City of Seattle
State of the Waters 2007

Executive Summary
Volume I: Seattle Watercourses

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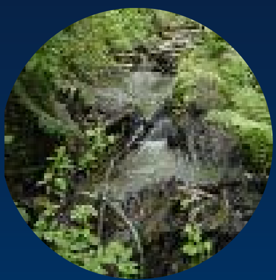
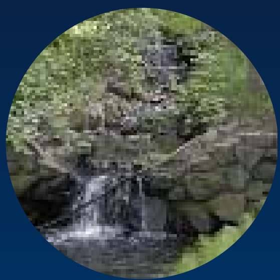
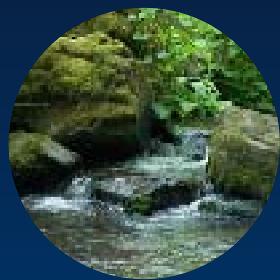


Fauntleroy

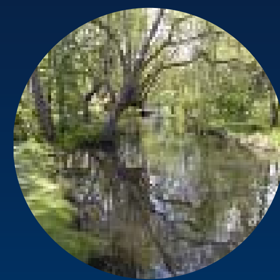


Longfellow



Piper's

Taylor



Thornton

Executive Summary

Seattle's extensive urban development over the past 150 years has drastically altered the city's watersheds. Previously forested areas and wetlands have largely been converted to residential, industrial, and commercial land uses, with some limited areas of open space. In the course of development, Seattle's watersheds have been covered by buildings, roads, parking lots, parks, and sidewalks. While urban development has created a livable environment for humans, it has brought a decline in the health of city watersheds, the water bodies that drain them, and their non-human inhabitants. By impairing the ecological health of aquatic areas, increasing urbanization continues to degrade the water resources people depend upon for human health, recreation, and aesthetic benefits.

The State of the Waters report describes the current conditions of Seattle's water bodies. This Executive Summary provides an overview of Volume I. Volume I outlines overall watershed health within the five major watercourses in Seattle, listed below. Graphics summarizing the existing conditions in each major watercourse are provided at the end of this Executive Summary.

- Fauntleroy Creek
- Longfellow Creek
- Piper's Creek
- Taylor Creek
- Thornton Creek.

For clarity, the City of Seattle has adopted the word *watercourse* to refer to the network of pipes, ditches, culverts, and open stream areas that deliver surface water from watersheds to receiving water bodies. Volume I evaluates conditions in the stream portions (open channels with banks and a streambed) of watercourses in particular.

Volume I focuses on stream hydrology, water quality, physical habitat, and biological communities, which indicate the ability of Seattle watersheds to perform critical functions and services, such as filtering water, moderating floods, and capturing sediment. The purpose is to condense and organize existing watercourse information to make it readily accessible to City of Seattle staff and interested citizens.

Identifying current conditions is a critical step for preserving and improving ecological conditions within Seattle. Accurate knowledge of existing conditions helps to inform decisions about where current improvement efforts should be continued and where efforts need to be refocused as new problems come to light. It is hoped that the Seattle State of the Waters report will help us all be aware of the role we play in protecting the health of our water bodies, and that awareness will lead to improved conditions for fish, wildlife, people, and the legacy we leave for future generations.

Volume I includes a detailed compilation of habitat and water quality data collected over the past several years. The methods used to collect and evaluate this information are described in Part 3 of Volume I. The information collected and its implications are summarized in the individual watercourse sections presented in Part 4. The habitat and water quality information is presented in a variety of formats, including narrative descriptions, and charts and data tables. Summary graphics including watershed graphics and associated maps are included in the map folio accompanying Volume I. Additional technical information about the methods and results of the analyses of aquatic conditions is included in a series of appendices.

Key Findings

- Both riparian habitat and instream habitat conditions in Seattle's urban watercourses range from relatively good (for an urban area) to poor. There appears to be a high level of correlation between the land use adjacent to a stream section and the quality of its riparian and instream habitat. Stream bank armoring and encroachment into riparian areas by roads and buildings are correlated with degraded habitat conditions on all watercourses, and particularly along Thornton Creek.

- Migratory fish can use only about one-third of the potential habitat in Seattle watercourses due to passage barriers. These barriers prevent fish from reaching some of the highest-quality habitat, particularly on Longfellow Creek and Taylor Creek.

- Physical habitat, stream flow patterns, and water chemistry collectively appear to be having adverse influences on the aquatic invertebrate species inhabiting Seattle watercourses. The results of Seattle Public Utilities (SPU) monitoring show that in most stream reaches the aquatic invertebrate communities are in poor condition compared with other Puget Sound streams. The best habitat conditions appear to be capable of only supporting fair aquatic invertebrate communities.

- Flows in Seattle watercourses appear to be flashy, with sudden high peak flows, although additional flow data are needed to provide a more accurate picture over time. High peak flows are major causes of poor instream habitat, and the adverse impacts are compounded by buildings and armoring along stream banks.

- The available water quality information for Seattle watercourses indicates that many of the chemical parameters generally meet Washington state water quality criteria for the protection of aquatic life in Seattle watercourses. However, at least some of the time, the watercourses that have been tested do not meet state criteria for fecal coliform bacteria, dissolved oxygen, and temperature. Fecal coliform bacteria levels in particular are high and frequently exceed state water quality criteria. Microbial source tracing indicates the main sources are pet and wildlife wastes.

- Metals concentrations in the urban watercourses generally meet state water quality criteria, based on limited sampling conducted mostly during non-storm conditions.

- Accurately characterizing Seattle watercourse conditions is difficult due to the limited data available, particularly for water quality and flow. Implementing a monitoring program to track status and trends for flow, water quality, and habitat, including storm and non-storm event sampling, is important for understanding watercourses, the condition of their watersheds, and the results of Seattle's collective efforts to improve conditions.

- Part 5 of Volume I provides a comparative summary of relative conditions in Seattle's five major watercourses (see also Figure ES-1). Conditions are categorized as good, moderate, or poor based on primary indicators, which are discussed in more detail throughout the report.

