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PART 4: SUMMARY AND NEXT STEPS

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ACRONYMS

(B)IBI	Benthic Index of Biotic Integrity
BMP	Best Management Practices
BOD	Biological Oxygen Demand
CDP	Comprehensive Drainage Plan (Seattle)
CIP	Capital Improvement Program (or Plan)
CFR	Code of Federal Regulations
COD	Chemical Oxygen Demand
COE	Corps of Engineers
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DCLU	Department of Construction and Land Use (Seattle)
DDT	Dichlorodiphenyltrichloroethane (pesticide)
DO	Dissolved Oxygen
DWU	Drainage and Wastewater Utility (Seattle)
ECA	Environmentally Critical Area Ordinance (Seattle)
EIS	Environmental Impact Statement
ESA	Endangered Species Act (of 1973)
ESU	Evolutionarily Significant Unit
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
GMA	Growth Management Act
GPS	Global Positioning System
HCP	Habitat Conservation Plan (Cedar River Watershed, Seattle)
HPA	Hydraulic Projects Approval (WDFW)
I-5	Interstate 5 freeway
I&I	Inflow and Infiltration
LWD	Large Woody Debris
MCTA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
NSCC	North Seattle Community College
NTU	Nephelometric Turbidity Units
PADS	Planning and Development Services
PAH	Polyaromatic hydrocarbons

PCB	Polychlorinated biphenyls
PEL	Probable Effects Level
PSWQAT	Puget Sound Water Quality Action Team
PWD	Public Works Department (Shoreline)
RCW	Revised Code of Washington
RTA	Regional Transit Authority
SEATRAN	Seattle Transportation Division
SEPA	State Environmental Policy Act
SGD	Stormwater, Grading, and Drainage Control Code
SMC	Seattle Municipal Code
SPU	Seattle Public Utilities
SWM	Surface Water Management
TCA	Thornton Creek Alliance
TCP	Thornton Creek Project
TCRC	Thornton Creek Riparian Corridor Map
TEL	Threshold Effects Level
TMDL	Total Maximum Daily Load
TP	Total Phosphorous
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WMC	Watershed Management Committee
WSDOT	Washington State Department of Transportation

GLOSSARY

Acute Toxicity: Any toxic effect that is produced within a short period of time, generally 96 hours or less. Although the effect most frequently considered is mortality, the end result of an acute effect could be any harmful biological effect.

Alevins: Larval salmonids from the time of hatching to the disappearance of the yolk sac. Alevins live in the gravel of the redd (see Redd).

Algae: Aquatic, nonflowering plants that lack true roots, stems, and leaves and use light energy to convert carbon dioxide and inorganic nutrients such as nitrogen and phosphorus into organic matter by photosynthesis. Common algae include dinoflagellates, diatoms, seaweeds, and kelp. Planktonic algal blooms occur when nutrient levels in bodies of water are excessive.

Alien Species: See Exotic species.

Alluvium: Clay, silt, sand, gravel, or similar material deposited by running water.

Aquifer: Underground layer of rock or soil in which groundwater resides. Aquifers are replenished or recharged by surface water percolating through soil. Wells are drilled into aquifers to extract water for human use. (See Groundwater.)

Base Flow: Flow contributed to a creek by groundwater. During dry periods, base flow constitutes the majority of stream flow.

Beneficial Uses: As referred to in the Washington State Water Quality Standards, activities such as swimming or fishing, that utilize water as their primary medium.

Benthic Macroinvertebrates: Small animals that live in or on the bottom of a body of water (e.g., mayfly and caddisfly larvae, tubifex worms).

Best Management Practice (BMP): A method, activity, maintenance procedure, or other management practice for reducing the amount of pollution entering a water body. The term originated from the rules and regulations developed pursuant to Section 208 of the Federal Clean Water Act (40 CFR 130).

Bioassay: A test procedure that measures the response of living plants, animals, or tissues to potential contaminants. For example, marine worms have been exposed to the sediments of Puget Sound, and their responses have been used to determine areas in the Sound where the sediments may be harmful to life.

Bioavailable: Available for biological uptake.

Biochemical Oxygen Demand (BOD): The quantity of oxygen-depleting materials present in a sample as measured by a specific test. A major objective of wastewater treatment is to reduce biochemical oxygen demand so that the oxygen content of the water body will not be significantly reduced. Although BOD is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act.

Biodegradation: The conversion of organic compounds into simpler compounds through biochemical activity. Toxic compounds can sometimes be converted into nontoxic compounds through biodegradation. In some cases complex compounds are first converted into intermediate substances that can be more toxic than the original substance.

Biofiltration: The use of plants to filter contaminants and sediment out of stormwater.

Bypass Pipe: A pipe used to convey excess storm flows around a particular section of a creek.

Canopy: The uppermost, spreading, branch layer of a forest. On Thornton Creek an intact canopy layer provides shade to maintain cool water temperatures necessary for salmonid survival.

Catch Basin: Traps installed in the street between storm drain inlets and the drain pipes to catch litter and pollutants that either sink to the bottom of the catch basin or float to the top. These captured materials are then removed periodically through City street maintenance activities. Catch basins serve to help keep storm drains clear and flowing properly, and help remove sediments and pollutants that would otherwise end up downstream.

Channelization: The process of making a channel or channels. A channel is the bed of a stream or river, or the hollow or course in which a stream flows.

Check Dam: A small dam designed to retard the flow of water and sediment in a channel, used especially for controlling soil erosion.

Chemical Oxygen Demand (COD): The quantity of oxygen-depleting materials present in a sample as measured by a specific test. The COD test is used to measure the concentration of a waste of unknown chemical composition. Different from biochemical oxygen demand.

Chronic Toxicity: Any toxic effect on an organism that occurs after exposure of long duration (often 1/10th of the life span or more). The end result of a chronic effect can be death, although the initial effects are sublethal (e.g., inhibited reproduction or growth). These sublethal effects may be reflected by changes in the productivity and population structure of the community.

Clean Water Act: An Act passed by Congress in 1972 and amended in 1977 to restore all the nation's waters to "fishable and swimmable" condition. Originally, the focus of the Act was on point source pollution from sources such as pulp and paper mills and sewage treatment plants. More recently the emphasis has shifted towards decreasing pollution from non-point sources such as run-off from yard and garden products, automobile fluids, and erosion stemming from development.

Cluster Development: A type of housing development which places homes close together, usually to increase the amount of contiguous open space to protect wetlands, forests, and streams.

Coliform Bacteria: Fecal coliform bacteria are those found in the intestinal tracts of warm-blooded animals, and include many species of bacteria. The presence of high numbers of fecal coliform bacteria in a water body can indicate the release of untreated wastewater and/or the presence of animal waste, and may indicate the presence of pathogens.

Combined Sewer Overflow (CSO): A pipe that discharges untreated wastewater during storms from a sewer system that carries both sanitary wastewater and stormwater. The overflow occurs because the system does not have the capacity to transport and treat the increased flow caused by stormwater runoff.

Combined Sewer System: A wastewater collection and treatment system in which domestic and industrial wastewater is combined with storm runoff. Although such a system does treat stormwater, the overflow from major storms results in discharge of untreated wastewater.

Comprehensive Drainage Plan (CDP): City of Seattle document prepared to address citywide flooding and water quality problems.

Creek Restoration Project: Project designed to restore the natural function and appearance of a creek. Examples include planting native vegetation in the riparian corridor, and instream improvements to create fish rearing habitat.

Culvert: A drain, usually a concrete or metal pipe, crossing under a road or an embankment.

Detention: The process of collecting and holding back stormwater for later release to receiving waters.

Detention Ponds: Engineered basins placed along creeks to temporarily capture excess flows of stormwater and thereby reduce flooding in an area. Several detention ponds ranging from 50 to over 300 feet in diameter have been installed in several places along Thornton Creek by SPU to alleviate flooding problems exacerbated by development and impervious surface runoff.

Dissolved Oxygen (DO): Oxygen present in water and therefore available for fish and other aquatic animals to use. If the amount of dissolved oxygen in the water is too low, then aquatic animals may die. Wastewater and naturally occurring organic matter contain oxygen-demanding substances that consume dissolved oxygen.

Environmental Impact Statement (EIS): A document that discusses the likely significant impacts of a proposal, methods to lessen the impacts, and alternatives to the proposal. Projects may merit an EIS following requirements of the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA).

Electro-fishing: A technique in which electric current is applied to the water surface, stunning fish. This is a common practice used in fish surveys to count fish.

Enterococcus: Bacteria normally found in the intestinal tract of warm-blooded animals, including humans. These organisms may be more resistant to chlorine than coliform bacteria, and survive longer in water.

Environmentally Critical Area (ECA): A Seattle building code designation for areas which contain one or more of the following: steep slopes, streams, wetlands, abandoned land fills, and fish and wildlife conservation areas or are landslide prone, liquefaction prone, or flood prone.

Erosion: Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical and chemical forces.

Eutrophication: Process by which a water body builds up excess nutrients so that rapid plant growth occurs. Presence of intense algal blooms is a sign that eutrophication is occurring. As a result, large amounts of plant materials decay, consuming dissolved oxygen and leaving less less dissolved oxygen available to aquatic organisms.

Exotic Species: Non-native species of plants or animals introduced from another habitat or region of the world that often out-compete native plants and animals for habitat or food. Extensive efforts are made to control the spread of exotic species in the watershed to preserve native species.

Fecal Coliform: (see Coliform Bacteria).

Geometric Mean: A calculated mean or average that is appropriate for data sets containing a few values that are very high relative to the other values (or skewed). To reduce the bias introduced to an arithmetic mean (see mean) by these very high numbers, the natural logarithms of the data are averaged. The anti-log of this average is the geometric mean.

Groundwater: Rainwater that soaks into the ground and flows downward until reaches an impermeable underground layer of the earth's crust where it collects in aquifers. Groundwater then usually flows laterally toward a river or lake or the ocean. Wells tap the groundwater for human use. (See also aquifer.)

Habitat: Specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be free of harmful contaminants. Puget Sound habitats include beaches, marshes, rocky shores, the bottom sediments, mud flats, and the water itself.

Headwater: The source of a stream or creek. Within a watershed, the headwaters are the upper and outer edges of the watershed basin and sub-basins where individual creeks begin and flow down towards the main creek branch.

Herbicide: A substance used to destroy or inhibit growth of vegetation.

Hydraulics Permit: A permit granted by Washington Department of Fisheries and Wildlife for work to be performed on or near a body of water, such as a creek.

Hydrology: The science of dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Impervious or Impermeable Surface: A surface that cannot be easily penetrated, for instance, rain does not readily penetrate asphalt or concrete surfaces.

Infiltration: The process of water permeating or soaking into a surface such as the ground. Infiltration of stormwater into the earth recharges groundwater and feeds streams during dry periods.

Inflow and Infiltration (I&I): Excess water that enters a sewer system. Since a sewer system can only handle a certain amount of wastewater at one time, excess flows can trigger overflows of raw wastewater. Inflow refers to water that unnecessarily flows into the system, for example, from household roof drains. Infiltration is water that seeps into the system through cracks and gaps in the pipes.

Insecticide: A substance, usually a chemical, used to kill insects.

Land Use: The way land is developed and used in terms of the types of activities allowed (agriculture, residences, industries, etc.) and the size of buildings and structures permitted. Certain types of pollution problems are often associated with particular land use practices, such as sedimentation from construction activities.

Mean: Same as average. The sum of a list of values divided by the number of items on the list.

Metals: Elements found in rocks and minerals that are naturally released to the environment by erosion, as well as generated by human activities. Certain metals, such as mercury, lead, nickel, zinc, and cadmium, are of environmental concern because they are released to the environment in excessive amounts by human activity. They are generally toxic to life at certain concentrations. Since metals are elements, they do not break down in the environment over time and can be incorporated into plant and animal tissue.

Monitor: To systematically and repeatedly measure conditions in order to track and assess changes. For example, dissolved oxygen in a bay might be monitored over a period of several years in order to identify any trends in its concentration.

National Pollutant Discharge Elimination System (NPDES): A federal Clean Water Act requirement for point source dischargers to obtain permits. These permits are also required for stormwater and Combined Sewer Overflow (CSO) discharges. Commonly referred to as NPDES permits, they are administered by the Washington State Department of Ecology.

Native Species: Plants and animals indigenous to, or original inhabitants of, a particular region of the world that have evolved to tolerate, and thrive in, that region's unique environmental conditions.

Nonpoint Source Pollution: Pollution that enters water from dispersed and uncontrolled sources (such as surface runoff) rather than through pipes. Nonpoint sources (e.g., forest practices, agricultural practices, on-site sewage disposal, and recreational boats) may contribute pathogens, suspended solids, and toxicants. While individual sources may seem insignificant, the cumulative effects of nonpoint source pollution can be significant.

Nonpoint Sources: Dispersed sources of pollutants that accumulate in surface or ground water. Generally, individual sites are insignificant, but can add to a cumulative problem, with serious health or environmental consequences.

Nutrients: Essential chemicals needed by plants or animals for growth. If other physical and chemical conditions are optimal, excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae. Some nutrients can be toxic to animals at high concentrations.

One-Year Storm Event: A storm with rainfall of an amount likely to occur on average once a year in a given area. A ten-year storm event would be likely to occur once in ten years.

Outfall: The downstream end of a pipe or ditch where the water joins a stream, lake, or other water body.

Oxygen Demanding Materials: Materials such as food waste and dead plant or animal tissue that use up dissolved oxygen in the water when they are degraded through chemical or biological processes. Biological Oxygen Demand (BOD) measures the oxygen demand of a particular substance.

Parameter: A quantifiable or measurable characteristic. Water quality parameters include temperature, pH, salinity, and dissolved oxygen concentration.

