by moderating in-stream temperature, stabilizing banks, controlling nutrients, pollution, and sediments (Johnson & O'Neil 2001). The linear nature of riparian areas lends themselves to be used as corridors for wildlife, such as beavers, river otters, and amphibians to move between important anchor habitats (COP BES TEES 2007).

Many riparian areas have been heavily impacted by streamside development, fragmentation and the invasion by non-native species. Many floodplains have been filled, degraded by development or cut-off from their connection to streams. Urban streams, such as Johnson Creek, have been straightened and are no longer able to meander (change course) through their floodplain. In many places, riparian areas are constricted by riverfront development, levees, seawalls, riprap, sheet pile, and other human-made structures. These changes have reduced habitat for fish and wildlife, eliminated floodwater and sediment storage capacity, and increased risks of downstream flooding (COP BES 2004).

WETLAND AREAS

Wetlands are areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas (USACE 1987). Floodplains often include wetlands. Wetlands provide many functions that support watershed health, including intercepting and storing water, filtering sediments and nutrients, moderating stream flows and providing food, water and shelter for many wildlife species such as birds and amphibians (COP BPS 2007).

Not only have many local wetlands been filled, but some have been replaced with perennial ponds (mitigation wetlands), which may not provide the same natural resource functions and/or values as those they are replacing. For example, non-native bullfrogs, which often eliminate native amphibian populations if found in the same wetlands, require perennially inundated ponds to reproduce. As a

result, perennial ponds provide much less value to native amphibians and turtles than seasonal wetlands (COP BES 2004).

Wetland types found in Portland, include forested wetlands, scrub/shrub wetlands, emergent wetlands, exposed mudflats and off-channel open water. The Columbia Slough contains a variety of wetlands, including the Blue Heron Meadow and Wapato wetlands.

UPLAND AREAS

Upland habitat refers to all areas that are not riparian, wetlands (although wetlands can be found in upland areas) or in-stream habitats. These areas provide temporary resting and feeding habitat for migratory bird species that stop in the region. Wildlife species use uplands for food, shelter and cover from predators. Some species use these areas on a temporary basis, while others reside in the area year-round (COP BPS 2007).

While the city has some relatively high-quality habitat, much of it is extremely fragmented and lacks corridors to connect one area of habitat to another (COP BES 2004). This is an important issue, because the survival of native terrestrial and aquatic wildlife species depends on having a variety of habitat types in the watershed connected by habitat corridors.

Habitat types found in Portland's upland areas include: wetlands, agriculture and mixed environments; grasslands, lowland conifer-hardwood forest, oak woodlands, dry Douglas-fir forest and woodlands; riparian-wetlands (Johnson & O'Neil 2001). Buttes and rocky habitats are also important upland habitat types used by a variety of species. Although Forest Park is the largest upland habitat area in Portland, many other areas are significant, for example, Woods Memorial Park provides an important stopover for migratory birds. Powell Butte also serves as stopover habitat, as well as being a corridor between other habitat patches or areas.

URBAN (BUILT ENVIRONMENT) AREAS

Urban areas are characterized by built structures and paved surfaces, providing minimal, yet important, habitat value – often for more adaptive resident wildlife species. Street trees help restore the natural hydrologic cycle, reduce the volume and negative effect of stormwater runoff, and provide some habitat. Residential neighborhoods often have bird feeders, bird baths, and bird and/or bat houses that support some backyard wildlife during parts of the year. Urban parks, environmentally-sensitive golf courses (several Portland area golf courses are Certified Audubon Cooperative Sanctuaries) also can be used by certain species.

The following paragraphs provide additional information about specific urban habitat types:

URBAN FOREST

Trees, shrubs, and grasses provide important habitat for many wildlife species. According to an inventory conducted by the Bureau of Portland Parks & Recreation, tree canopy coverage also varies broadly across the city, but generally covers 26% of Portland boundaries. The city contains more than 236,000 street trees and approximately 1.2 million trees in parks and natural areas. Approximately half of the urban forest canopy is on private

Watershed Health

property. The age of the trees varies depending on with tree species and area of town. More than 90% of street and park trees are in fair to good condition (COP PP&R 2007).

Broadleaf deciduous trees (specifically maples) dominate the landscape accounting for 85% of street trees and 77% of park trees. Norway maple is the most abundant tree type in north, northeast and southeast neighborhoods. Big-leaf maple is most abundant in the Northwest. Arborvitae is most abundant in southwest Portland (COP PP&R 2007).

Tree size is a function of height, diameter, canopy spread and leaf area. Thirty-three percent of the street trees are considered to be small, compared to 25% of the trees found in parks. The majority of trees found in parks (64%) are considered to be large, compared to 37% of the street trees (COP PP&R 2007).

Forested upland areas also provide important functions for hydrology, water quality and air quality. Mature tree canopy intercepts up to 30 percent of rainfall and provides onsite infiltration. This helps decrease the amount of rainwater that enters the stormwater sewer system, intercept pollutants, and provide some level of groundwater recharge. Upland forests also cool stormwater runoff, provide shade that reduces the urban heat island effect, reduce noise and sequester carbon (for more information, see the Portland Plan Urban Forestry Background Report.)

LANDSCAPED AREAS

This urban habitat type includes open space that is maintained for specific purposes, such as golf courses, agricultural lands, athletic fields, cemeteries, and maintained parks. Typically, most of the understory vegetative cover is non-native grass species. However, edges and roughs in golf courses, and some ornamental plants and landscapes with native plants, can provide islands of wildlife habitat. Wildlife species may also use the edges of landscaped areas as corridors to move between other habitat types.

URBAN FEATURES

Bridges, chimneys, utility poles/towers and channel markers are also used by a variety of wildlife species. Peregrine falcons and bats use bridges crossing the Willamette River. Raptors, including osprey and bald eagles, use channel markers and utility poles in the Willamette and Columbia Rivers, and Vaux's Swifts nest in the chimneys at Chapman School.

Additional urban features include ecoroofs, street-side planters, rain gardens, backyard habitat, and nesting boxes. Because natural habitat has been fragmented, these islands within the urban environment have become critical patches where wildlife can nest, roost, feed or rest.

Ecoroofs provide unique urban habitat for a variety of species. They can help mitigate habitat loss due to development by providing habitat for birds and beneficial insects. This can be especially important in dense urban areas where very little habitat exists. Ecoroofs can also provide corridors

to connect isolated parks and provide wildlife with a safe haven from humans and domestic animals.

Research on the habitat benefits of ecoroofs shows the greatest benefits are found on ecoroofs with both sunny and shady areas, roofs with varying soil depth and associated vegetation, and using materials like small rocks or logs. Kildeer and Canadian geese have been observed nested on Portland ecoroofs. In a Portland study, researchers captured 562 insects, including valuable pollinators.

SPECIAL STATUS HABITAT TYPES

Special status habitats are particular types of habitat that were identified by the TEESAG as being especially important, due to their rarity or because they are declining rapidly, locally and regionally. Maintaining diversity in habitat types is critical to ensuring ecosystem vitality. Metro's Title 13 has established targets to preserve 95% of the areas identified in their 2004 inventory. These habitats provide important areas for a variety of species, including migrating and breeding waterfowl, shorebirds, water birds, songbirds, mammals, amphibians and/or reptiles. The following lists special status habitats from the 2007 TEES Summary and draft NRI:

Herbaceous wetlands: Almost all of the wetlands that remain in Portland have been degraded to some degree by altered hydrology, pollution, invasive plants and animals. In the Willamette Valley, between 40% and 70% of documented wetlands have been lost, with continuing losses of more than 500 acres per year.