Factors Affecting Seattle Watercourses

Watercourse conditions are shaped by their upland watersheds, as well as by conditions immediately surrounding their margins. Watershed characteristics such as topography, geology, soils, rainfall patterns, and vegetation influence how water, sediment, wood, and nutrients are moved from land to streams or other watercourses. The hydrology and water quality of a watercourse depend heavily upon watershed conditions.

A watercourse is also affected by local features, such as the riparian corridor, which serves as the interface between the upland, terrestrial system and the aquatic environment in the watercourse. The watercourse shapes and maintains habitat using materials supplied by the watershed and the riparian zone, and provides a home for aquatic animals.

Piper's Creek (photo by Bennett)

Human influences on watercourses and their watersheds affect the interplay among watershed, riparian habitat, and watercourse conditions, resulting in changes in stream habitat and stream communities. Seattle's watershed and watercourse conditions, and their likely impacts on the overall health of watercourses within the city, are summarized below.

Watershed-Scale Conditions

Hydrology

The conversion of forested watershed areas within Seattle to developed areas with impervious surfaces has changed the processes by which upland areas deliver water to their watercourses. These impervious surfaces—roads, buildings, and parking lots—cover more than 60 percent of the land in some Seattle watersheds.

All Seattle watercourses experience high-volume, rapid peak flows (i.e., flashiness) as stormwater rapidly drains from impervious surfaces and enters constructed drainage systems for fast delivery to watercourses and other water bodies. While the Seattle Public Utilities record of flow data is limited—it covers less than the past ten years and includes only a few locations—it illustrates dramatic changes in stream flows compared to expected natural conditions in the watershed. In the five major Seattle watercourses, computer modeling indicates that flow rates and volumes from a common storm event (defined as a rainfall event that occurs on average every 2 years) have increased approximately four or five times over flows expected under forested watershed conditions.

High-volume, rapid peak flows (i.e., flashy flows) damage stream habitat, and that damage is aggravated by stream bank armoring and protection that restricts a stream from using its floodplain. The high flows trigger erosion of unarmored stream banks, which introduces fine sediment into the watercourse. Without a floodplain, there is no release valve for streams under siege from high flows, and as a result, the flows dig into the streambed and erode the gravels and cobbles needed for fish spawning and insect production. This change in stream flows resulting from urban development in the watershed is a major cause of degraded and simplified stream habitat in Seattle.

Water Quality

King County has monitored water quality in three of Seattle's major watercourses: Longfellow Creek, Piper's Creek, and Thornton Creek. Long-term records (covering ten years or more) are generally available for most conventional water quality parameters (i.e., temperature, dissolved oxygen, total suspended solids, turbidity, pH, and fecal coliform bacteria), but information on toxic pollutants such as metals and organic chemicals is fairly limited. The Washington Department of Ecology has also recently begun routine monitoring in Fauntleroy Creek. However, no data are available for other urban watercourses in Seattle (e.g., Taylor Creek and other small watercourses).

The available information indicates that Fauntleroy, Longfellow, Piper's, and Thornton creeks generally meet Washington state water quality criteria for ammonia, suspended solids, turbidity, and metals. However, temperature, dissolved oxygen, fecal coliform bacteria, and nutrients (i.e., phosphorus and nitrogen) can be problematic.

Fecal coliform bacteria levels are high and frequently exceed the state water quality standard in all four of the urban watercourses that have been tested (Thornton, Piper's, Longfellow, and Fauntleroy). Bacteria levels in Seattle watercourses are typically higher under storm flow conditions than under non-storm flow conditions, reflecting contributions from urban stormwater runoff and the effects of nonpoint source pollution. Microbial source tracing conducted in Thornton Creek and Piper's Creek shows that pets and urban wildlife (e.g., rodents and waterfowl) are the largest sources of fecal coliform bacteria. Human sources (e.g., leaking sanitary sewer systems) appear to be minor contributors to high fecal coliform levels.

Water temperature is a critical water quality variable, influencing fish metabolism, as well as dissolved oxygen concentrations. Dissolved oxygen concentrations and water temperature exhibit distinct seasonal patterns. For example, temperatures are generally higher in the summer and lower in the winter, while dissolved oxygen levels decrease in summer months and rise in the winter. During the summer, the lack of riparian vegetative cover and limited base flow likely account for higher temperatures and lower dissolved oxygen concentrations, particularly in Longfellow Creek and Thornton Creek, which frequently fail to meet state water quality criteria for temperature and dissolved oxygen during the summer months. In comparison, Piper's Creek and Fauntleroy Creek, which pass through steep forested ravines with tree canopies that are largely protected from development, do not experience temperature and dissolved oxygen problems.

No state water quality criteria have been established for nutrients. However, total nitrogen and total phosphorus concentrations in Longfellow Creek, Piper's Creek, and Thornton Creek frequently exceed established U.S. Environmental Protection Agency criteria. Exceedances in Longfellow Creek and Piper's Creek generally occur more frequently during storm flow conditions. Thornton Creek experiences occasional exceedances of the nutrient benchmarks under non-storm flow conditions; no data are available for storm flow conditions.

Data on metals and organic pollutants are very limited and have been collected primarily under non-storm flow conditions. The available data indicate that metals concentrations in Seattle urban watercourses generally meet state water quality criteria. Similar to fecal coliform bacteria patterns, most metals concentrations are higher in storm flow samples than in non-storm flow samples due to contributions from urban stormwater runoff. An exception is zinc, which exhibits comparable concentrations in storm and non-storm samples.

Pollutants in watercourses have larger direct effects on the plants and animals than on physical stream conditions. Pollutants can trigger growth in bacteria or algae, or injure or kill plants and animals. For example, too much of a nutrient such as phosphorus can cause algal blooms, which can reduce dissolved oxygen levels and affect the lower levels of the food web, with spiraling consequences to all species in the web. Heavy metals, on the other hand, can injure aquatic life when present in lower concentrations, or can cause death at higher concentrations. Metals can also be ingested or absorbed by animals at the base of the food web and accumulate in larger animals higher in the food web. Water pollution ultimately results in a less diverse aquatic community and could affect human health.