Permeable Surface: Surface, such as dirt, that allows some percolation or infiltration of water into the ground and ultimately the groundwater system. This is in contrast to impermeable surfaces, such as concrete, that allow water to run off without any infiltration.

Pesticide: Chemical substance used to destroy or control organisms. Pesticides include herbicides, insecticides, algicides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins extracted from plants and animals.

pH: The degree of alkalinity or acidity of a solution. For example, a pH of 7.0 indicates neutral water, a pH of 5.5 indicates an acid solution, and a pH of 8.5 indicates an alkaline or basic solution. The pH of water influences many kinds of chemical reactions that will occur in it. For instance, a slight decrease in pH may greatly increase the toxicity of substances such as cyanides, sulfides, and most metals. A slight increase may greatly increase the toxicity of pollutants such as ammonia.

Point Sources: A single point of discharge such as a pipe, that contributes pollutants into a water body. For example, the outfall from a sewage treatment plant or a factory is a point source.

Pollutant: A substance that adversely alters the physical, chemical, or biological properties of the environment. The term includes coliforms, metals, oxygen-demanding materials, and all other potentially harmful substances. With reference to nonpoint sources, the term is sometimes used to apply to substances released in low concentrations from many activities that collectively degrade water quality. As defined in the federal Clean Water Act, pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Priority Pollutants: Substances listed by EPA under the Clean Water Act as toxic and having priority for regulatory controls. The list currently includes metals (13), inorganic compounds (cyanide and arsenic), and a broad range of both natural and artificial organic compounds (111). The list of priority pollutants includes some substances that are not of immediate concern in Puget Sound, and it does not include all known harmful compounds.

Puget Sound Water Quality Action Team (PSWQAT): The Washington State agency responsible for developing and overseeing the Puget Sound Water Quality Management Plan.

Redd: The area of stream or lake bottom excavated by female salmonoid during spawning. The redd is the "nest" where the eggs are deposited.

Re-vegetation: The process of removing exotic and invasive plant species from an area and re-planting with native species indigenous to the site.

Right-of-way: Publicly used land, including streets, sidewalks, ditches and road shoulders. Includes publicly owned land and easements negotiated with private owners.

Riparian: Pertaining to the banks of streams, lakes, or tidewater.

Riparian corridor: Strip of land on and above the banks of waterways such as streams, creeks, or rivers (and some water bodies) that supports riparian vegetation such as water tolerant shrubs, trees, and plants, in addition to animals. Usually does not refer to marine or lake near-shore areas.

Riprap: A foundation or wall made of broken stones thrown together irregularly or loosely, as in water or on the soft bottom of a water body. Riprap also refers to the stones used for constructing such a foundation.

Salmonid: A fish of the family *Salmonidae* (as distinct from a *salmonoid* which is merely a fish that resembles a salmon). Fish in this family include salmon and trout. Many Puget Sound salmonids are anadromous.

Sediment: Material suspended in or settling to the bottom of a liquid, such as the sand and mud that make up much of the shorelines and bottom of Puget Sound. Sediment input to Puget Sound comes from natural sources, such as erosion of soils and weathering of rock, or human activities sources, such as forestry, agriculture, or construction. Certain contaminants tend to collect on and adhere to sediment particles. The sediments of several areas around Puget Sound contain elevated levels of toxic contaminants.

Sedimentation: The process by which a river, lake, or other water body becomes increasingly filled with sediment. Sediment can clog gravel beds and prevent successful salmon spawning.

Separated Sewer System: A wastewater collection and treatment system where domestic and industrial wastewater is separated from storm runoff. A separated system consists of independent sanitary wastewater and stormwater systems. The stormwater is discharged directly into open water and the sanitary wastewater goes to a treatment plant.

Side Sewer: A sewer that connects from a structure to the municipal sewer line. Side sewers are the responsibility of the property owner.

Storm Drain: A system of gutters, pipes, or ditches used to carry stormwater from surrounding lands to streams, lakes, or Puget Sound, and in practice, carrying a variety of substances such as oil and antifreeze which enter the system through runoff, deliberate dumping, or spills. This term also refers to the end of the pipe where the stormwater is discharged.

Stormwater: Water generated by rainfall and often routed into drain systems in order to prevent flooding.

Sub-basin: A smaller basin contained within a larger watershed. A large watershed is composed of many smaller sub-basins (see Watershed).

Suspended Solids: Organic or inorganic particles suspended in and carried by the water. The term includes sand, mud, and clay particles as well as solids in wastewater.

Swale: A broad, shallow, vegetated channel. A biofiltration swale is a vegetated drainage ditch that has been engineered to collect and transport stormwater in a way that allows the vegetation to filter sediments and pollutants. A swale can be any natural or constructed drainageway.

Taxa: The name applied to a taxonomic group in a formal system of nomenclature. Plants and animals are classified and divided by taxa groups.

Terrestrial: A term used to describe something related to land, as distinct from air or water.

Total Suspended Solids (TSS): A measure of the weight of particles suspended in water. Suspended solids in water reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles.

Toxic: Poisonous, carcinogenic, or otherwise directly harmful to life.

Tributary: A stream that flows into another stream or river.

Turbidity: A measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity are harmful to aquatic life.

Twenty-Five Year Storm: A storm of severity that occurs on average of once every twenty-five years.

Urban Runoff: Rainwater that flows over surfaces in a watershed and is not absorbed by the ground. Urban runoff can contain sediments and contaminants (nonpoint source pollution) that can add to water quality degradation in the watershed. Increases in impervious surface usually result in increased urban runoff.

Water Column: The water in a lake, estuary, or ocean that extends from the bottom sediments to the water surface. The water column contains dissolved and particulate matter, and is the habitat for plankton, fish, and marine mammals.

Water Rights: Rights held by an individual landowner which were originally deeded or granted by a public agency (currently the Washington Department of Ecology) to take water from a creek or water body for use by the landowner.

Watershed: The geographic region from which water drains into a particular river or body of water. A watershed includes hills, lowlands, and the body of water into which the land drains. Watershed boundaries are defined by the ridges that separate watersheds.

Weir: A low dam or fence built across a stream, primarily to control water level or to divert water into another facility.

Wetlands: Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (water loving plants); (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is not soil and is saturated with water or covered by shallow water at some time during the growing seasons each year.

Zoning: Classification of land are designated by ordinance to be reserved and regulated for specified land uses.

EXECUTIVE SUMMARY

This Thornton Creek Characterization Report and forthcoming Watershed Action Plan are being developed by a Watershed Management Committee representing community leaders and government agencies, with funds from a Department of Ecology Centennial Fund loan to Seattle Public Utilities (SPU). When completed in fall 2000, the Plan will be submitted for adoption by the Cities of Seattle and Shoreline and approval by Ecology. The adopted plan will guide actions by government agencies, citizens and businesses to:

- Reduce non-point pollution.
- Protect biological resources.
- Preserve, enhance, and restore fish and wildlife habitat.

Introduction to Thornton Creek Watershed

Thornton Creek drains a 7,402-acre (11 sq. mile) urban watershed in northwestern King County between Puget Sound and Lake Washington, extending roughly from NE 190th St. in the City of Shoreline to NE 80th St in the City of Seattle. The watershed is full of contrasts: large, mature conifer forest in Hamlin Park and the busy stretch of Interstate-5 adjacent to the Northgate Mall area; steep ravines and gently sloped floodplains; dense multi-family neighborhoods near retail cores such as Lake City and neighborhoods with large wooded lots.

Over the last 150 years, the watershed's native forest has been replaced by urban development. An estimated 75,400 people live in the watershed, and thousands more work there. The watershed is also home to a variety of wildlife and plant species and remnants of once abundant salmon runs.

Unlike other urban watersheds, over 90% of the creek's main channel – more than 15 miles – flows above ground, through more than 700 backyards and over 15 parks and natural areas, on its way southeast across town toward Lake Washington.

The community takes pride in its watershed, which retains a rural flavor, with large trees and few curbs and sidewalks. Many residents enjoy spotting blue heron and an occasional bald eagle, knowing a few salmon still return to spawn in the creek, and sharing the neighborhood with coyotes, raccoons, river otters and possums.

The Committee has identified the following potential benefits provided by Thornton Creek and its watershed:

- Water and air resources
- Fish and wildlife habitat
- Community identity
- Education
- Refuge and recreation
- Water supply (irrigation)

Summary of Findings

The Committee identified four major problems in the watershed:

- Excessive stream flows caused by stormwater runoff.
- Degradation of water quality resulting from non-point pollution.
- Habitat degradation caused by development, stormwater, and pollution.
- Public education and stewardship efforts that haven't reached full potential.

Interwoven among these are problems associated with regulations and enforcement, and monitoring, and coordination.

The Committee's findings about these problems and current solutions are summarized below.

Stormwater

About half the watershed is covered by impervious surfaces, resulting in large volumes of stormwater runoff. High flows in the rainy season erode stream banks and scour the creek bed, which raises sediment levels; increase downstream flooding, flush salmon eggs and juveniles out of the stream. In summer, flows are reduced because rainwater is not stored in soil for gradual release to the stream.

Seattle and Shoreline address stormwater problems in three basic ways: improving conveyance, increasing storage, and reducing runoff volumes. A hydraulic and hydrological study of Thornton Creek is currently evaluating the potential for various flood control strategies and to improve habitat and instream conditions. The two cities will use the results to guide future capital improvement projects, with the involvement of local citizens. (See Chapters 3 and 8 for details.)

Non-point Pollution

Sources of non-point source pollution, found all over the watershed, include automobiles, lawn and gardens, construction, pets, and home maintenance activities. The 13-year record of water quality data taken from the mouth of Thornton Creek doesn't reveal whether water quality is improving or deteriorating; data from other locations are sparse. Key findings:

- Fecal coliform bacteria. Over 98% of samples exceed State criteria, usually significantly. Thornton Creek is on the Washington State 303(d) list because of recurring exceedances.
- Temperature and dissolved oxygen. Levels occasionally exceed State standards.
- Pesticides have been found in the water, especially during spring storms.
- During dry weather, the water is usually clear and odorless, but during storms, water quality rapidly deteriorates, with higher levels of sediments, turbidity, nutrients, bacteria,

organic compounds, metals, oils, and grease. Even in dry weather, pollutants find their way into the creek.

- Thornton Creek sediments have been found to contain elevated levels of persistent heavy metals, pesticides, PCBs, and hydrocarbons harmful to aquatic life.

Municipal non-point pollution prevention activities include: enforcing regulations such as stormwater, grading, and drainage ordinances; constructing drainage-related capital improvement for water quality treatment and flood control; improving maintenance activities such as street sweeping, outdoor storage of materials, employee training, and reduced use of pesticides and fertilizers; and encouraging businesses to adopt good housekeeping, storage, and material handling.

Non-profit organizations and government offer programs on topics such as gardening naturally without reliance on chemicals and pesticides, mass transit and bicycling, oil recycling, and reduced use of toxic household chemicals. (See Chapters 5 and 9 for details.)

Habitat

Habitat is one of the most critical elements in protecting water quality and beneficial uses of water. Good habitat provides cover, shelter, and food for fish and wildlife. It also filters stormwater runoff and absorbs rainwater, allowing it to enter stream systems more slowly.

In this urban setting, much of the historical habitat is gone. Only four percent of the land remains in parks. Wetlands are physically and functionally gone. Native plants are out-competed by exotic species such as Himalayan blackberry and English ivy. Mature alders and maples in watershed parks are not being replenished by young conifers, as in a natural succession process, due to the shortage of conifer seeds and competition from invasive plants.

Like most urban streams, Thornton Creek does not offer prime habitat for fish. Significant problems affecting fish survival include high storm flows, channelized banks, sedimentation, lack of food, poor water quality, high temperatures, low dissolved oxygen levels, barriers to passage, inadequate instream wood and rock structures, and lack of refuge, spawning and rearing areas.

Habitat is protected through laws such as critical areas ordinances, flood control projects with habitat enhancement elements, and volunteer activity. Since only four percent of the watershed is parkland, efforts to improve habitat must focus on private property. Programs such as backyard sanctuaries, native plant landscaping, and tree planting are sponsored by non-profit organizations and local governments. Hundreds of volunteers donate time to clean up trash and debris, remove invasive plants, and replace them with trees and native plants. (See Chapters 4 and 10 for details.)

Awareness/Education

In a recent phone survey of watershed residents, half the people contacted couldn’t name Thornton Creek or its tributaries when asked to identify a creek near their home. The ultimate goal of awareness and education is to create stewards. However, people have to know and appreciate a thing before they want to take care of it. So the first challenge is to make watershed residents aware of the creek, the benefits it offers, and the impacts people have on the creek. The real challenge is to get people to change their behaviors.

Local residents learn about the watershed in a number of ways, including articles in local papers, community meetings, workshops and lectures, newsletters, and welcome-to-the-watershed signs. More than 30 schools are located in the watershed and many have programs that bring students to the creek; these include Salmon in the Classroom, storm drain stenciling, creek and wildlife monitoring. Writing, art, and history classes sometimes use the creek as a learning focus.

Two non-profit groups, Thornton Creek Alliance and Thornton Creek Project, are key partners in developing the Watershed Action Plan. Several local government groups also support stewardship, including Seattle's Adopt-a-Park and Urban Creeks Legacy programs. (See Chapters 7 and 11 for details.)

Regulations/Enforcement

At all levels of government, many laws and policies have been developed to protect natural resources. However, many buildings in the watershed pre-date local regulations for stormwater detention and treatment and structural Best Management Practices (BMPs) designed to minimize environmental impacts associated with building construction. The Committee is concerned that existing regulations do not adequately protect stream resources from development; enforcement programs are generally under-funded and understaffed and cities do not seem to carry out their own policies and regulations in regards to creek and wetland protection.