Upland prairie, grasslands, and oak savannas: In the Willamette Valley, over 99% of the historic grasslands have been lost or converted. Remaining patches are fragmented and isolated, leaving them extremely vulnerable.

Interior forest; late-successional conifer forests: In the West Cascades, 23% of the late-successional Douglas fir-mixed conifer forests remain, of which less than 10% of low-and mid-elevation late-successional forests remain.

Oak woodland: In the Willamette Valley, an estimated 400,000 acres historically consisted of oak woodlands. Very few isolated pockets remain (less than 1% of historic levels), most of which are in private ownership requiring incentive-based approaches to conservation.

Bottomland hardwood forest, riparian habitats: In the Willamette Valley, riparian forests have declined significantly with over 70% lost. Many streams only have a thin strip of riparian vegetation or none at all.

The City has begun giving special consideration to enhancing these habitat types. In addition, backyard habitat education calls attention to the variety of habitat types found in Portland. These efforts will enhance Portland's habitat diversity and resiliency in the face of climate change and other ecological challenges.

CRITICAL HABITAT FOR SALMON

Portland's watersheds contain several "critical habitat areas" – those areas that are essential for the conservation of a target species. Critical habitat areas are legally defined as:

- “(1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and
- (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation” (NOAA NMFS 2009).

These areas may require special management practices. With a critical habitat designation, federal agencies must ensure that any activity that they fund, carry out or authorize is not likely to destroy or adversely modify a protected species critical habitat.

In Portland, critical habitat areas for ESA listed salmon and steelhead, include Johnson Creek (and its tributaries Kelley Creek and Crystal Springs), Tryon Creek, the north part of the Columbia Slough (and Smith and Bybee Lakes) and the mainstem of the Willamette River.

NATURAL AREA OWNERSHIP

The ability to preserve key habitats that support biological communities and improve water quality is influenced by ownership, funding for maintenance and land management protocols. Portland has one of the largest urban forest reserves in the country – Forest Park covering 5,100 acres, and an additional 4,900 acres of City of Portland parks (COP P&R 2009).

There is also considerable amount of privately-owned land with significant natural resources. Activity on some of this land is regulated by environmental overlay zones (see Chapter 2 for more information). These overlay zones provide some level of protection for important natural resources, however, they are not intended to protect all areas with habitat value. In addition, the draft NRI identified 10% (more than 20 miles) of Portland waterways, and more than 100 acres of wetland outside of environmental or other resource overlay zones. Overall, the NRI identified about one-third of the total natural resources outside of the major river channels as having no regulatory protections (most of which are lower-quality resources).

Even where overlay zones apply, they provide limited protections. For example, within the 100-foot stream buffer (i.e. riparian habitat) along the Columbia Slough, 79% is in an environmental overlay zone - 39% is covered by an environmental protection zone and 40% is an environmental conservation zone that allows some impacts to resources.

INVASIVE PLANT SPECIES

Invasive plants are those species that spread at such a rate that they cause harm to human health, the environment, and/or the economy. Invasive plants pose a significant threat to wildlife habitat because they reduce biodiversity, alter habitat quality, reduce tree cover, change soil characteristics, increase risk of fire and degrade water quality. Invasive plants also often thrive in urban areas where habitats are fragmented and their presence makes it difficult for native species to survive and flourish. According to the City of Portland's *Invasive Plants Strategy Report*, invasive plants cover about 4,200 – 12,900 acres within Portland (COP BES 2008).

The City of Portland maintains several plant lists for native, nuisance or prohibited plants, and plants required for eradication. Examples of some common invasive plant species include:

- Invasive terrestrial plant species: Himalayan blackberry, English ivy, clematis, knotweeds, reed canary grass, tree of heaven, garlic mustard and false brome.
- Invasive aquatic plant species: Parrot feather, purple loosestrife, and yellow-flag iris.

In 2005, the City adopted a Resolution to integrate invasive plant management into existing programs. The strategy is developing a citywide inventory of key invasive plants, implementing the City's invasives control strategy, and executing an early detection/rapid response approach for specific species. According to the strategy, Portland wildlife habitat can be strengthened by focusing on the eradication of non-native invasive plants and the establishment of native plant communities (COP BES 2008). In ten years, full implementation of the strategy is expected to improve 4000 acres or 40% of City-owned land.

CLIMATE CHANGE AND HABITAT

In 2009, the City of Portland adopted the *Climate Action Plan*, which sets out targets, policies and strategies aimed at reducing carbon emissions 80% by the year 2050. While much of the Plan focuses on energy and resource use, it also acknowledges the role of the urban forest and natural system in addressing climate change, by sequestering carbon, cooling and shading buildings in the summer, and lessening heat loss in the winter. The Plan calls for increasing tree canopy coverage from over one-quarter of the City to one-third. It also calls for reducing stream temperatures as an indicator of overall watershed health.

Watershed Health

This year the Climate Change Initiative at the University of Oregon brought together local scientific experts to examine how climate change is likely to impact local habitats and species. Their analysis concluded that the local Willamette River watershed can expect an increase of invasive species, loss of existing habitat and species diversity, change in migration patterns and habitat range, and loss of culturally-important species and landscapes – and included the following recommendations related to Portland area habitats:

- Protect existing high-quality habitats and floodplains.
- Increase the complexity of streams.
- Reconsider species management, including threatened and invasive species, understanding that species' territories with shift.
- Identify low impact development principles and policies.

PHYSICAL HABITATS & VEGETATION TYPES BY WATERSHED

Portland's five watersheds each have distinct vegetation characteristics. Table 9 below uses NRI data to give a sense of the nature and extent of habitats found within each watershed. The data is also represented in pie charts for each watershed.

Watershed	Size – acres w/in the city (open water)	Wetlands	Forest/ Trees	Woodland	Shrubland	Herbaceous
Columbia Slough	27,216 (470)	2,012 (7.5%)	1,020 (4%)	1,118 (4%)	349 (1%)	4,216 (16%)
Fanno Creek	5,135	10 (0.2%)	1,190 (23%)	379 (7%)	15 (0.3%)	274 (5%)
Tryon Creek	3,290	1 (0%)	1,178 (36%)	176 (5%)	13 (0.4%)	219 (7%)
Johnson Creek	13,660 (40)	131 (1%)	1,741 (13%)	780 (6%)	201 (1.5%)	1,333 (10%)
Willamette River	39,159 (3,232)	298 (0.8%)	8,365 (21%)	1,086 (3%)	289 (0.7%)	694 (2%)
Columbia River³⁵	5,176 (1,665)	49.5 (1%)	435 (8%)	151 (3%)	40 (1%)	194 (4%)

³⁴ City of Portland – Bureau of Planning and Sustainability. *Natural Resource Inventory Analysis: Watershed Statistics*. 2/16/2012.

³⁵ This data is drawn from a set of reports that cover Portland's portion of the Columbia River watershed from the Willamette confluence to NE 122nd Avenue. Current data is not available for the area from 122nd to the eastern city boundary.