Stream-Scale Conditions

Riparian Habitat

Riparian corridor along Piper's Creek (photo by Bennett)

Riparian conditions along Seattle's major watercourses are heavily influenced by land use. Almost all high-quality riparian areas within the city are found within park areas, where deciduous and coniferous trees provide stream canopy, and where native plants help to stabilize stream banks. These riparian areas are often wide, extending more than 200 feet from the stream. The riparian zones along Piper's Creek and Taylor Creek are dominated by high-quality habitat (along 65 percent or more of these watercourses) located almost exclusively within city parks. However, these riparian areas face challenges from invasive plant species like English ivy and Himalayan blackberry.

Low-quality riparian areas are dominated by grass, invasive plants, and the absence of trees to provide shade and bank stability. These low-quality riparian areas are found near residential and commercial land uses where invasive plants are either allowed to take over or where land owners replace native plants with ornamental species. For example, Thornton Creek, which has the highest percentage of its watershed in residential and transportation uses, also has less than 10 percent of its riparian area in good condition. Low-quality riparian areas, which are more susceptible to stream bank erosion (where banks are not armored), allow sunlight to heat the stream, and disrupt the connections between riparian and instream processes and habitats.

Instream Habitat

Instream habitat quality varies widely among Seattle watercourses and within individual watercourses. In general, habitat quality is challenged by high-volume, rapid peak flows (flashy flows), the lack of floodplain connections to relieve habitat damage caused by high flows, and a scarcity of large instream wood to create diverse habitat and scour pools. These factors lead to simple, uniform stream conditions, where gravel and cobble sediments that support instream biota are scarce and pools are sparse.

Immediately adjacent land uses appear to have substantial effects on instream and riparian conditions. High-quality instream habitat typically is found in open spaces, such as in Carkeek Park in the Piper's Creek watershed, and in Lakeridge Park in the Taylor Creek watershed. Most park areas have limited bank armoring, and buildings and roads are located at a distance from open stream channels, promoting stream and riparian processes that maintain habitat. However, even areas with higher-quality habitat tend to lack the number and quality of pools and woody debris that would be expected in less intensively used watersheds.

Lower-quality instream habitats suffer from bank armoring, nearby encroachment, and degraded riparian areas, which often coincide with adjacent residential and commercial land uses. Both Longfellow Creek and Thornton Creek, which have development along most of the length of the watercourse, have large percentages of lower-quality habitat and rather small percentages of high-quality instream habitat.

Lower section of Thornton Creek (photo by Bennett)

Biological Communities

Chinook salmon (photo courtesy Seattle Municipal Archives)

To help evaluate the biological health of Seattle watercourses, Seattle Public Utilities routinely examines stream-dwelling fish and benthic invertebrates within the five major watercourses of Seattle.

The types of fish using Seattle's major watercourses vary by watercourse and receiving water body (e.g., Puget Sound, Lake Washington, or the Duwamish River). Common fish species include cutthroat trout, salmon, stickleback, sculpin, lamprey, and nonnatives such as sunfish. Fish within Seattle watercourses are limited by passage barriers such as culverts and weirs. Migratory salmon and trout can access about one-third of the potential stream habitat in the five major systems. Some of the inaccessible habitat is of the highest quality, particularly in Longfellow Creek and Taylor Creek.

Seattle watercourses are not in sufficiently good condition to support diverse or abundant fish communities. Many coho salmon die before they are able to spawn, a phenomenon known as coho prespawn mortality. Average coho prespawn mortality rates have ranged annually between 39 and 79 percent, although rates can vary widely from year to year and from watercourse to watercourse. A specific single cause of coho prespawn mortality has not yet been determined; it is possible that many factors, including water pollutants, work in combination to cause prespawn mortality. Habitat conditions, such as the lack of pools and woody debris in streams, limit rearing opportunities for juvenile salmon and other fish.

Because benthic invertebrates are sensitive to human disturbance, as well as being abundant, easy to collect, and nonmigratory, they are used as an indicator of biological integrity in streams. The benthic invertebrate communities of Seattle watercourses are typically dominated by species that can tolerate degraded conditions, such as aquatic worms and midges, and have low diversity. Seattle Public Utilities uses the benthic index of biotic integrity (B-IBI) to measure the health of a watercourse based on the numbers and kinds of stream-dwelling insects present. A comparison of the benthic index results for Seattle watercourses with other streams in the Puget Sound region shows that most Seattle watercourses are in poor condition. Fauntleroy Creek, which is considered to be in only fair condition, received the highest (best) scores among the five major watercourses. Thornton Creek and Longfellow Creek received the lowest scores.