However, habitat protection, stormwater treatment and detention requirements, and development standards have evolved. For example, in the last two years, Seattle has increased the number of staff available to respond to development concerns and inspect private detention systems, and is developing an enforcement protocol to penalize water quality violators. Seattle is preparing its second, more comprehensive NPDES five-year permit application; and rewriting its BMP manuals to better address detention, infiltration, treatment, structural, and operational BMPs. As a newly incorporated city, Shoreline adopted many King County codes, and has been revising a number them to offer more environmental protection. (See Chapter 6 for details.)

Monitoring

A lot of data about this watershed has been collected by local and state agencies, volunteers, and students. Challenges include: sharing information, essential data analysis, using data as a basis for decision making, ensuring high quality data, and a coordinated approach involving all participants. (See Chapters 4, 5,10, and 11 for details.)

Coordination

Many agencies and organizations work within the watershed. The Committee would like to see more internal organization within cities, between Seattle and Shoreline and between cities and King County. An interlocal agreement between Seattle and Shoreline to manage the Watershed Action Plan is needed. The Committee believes that a Watershed Council representing a broad group of stakeholders should be convened to manage the Action Plan, communicate with decision makers and the community, and address future issues as they arise.

Next Steps

A draft Thornton Creek Watershed Action Plan will be available for public comment and agency review in summer 2000. The draft Watershed Action Plan will be reviewed by the public, all affected local agencies, affected Tribes, and state and/or federal agencies. In addition, the Committee will sponsor a public meeting on the Plan.

The final Action Plan will describe specific actions, budgets, and schedules. Most importantly, it will include letters of concurrence, or commitment, from sponsoring agencies and organizations.

When completed in 2000, the plan will be submitted for approval by the Seattle and Shoreline City Councils and the Department of Ecology (Ecology). The plan will be implemented largely by the cities of Seattle and Shoreline; however, other actions may be completed by other government agencies, volunteers, non-profit organizations, businesses, and individual landowners.

The Action Plan agreement between Ecology and SPU has set aside a minimum of $100,000 to implement three projects addressing instream improvements, water quantity control, and non-point water quality improvements that are scheduled to be completed within one year of the final Action Plan.

Mission and Goals

To guide development of the Thornton Creek Watershed Action Plan, the Committee has developed the following mission statement and goals.

Mission. Protect and restore the Thornton Creek ecosystem for the welfare of fish, wildlife and people; improve the quality of life in the watershed; and prevent further degradation as human population and development increase.

Goals

1: Reduce stormwater-related flooding and damage to stream and wetland habitat, and increase infiltration.

2: Improve water quality by reducing non-point pollution in Thornton Creek and its watershed.

3: Protect and improve instream, riparian, and upland habitat for the survival of remaining native species.

4: Increase public awareness and develop stewardship of the watershed.

PART 1

Welcome to the Watershed

CHAPTER 1: INTRODUCTION

This Thornton Creek Watershed Characterization Report presents background information about the Thornton Creek watershed. It is the first step in developing a Watershed Action Plan that will guide actions by government agencies, citizens, and businesses to:

- Reduce non-point source pollution.
- Protect biological resources.
- Preserve, enhance, and restore fish and wildlife habitat.

The Plan is being developed by a Watershed Management Committee (Committee) representing community leaders and government agencies, with funds from a Department of Ecology Centennial Grant to Seattle Public Utilities (SPU).[1] When completed in 2000, the Plan will be submitted for adoption by the Cities of Seattle and Shoreline.

This chapter gives an overview of the Thornton Creek Watershed, the nature of non-point pollution, the watershed action planning process, and the impacts of urbanization on watershed hydrology and habitat.

1.1 Thornton Creek Watershed

Thornton Creek provides the natural drainage for its 7,402 acre (11 sq. mi.) watershed into Lake Washington.[2] The Thornton Creek Watershed is located in northwestern King County between Puget Sound and Lake Washington. It is an urban watershed, about two-thirds situated in the City of Seattle, one of the oldest and most developed areas in the Puget Sound region, and about one-third situated in the recently incorporated City of Shoreline (Figure 1.1).

[1]*SPU was formed in 1997 and is a combination of the Drainage and Wastewater Utility, Solid Waste Utility, (formerly part of the Seattle Engineering Department), the former Seattle Water Department, and portions of Seattle City Light and the Seattle Engineering Department.*

[2]*A watershed is the land area, bounded by hilltops and ridges, which drains to a particular stream, river, or other water body.*

An estimated 75,400 people live in the watershed, and thousands more work within its boundaries. The watershed is home to Northgate Mall, America's first shopping mall. A three and a half mile stretch of Interstate 5, the State's busiest highway, with daily traffic of over 187,000 cars, passes through the watershed. Vibrant communities, such as Lake City, are located in the watershed. As the Puget Sound region grows, additional people and buildings, wider roads, and more community services will be located here.

In many cities, people have been disappointed by the loss of their creeks as they were channeled into drainage pipes. Within Seattle, community groups have sought to raise millions of dollars to reverse this process and "daylight" piped creeks, returning them to the surface and recreating riparian corridors. As this watershed developed, most of Thornton Creek was spared the fate of being forced into a network of pipes. Over 90% of the creek's main channel – more than 15 miles – flows as surface water, above ground toward Lake Washington and eventually into Puget Sound via the Ballard Locks. Thornton Creek flows through more than 700 backyards and over 15 parks and natural areas.

The community takes pride in this watershed. Despite heavy growth, this area has retained a more rural character than many other Seattle area neighborhoods. This is due in part to the creek, numerous parcels covered with large evergreen trees, and a lack of curbs and sidewalks. Thornton Creek watershed residents enjoy knowing a coyote family may move into the watershed to take up residence beside raccoons, river otters, and possums. Residents can see blue heron and the occasional bald eagle flying overhead. Some salmon still return to the creek to spawn, although not in their historical abundance. These symbols of the Pacific Northwest are located only ten minutes drive from downtown Seattle. However, the community is in jeopardy of losing these and other watershed treasures to future urban growth.

Growth in the Puget Sound region is being directed toward existing urban areas through the state's Growth Management legislation and local comprehensive planning in order to protect remaining agricultural and natural areas from urban sprawl. If growth occurs as projected, many more people will work, live, and pass through this watershed than ever before.

People in this community want to protect Thornton Creek from further degradation and restore sites along the stream. Although the clock can't be turned back to pre-settlement times when the watershed was in a more natural condition, significant improvements can be made.

1.2 Focus on Non-Point Pollution

While many factors affect the health of urban watersheds, watershed action plans are being developed by Washington cities and counties to focus particularly on non-point pollution. This section reviews the causes of non-point pollution and how Federal and State governments have addressed this issue during the past three decades.

What Is Non-Point Pollution?

Non-point pollution comes from everyday activities, such as driving and vehicle maintenance, over-use of lawn and garden chemicals, pet wastes, runoff from construction sites, cigarette butts, and other litter. Pollutants from these activities are deposited on streets, rooftops, driveways, sidewalks, and other hard surfaces. When it rains, stormwater runoff carries these pollutants to nearby streams and water bodies. Non-point pollution is also generated by agricultural and forestry practices, although these sources are not significant in the Thornton Creek watershed because houses, roads, and businesses represent the majority of land uses.

Figure 1.1. Thornton Creek Watershed (1999)

By contrast, point source pollution comes from specific, identifiable contributors, such as paper mills and sewage treatment plants. During the past 25 years, the pollution from point sources in the Thornton Creek watershed has been significantly reduced as uses have changed and regulatory agencies have addressed point source pollution Today, most of the remaining pollution entering Lake Washington and Puget Sound from the Thornton Creek watershed comes from non-point sources.

Individual sources of non-point pollution are typically small and insignificant by themselves. However, when these sources are multiplied by the number of people and the amount of activity within an urban watershed like Thornton Creek, the scale of the problem quickly magnifies.

Controlling and preventing non-point urban pollution requires individuals, agencies, and businesses within a diverse population to change their behaviors. To accomplish this, people must understand how their actions contribute to pollution and be moved to live and act in ways that don't pollute.

What Is Being Done about Non-point Pollution?

In 1972, Congress passed the Clean Water Act, aiming to restore all of the nation's waters to a "fishable and swimmable" condition. Early efforts under this Act were designed to reduce pollution from point sources such as sewage treatment plants and pulp and paper mills. Despite significant reduction in pollution from point sources, water quality in Puget Sound and other bodies of water throughout the nation remained damaged by pollution. Federal and State agencies added focus to local efforts to address non-point pollution.

In 1987, the Puget Sound Water Quality Authority developed a management plan to confront increasing problems with water quality in Puget Sound. One major source of water quality degradation identified in this plan is non-point pollution. The Puget Sound Water Quality Management Plan directed each county adjacent to Puget Sound to rank its watersheds in order to address non-point pollution issues. The Authority also adopted the "Non-point Rule" (WAC 400-12), a regulation to direct the ranking and subsequent planning for individual watersheds. This rule is administered by the Washington State Department of Ecology (Ecology). Ecology also administers grants and loans from the Centennial Clean Water Fund (using revenue from a tax on tobacco products) to promote development of Watershed Action Plans. Ecology provides technical assistance and reviews and approves completed action plans.

State regulations (WAC 400-12, Local Planning and Management of Non-point Source Pollution) outline the process local governments should follow to develop watershed action plans. The WAC also provides guidelines describing the content of an action plan. Generally an action plan consists of a watershed characterization report, a definition of the problems, goals, and objectives to prevent and correct non-point pollution, specific control strategies, and an implementation strategy.

1.3 Thornton Creek Watershed Action Planning

SPU received a Centennial Clean Water loan from Ecology to develop the Thornton Creek Watershed Action Plan. Watershed Action Plans have been adopted by Seattle City Council and approved by Ecology for two other Seattle watersheds, Pipers Creek in 1990 and Longfellow Creek in 1992. Since then, millions of dollars have been spent implementing many recommendations made in these plans.

Watershed Management Committee

The Thornton Creek Action Plan is being written by a group of residents, State, Tribal, City and County governmental agency representatives, and community, education, and business leaders, with staff support from SPU. Participating individuals and organizations are listed on the first page of this report. Organized as the Thornton Creek Watershed Management Committee (Committee), these people began meeting monthly in the summer of 1997. They reached consensus on a vision of the watershed's future and have spent many hours examining the condition of the watershed and considering what new actions are needed. Throughout the development of the Action Plan, the Committee is seeking advice and suggestions from people within the watershed.

The mission of the Committee is to restore the Thornton Creek ecosystem for the welfare of fish, wildlife, and people and to improve the quality of life in the watershed.

Characterization Report

After agreeing on a vision and mission for the watershed, the Committee's next major task was to develop this Watershed Characterization Report. Following this introductory chapter, Part 2 (Chapters 2-5) describe the character and condition of the Thornton Creek watershed. It presents geophysical, biological, historical, and demographic information on the watershed, and assesses the aquatic and terrestrial resources and water quality of Thornton Creek and its tributaries.

Part 3 (Chapters 6-11) describe governmental laws, policies, programs, and activities that currently work to protect the watershed. These actions address stormwater management, non-point pollution, habitat, and education/ stewardship. These chapters include assessments of how well these laws, actions and programs are protecting the watershed.

Finally, Part 4 (Chapter 12) summarizes the values and benefits the creek provides to the community and sets the stage for the Action Plan by summarizing the challenges that remain in the way of restoring this watershed.

Action Plan

Using the background information and problem analysis in the Characterization Report, the Committee will develop an Action Plan outlining specific recommendations for steps needed to control sources of non-point pollution and improve habitat and biological diversity. The Action Plan will likely include recommendations on enhancement of existing improvements and regulations, new projects, public awareness and education programs, water quality monitoring, maintenance activities, and community action. A draft Action Plan will be available for public comment and agency review. The final Action Plan will describe specific actions, budgets, and schedules. Most importantly, it will include letters of concurrence, or commitment, from sponsoring agencies and organizations. When completed in 2000, the plan will be submitted for approval by the Seattle and Shoreline City Councils and by Ecology. The plan will be implemented largely by the Cities of Seattle and Shoreline; however, other actions may be completed by other governmental agencies, volunteers, non-profit organizations, businesses, and individual landowners.

Public Participation

One of the Committee's first steps was to develop a public participation plan to ensure that anyone interested would have a voice in the process. The committee began by sending a newsletter to every household in the watershed in Fall 1997 informing residents about the Action Plan process and inviting them to add their names to the mailing list.

In 1998, the Committee hosted a four-part lecture series at North Seattle Community College. Lecture topics included urban streams, salmon, local wildlife, naturescaping (a type of landscaping using native plants), and "green" gardening tips. In June 1998, the committee held a public meeting to present background information about the watershed and problems found in the watershed.

The Committee formed partnerships with two local non-profit groups, the Thornton Creek Project and the Thornton Creek Alliance, to reach additional interested citizens. The Thornton Creek Project is a cooperative educational network among watershed schools, using Thornton Creek as its central focus. The Thornton Creek Alliance is a grass roots umbrella organization formed by people living and working within the Thornton Creek watershed who are dedicated to preserving and restoring an ecological balance in the watershed. Numerous workshops, watershed tours, demonstrations at the Northwest Flower and Garden Show, and student assemblies were held. Work parties encouraged people to see the watershed streamside parks and participate in their restoration. A website, www.thorntoncreek.org, was developed by the Thornton Creek Project along with an on-line community library.

The draft Watershed Action Plan will be reviewed by the public, all affected local agencies, affected Tribes, and State and/or Federal agencies. In addition, the Committee will sponsor a public meeting on the Plan.