Portland Plan

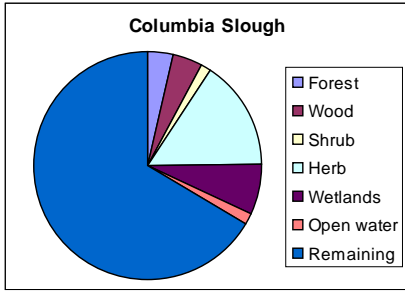


Figure 8: Columbia Slough watershed vegetation feature distribution

Columbia Slough – Within Portland, the Columbia Slough contains the majority of the City’s remaining wetland acreage (2,012 acres) and a large portion of the active floodplains (1,733 acres of vegetated floodplains and 1,536 acres of non-vegetated floodplains). Most of the larger vegetated areas in the slough are classified as herbaceous vegetation. The watershed contains 4,706 acres of special habitat areas³⁶ including Smith and Bybee Wetlands, Big Four Corners, Rocky Butte and the Grotto, and the Wilkes Creek headwaters. These areas make up about 17% of the watershed area (COP BPS 2012).

Fanno Creek – The dominant habitat feature of Portland’s portion of the Fanno Creek watershed is forest/trees, comprising 23% of area. The watershed contains about 32 acres of special habitat areas, primarily in Woods Memorial Park, providing important connectivity between larger habitat areas including Forest Park (COP BPS 2012).

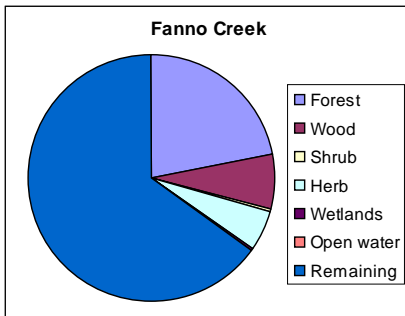


Figure 9: Fanno Creek watershed vegetation feature

Tryon Creek – Within the City of Portland, the Tryon Creek watershed has the highest proportion of forest/trees, about 36% of the area. Tryon Creek State Park is the largest of the special habitat areas in this watershed. Along with several smaller areas, special habitat areas comprise 479 acres or about 15% of the watershed (COP BPS 2012).

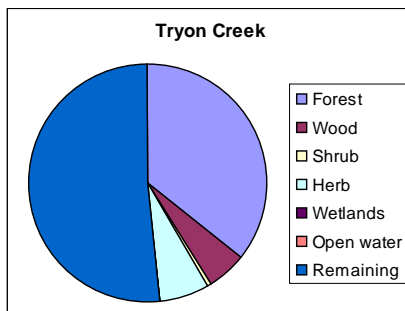


Figure 10: Tryon Creek watershed vegetation feature

³⁶ Special habitat areas are areas that have been documented to provide especially important fish and wildlife habitat values and function.

Watershed Health

Johnson Creek – In Portland’s portion of the Johnson Creek watershed about 16% of the area is classified as herbaceous vegetation (i.e. without trees or woody vegetation). Forest/trees cover about 13% of the watershed. The watershed contains a significant portion of active floodplain in the city; 390 acres of floodplain is vegetated, 328 acres is non-vegetated and 39 acres is in open water. The 13 special habitat areas total approximately 1,044 acres (about 8% of the watershed area), including Powell Butte, Tideman Johnson Park, the Springwater Wetlands Complex, the Kelley Creek Refuge, and Johnson Creek (COP BPS 2012).

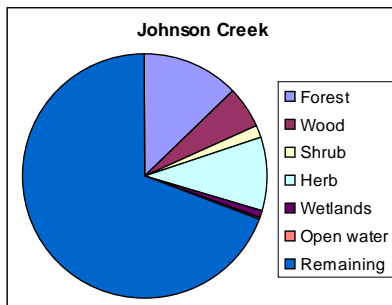


Figure 11: Johnson Creek watershed vegetation feature

Willamette River – The Willamette watershed is Portland’s largest watershed. Portland’s portion of the watershed includes substantial floodplains, nearly two-thirds of these floodplain areas are developed (671 acres) with the remaining 480 acres classified as vegetated. Forest/trees cover about 21% of the watershed, much of that is within Forest Park. About 9,616 acres of special habitat areas are located in 23 locations including the Willamette River mainstem, Oaks Bottom Wildlife Refuge, Riverview Cemetery, Forest Park, the oak woodlands on both sides of the river, the Ross Island complex, and areas of bottomland hardwood forest and mudflats along the river (COP BPS 2012).

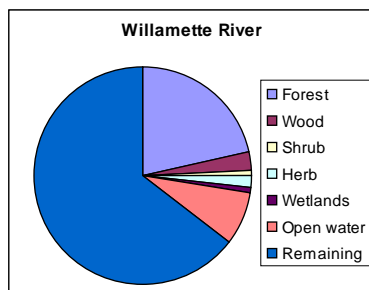


Figure 12: Willamette River watershed vegetation feature

Portland Plan

Columbia River – Most of Portland’s section of the Columbia River watershed is from the top of the levee, much of it along Marine Drive, into the water to the City of Portland boundary. For the portion of the watershed from the river’s confluence with the Willamette, east to 122nd Avenue (including all of Hayden Island), about 850 acres is vegetated floodplains; over 400 acres of floodplain is not vegetated. About 3,000 acres is in open water (COP BPS 2011).

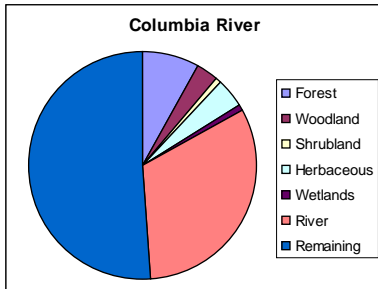


Figure 13: Columbia River watershed vegetation feature distribution

PHYSICAL HABITAT – SUMMARY AND A LOOK AHEAD

Portland's physical habitats are diverse and critical to supporting a variety of wildlife; however, they face continued risk due to invasive species, degradation and loss, fragmentation, human disturbance and pollution (COP BES 2007). Most in-stream habitat is severely degraded and is rated as marginal to poor. Riparian areas continue to be heavily impacted by streamside development and loss of vegetation. Upland habitats in the region are also extremely fragmented and lack wildlife corridors connecting them to other uplands, riparian areas, or wetlands. Invasive plants continue to threaten watershed function and habitat. Climate change is expected to significantly alter habitats in the future.

However, a significant increase in the base knowledge of habitat conditions now guides decision-making. Restoration projects have enhanced stream banks and upland habitat. Consideration of habitat diversity is being used for restoration projects. New information calls attention to the special habitat areas that have been nearly eliminated from Portland. For example, grasslands and oak woodlands have now been identified as focal habitat types for restoration.

Previously, City efforts to protect and enhance habitat focused on aquatic and riparian areas. The draft NRI provides more accurate and complete information about the location of significant natural resources. The TEESAG helped identify areas that might be restored to provide connectivity between habitats. Because of this effort, essential terrestrial information can be considered and valuable terrestrial components can be added to projects.

Portland is situated in a unique location on the Pacific Flyway of migratory birds. With bird populations declining regionally and globally, the City has an opportunity to address bird-related issues including protection and enhancement of natural habitat as well as reducing the risks associated with the built environment (i.e. building design, lighting, communication towers, etc.).