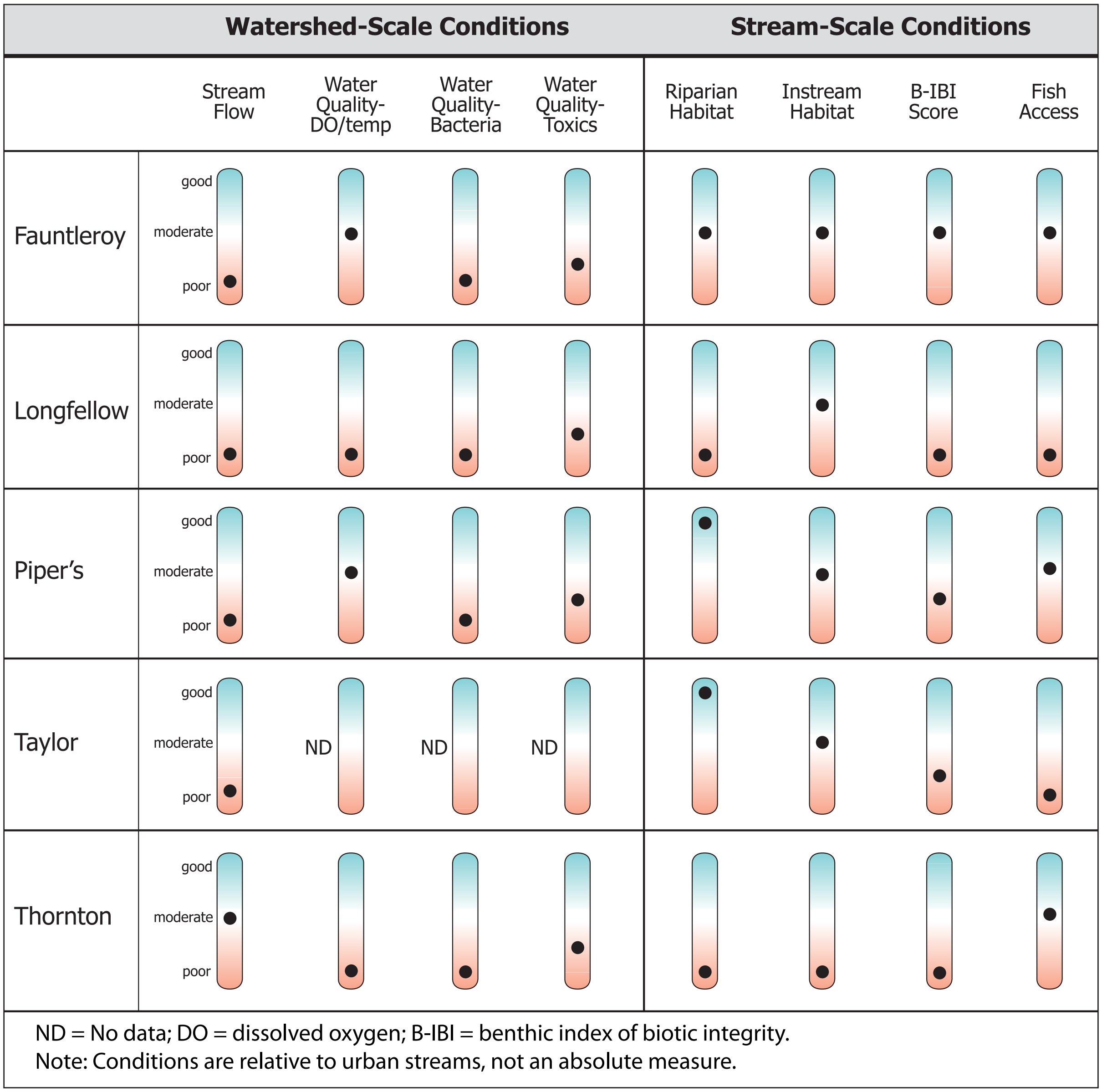


Figure ES-1. Summary of watershed-scale and stream-scale conditions within Seattle's five major watercourses.

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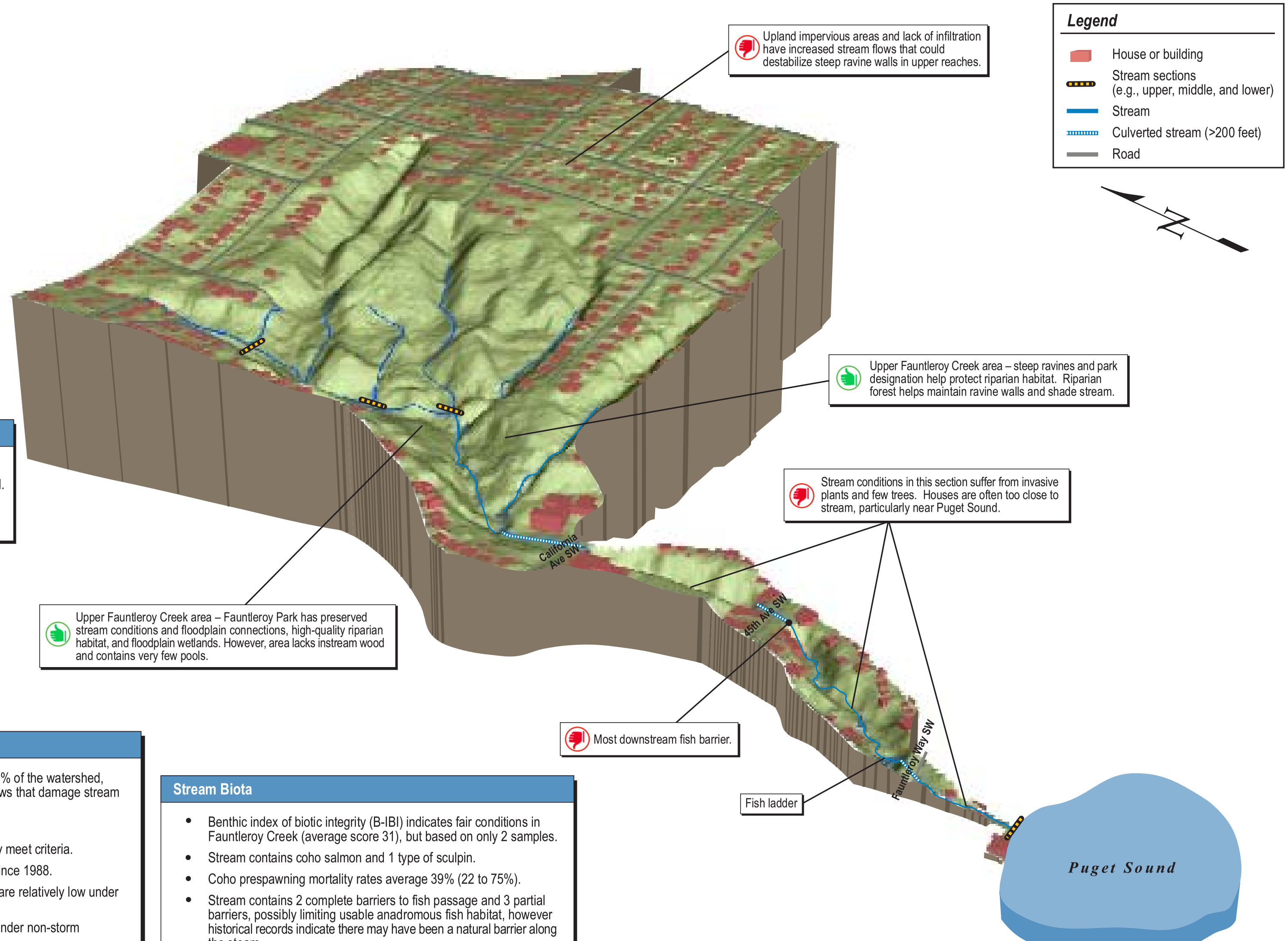
Unique Conditions

- Smallest watershed of Seattle streams (0.23 mi^2).
- Fauntleroy Park covers a large proportion of the watershed.
- Mostly residential land use.
- Drains to Puget Sound.