The Committee will continue outreach efforts during the development of the Action Plan to keep people informed of progress and encourage them to participate. The following methods will be used:

- Semi-annual newsletter sent to people on the project mailing list.
- Public meeting to present implementation strategies.
- Educational workshops, work parties, and watershed tours advertised in local newspapers and to people on the project mailing list.
- Semi-annual updates mailed to local community groups.
- Improvements to the existing website.

1.4 Impacts of Development on Streams and Watersheds

Recent University of Washington research on Puget Sound lowland streams, confirmed in nationwide studies, has demonstrated how urbanization affects stream ecosystems (May et al., 1997). This research indicates that the most important factors affecting streams are changes in hydrology (water cycle), riparian corridor vegetation, instream physical conditions, and water quality. This section summarizes the urbanization process in Thornton Creek watershed and generalized impacts on:

- Water cycle (hydrology)
- Riparian corridor vegetation
- Instream habitat conditions
- Water quality
- Fish and aquatic invertebrates

Familiarity with these changes will help the reader better understand the existing conditions in the Thornton Creek watershed and approaches to improving these conditions.

Thornton Creek is one of 22 Puget Sound lowland streams included in this research and is the watershed with the highest level of development and impervious surface (May et al., 1997). The study found that the cumulative effects of a modified (disturbed) hydrology, modification of riparian corridor vegetation, loss of instream structural complexity, and the alteration of channel morphological characteristics accompanying urbanization resulted in rapid degradation of instream habitat during the initial phases of development. The study found that damage occurs to nearby creeks with increasing levels of impervious surfaces. As the level of basin development (total impervious area) increases above 5%, results indicated a precipitous decline in biological integrity as well as the physical habitat conditions necessary to support natural biological diversity and complexity.

The study concluded with recommendations for resource managers on ways to preserve and protect high quality stream ecosystems. Many of these recommendations, such as preserving wide intact forests along the stream, were not helpful to restoring Thornton Creek given the existing high level of development. This study implied that the Thornton Creek system is too developed to support biological diversity and complexity similar to a natural environment.

Changes in Land Use

As mature conifer forests in the Thornton Creek watershed gave way to urban development, the landscape and its natural resources changed dramatically. For example, water that used to soak into the ground or be taken up by trees began flowing off rooftops, roads, and other impervious surfaces directly into Thornton Creek and its tributaries. The remaining vegetation is comprised of native and non-native plant species that create very different habitat conditions than the undisturbed forests. Many of the watershed’s wildlife inhabitants have been replaced with non-native species such as starlings, dogs, and cats.

The most striking change has been the watershed-wide loss of mature conifer forests to roads, rooftops, parking lots, and driveways of the Cities of Seattle and Shoreline. Early European settlers logged the forests in the late 1800s, then cleared land for farms and orchards. Farms gave way to homes and eventually the suburbs and cities of today.

US Geological Survey (USGS) maps dating back to 1894 reveal that the entire Thornton Creek watershed, indeed much of area west of Lake Washington, had been logged by 1894. The changes since then are evident by comparing a 1908 USGS map (Figure 1.2) with a 1999 map (Figure 1.1). In 1908, when the population was counted in the hundreds, not tens of thousands, the map shows only Thornton Creek, wetlands, and a few homes and roads.

The transformation of the landscape can also be illustrated by the series of aerial photographs in Figures 1.3 to 1.5. These pictures were taken of an area near Northgate Mall. They illustrate the transition from farms to rural housing to suburbs, and the growth of businesses and highways, leading to more intensive levels of development. The 1936 photo shows large areas of farmland and some homes. The 1946 photo shows an increased number of roads and buildings. By 1960, I-5 and the mall had been built, and buildings were found on almost every lot. Interstate 5 was built in the mid-1960s.

Figure 1.2. Thornton Creek Watershed (USGS, 1908)

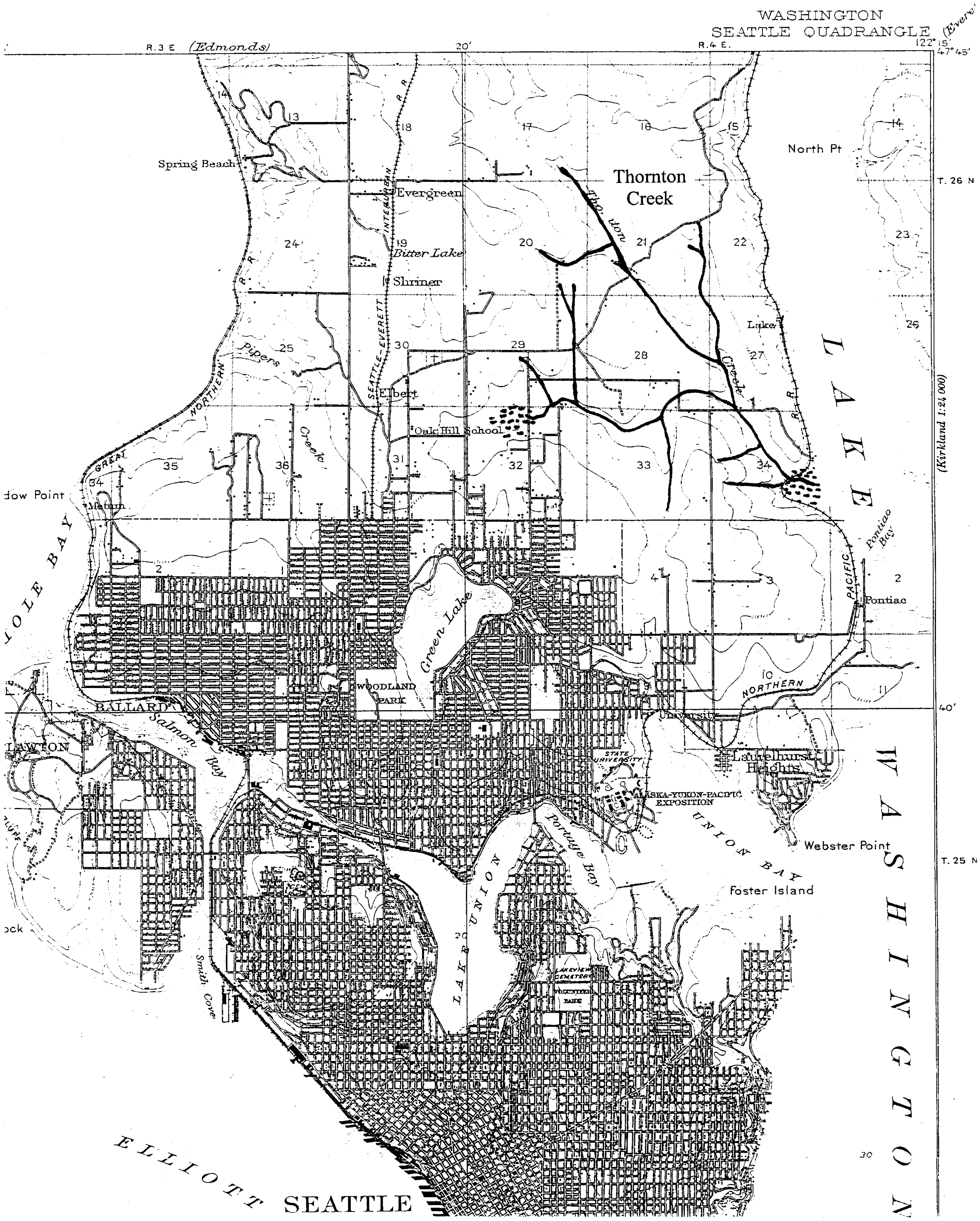


Figure 1.3. Northgate Mall Vicinity (1936)

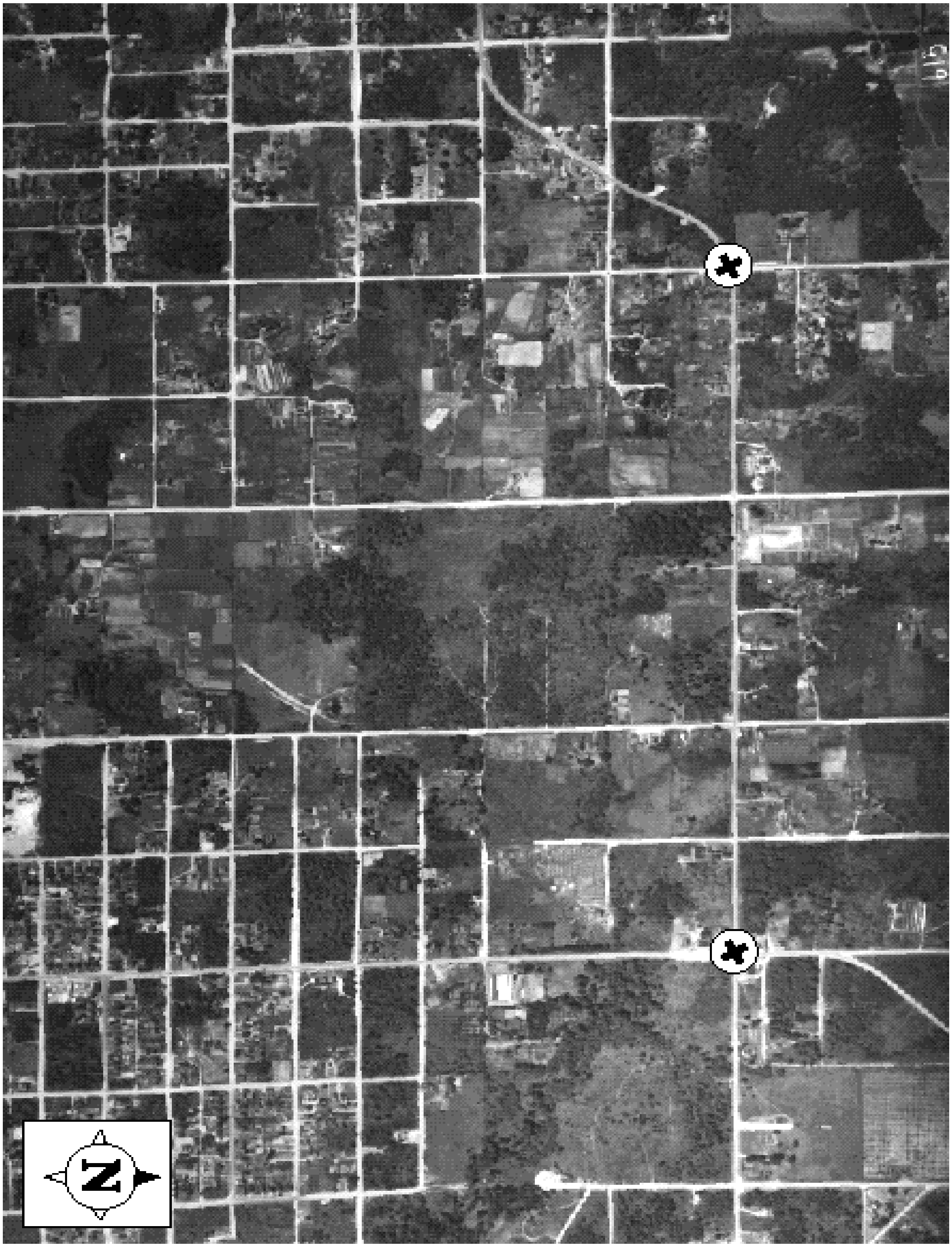


Figure 1.4. Northgate Mall Vicinity (1946)