Efforts by the City of Portland and community organizations, such as the Friends of Trees have expanded the urban forest. These efforts will become even more critical to reduce the effects of climate change.

CHAPTER 9: STEWARDSHIP, EDUCATION, AND PUBLIC INVOLVEMENT

Achieving watershed health goals requires the shared efforts of community groups, individual Portlanders, public agencies and nonprofits. Portland's rate of volunteerism is second in the nation³⁷. This ethic yields real benefits for watershed health. Volunteers for the Bureau of Parks and Recreation log 450,000 hours annually, equivalent to more than 215 full-time employees. Watershed councils and stewardship organizations also contribute to efforts to improve watershed health by engaging a broad range of stakeholders in public education campaigns and on-the-ground restoration projects.

The *Portland Watershed Management Plan* (PWMP) identifies the following actions to help reach related to stewardship and education:

- Provide pollution prevention education to City staff, the business community, organizations, and general public.
- Provide technical assistance and incentives to City staff, the business community, organizations, and general public on pollution prevention.
- Promote watershed awareness with City staff, schools, the business community, organizations, and general public.

The Bureaus of Environmental Services, Parks and Recreation, Planning and Sustainability, Water, and Transportation promote education, involvement and stewardship to raise awareness of the importance of healthy watersheds, and engage community members in improving environmental conditions. Numerous City programs provide technical support, public events, workshops, incentives or grants to:

- Assist City employees in understanding how their projects affect watershed conditions.
- Demonstrate to Portland residents and businesses how their individual behavior and actions can improve environmental conditions and promote healthy watersheds.
- Increase stewardship of natural areas.
- Provide incentives to plant trees, replace paving with vegetation, and construct eeroofs.
- Increase community interest in pursuing stewardship grants and volunteer opportunities.



Volunteer applying "Drains to River" curb marker

³⁷ Corporation for National and Community Service, using data collected from Metropolitan Statistical Areas, as designated by the Federal Office of Management and Budget.

<http://www.volunteeringinamerica.gov/assets/resources/VolunteeringInAmericaResearchHighlights.pdf>

Watershed Health

Green streets and other vegetated stormwater systems are one of the City's most visible reminders about the importance of environmental stewardship and the link between watershed health and the health of our rivers and streams. They are working examples of the natural systems that are part of the green infrastructure that Portlanders rely upon, and they are increasingly sought by community members as neighborhood enhancement projects.

Restoration projects also provide an opportunity for community members to make a difference, whether it is school children planting trees, volunteers pulling ivy, or a group of coworkers engaging in a long-term project to improve a local wetland.

CITY PROGRAMS

The following list highlights a few City programs aimed at Stewardship and Education, and summarizes their successes for the 2007-2008 fiscal year:

Bureau of Environmental Services

- **Clean Rivers Education Program (CREP)** – Through the CREP program, educators work in classrooms to provide hands-on interactive science education on stormwater, support assembly programs, and provide curriculum. Educators also facilitate field trips to teach students how to assess the health of watersheds and restore natural areas. In addition, they provide teacher and volunteer trainings to support these activities.
 - 26,371 students reached
- **Clean Rivers Rewards Workshops** – These workshops teach community members how to manage stormwater on their property.
 - 3,600 people attended the program's 40 events
- **Portland Ecoroof Seminar Series** – A free training series increases the technical knowledge and skills of stormwater professionals and 'do-it-yourselfers'.
 - 500 people attended
- **Community Watershed Stewardship Program (CWSP)** – This partnership between BES and Portland State University (PSU) provides funds to neighbors, schools, and organizations to develop and implement their own projects. In 2008, CWSP was awarded the first U.S. National Jimmy and Rosalynn Carter Partnership Award for Campus Community Collaboration.
 - 13 stewardship grants awarded totaling \$60,200
 - 20 mini grants awarded totaling \$7,800
 - 2,300 participants were involved in project implementation

Portland Parks and Recreation

- **Portland Parks Natural Areas Volunteer Program** – Activities include invasive plant species removal, native plant installation, trail building, fencing sensitive aquatic resource, education for dog owners and litter pickup.
 - Over 450,000 volunteer hours annually
- **Neighborhood Tree Liaison Program** – Educates neighborhood representatives through a 10-session course about general tree care, biology, planting, preservation and identification, so they can serve as resources to their neighborhood.

Bureau of Planning and Sustainability

- **Green Investment Fund (GIF)** – A competitive grant program that supports innovative green building projects in Portland. The primary intent is to support early building and site-related project activities that examine the potential and identify the means to realize an exemplary, comprehensive green building project.
 - \$425,000 was available for 2008

Portland Water Bureau

- **Groundwater Education and Outreach** – In 2008, 828 people participated in the following activities aimed at educating the public about groundwater and groundwater issues.
 - 402 took part in **Aquifer Adventure**, a pirate-themed groundwater festival geared toward families with children, including fun and educational hands-on activities about groundwater, live music and treasure hunt
 - 30 people rode in **Cycle the Well Field**, a 16-mile bike ride with groundwater experts through the Columbia South Shore Well Field
 - 42 people attended **Groundwater 101**, a half-day class focusing on the basics of groundwater, local hydrogeology, groundwater's importance to the region and how to protect it
 - 219 learned from the **Slough School Groundwater Curriculum**, developed as part of the Columbia Slough Watershed Council's Slough School, which includes a groundwater model
 - 135 attended the **Clean Water Festival**, a set of classes about groundwater and groundwater protection using a hands-on groundwater model

Bureau of Transportation

- **Stormwater Bicycle Tours** – BES and PBOT partner to lead bicycle rides educating groups of stormwater facilities throughout the city.
 - 90 attendees participating in four tours

WATERSHED COUNCILS & COMMUNITY ORGANIZATIONS



Volunteer tree planting at Dickinson Park

Watershed councils play a fundamental role in engaging a wide variety of community stakeholders in working to achieve watershed health goals. These are locally organized, voluntary, non-regulatory groups established to improve watershed conditions. Councils are made up of community members, local jurisdictions, business people and representatives of nonprofit organizations. A key benefit of councils is their ability to work across jurisdictional boundaries and beyond agency mandates to address issues throughout a watershed. Three active councils work in Portland watersheds to improve water quality, enhance riparian and upland habitats, inform

community members and foster stewardship (OWEB 2009):

- Johnson Creek Watershed Council
- Columbia Slough Watershed Council
- Tryon Creek Watershed Council

In addition, nonprofit organizations, “friends” organizations and volunteer groups also provide essential education, stewardship, volunteer and advocacy opportunities around watershed health issues. Table 10 provides a sampling of organizations actively focusing on stewardship and restoration activities within Portland watershed.

<p>All Watersheds</p> <ul style="list-style-type: none"> • Friends of Trees • SOLV <p>Fanno and Tryon Creeks</p> <ul style="list-style-type: none"> • Bridlemile Creek Stewards • Dickinson Park Stewards • Fans of Fanno Creek • Friends of April Hill Park • Friends of Marshall Park • Friends of Tryon Creek State Park • Friends of Vermont Creek • Friends of Woods Park • North Ash Creek Neighbors • Three Rivers Land Conservancy • Tryon Creek Watershed Council • Tryon Life Community Farm • Tualatin Riverkeepers 	<p>Columbia Slough</p> <ul style="list-style-type: none"> • Columbia Slough Watershed Council • Friends of Smith and Bybee <p>Johnson Creek</p> <ul style="list-style-type: none"> • Friends of Tideman Johnson Park • Friends of Errol Wetlands • Friends of Powell Butte • Johnson Creek Watershed Council • Zenger Farm <p>Willamette River</p> <ul style="list-style-type: none"> • No Ivy League • Forest Park Conservancy • Friends of Baltimore Woods • Friends of Marquam Nature Park • Friends of Mount Tabor • Friends of Oaks Bottom • Friends of Ross Island
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³⁸ This sampling is subset of the organizations that provide valuable stewardship efforts in Portland watersheds.