Watershed Conditions*

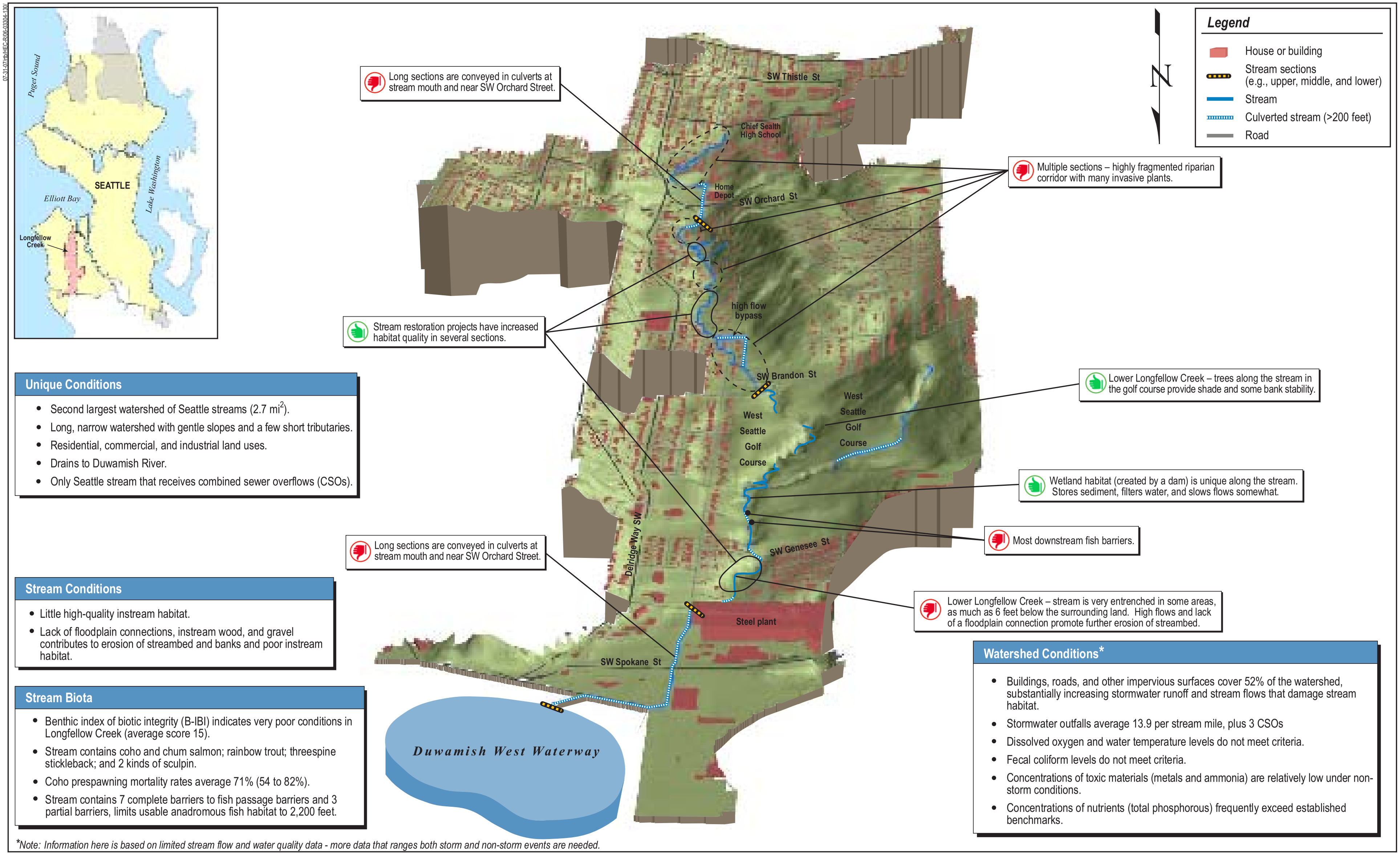
- Buildings, roads, and other impervious surfaces cover 38% of the watershed, substantially increasing stormwater runoff and stream flows that damage stream habitat.
- Stormwater outfalls average 5.6 per stream mile.
- Dissolved oxygen and water temperature levels generally meet criteria.
- Fecal coliform levels exceed criteria, but have declined since 1988.
- Concentrations of toxic materials (metals and ammonia) are relatively low under non-storm conditions.
- Concentrations of nutrients (total phosphorous) are low under non-storm conditions.

Stream Biota

- Benthic index of biotic integrity (B-IBI) indicates fair conditions in Fauntleroy Creek (average score 31), but based on only 2 samples.
- Stream contains coho salmon and 1 type of sculpin.
- Coho prespawning mortality rates average 39% (22 to 75%).
- Stream contains 2 complete barriers to fish passage and 3 partial barriers, possibly limiting usable anadromous fish habitat, however historical records indicate there may have been a natural barrier along the steam.

Note: Information here is based on limited stream flow and water quality data - more data that ranges both storm and non-storm events are needed.

Figure ES-2. Current conditions of Fauntleroy Creek



Unique Conditions

- Second largest watershed of Seattle streams (2.7 mi^2).
- Long, narrow watershed with gentle slopes and a few short tributaries.
- Residential, commercial, and industrial land uses.
- Drains to Duwamish River.
- Only Seattle stream that receives combined sewer overflows (CSOs).

Stream Conditions

- Little high-quality instream habitat.
- Lack of floodplain connections, instream wood, and gravel contributes to erosion of streambed and banks and poor instream habitat.

Stream Biota

- Benthic index of biotic integrity (B-IBI) indicates very poor conditions in Longfellow Creek (average score 15).
- Stream contains coho and chum salmon; rainbow trout; threespine stickleback; and 2 kinds of sculpin.
- Coho prespawning mortality rates average 71% (54 to 82%).
- Stream contains 7 complete barriers to fish passage barriers and 3 partial barriers, limits usable anadromous fish habitat to 2,200 feet.