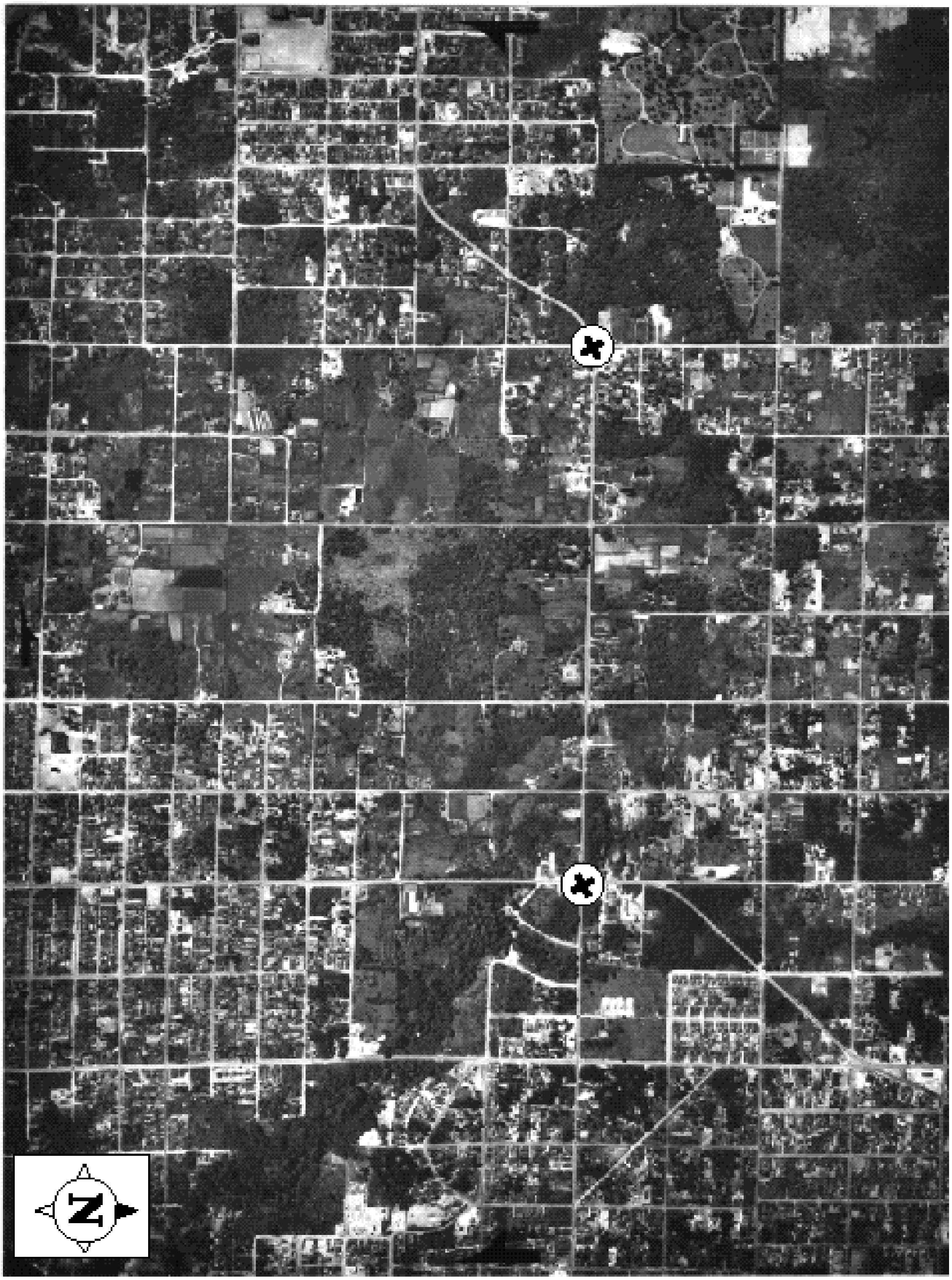
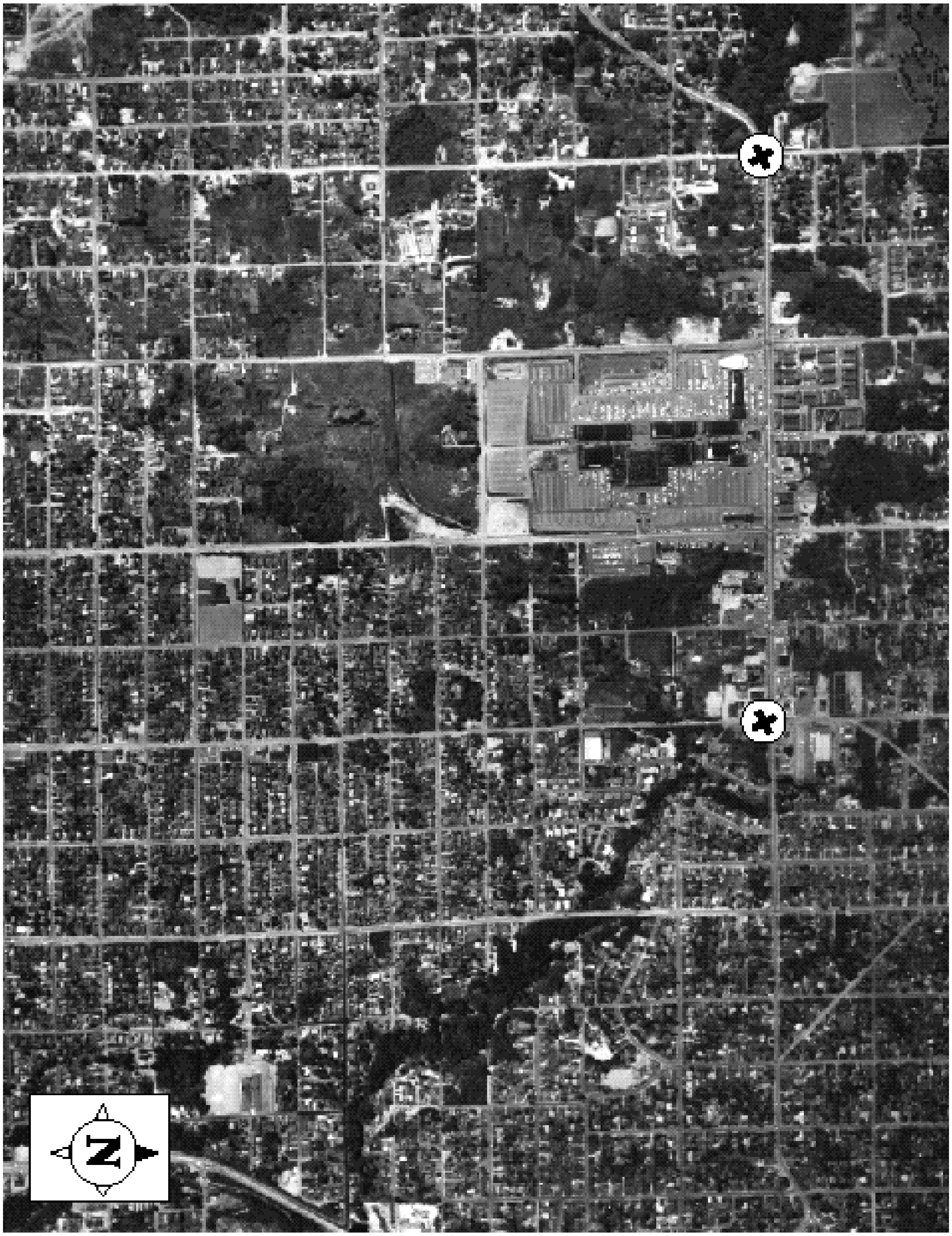


Figure 1.5. Northgate Mall Vicinity (1960)



The natural features of the Thornton Creek watershed have changed drastically since the turn of the century. Mature forests were logged and never replanted Wetlands were filled in or drained through ditch networks, expanding the stream network and providing sites for schools, public housing, shopping centers and parking lots.. Thornton Creek and its tributaries were modified by culverts, filling, channel constrictions, and direct paving over portions of the channel. The remaining undeveloped "natural" areas were fragmented by roads and buildings. These "natural areas" are mostly in parks and vacant lots. Many local parks have been paved to provide hard surfaces for playgrounds and ball fields. Only a few parks retain a "wild" character, where the vegetation is allowed to grow freely.

The next sections generally describe how urbanization typically impacts natural conditions in watersheds like Thornton Creek. For more detail on land use in the watershed, see Section 3.6.

Impacts on the Water Cycle (Hydrology)

Natural Water Cycle

In an undeveloped, forested watershed, little rainfall runs off the land directly into streams and wetlands. As much as half of the rainfall in a forest may be returned to the atmosphere by evaporation and transpiration – the process by which plants release water vapor from leaves. The layer of organic debris on the forest floor absorbs enormous amounts of water. Most water movement is below the surface, as water stored in the soil and wetlands slowly filters through the ground into streams.

Urban Water Cycle

Recent research demonstrates that the change in a watershed's hydrologic regime resulting from urbanization is the most influential factor affecting Puget Sound streams (May, 1997). In addition to the loss of forests, impervious (hard) surfaces such as roads, parking lots, sidewalks, and buildings further prevent water from filtering or permeating into the underlying soil. Replacing natural infiltration areas such as wetlands, meadows, and forests with pipes and ditches diverts water directly to creeks.

These alterations reduce infiltration, increase the volume and velocity of stormwater runoff, and reduce dry season stream flow. The greater range between storm flows and dry weather flows, along with the greater frequency of high flows and change in timing of flows, has altered the physical conditions to which most aquatic organisms have adapted. Examples of these hydrological changes are summarized below. For more detail, see Section 3.2.

Quantity. In urban watersheds, rainfall quickly runs off roofs and roads, enters ditches and pipes, and flows rapidly to the nearest stream or water body. The result is high volumes of water, which can increase the number of floods, as well as the extent of flooded areas.

Velocity. The velocity of water entering urban streams is also higher than in undeveloped watersheds. Urban streams are considered "flashy" because rainwater quickly reaches a stream, and the intense flows can quickly fill the entire channel. After a storm, water levels quickly recede. In a forested watershed, there may be a ten-fold difference in stream flows between dry weather and a moderate storm that fills the stream channel. In urban areas, such as the Thornton Creek watershed, there may be a thirty-fold difference in stream flows between dry weather and a moderate storm. (May, 1997).

Low Dry Season Flow. During the summer, there is less water in urban creeks. Because impervious surfaces and filled wetlands drastically reduce infiltration and subsurface flows, less water is available to supplement stream flows during drier parts of the year – typically in July, August, and September.

Impacts on Riparian Vegetation

The land and vegetation along a stream is called the riparian corridor. According to UW researchers, the second biggest factor affecting stream health is the extent of vegetation in the riparian buffer– the area between the stream and drier uplands (May, 1997). In a forested watershed, riparian buffers generally contain trees and shrubs that serve several functions: slowing runoff, filtering out sediments and pollutants, stabilizing streambanks, and providing organic matter that is food for aquatic insects. A developed canopy of trees and shrubs shades the stream, regulating air and stream temperatures, and provides the large woody debris (LWD) important to stream habitat.

According to one study, to support natural levels of stream quality, at least 70% of the riparian corridor needs a buffer width of 30 meters, while more sensitive areas would ideally have 100 meter buffers (Horner and May, 1998). In urban settings, 30 meter buffers are rare; 10 meter buffers are more common. Buffers that do exist tend to have a sparse canopy and lack shrub layers. Often the effectiveness of buffers is further reduced by storm drainpipes that discharge directly into the creek.

In addition to being narrow, urban riparian buffers tend to be fragmented and composed of deciduous and/or non-native species that are generally considered functionally different than mature conifer trees.

Habitat conditions outside the riparian corridor also affect stream health. Detrimental effects of upland habitat loss include:

- Disturbance of natural forest succession from deciduous to conifer trees.
- Lack of habitat diversity and fragmentation of remaining habitat.
- Encroachment of non-native vegetation that out-competes native species used by wildlife.
- A general lack of species and structural diversity within all habitat types (e.g., few tree species and no shrub layer).
- Lack of dead wood, either as standing snag trees or down as woody debris.
- Limited connection or linkage between riparian habitats and upland habitats.
- Disturbance due to the proximity of housing, domestic animals, and recreational uses.

For more specific information on riparian conditions in Thornton Creek watershed, see Section 4.7.

Impacts on Instream Habitat Conditions

Changes in watershed hydrology significantly influence the physical structure of streams. These structural impacts include enlarged channels, accelerated streambank erosion, increased landslides, increased streambed movement, and degraded instream habitat. (May, 1997). Other factors that affect instream conditions include the construction of bridges, culverts, and rip-rapped banks; the presence or absence of a floodplain; and erosion of soils from construction sites and other unprotected areas.

In the case of Thornton Creek, several areas of the stream have been relocated, straightened, dredged, and/or cleaned of LWD important to habitat. Where mature conifers and hardwood trees used to grow, the streambanks are now often reinforced with concrete walls or large rocks. Like other urban streams Thornton Creek lacks fully functional floodplains due to the encroachment of human-made structures.

As a result of these factors, the rapid, high stormwater flows discharged to Thornton Creek cause increased flooding and streambank and channel erosion. The result is damage to property and aquatic species and their habitat.

Eroded sediments can destabilize streambed materials and scour gravel from spawning areas. Fine sediment deposits can smother fish eggs and aquatic insects and damage the gills of juvenile and adult fish, leading to disease and predation. Eventually, sediment levels may drop below natural levels and the stream can become “sediment-starved,” leading to streambed incision and loss of spawning gravel.

Another significant effect is the loss of LWD due to removal of native riparian vegetation. LWD falling into the stream shapes stream channels, dissipates flow energy, protects streambanks, stabilizes streambeds, stores sediment, and provides instream cover, food for macro-invertebrates, and habitat diversity for fish and other aquatic life. The reduced volume and frequency of LWD due to removal of riparian vegetation and dredging of streambeds results in generally smaller and fewer pools (lower habitat diversity). All of these combine to reduce diversity and population sizes of aquatic species, such as salmon (May, 1995).

The loss of habitat diversity can change the aquatic species that live in streams by favoring some species over others. For example, Cutthroat trout tend to be better adapted to more uniform stream habitats than are salmon species such as Chinook and Steelhead trout. Cutthroat trout tend to be more abundant in urban streams like Thornton Creek than other sensitive salmon species.

For more specific information on instream physical habitat conditions in Thornton Creek and its tributaries, see Section 4.7.

Impacts on Water Quality

Water quality in streams is impacted by chemical pollutants in stormwater runoff, biological contamination, thermal pollution, and excess sediment. Stream flows in urban areas carry more water and more pollutants than in forested areas. The pollutants in urban runoff come from a myriad of sources, including construction, automobiles, industries, businesses, lawns and gardens, pets, and home maintenance activities. In most areas, pipes and ditches deliver runoff to streams with little or no water quality treatment.

Urban runoff contains automotive by-products such as motor oil, exhaust fumes, antifreeze, brake, and tire dust. Motor vehicles produce by-products that contain heavy metals and petroleum that can bind to fine sediments and end up in streams and wetlands. Vehicle maintenance, such as car washing, can discharge soap and cleaning chemicals into streams.

Yard maintenance is another source of pollutants. Lawn and garden chemicals, such as pesticides, herbicides, and fertilizers, can be overapplied and may wash off landscaped areas and into streams. Yard waste such as lawn clippings and leaves may also enter the drainage system and lower instream oxygen levels by overfertilizing aquatic plants and algae. Improper landscaping techniques can leave exposed soils vulnerable to erosion, and may compound other water quality problems by adding fine sediments to streams. Landscape choices and alterations directly impact stream quality by changing rainfall runoff patterns and changing the vegetation of wetlands and streams to non-native species, or species that are not functionally equivalent to the mature conifer forests that previously existed in the Thornton Creek watershed.

Home maintenance activities, such as painting, cleaning carpets, installing a sidewalk, and killing moss on a roof, can also contribute pollutants to streams when materials from these activities run off the property during storms.