TABLE 10. STEWARDSHIP AND RESTORATION ORGANIZATIONS BY WATERSHED³⁸

	<ul style="list-style-type: none"> • Friends of Terwilliger • South Portland Riverbank Planning Team • Stewards of Stephens Creek • Willamette Riverkeeper
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COMMUNITY ATTITUDES

The ability to continue to improve watershed health depends upon an informed, concerned and engaged community. Community attitudes shape policy choices and help prioritize public investments. Over the past several years, community members have shared their thoughts about environmental issues through several public processes, including *visionPDX*, Portland Plan workshops and summits, and Metro’s Regional Attitudes toward Population Growth and Land Use Issues report. While these efforts were initiated for different reasons, various themes emerge that can inform and encourage strategies for improving watershed health.

Portland residents are knowledgeable and concerned about urban hydrology. They want more sustainable stormwater projects, such as green streets, ecoroofs and rain gardens more integrated within the urban fabric. Most people support restoration projects that enhance habitat, improve recreation opportunities and improve watershed health. However, they are concerned with the costs associated with these projects.

Residents also support habitat conservation, land acquisition and habitat restoration projects. In *visionPDX: Voices from the Community*, one resident stated, “We should boast to other cities how we have wild trout and salmon in our urban streams.” People want to reduce development in or around natural areas and would like more programs that support conservation before restoration. Another resident quoted in the *River Renaissance 2004 Strategy Report* declares: “We want our rivers and streams to be clean enough to provide habitat for native fish and wildlife, and to be places of natural beauty for all to enjoy.”

Portland residents also want more opportunities for volunteerism. A resident quoted in the *River Renaissance 2004 Strategy Report* states: “We want to be involved in reclaiming our rivers and streams, and to know we are making a difference at home, at work, and in the community.” The public feels that in order to increase stewardship from all citizens, there could be increased training and incentive opportunities.

In Spring 2010, Portland Plan participants ranked watershed health in the top five priority issues, of over 20 identified. Participants emphasized the importance of having clear information about the impacts of individual actions on the natural environment. They placed a high priority on clean-up of the Willamette River and called for ensuring that all Portland residents have access to nature.

STEWARDSHIP, EDUCATION & PUBLIC INVOLVEMENT – SUMMARY AND A LOOK AHEAD

Improving the health of Portland's watersheds is only possible with the work of the numerous organizations and partnerships. Portlanders are taking action: School children learn about clean rivers and plant native trees. Developers, architects and property managers attend ecoroof seminars. Neighbors join together to restore a segment of a creek or to find out how to transform their block with a green street.

Sustainable stormwater projects installed at schools, churches and parking lots lead to a greater understanding of urban hydrology and an acceptance of green infrastructure. Restoration projects serve as catalysts for increased community stewardship in natural areas. The newly formed "Stewards of Stephens Creek" came together through public involvement for the Stephens Creek restoration project, and community members are now galvanizing around restoration efforts on Crystal Springs.

Through surveys and outreach events, Portlanders continue to express their support of a healthy environment. They consistently call for increased habitat, improved recreation opportunities and improved watershed health. In order to achieve the goals of the PWMP, stewardship, education and public involvement efforts should continue.

CHAPTER 10: IMPLICATIONS

According to Metro projections, Portland will grow by 105,000 to 136,000 households by the year 2035³⁹. Accommodating that growth will intensify many of the challenges of protecting and improving watershed health. In order to address these challenges, the City will need to adopt new approaches for allocating growth, constructing buildings, designing streets and stormwater systems, and providing open space.

Although Portland has come a long way since the days when sewage and industrial waste were regularly dumped into the Willamette River, ecological processes continue to weaken under the pressures of increasing impervious areas, spreading invasive species, loss of vegetation, hardening of riverbanks and a myriad of other problems. Without thoughtful interventions, threatened fish and wildlife species will continue to decline and Portlanders will experience an increasingly polluted environment.

The previous sections of this report provided a view of current conditions in the Portland area from a watershed health perspective. The days have passed when floodplains, wetlands and riverfronts were indiscriminately filled or when rivers were visibly polluted from industrial waste. These days, it is the combined result of individual actions that pose the greatest threat: each hardened stream bank, pavement project, gallon of pesticide, or vegetation removed that gradually degrades the environment. Individual actions can yield positive benefits as well in each foot of streambank revegetated, culvert removed, or property that is Naturescaped. With the adoption of the *Portland Watershed Management Plan (PWMP)*, a more holistic approach to protect and restore natural conditions is being implemented to improve natural conditions.

DEVELOPMENT-RELATED CHALLENGES

Despite the variety of laws, regulations, plans, strategies and actions aimed at protecting or improving the natural environment, a number of issues continue to be stumbling blocks to further progress. Watershed managers at BES identified a number of development-related challenges they encounter on a regular basis. Their responses are grouped in the following categories:

Environmental Overlay Zones

- Many ecologically important sites are not covered by environmental overlay zones. An analysis of the draft NRI determined that approximately 45% of recently ranked resources are outside of existing overlay zones. Approximately 16% of those not currently protected by environmental overlay zones are classified as high-ranked resources.

³⁹ City of Portland. *Portland Plan Housing Demand and Supply Projections*. Fall 2009. <http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=283476>

Watershed Health

- The environmental conservation overlay zone limits the amount of development that can occur in a resource area. However, as development occurs in the conservation zone resource functionality can be degraded. In addition to the zoning provisions, consider the implementation of tools that will result in improved resource functionality, including tools that encourage landscaping with native plants, the use of sustainable stormwater facilities, or habitat restoration.
- Consider adding a provision to the environmental overlay zoning code to promote restoration of natural resources when development is happening on other parts of the same site, or within other parts of the sub-watershed. For example, when Costco proposed additional development on its site, the provisions in the Columbia Slough South Shore Plan District prompted Costco to remove part of a parking lot that was located within the environmental protection zone. By expanding this provision citywide, property owners would have the flexibility to propose restoration of missing or degraded habitat in a way that compliments proposed development.
- Revisions are needed to expand the consideration for “native plants” to “native plant habitat types.” For example, if a Douglas fir is encroaching on oak habitat it is difficult to obtain a permit to remove the fir, even if the oak is part of the desired and rarer native habitat type.
- The code is written to handle the impacts of development. The processes should be simplified for restoration projects in or adjacent to water bodies.