Watershed Conditions*

- Buildings, roads, and other impervious surfaces cover 52% of the watershed, substantially increasing stormwater runoff and stream flows that damage stream habitat.
- Stormwater outfalls average 13.9 per stream mile, plus 3 CSOs
- Dissolved oxygen and water temperature levels do not meet criteria.
- Fecal coliform levels do not meet criteria.
- Concentrations of toxic materials (metals and ammonia) are relatively low under non-storm conditions.
- Concentrations of nutrients (total phosphorous) frequently exceed established benchmarks.

*Note: Information here is based on limited stream flow and water quality data - more data that ranges both storm and non-storm events are needed.

Figure ES-3. Current conditions of Longfellow Creek

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Unique Conditions

- Piper's Creek watershed covers 2.5 mi^2, the third largest in Seattle.
- Stream is unique in having multiple high-gradient tributaries in steep ravines with grades of more than 20%.
- Large portion of stream is located in Carkeek Park.
- Watershed contains a mixture of land uses, dominated by residential.
- Drains to Puget Sound.

Watershed-wide Conditions*

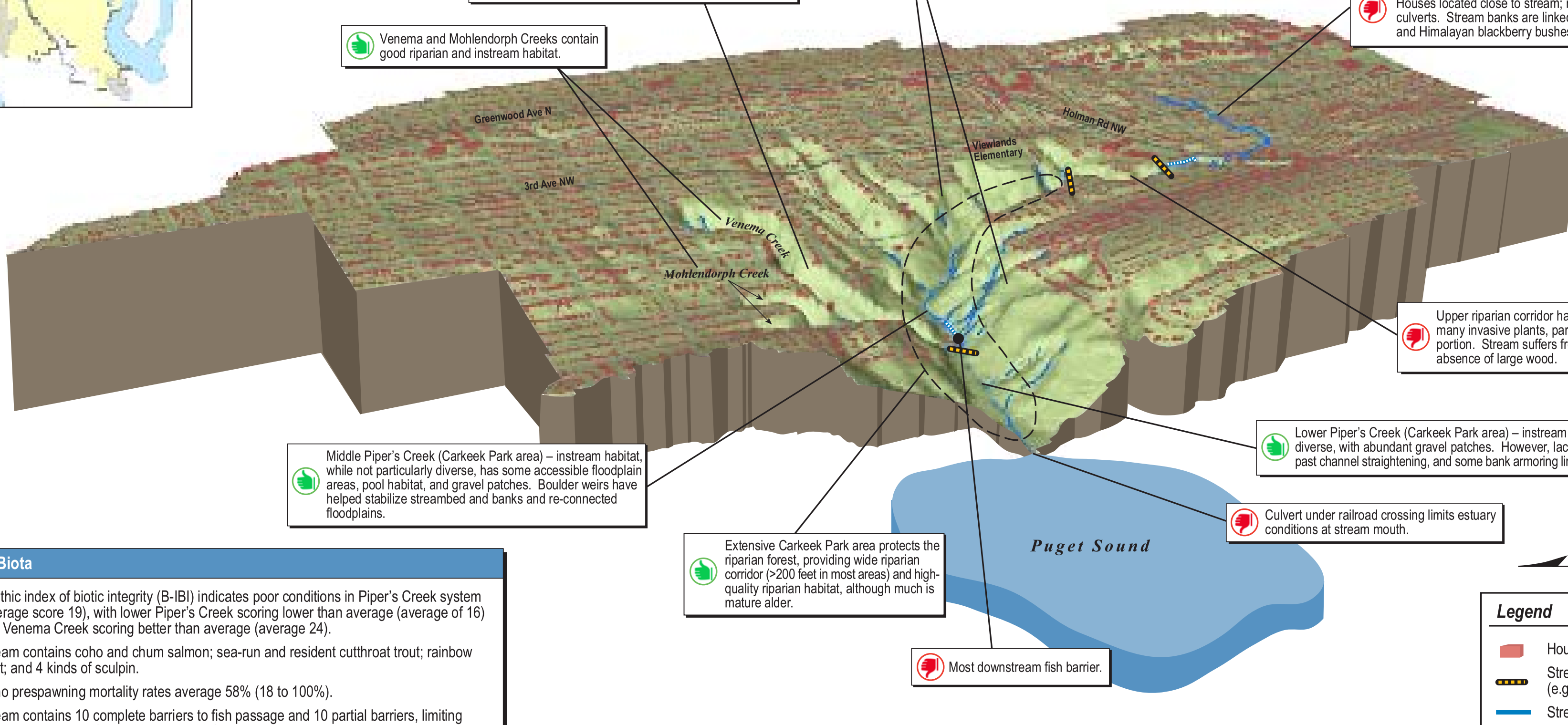
- Buildings, roads, and other impervious surfaces cover 57% of the watershed, substantially increasing stormwater runoff and stream flows that damage stream habitat.
- Stormwater outfalls average 5.8 per stream mile.
- Dissolved oxygen and water temperature levels generally meet criteria.
- Fecal coliform bacteria levels exceed criteria.
- Concentrations of toxic materials (metals and ammonia) are moderate under storm flow conditions. Parameters of concern include dissolved lead, and dissolved copper.
- Concentrations of nutrients (total nitrogen and total phosphorous) frequently exceed established benchmarks.

Upland impervious areas and lack of infiltration have increased stream flows that could destabilize steep ravine walls.

Venema Creek, which cuts through erosion-susceptible sand deposits, is suffering from runoff-related erosion of valley walls and streambed.

Venema and Mohlendorph Creeks contain good riparian and instream habitat.

Upper Piper's Creek – low-quality instream and riparian habitat. Houses located close to stream; many sections conveyed in culverts. Stream banks are linked with lawns, landscaping, and Himalayan blackberry bushes that provide no shading.



Upper riparian corridor has sparse tree canopy and many invasive plants, particularly in the upstream portion. Stream suffers from streambed erosion and absence of large wood.

Middle Piper's Creek (Carkeek Park area) – instream habitat, while not particularly diverse, has some accessible floodplain areas, pool habitat, and gravel patches. Boulder weirs have helped stabilize streambed and banks and re-connected floodplains.