Animal waste from pets and wildlife contributes to the pollution problem by adding nutrients to streams and increasing the levels of bacteria such as fecal coliform. The increase in fecal coliform bacteria can pose a risk to pets and people that are exposed to the stream. In forested areas, there is an organic layer of duff that can filter these wastes before they reach surface waters.

Urbanization also causes thermal pollution. The loss of riparian vegetation reduces shading and increases both air and water temperatures. Lower summer flows also mean the water is shallower and warmer. Warmer temperatures can be detrimental to aquatic life, particularly salmon and trout that have adapted to cold water conditions.

For more specific information on water quality in Thornton Creek and its tributaries, see Chapter 5.

Impacts on Fish and Aquatic Invertebrates

Once abundant, many native spawning populations of salmon and steelhead in the Pacific Northwest have declined to critically low levels. The cumulative effects of human activities have contributed to the depletion of native salmonid populations. These effects include changes in ocean conditions, over-harvesting, and degradation of freshwater and estuarine habitats – including urbanization of stream watersheds.

In rivers and streams, all salmonids require cool, flowing water free of pollutants and high in dissolved oxygen; gravel substrates low in fine sediment for reproduction; unimpeded access to and from spawning and rearing areas; sufficient refuge and escape cover; and sufficient invertebrate organisms for food. Salmon in Puget Sound streams have been adversely impacted by:

- Changes in water flow regime.
- Sedimentation.
- Increased water temperatures.
- Streambed instability and erosion.
- Loss of habitat (for spawning, rearing, and refuge) due to channelization, wood removal, lack of riparian areas, instream wood, etc.
- Exposure to toxic materials in the water column and sediments.
- Potential competition with hatchery stocks.

At the watershed scale, the major physical processes that affect salmon habitat include hydrology, sediment transport, energy transfer, nutrient cycling, and deposits of large woody debris (LWD).. Hydrology may be the “forcing” process at this scale. Hydrology determines the quantity and timing of stream flow, which in turn directly influences sediment transport, channel configuration, and habitat availability. Flow indirectly controls nutrient cycling and energy transfer by affecting the movement of litter, emergence of aquatic insects, and distribution of temperature in the stream environment. LWD influences flow and sediment transport in such a way that pools and riffles are formed and habitat is modified. Each physical change in the watershed affects salmonid populations.

Aquatic insects, a primary food source for fish, are less abundant in urban areas. Samples of invertebrates from one of the healthiest local streams, Rock Creek in rural King County, contained 27 kinds (taxa) of invertebrates. Similar samples from an urban stream (Thornton

Creek) contained seven taxa. A typical Puget Sound lowland stream may have 18 taxa of mayflies, stoneflies and caddisflies, a typical urban stream only two or three (Karr, 1998).

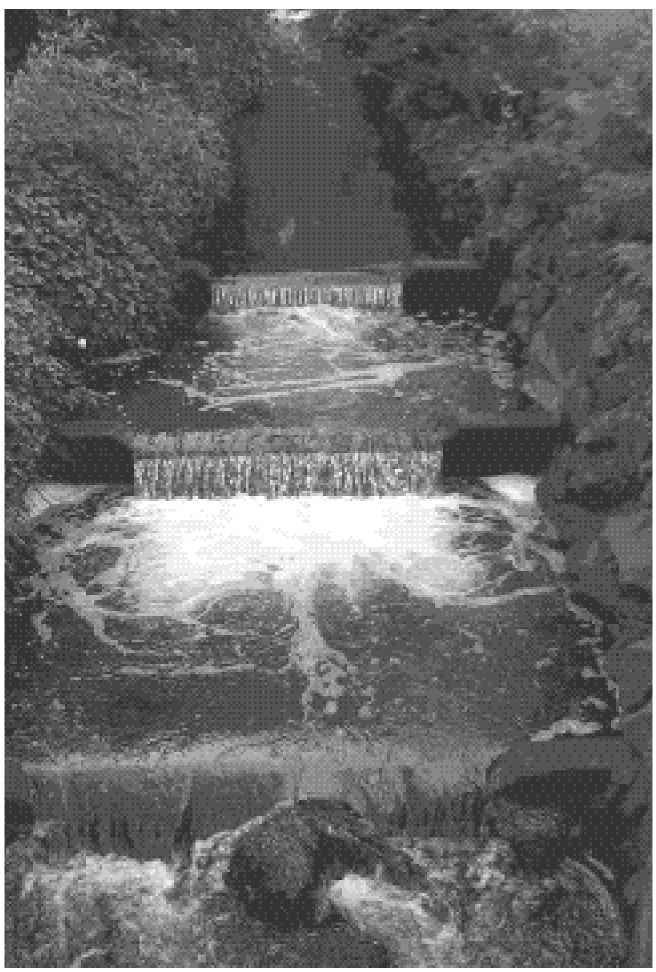
Some scientists believe that habitat rather than food is the limiting resource for most salmonids in the Pacific Northwest. Coho rely heavily on small lowland streams and associated off-channel wetland areas during their rearing phase. Cutthroat trout are commonly found in almost all small streams in the Pacific Northwest, and are potential competitors with coho. In urban streams, rearing habitat appears to be the factor that most limits salmonid populations. Coho and cutthroat require pools in streams. Coho rear primarily in pools with abundant cover, high habitat complexity, and LWD as the main structural component – all features which are lacking in the majority of urban streams.

For more specific information on fish and aquatic invertebrates in Thornton Creek and its tributaries, see Section 4.4.

Summary

Urban streams are quite different than their counterparts in undeveloped watersheds. Development, particularly of hard surfaces and storm drains and ditches, has altered the water cycle and movement of water within the creek, and removed native riparian vegetation. In turn, the character of the creek banks and bed has been altered. The result is elimination or reduction in native species and replacement in some cases by species more adapted to an urban environment.

PART 2
Watershed Character and Condition



South Branch (Maple Creek)

Chapter 2: People of the Watershed

For thousands of years, people have lived in the Thornton Creek watershed. Native Americans lived lightly upon the land without changing the landscape significantly. The arrival of European settlers broke that rhythm. Settlers arrived, continued to come, and are still coming today. The first wave of settlers changed the watershed by logging and farming it. Next came the automobile and brick highways, along with more people. After World War II there was a surge of new city dwellers seeking housing and job opportunities. The Boeing boom of the 1960s brought more, and the region's economic vitality of the 1990s has brought still more.

An estimated 75,400 people now live within this 11 square mile watershed. Over time, homes, roads, stores, offices, hospitals, schools, parks, and other attributes of a city have been developed. The watershed is full of contrasts, from the large, mature conifer forest in Hamlin Park to the busy stretch of Interstate 5 adjacent to the Northgate Mall area. There are steep ravines and gently sloped floodplains. Some people live in apartments near retail cores such as Lake City while others live in houses on large wooded lots. The Thornton Creek system, mostly above ground, flows throughout the area sometimes in back yards, sometimes along streets or under highways, sometimes through wooded areas and sometimes through highly developed paved areas. This chapter describes the history of the watershed, its people, and how the land is used.

2.1 Historical Settlement

Native Americans

Prior to European settlement, Native Americans lived around Lake Washington in distinct villages. They have been loosely grouped and collectively called the lake people. Their culture was described by historian David Buerge in an August 1-7,1984 article (pp. 29-33) for the Seattle Weekly on "Indian Lake Washington." The following excerpts are from this article.

> Enough material survives in the form of surveyors' notes, timber records, and the recollection of early observers for us to reconstruct the aboriginal environment in some detail. One thing these early records reveal is that the large lakes of the area provided their early users with an amazingly rich variety of resources. Whereas, for example, the rivers were valued primarily as a source of anadromous fish, the lakes had their own large resident populations of species like the kokanee and others like suckers, chubb and peamouth…. There were also waterfowl and large populations of muskrats, beaver, otters and other animals that were hunted and trapped. And there were edible plants too, like the wapato, the water lily whose seeds ground to paste, and the cattail whose root was edible and whose pithy stalk was used to make mats.

> To gather in this richness, the people living near the lakes developed tools suited to their habitat such as seine nets and weirs adapted to the lake, and the special duck catching spears, with barbs to lodge in the duck's feathers. Aside from a differing technology, the dwellers on the lakes differed from their river or saltwater kin in their food gathering schedule, since fish spawned in the lakes and their tributaries at different times than they did on the Sound and in its debouching rivers. . .
>
> . . .the people of Lake Washington . . . are the ones most adapted to the lake environment. From a variety of sources, we can identify 18 of their house sites…. Houses of this size probably sheltered between four and five families each. These households appear to have been divided among seven winter villages – groups of houses usually clustered about the mouth of important salmon-spawning streams.
>
> [A description of various tribal bands followed, including the group living on Thornton Creek.]
>
> North of this [Ravenna] lived the Tu-oh-beh-DAHBSH, a small group that had one house at the mouth of Thornton Creek and possibly another at the mouth of McAleer Creek, the outlet of Lake Ballinger. Those at Thornton Creek had access to the large cranberry bog near its head at what is now Northgate. . .
>
> The division of the lake people into separate winter village groups reflected the unique character of the lake fishery. On the rivers a weir built across the channel by a group could keep fish from moving upstream, and agreements were worked out between up and downstream groups over the placement of weirs and the times a group could keep its screens in the water. On the lake, however, a weir built on one tributary would have no effect on the catch at any other, so there was no need to cooperate in the same ways as there was among river groups. . .
>
> This complex arrangement seems to have lasted a long time. The lake people remembered when their aquatic world had been an arm of the sea, as it was about 5,000 years ago. After that, the Cedar River pushed its delta against Earlington Hill – the southern extension of Beacon Hill – and at once blocked the tides and dammed the ancestral Sammamish River, creating a lake in its broad lower valley. As the delta rose, so did the lake level, and gradually more and more of the shoreline was submerged. That this transformation was witnessed – and endured – by ancient inhabitants was discovered in 1916 when the lake level was lowered nine feet and old hearth sites were found on the newly exposed shore. . .
>
> Many of the house sites on the lake appear to have been occupied up to the 1860s. . .But gradually the old village and house structures broke up and families drifted away, many going – or being removed – to the reservations. When they could, family heads took up claims at places near their old house sites, and a few did so on Lake Washington, but by the 1890s most of the population had disappeared. . .
>
> 1916. . . This was the year the lake level was lowered by the US Army Corps of Engineers with the creation of the ship canal. The lowering was an ecological disaster for the lake and its people. The marshes that sheltered vast populations of waterfowl were left to dry out and be overgrown with willow and cottonwood, and even though they eventually restored themselves at a lower level, the birds never returned in anything like their former numbers. Nor did the muskrats, the Sockeye, and any of the other fish whose gravel spawning beds were exposed to the air. The water lilies and cattails took years to reestablish themselves, but the wapato seems to have disappeared altogether. And so, the wading root gatherers and the flickering lights of the duck hunters were seen no more, , ,

The lake people were moved to at least three reservations during the late 1800s: Port Madison, Muckleshoot, and Tulalip. The descendants of these people still rely on fish and wildlife resources produced by Thornton Creek and other areas in the larger Lake Washington/Cedar River/ Sammamish Basin. As a result of the landmark case, *U.S. v. Washington* (1970s) Thornton Creek is within the "usual and accustomed" area of the Muckleshoot Indian Tribe, which means that the Tribe is entitled to salmon and trout that are produced from Thornton Creek (as well as other areas) and have an interest in ancestral sites of cultural significance. The Tribe works cooperatively with the Washington Department of Fish and Wildlife and the

Suquamish Tribe to ensure that salmon are managed to produce salmon for the future. The Tribe also works with the entities controlling land use and subsequently habitat to ensure that salmon habitat is protected and/or restored to support salmon.

Settlers

In 1848 Congress created the Oregon Territory, which stretched from California to Canada. Two years later, the government extended the Federal system of land disposal to this area and created the Oregon Territory Donation Land Claim Act. This act allowed white settlers to claim up to 160 acres per adult, provided the land was cleared, cultivated, and occupied for four consecutive years. Some of the earliest documentation of conditions in much of the Pacific Northwest – including the Thornton Creek watershed – comes from land surveyor records. In an 1859 surveyor map of King County, Thornton Creek is identified but not named.