Other Zoning Code Provisions

- Zoning provisions should limit or prohibit commercial development on industrially-zoned sites in order to safeguard land for industrial uses, and reduce the demand to convert open space and environmentally-sensitive land into industrial sites.
- The code provisions for trails, such as the Columbia Corridor Trail, need to be further clarified to ensure that dedicated trail easements are secured through the development process.
- The floodplain is inaccurately mapped, which continues to allow development to occur in areas that are known to flood on a recurrent basis.
- Floodplain provisions should consider the potential expansion of floodplains due to changed weather patterns and sea-level due to climate change.⁴⁰
- National NOAA Fisheries released a biological opinion regarding Federal Emergency Management Agency’s (FEMA) administration of the National Flood Insurance Program (“NFIP”) in the Puget Sound region - the opinion stated that the program jeopardizes several threatened species and their critical habitat, which could have implications for local floodplain regulations and development (NOAA 2008).

⁴⁰ The Willamette River is influenced by tidal changes, so changes in sea level could change its floodplain.

Habitat

- The City of Portland and Metro have robust natural area acquisition programs. However, these programs, even when paired with environmental overlay zones, are not sufficient to protect or enhance all significant natural resources.
- Maintenance of natural areas can be costly and difficult. New management and/or funding approaches are needed to preserve the quality of natural resources.
- Invasives pose a significant threat to habitat quality. For both public and private property owners, the magnitude of the problems posed by invasive species like ivy, blackberry and clematis is overwhelming. At the same time, new invasive species are being introduced to the region, threatening to exacerbate habitat management issues. While the Grey-to-Green Program provides near-term funding to address this issue, long-term funding is needed to hold the line or make progress toward controlling the spread of invasive species.
- The need for habitat preservation and enhancement sometimes conflicts with the need to provide land for industrial development. Focused efforts are needed to explore how to support watershed health goals and jobs goals, especially in the Columbia Slough and the Portland Harbor.

Urban Forestry

- Tree removal has implications for stormwater management, erosion control and mitigating the impacts of climate change. Implementation of the City's new tree ordinances in 2013 should provide more effective tree protection than previous regulations.
- The street tree list does not allow enough native or large-canopy trees.
- Tree mitigation sites should be identified where the urban canopy can be expanded if it is not possible to accommodate sufficient trees on a newly developed site.
- Greater recognition is needed of the threats posed by invasive species and the benefits of their early detection and rapid removal.
- Maintenance costs can deter people from planting and caring for street trees. New methods of funding street tree planting and maintenance could recognize street trees as essential public infrastructure.

Stormwater Management

- Meeting Stormwater Management Manual requirements for infiltration is particularly challenging in areas with high groundwater. New standards should be developed to address stormwater requirements in these areas, especially those adjacent to sensitive natural resources and drinking water wells.
- Incentives and education are needed to encourage private parties to do more than the minimal amount required in the Stormwater Management Manual. These could be especially targeted to areas where stormwater problems exist (e.g. Tabor to the River).
- High density or "zero lot-line" development, especially along transportation corridors, does not allocate space for stormwater planters, rain gardens or other landscaped stormwater facilities. Areas where high density is a priority should be delineated and

Watershed Health

appropriate strategies for these areas, such as ecoroofs, should be developed to address stormwater requirements.

- More thorough training is needed for professionals involved in the design, plan review, construction, inspection and maintenance of stormwater facilities.
- Consider limiting impervious area coverage for residential areas and/or setting an overall impervious area targets for the city.
- In addition to streets, multiple bureaus have interests in what happens within rights-of-way including Parks (urban forestry), Water, Transportation (parking, sidewalks, bike facilities), and Environmental Services (sanitary and stormwater). New approaches are needed to manage these public needs within limited rights-of-way widths.

Development Review and Enforcement

- At times, a development plan is approved that complies with the Stormwater Management Manual and then the facilities then are not built. More attention needs to be paid to enforcement to ensure that stormwater management outcomes are achieved.
- Encroachment into environmental overlay zones (e.g. parking, paving, tree cutting, clearing) can occur due to insufficient enforcement. There are concerns that environmental protection overlay zoning may be removed from degraded sites, which could prompt further degradation.
- In some cases, development is allowed to occur next to the stream bank. Stricter riparian area buffers are needed, such as those found in other jurisdictions.
- It would be helpful to document and track when sensitive sites are developed or removed from environmental zone protection to provide an understanding of the net losses over time.
- Land use reviews focus on the site-by-site issues and do not sufficiently account for the cumulative impacts of development on the natural systems.

Policy

- Consider setting a “no-net loss” policy for environmental resources, so that all environmental impacts of development are mitigated through corresponding environmental enhancements.
- City projects need to consistently adhere to the green building policy.
- Policy choices need to be informed by current scientific data.

Planning

- City sewers/drainage service plans should be considered when establishing long-range planning for development. Currently, parts of the city do not have sufficient infrastructure and are not planned to have extensions in the future.
- Greater attention is needed on to increase natural area parks in parks-deficient neighborhoods.
- Long-range planning should develop strategies to protect and improve the connectivity of streams and upland habitat.

Portland Plan

- Planning processes need to more thoughtfully consider the impacts of upstream and upland activities on downstream properties, floodplains and overall watershed health conditions.

Communication/Education

- Community members need more information about the economic and other values of natural systems – their ecosystem services. These values should be translated into the City’s asset management approaches.
- Further education assistance is needed to help individuals recognize how their actions and choices can influence watershed health.
- Property owners need technical assistance to aid them in caring for privately-owned habitat.

CRITICAL QUESTIONS

Currently the Comprehensive Plan lacks sufficient policies to address many contemporary natural resource issues including the ones described above. The information provided in this report highlighted natural resource conditions and management practices that has evolved since the original Comprehensive Plan was developed. As the Portland Plan sets priorities for the City’s future, some critical questions should be considered:

Citywide

- How can watershed health be maximized, while accommodating population growth, promoting job and economic growth, and creating compact urban communities?
- How can land use and transportation planning be informed and guided by the characteristics of natural systems, including slopes, streams, groundwater, habitat areas, and floodplains?
- How can natural functions be considered and incorporated into planning for highly urban areas like the central city?
- How could a contemporary understanding of “Nature in the City” enhance the urban form and urban design of Portland communities?
- What would it mean to consider natural resources (including tree canopy, aquifers, open spaces, streams and wetlands) as part of the city’s infrastructure?
- How can the City maximize infrastructure investments to most effectively meet goals for stormwater management, transportation, environmental health and community livability?
- How can cumulative environmental losses and/or gains be considered in transportation and land use decision-making?
- How do we increase awareness of the connections between human quality of life and watershed health?
- How do we mitigate for and adapt to climate change to ensure ecological resiliency and the ongoing health and safety of Portlanders?
- How can the City ensure protections for significant natural resources given limited funding for property acquisition and management, and public attitudes toward land use regulations?

Hydrology and Water Quality

- How should the relationship between increased impervious area and decreased water quality be addressed in areas targeted for growth?
- How can the City develop an integrated strategy to expand the urban forest and improve its health in order to maximize benefits for hydrology, water quality, etc.?
- How can planning and development review processes prevent the cumulative impacts of development?
- How should the City support efforts to clean up brownfield sites and remove legacy pollutants from the water cycle?