Lower Piper's Creek (Carkeek Park area) – instream habitat is diverse, with abundant gravel patches. However, lack of pools, past channel straightening, and some bank armoring limit habitat.

Culvert under railroad crossing limits estuary conditions at stream mouth.

Extensive Carkeek Park area protects the riparian forest, providing wide riparian corridor (>200 feet in most areas) and high-quality riparian habitat, although much is mature alder.

Most downstream fish barrier.

Stream Biota

- Benthic index of biotic integrity (B-IBI) indicates poor conditions in Piper's Creek system (average score 19), with lower Piper's Creek scoring lower than average (average of 16) and Venema Creek scoring better than average (average 24).
- Stream contains coho and chum salmon; sea-run and resident cutthroat trout; rainbow trout; and 4 kinds of sculpin.
- Coho prespawning mortality rates average 58% (18 to 100%).
- Stream contains 10 complete barriers to fish passage and 10 partial barriers, limiting usable anadromous fish habitat to 2,100 feet.

Legend

- House or building
- Stream sections (e.g., upper, middle, and lower)
- Stream
- Culverted stream (>200 feet)
- Road

Note: Information here is based on limited data for stream flow and water quality – more data representing both storm and non-storm events are needed.

Figure ES-4. Current conditions of Piper's Creek

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Unique Conditions

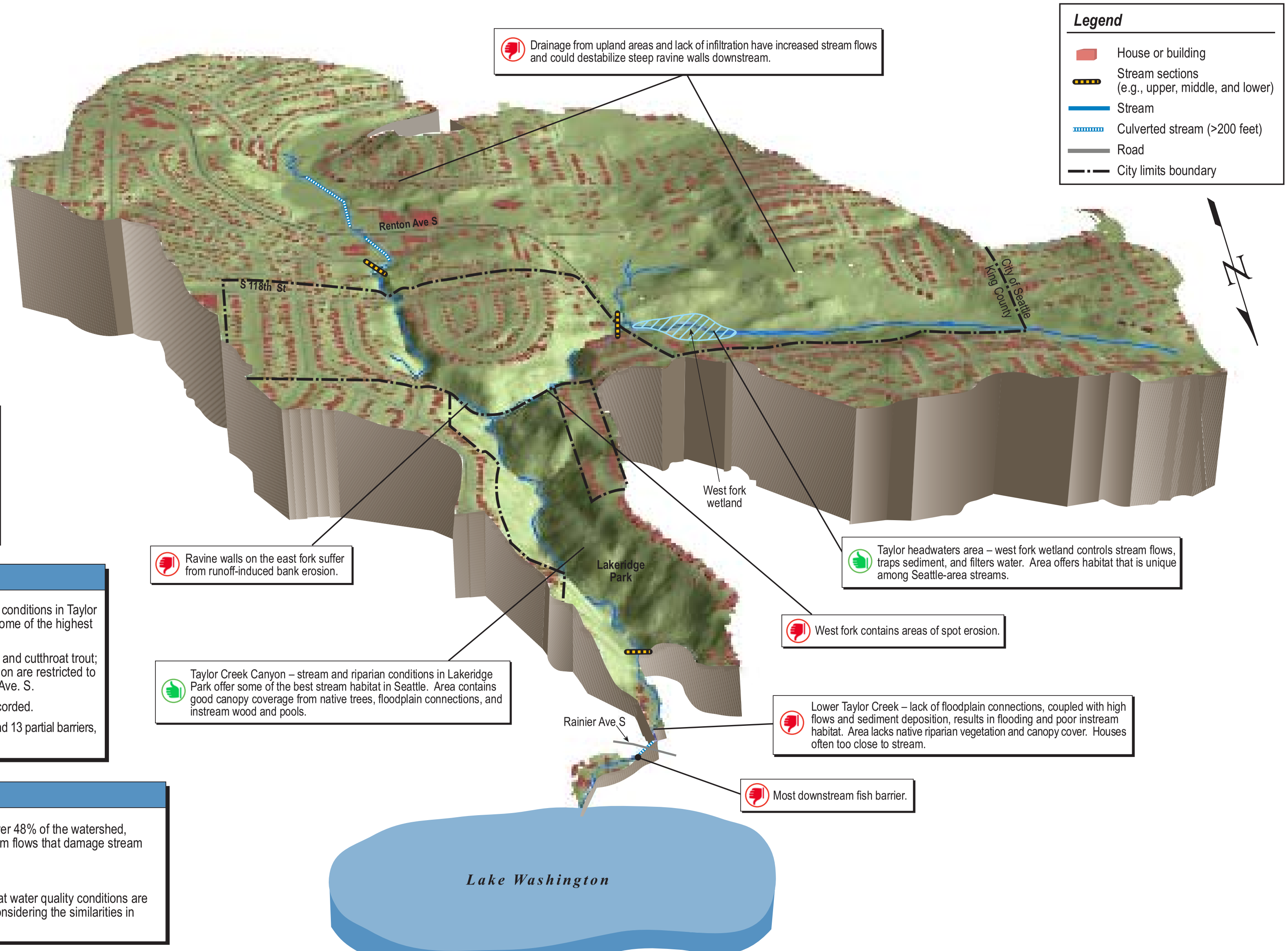
- Relatively small watershed (1 mi^2).
- Two major branches, with 1 small tributary.
- Large portion is contained within Lakeridge Park.
- Mostly residential land uses.
- Drains to Lake Washington.

Stream Biota

- Benthic index of biotic integrity (B-IBI) indicates poor conditions in Taylor Creek (average score 19), even though it contains some of the highest quality habitat in Seattle.
- Stream contains coho and sockeye salmon; rainbow and cutthroat trout; threespine stickleback; and 3 kinds of sculpin. Salmon are restricted to a very small area of stream, downstream of Rainier Ave. S.
- Coho prespawning mortality rates have not been recorded.
- Stream contains 7 complete barriers to fish passage and 13 partial barriers, limiting usable anadromous fish habitat to 600 feet.