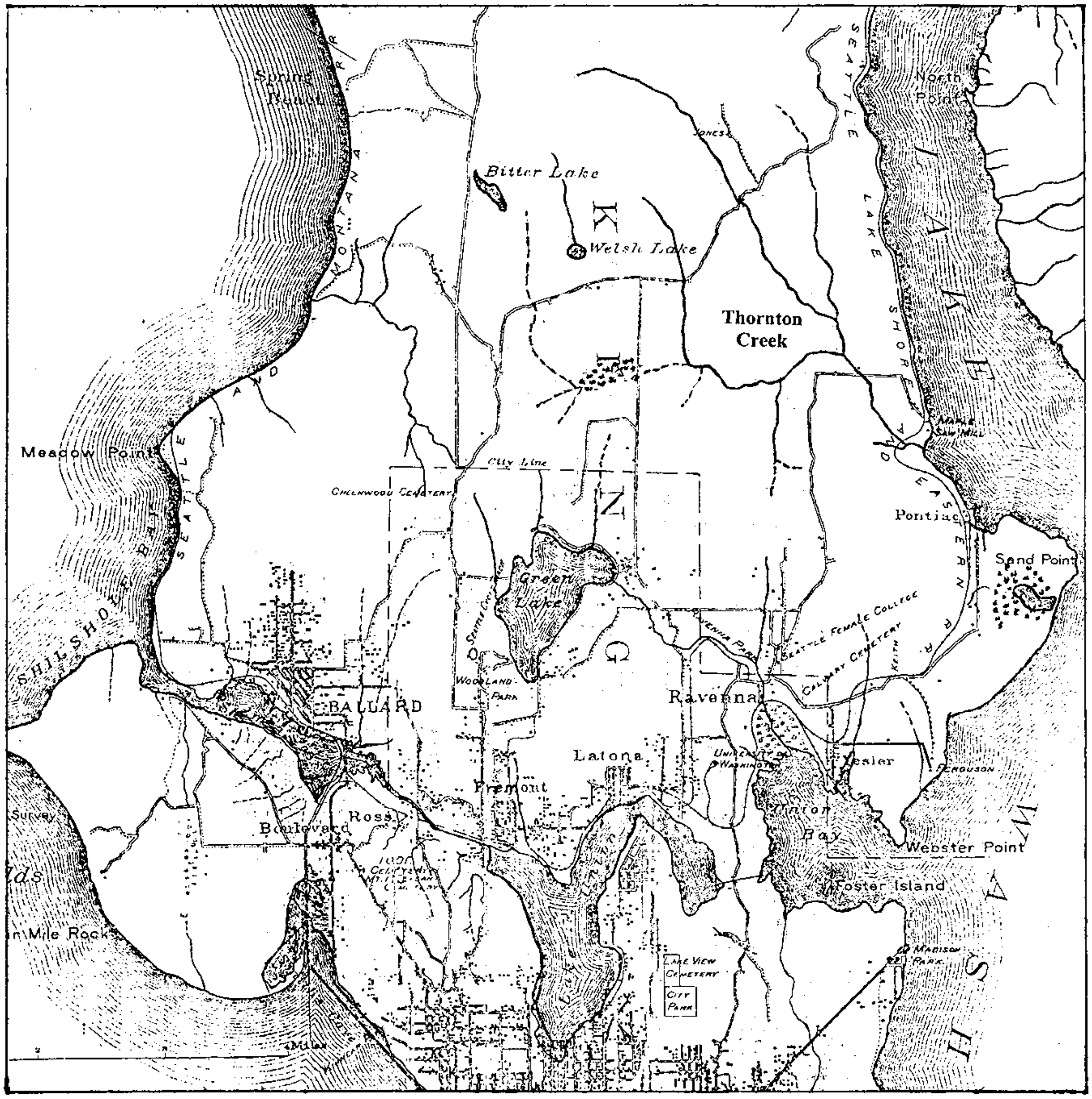
Early settlers quickly took advantage of the Land Claim Act and the rich natural resources in the area. Logging was the first industry to reach the Thornton Creek watershed. Several mills sprang up in the Seattle area during the late 1800s and much of the forested area was quickly harvested.

After the forests were logged off, farms, orchards, and dairies dominated the area. Some prominent early land-owning families include Edith Thornton (Northgate area) and the Littles, Beckers, Ebbinghausers, Fischers, Jones, Ohlands, and Maples.

McKees Accurate Road Map of Seattle and Vicinity (1894) shows Thornton Creek as an unnamed creek (see Figure 2.1). The map also shows the Seattle Lakeshore & Eastern Railroad, established in 1885, which connected Seattle to “points north” along the west shore of Lake Washington. One station or “depot” was located near the mouth of Thornton Creek. This map also shows a limited system of wagon roads and a sawmill located near a cove at present-day Matthews Beach.

In the early 1900s, the Little family settled next to what is today Paramount Park in Shoreline. They did some peat mining in the ravine and logged, developed, and filled much of the surrounding land. Littles Creek, one of the main tributaries originating north of Paramount Park, is named after the family. The Littles operated a sawmill on three sites in the watershed. The mill was brought north on the interurban railroad and dragged by its steam-powered donkey engine on its skids from the rail line to its first location near the current site of Northgate shopping center. As surrounding forests were cut down, the mill was relocated twice, first to a site near the current Pinehurst School, then to the banks of the North Fork just downstream of the current Jackson Park Golf Course (established in 1927). A log dam created a millpond reaching from the site up into the current golf course.

Figure 2.1. McKees Accurate Road Map of Seattle and Vicinity (1894)



Early 20th Century Dwellers

In 1905, the Bothell road (now Lake City Way) became a brick highway and brought more residents to the watershed. Farm sizes were reduced as new homes were built. In 1914, a state sanatorium for tuberculosis sufferers was established at Firlands.

In 1916, when the Ship Canal was constructed, the water level in Lake Washington was lowered by nine feet. A sizeable amount of underwater property surfaced. As described earlier in this chapter, a substantial amount of near shore habitat was left high and dry, most of which has been filled in by residential development.

With the growing number of automobiles, development accelerated in the watershed. In 1922 the Bothell road, then called Victory Way, became the first concrete road in the county. This road was quickly labeled a “death trap” – 21 wrecks occurred in one night alone (Halloween 1923). The Bothell road gave birth to the Lake City business district in 1923 with the establishment of Adair’s Garage & Repairs. Other stores, shops, and houses soon followed. In 1930, NE 125th St was built, connecting Sand Point Way (State Highway 513) with Victory Way (renamed Bothell Way and later renamed Lake City Way). The intersection of 125th St has remained the center of the Lake City business district since that time.

Mid-20th Century Population Boom, the Post-War Era

Following World War II, when Seattle’s population more than doubled to support war industries, population rapidly increased in the Thornton Creek area. Population in the watershed jumped from 2,898 in 1920 to 17,500 in 1940 and reached 43,680 ten years later (Lake City Journal 5/18/77). The watershed was under King County jurisdiction and building codes were less restrictive than in Seattle. Streets were often built without grading, sidewalks, or gutters, and rainwater gouged gullies into the creek.

Schools and parks were developed to support the watershed’s burgeoning family-oriented population. Hamlin Park was acquired in 1945 and Matthews Beach Park was established soon after. In the late 1950s, the private Meadowbrook Golf Club site was bought and converted into Nathan Hale High School and playfield. In 1963, the creek section near Nathan Hale was re-located.

In 1950, developers constructed “America’s First Regional Shopping Center: Northgate Shopping City.” It featured an open-air pedestrian mall with a major department store, 77 specialty shops, theater, hospital, medical and dental offices, and a parking lot. In the early 1960s I-5 was completed, and Northgate was expanded.

In 1954, the Seattle city limits were extended from 85th St. to NE 145th St when local voters chose to be annexed. The Lake City Sewer District developed in the 1950s and a sewer system was installed with a treatment plant at NE 105th St and 35th Ave NE. The treated sewage was discharged into Lake Washington.

Throughout the 1950s and 1960s, the public schools in the area served as community centers and neighborhood organizations developed, taking their names from the local schools. Since then, these service organizations, including the Lions Club, Elks Club, and Rotary, have provided strong local support for family and children’s activities. The Lions Club, for instance, developed the Lake City Community Center, made land available for the Lake City Library, developed Albert Davis Park, and supported the development of the first aid car in Seattle. The Lake City Chamber of Commerce developed and still supports the annual summer children’s parade and Pioneer Days. A community newspaper thrived during this time, and the business community developed a strong economic base, in part because of proximity to regional markets accessible from State Highway 522 (Lake City/Bothell Way). Automobile distributors became the most visible businesses along Lake City Way, including the first Toyota dealership in North America. A center (Little Ole’ Lake City) developed around NE 125th and Lake City Way, where the Lake City (movie) Theater and the local Post Office were located. Seattle Housing Authority built Lake City House and Family Townhouses nearby for poor families; the townhouses were built right on top of Little Brook.

Redeveloping the Watershed with an Environmental Focus

From 1969 until the present, concerned people in the watershed have actively sought ways to retain and improve the quality of life in the area. The Seattle portion of the watershed is now nearly built out – vacant lots are rare – and the story of the 1980s and 1990s is one of “in-fill” development and re-development (filling in vacant land, subdiving or “short platting” existing lots, creating larger structures to replace smaller ones).

Improvements in the 1960s and 1970s

In 1969, a Lake City community-wide study, Lake City Improves for Tomorrow, was begun. Shoreline Tower was built about this time, utility lines were undergrounded, new street lighting was installed, and 125th St was improved. North Seattle Community College opened in the early 1970s and has continuously supported both educational and facilities development projects to restore Thornton Creek. In 1977, a “Seattle Gateway Improvement Plan” for Lake City was developed and policy direction for the future was subsequently adopted by City Council, including a focus on maintaining the natural environment. Lake City Park was developed at the corner of Lake City Way and 125th. Street trees were planted along Lake City Way, and the median and sculpture, including a salmon, were installed. Only a portion of the Gateway Plan was implemented, however. When the School District closed Lake City School, the community raised significant funding to retain the Lake City Playground as a green park.

Volunteer Activity

During the late 1980s and 1990s, citizens throughout the watershed began to take on small volunteer projects to rediscover Thornton Creek, leading to some very large projects. Citizens prevailed upon Seattle’s Parks and Recreation Department to purchase several sensitive sites along the creek with open space bond funds. They continue to support restoration projects with their volunteer labor. During planning and site development of the new Meadowbrook Community Center, citizens restored areas along the creek and began ongoing support for development of Meadowbrook Pond, a detention facility across the street. Cedar Park School, currently in use as an artists’ residence, is the home of a new park in the former playground. Local school classes, led by private school teachers, began to monitor water quality in Thornton Creek. A wide range of educational opportunities have been made available not only by local schools for students, but also for adults in venues throughout the watershed. The Thornton Creek Alliance and the Thornton Creek Project, each coordinating, advocating, and educating about the watershed, emerged in the early 1990s, and each has worked effectively since to bring Thornton Creek to the attention of local service, business, and educational groups who have, in turn, supported watershed reclamation efforts with volunteer labor and funding.

Northgate Comprehensive Plan

During the late 1980s, citizens brought to the City of Seattle’s attention the fact that traffic was reaching gridlock in the vicinity of Northgate Mall. Over the course of several years, a Northgate Comprehensive Plan was developed with innovative ideas about how the area surrounding Northgate Mall could develop while protecting Thornton Creek in surrounding residential neighborhoods. Adopted by City Council in 1993, this Plan is undergoing a thorough public review as the Northgate Mall plans for significant expansion.

Community Economic Base

A Business Survey and Economic Analysis of the Lake City area conducted in 1997 by the City of Seattle’s Office of Economic Development in conjunction with the Lake City Chamber of Commerce and the North Neighborhoods’ Neighborhood Planning Group indicates that this portion of the watershed is one of the most diverse business districts in Seattle and one of the most stable and mature business districts in the area.

The survey also found that:

- 26% of the businesses own their own space,
- The average business occupies about 6,000 square feet and hires an average of ten full time and two part time employees.
- 16% of the business owners live in Lake City.

Business activity in the Lake City area totaled almost $1.9 billion in 1996, and wholesale business was the leading revenue generator. In other words, Lake City has a strong "neighborhood" business district and economic base as a community.

Plan for Neighborhoods in Lake City Communities (1999)

When the City of Seattle adopted a new Comprehensive Plan in 1994, an opportunity to develop a neighborhood plan for Lake City with assistance from the City was discussed in all the neighborhoods throughout the Seattle portion of the watershed. In 1995, a North District Neighborhoods' Planning Group formed to undertake this plan. The group decided that:

- The plan would include all neighborhoods that wished to participate from the larger Lake City area.
- The plan would begin work by putting Thornton Creek on the map, and planning would be based on the fundamental notion that the creek must be protected and restored.
- Business people and residents would join together in an open public process to create the plan.

The Plan for the Neighborhoods of the Lake City Community 1999-2014 was completed in 1999, and recommendations from the Plan were adopted by City Council. This Plan's recommendations for City action include comprehensive recommendations focused on creek restoration and preservation. (DeCoster, NPO, 1999) Development of this Watershed Action Plan was based in part upon the discussions and recommendations of citizens working on neighborhood planning and provides detail where the neighborhood plan provided only policy guidance. Additional information on these and other plans can be found in Chapter 6.

Environmental Impacts

Several notable environmental events occurred in the late 1960s and 1970s. In 1969, City commissioners approved plans to culvert the creek near Nathan Hale High School, against the wishes of many residents. A contractor cleared the ravine of all trees with a bulldozer to make room for apartments. The contractor was later fined by the Washington State Department of Fisheries for not having a fish permit.

In 1971, Square Lake, a small lake associated with a peat bog just south of Northgate Mall, was paved over for use as a parking lot, while environmentalists and the Park Board were discussing whether it should form part of a park. (Parks Commission records.)

In 1977, Thornton Creek "blew up" when a 300-gallon gasoline spill ignited. Gasoline had leaked into the storm drain from a gas station located at NE 145th St and 15th Ave NE. Citizen reports notifying government agencies about the problem were not enough to prevent the disaster. Neighbors reported seeing a "wall of fire" flowing down the creek. Fish, ducks, and other birds and wildlife were casualties. (Newspaper articles from 1977.)

In the 1970s, despite residents' complaints about ongoing flooding problems, proposals to build separate storm sewers at a cost of $50 - $90 million dollars were not approved as part of Seattle's Forward Thrust initiatives. In 1989, the City of Seattle created a Drainage and

Wastewater Utility to take responsibility for flood control and prevention. (City of Seattle records.)

In 1993, Assistant US Attorney General Neil Wise, commenting on a lawsuit brought by citizens to prevent the issue of a development permit, stated that the Department of Fisheries "cannot afford to expend its limited resources on low-priority sites such as this portion of Thornton Creek [1759 NE 130th Pl]." Neighbors videotaped steelhead spawning at the same site.