Biological Communities and Habitats

- How should degraded habitats be improved and connections between habitat areas reestablished?
- How should threats from existing, establishing and emerging invasive species be handled?
- How can decisions about urban form protect and enhance habitat and reduce risk from hazards such as landslides and floods?
- What would it take to achieve and sustain a healthy, connected and diverse array of habitat types within Portland?
- How can planning processes accommodate differing environmental management needs? For example, old trees are cut down because of concerns for human safety, but often provide important habitat for bird or bat species. Vegetation is cleared for wildfire protection that may provide critical habitat for some species.
- How can we design buildings, bridges, lighting, communication towers, transmission lines, landscaped areas, etc. in a way that provides habitat and/or minimizes risks to birds and other wildlife?
- How should Portland's habitat preservation and enhancement efforts link to those of neighboring jurisdictions and Metro's regional efforts?

Stewardship and Education

- How can the City work more effectively with stewardship groups, nonprofit organizations and community members to maintain and enhance Portland's natural resources and green infrastructure?
- How can the City increase awareness about non-point source pollution and reduce the impacts of landscaping practices and "Priority Persistent Pollutants"?
- How can the City ensure that all Portland youth have access to nature and achieve a basic environmental literacy, given limited school and local government funding?

REFERENCES

Audubon Society of Portland. *Cats and Wildlife*. Website confirmed November 2011.

<http://www.audubonportland.org/backyardwildlife/brochures/cats>

Audubon Society of Portland. *Portland Christmas Bird Count*. Website confirmed November 2011.

http://www.audubonportland.org/local-birding/christmas_count

Batker, David, et. al., Earth Economics. *A New View of the Puget Sound Economy: The Economic Value of Nature's Services in the Puget Sound Basin*. 2008.

http://www.eartheconomics.org/FileLibrary/file/Reports/A_New_View_of_the_Puget_Sound_Economy.pdf

Birds and Buildings Forum. Birds and Buildings website. Confirmed November 2011. <http://www.birdsandbuildings.org/index.html>.

City of Portland *Terrestrial Ecology Enhancement Strategy: Review Draft*. August 22, 2007.

City of Portland *Terrestrial Ecology Enhancement Strategy: Summary and Update*. June 2011.

<http://www.portlandonline.com/bes/index.cfm?c=51052&a=354986>

City of Portland Bureau of Environmental Services – *Clean River Plan*. March 2000.

<http://www.portlandonline.com/bes/index.cfm?c=45548&a=326137>

City of Portland Bureau of Environmental Services – *Controlling Combined Sewer Overflows*.

October 2011. <http://www.portlandonline.com/bes/index.cfm?c=31030&a=316721>

City of Portland Bureau of Environmental Services – *Draft Portland Plan Comprehensive Plan Evaluation. Environment Technical Working Group*. March 2008.

<http://www.portlandonline.com/portlandplan/index.cfm?c=47108&a=191223>

City of Portland Bureau of Environmental Services – *Draft Watershed Characterization Summary*. March 2004.

City of Portland Bureau of Environmental Services - *Framework for Integrated Management of Watershed Health*. December 2005a. <http://www.portlandonline.com/bes/index.cfm?c=33528>

City of Portland Bureau of Environmental Services – *Invasive Plants Strategy Report*. October 30,

2008. <http://www.portlandonline.com/bes/index.cfm?c=47815&a=332727>

City of Portland Bureau of Environmental Services – *Portland Watershed Management Plan. Actions for Watershed Health*. 2005b. <http://www.portlandonline.com/bes/index.cfm?c=38965>

Watershed Health

City of Portland Bureau of Environmental Services – *Portland Watershed Management Plan*. – *Annual Reports* (2007 - Current) <http://www.portlandonline.com/bes/index.cfm?c=38965&a=370062>

City of Portland Bureau of Environmental Services – Portland Watershed Characterizations:

- Columbia Slough - <http://www.portlandonline.com/bes/index.cfm?c=36079&>
- Johnson Creek - <http://www.portlandonline.com/bes/index.cfm?c=33212&a=214368>
- Fanno Creek - <http://www.portlandonline.com/bes/index.cfm?c=43097&a=128492>
- Tryon Creek - <http://www.portlandonline.com/bes/index.cfm?c=43097&a=128492>
- Willamette River - <http://www.portlandonline.com/bes/index.cfm?c=31806>

City of Portland Bureau of Environmental Services. *Stormwater Permit Year 13 Annual Compliance Report* (FY 2007 - 2008). <http://www.portlandonline.com/bes/index.cfm?c=50289&a=371659>

City of Portland Bureau of Environmental Services. *TMDL Implementation Plan*. March 31, 2008. (No longer available on-line; for related information see: <http://www.deq.state.or.us/wq/willamette/willamette.htm>.)

City of Portland – Bureau of Environmental Services. *Watershed Assessment Summary*. October 2004. <http://www.portlandonline.com/bes/index.cfm?&a=65171>

City of Portland – Bureau of Environmental Services. *Wildlife of Portland*. (poster). June 2010. <http://www.portlandonline.com/bes/index.cfm?a=371508&c=51269>

City of Portland – Bureau of Planning. *Comprehensive Plan Goals and Policies*. Adopted October 1980. <http://www.portlandonline.com/planning/index.cfm?c=34249>

City of Portland – Bureau of Planning. *Natural Resource Inventory Update – Riparian Corridors and Wildlife Habitat*. Discussion Draft. August 2007. <http://www.portlandonline.com/bps/index.cfm?c=40439>

City of Portland – Bureau of Planning and Sustainability. *Climate Action Plan 2009*. October 2009. <http://www.portlandonline.com/bps/index.cfm?c=49989&a=268612>

City of Portland, Bureau of Planning and Sustainability. *Hayden Island Natural Resources Inventory: Riparian Corridors and Wildlife Habitat; Public Review Draft*. June 2011. <http://www.portlandonline.com/bps/index.cfm?a=355337&c=55273>

City of Portland, Bureau of Planning and Sustainability. *Middle Columbia Corridor/Airport Natural Resources Inventory: Riparian Corridors and Wildlife Habitat*;

Portland Plan

Final Report. May 2011. <http://www.portlandonline.com/bps/index.cfm?c=50484>

City of Portland – Bureau of Planning and Sustainability. *Natural Resource Inventory Analysis: Watershed Statistics*. 2/16/2012.

City of Portland – Bureau of Planning and Sustainability. *Portland Plan Housing Demand and Supply Projections*. Fall 2009.
<http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=283476>

City of Portland – Bureau of Planning and Sustainability. *Portland Plan Infrastructure Capacity and Condition Background Report*. Fall 2009.
<http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=270882>

City of Portland – Bureau of Planning and Sustainability. *Portland Plan Natural Resource Inventory Background Report*. Fall 2009.
<http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=270883>

City of Portland – Bureau of Planning and Sustainability. *Portland Plan Urban Forestry Background Report*. Fall 2009. <http://www.portlandonline.com/portlandplan/index.cfm?c=51427&a=270889>

City of Portland – Parks and Recreation. *Portland's Urban Forest Canopy. Assessment and Public Tree Evaluation*. October 2007.
<http://www.portlandonline.com/parks/index.cfm?a=171829&c=38306>

City of Portland, Bureau of Planning and Sustainability. *Willamette River Natural Resource Inventory Report: Riparian Corridors and Wildlife Habitat; Proposed Draft*. July 2008. Inventory Site WR1: Kelley Point Park. <http://www.portlandonline.com/bps/index.cfm?c=44745&a=158891>

City of Portland – River Renaissance. *2005 State of the River Report*. January 2006.
<http://www.portlandonline.com/river/index.cfm?c=43324&a=105003>

City of Portland – River Renaissance. *2007 State of the River Report*. Fall 2008.
<http://www.portlandonline.com/ohwr/?a=292727&c=51916>

City of Portland – River Renaissance. *2004 Strategy Report*. December 2004.
<http://www.portlandonline.com/ohwr/?a=292735&c=51916>

City of Portland – River Renaissance. *Willamette River Conditions Report*. October 2004.
<http://www.portlandonline.com/ohwr/?a=292728&c=51916>

City of Portland – *visionPDX*. 2007. <http://www.visionpdx.com/reading/visiondocument/>

City of Portland – Water Bureau. *Discover Your Drinking Water*. Fact sheet. No date.