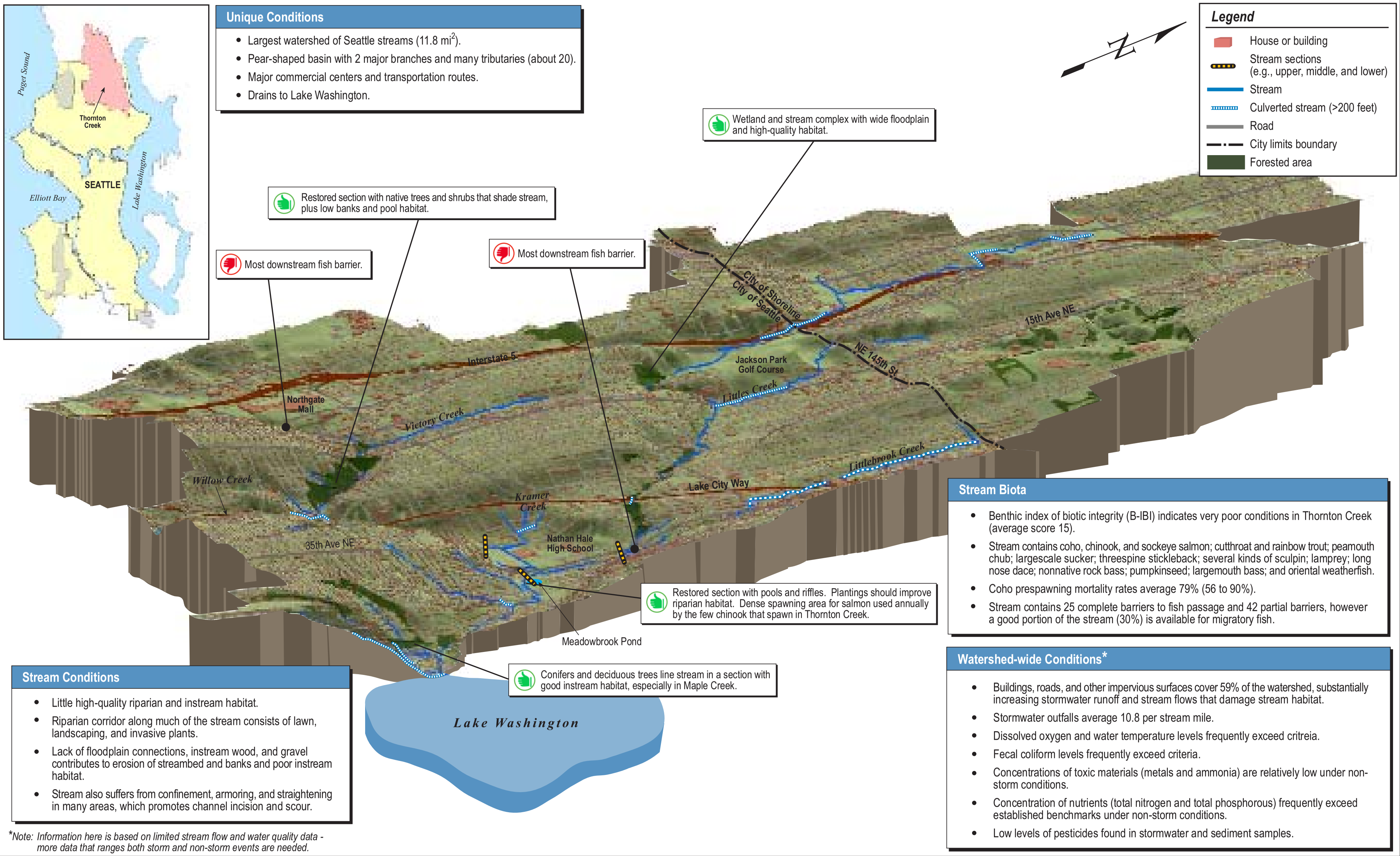
Watershed Conditions*

- Buildings, roads, and other impervious surfaces cover 48% of the watershed, substantially increasing stormwater runoff and stream flows that damage stream habitat.
- Stormwater outfalls average 6.7 per stream mile.
- No water quality information available. It is likely that water quality conditions are similar to those of Fauntleroy and Piper's creeks, considering the similarities in watershed land uses.



*Note: Information here is based on limited data for stream flow and water quality – more data representing both storm and non-storm events are needed.

Figure ES-5. Current conditions of Taylor Creek



Unique Conditions

- Largest watershed of Seattle streams (11.8 mi^2).
- Pear-shaped basin with 2 major branches and many tributaries (about 20).
- Major commercial centers and transportation routes.
- Drains to Lake Washington.

Stream Conditions

- Little high-quality riparian and instream habitat.
- Riparian corridor along much of the stream consists of lawn, landscaping, and invasive plants.
- Lack of floodplain connections, instream wood, and gravel contributes to erosion of streambed and banks and poor instream habitat.
- Stream also suffers from confinement, armoring, and straightening in many areas, which promotes channel incision and scour.

Stream Biota

- Benthic index of biotic integrity (B-IBI) indicates very poor conditions in Thornton Creek (average score 15).
- Stream contains coho, chinook, and sockeye salmon; cutthroat and rainbow trout; peamouth chub; largescale sucker; threespine stickleback; several kinds of sculpin; lamprey; long nose dace; nonnative rock bass; pumpkinseed; largemouth bass; and oriental weatherfish.
- Coho prespawning mortality rates average 79% (56 to 90%).
- Stream contains 25 complete barriers to fish passage and 42 partial barriers, however a good portion of the stream (30%) is available for migratory fish.

Watershed-wide Conditions*

- Buildings, roads, and other impervious surfaces cover 59% of the watershed, substantially increasing stormwater runoff and stream flows that damage stream habitat.
- Stormwater outfalls average 10.8 per stream mile.
- Dissolved oxygen and water temperature levels frequently exceed critreia.
- Fecal coliform levels frequently exceed criteria.
- Concentrations of toxic materials (metals and ammonia) are relatively low under non-storm conditions.
- Concentration of nutrients (total nitrogen and total phosphorous) frequently exceed established benchmarks under non-storm conditions.
- Low levels of pesticides found in stormwater and sediment samples.

*Note: *Information here is based on limited stream flow and water quality data - more data that ranges both storm and non-storm events are needed.*

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Figure ES-6. Current conditions of Thornton Creek