Watershed Health

Climate Leadership Initiative, Institute for a Sustainable Environment, University of Oregon. *Lower Willamette Subbasin: Natural Systems Workshop Summary Report*. April 2010. <http://www.portlandonline.com/portlandplan/index.cfm?a=326864&c=51427>

Corporation for National and Community Service. *Volunteering in America Research Highlights*. July 2009. <http://www.volunteeringinamerica.gov/assets/resources/VolunteeringInAmericaResearchHighlights.pdf>

David Evans and Associates, Inc. and ECONorthwest. *Comparative Valuation of Ecosystem Services: Lents Project Case Study*. June 2004. [http://yosemite.epa.gov/SAB/sabcvpress.nsf/b3172537ac8bc12b85256dbf0056c462/7d3938054039aeee85256ed70050b52f/\\$FILE/Lents%20Project%20Final%20Submittal%20June.pdf](http://yosemite.epa.gov/SAB/sabcvpress.nsf/b3172537ac8bc12b85256dbf0056c462/7d3938054039aeee85256ed70050b52f/$FILE/Lents%20Project%20Final%20Submittal%20June.pdf)

ECONorthwest. *Economic Arguments for Protecting the Natural Resources of the East Buttes Area in Southeast Portland*. May, 2009. <http://www.econw.com/>

Johnson, D. and O'Neil, T., eds. *Wildlife-Habitat Relationships in Oregon and Washington*. Oregon State University Press. 2001. <http://osupress.oregonstate.edu/book/wildlife-habitat-relationships-in-oregon-and-washington>

Lower Willamette Group. (LWG). *Portland Harbor RI/FS Remedial Investigation Report. Draft Final*. 2011.

Metro. *State of the Watersheds Monitoring Report*. December 2006. <http://www.oregonmetro.gov/index.cfm/go/by.web/id=27579>

NOAA. National Marine Fisheries Service. 2009. <http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/>

NOAA. National Marine Fisheries Service. *Endangered Species Act – Section 7 Consultation Final Biological Opinion: Implementation of the National Flood Insurance Program in the State of Washington Phase One Document – Puget Sound Region*. September 22, 2008. http://online.nwf.org/site/DocServer/NMFS_Puget_Sound_nfip-final-bo.pdf?docID=10561

Netusil N.R. and S. Chattopadhyay. *Economic Benefits of Large Patches of Tree Canopy: A Second-Stage Hedonic Price Analysis Conference Proceedings*. W-1133 2005 Annual Conference, Salt Lake City, Utah. 2005. <http://ideas.repec.org/a/uwp/landec/v86y2010i2p281-293.html>

New York City Audubon. *Bird-safe Building Guidelines*. Website confirmed November 2011. <http://www.nycaudubon.org/home/BirdSafeBuildingGuidelines.pdf>

Oregon Department of Environmental Quality. Oregon Water Quality Index Summary Report, Water Years 1997-2006. (May 2007)

Oregon Department of Environmental Quality. Total Maximum Daily Load's Program. Website confirmed November 2011. <http://www.deq.state.or.us/wq/tmdls/tmdls.htm>

Oregon Department of Environmental Quality. *Willamette Basin TMDL*. June 2004. <http://www.deq.state.or.us/WQ/willamette/willamette.htm>

Oregon Department of Environmental Quality. Website confirmed November 2011. <http://www.oregon.gov/DEQ/>

Oregon Department of Environmental Quality. *Fact Sheet: Implementing Senate Bill 737*. June 2011 Update. <http://www.deq.state.or.us/wq/pubs/factsheets/programinfo/09-WQ-25SB737FS.pdf>

Oregon Department of Environmental Quality. *Willamette Basin TMDL*. June 2004. <http://www.deq.state.or.us/WQ/willamette/willamette.htm>

Oregon Department of Fish and Wildlife, Ocean Salmon and Columbia River Program. – *Abundance and Distribution of Fish Species in City of Portland Streams: Completion Report 2009*. <http://www.portlandonline.com/bes/index.cfm?a=280352&c=51049>

Oregon Department of Fish and Wildlife, Ocean Salmon and Columbia River Program. – *Seasonal Composition and Distribution of Fish Species in the Lower Columbia Slough: Completion Report 2009*. <http://www.portlandonline.com/bes/index.cfm?a=291276&c=51049>

Oregon Department of Human Services. *Fish Advisories and Consumption Guidelines*. Website confirmed November 2011. <http://public.health.oregon.gov/HealthyEnvironments/Recreation/Pages/fishconsumption.aspx>

Oregon Watershed Enhancement Board. Website confirmed November 2011. http://www.oregon.gov/OWEB/WSHEDS/wsheds_councils_overview.shtml

Poracsky, Joseph & Michael Lackner. Portland State University – Geography Department. *Urban Forest Canopy Cover in Portland, Oregon, 1972 – 2002. Final Report*. April 2004. <http://web.pdx.edu/~poracskj/Cart%20Center/psucc200404-047.pdf>

Schueler, T. and H. Holland, eds. *The Practice of Watershed Protection*. Center for Watershed Protection. Ellicott City, MD. 2000. http://www.stormwatercenter.net/Library/Practice_Articles.htm

Snyder, Daniel T. *Estimated Depth to Ground Water and Configuration of the Water Table in the Portland, Oregon Area*. U.S. DOI and USGS. Scientific Investigations Report 2008-5059. <http://pubs.usgs.gov/sir/2008/5059/pdf/sir20085059.pdf>

Watershed Health

Tinus, Eric S., James A. Koloszar, David L. Ward. Oregon Department of Fish and Wildlife. "Abundance and Distribution of Fish in City of Portland Streams." Final Report 2001-03. Volume 1 – Final Report of Research. December 2003.

<http://www.portlandonline.com/bes/index.cfm?a=264238&c=51049>

U.S. Army Corps of Engineers. *Corps of Engineers Wetland Delineation Manual*. Department of the Army, Waterways Experiment Station. 1987. <http://www.wetlands.com/regis/tlpge02e.htm>

U.S. Environmental Protection Agency. "Protecting Water Resources with Higher-Density Development." No date. http://www.epa.gov/piedpage/pdf/protect_water_higher_density.pdf

U.S. Environmental Protection Agency. *Polluted Runoff (Nonpoint Source Pollution)*. Website. Accessed December 2011. <http://www.epa.gov/owow/NPS/ga.html>

U.S. Fish and Wildlife Service – Columbia River Fisheries Program Office. *Tryon Creek Restoration Monitoring Project: FY2008 Progress Report*. February 2009.

<http://tcwc.tryonfriends.org/pics/Tryon%20Creek%20Restoration%20Monitoring%20Project%202008%20Progress%20Report%20Final.pdf>