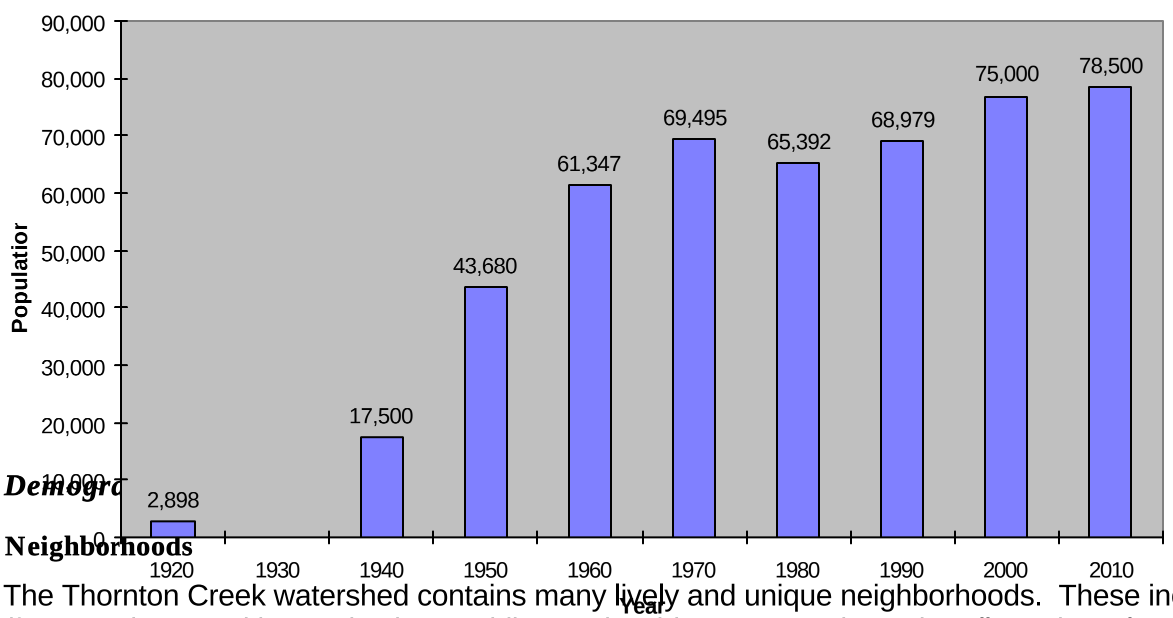
2.2 Population

An estimated 75,400 people live in the Thornton Creek watershed today. Population in the watershed grew rapidly from the early part of the century to the 1960s. Growth spurts were most noticeable in the post World War II era. Growth has slowed down, but population continues to rise.

Figure 2.2 shows population growth, based on estimates derived from US census data. The 1990 US Census has the most recent available data; 1930 census figures were not available. For census tracts located entirely within the watershed, the entire population count was used. For tracts only partially in the watershed, an equivalent portion of the population was counted. This method assumes population within a census tract is equally distributed.

Population estimates for 2000 and 2010 were developed using growth projections in the Seattle Comprehensive Plan (1994). This plan projects that population in Seattle will increase 9 percent between 1990 and 2000 and 13.9 percent between 1990 and 2010. These growth projections were applied to the Thornton Creek watershed. Based on the 1990 population of 68,979, the projected population is 75,000 in 2000 and 78,500 in 2010.

Figure 2.2. Thornton Creek Watershed Population Estimates 1920 – 2010



Demogr

Neighborhoods

The Thornton Creek watershed contains many lively and unique neighborhoods. These include (from north to south): North City, Meridian Park, Ridgecrest, Parkwood, Haller Lake, Olympic Hills, Cedar Park, Maple Leaf, Pinehurst, Lake City, Northgate, Victory Heights, Meadowbrook, Matthews Beach, Olympic View, Sacajawea, Fairview, and Wedgwood. Neighborhoods often overlap and have loose boundaries. Approximate locations of the neighborhoods are shown in Figure 2.3.

Population Density

Population densities are shown in Figure 2.4 (1990 census data). Population is most dense in the areas surrounding Northgate Mall, near NE 145th St, and along Lake City Way, where zoning permits multi-family development. Other heavily populated areas include North City and Wedgwood. The Hamlin Park area has the lowest density.

Ethnic Diversity

People of many ethnic backgrounds live in the watershed today. Although 1990 US census data provides some information on race, it does not capture the rich diversity of cultures in the area. For this report, staff from the North Seattle Family Center in Lake City were interviewed to identify groups using the facility. According to their 1998 client survey, Caucasian, Chinese, African American, Latino, and Southeast Asian families use the center, speaking over 20 different languages and dialects.

Type and Size of Households

In 1998, there were an estimated 33,362 household units in the watershed (Table 2.1). Slightly more than two-thirds (68%) of the households live in single family houses, the remainder in apartments. This data comes from US Postal Service carrier route information. Assuming City of Seattle estimates are true for the watershed, most single family homes in the watershed are owner-occupied (84.3%), while the majority of multi-family units (including some condominiums) are renter occupied (90%) (City of Seattle Comprehensive Plan, 1994).

Household sizes are expected to decrease. The Seattle Comprehensive Plan (1994) projected average household size would drop from 2.06 people per household in 1994 to 1.88 in 2014. The decrease in average household size reflects the trend toward smaller families and more people living alone. As fewer people live within a single household, the number of households citywide is expected to increase 24.6% over 20 years. Assuming these projections are true for the Thornton Creek watershed, the watershed will have 40,700 households by 2010.

Table 2.1. Number and Type of Household Units in Thornton Creek Watershed (1998)

Type of Housing	Number of Units	Percent of Total Units
Houses	22,686	68%
Apartments	10,676	32%
Total	33,362	100%

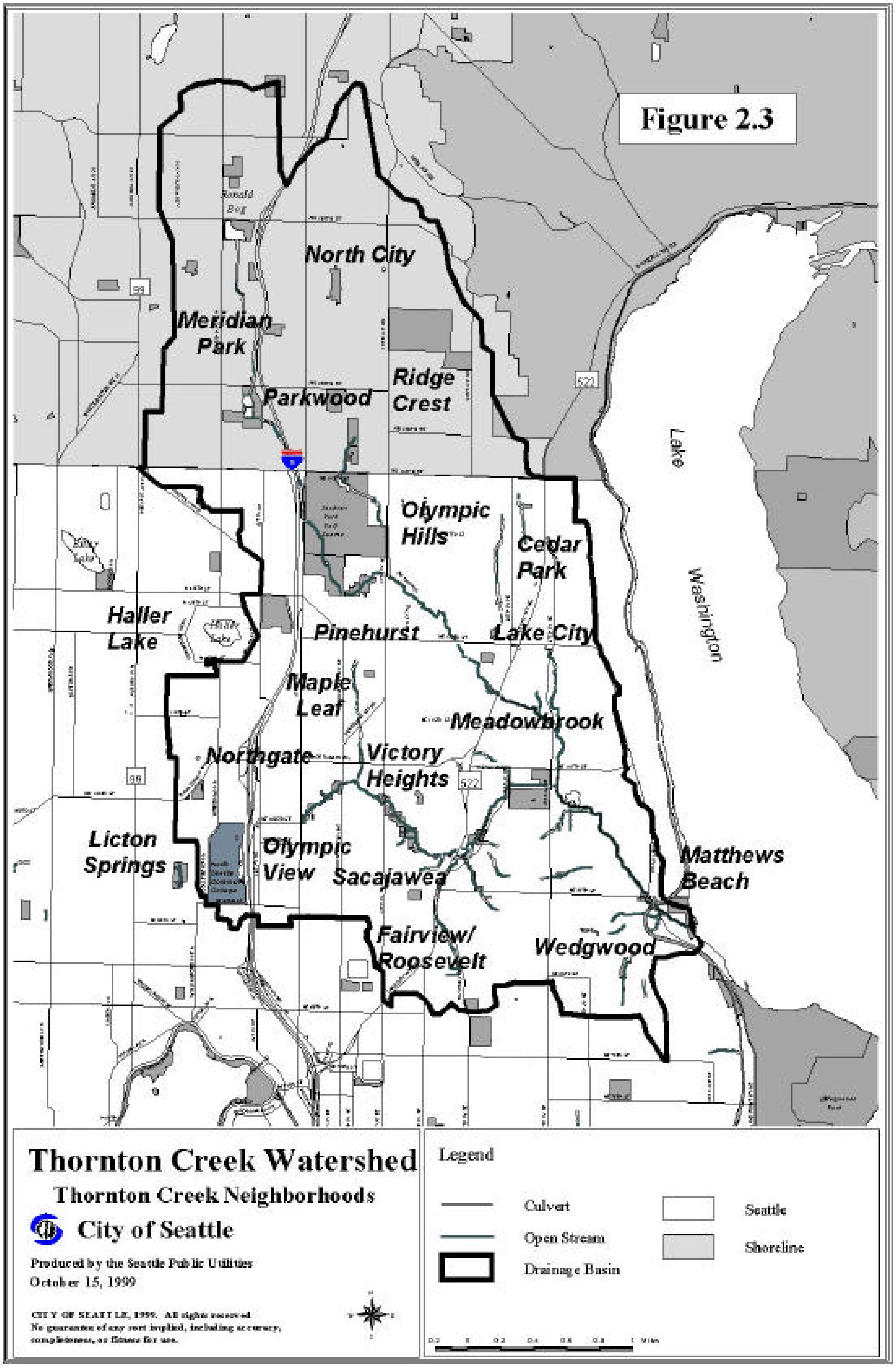
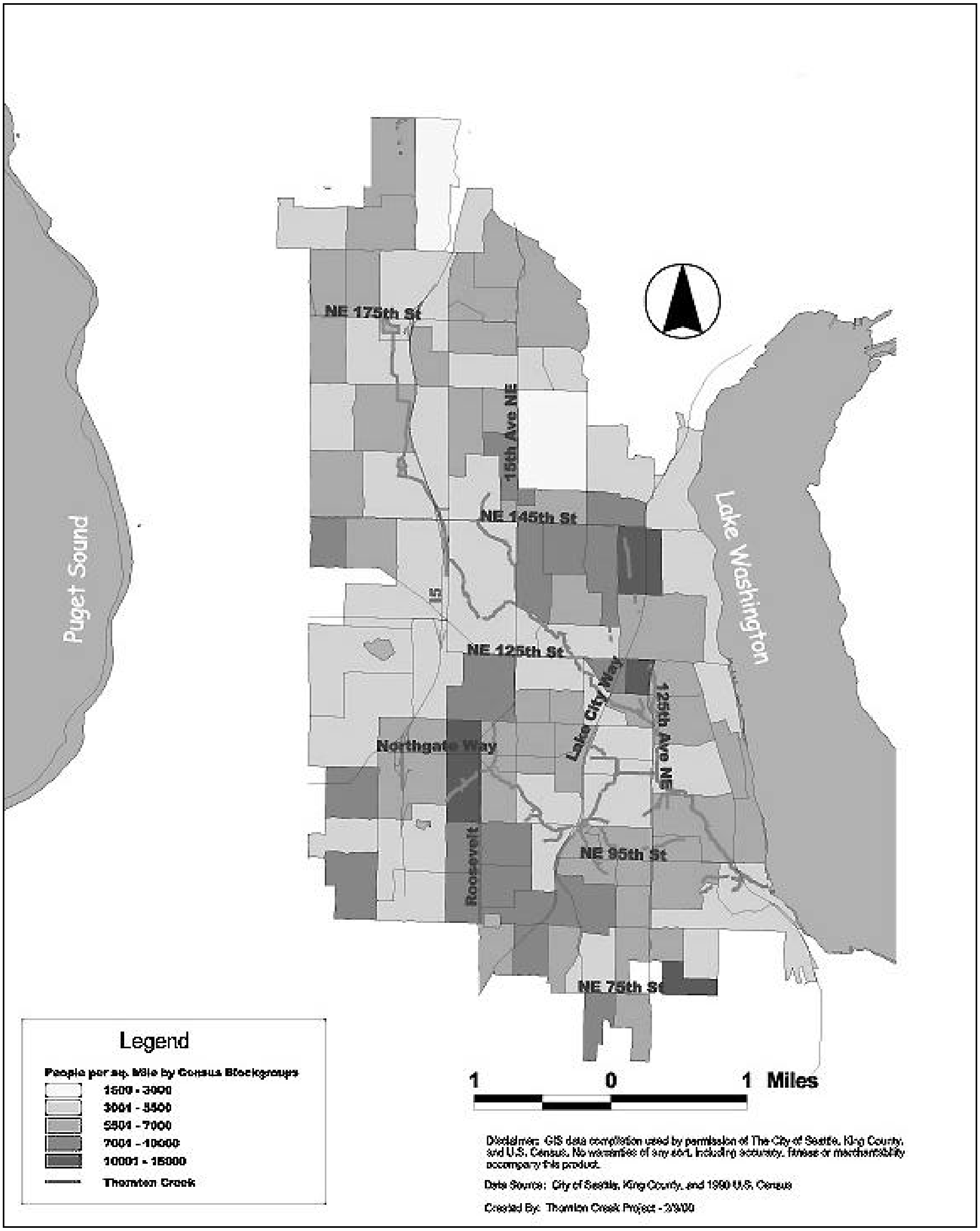


Figure 2.3
North City
Meridian Park
Parkwood
Ridge Crest
Olympic Hills
Cedar Park
Haller Lake
Pinehurst
Lake City
Maple Leaf
Meadowbrook
Northgate
Victory Heights
Licton Springs
Olympic View
Sacajawea
Matthews Beach
Fairview/ Roosevelt
Wedgwood
Lake Washington
Thornton Creek Watershed
Thornton Creek Neighborhoods
City of Seattle
Produced by the Seattle Public Utilities
October 15, 1999
CITY OF SEATTLE, 1999. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Culvert
Open Stream
Drainage Basin
Seattle
Shoreline

Figure 2.4. Population Density in Thornton Creek Watershed



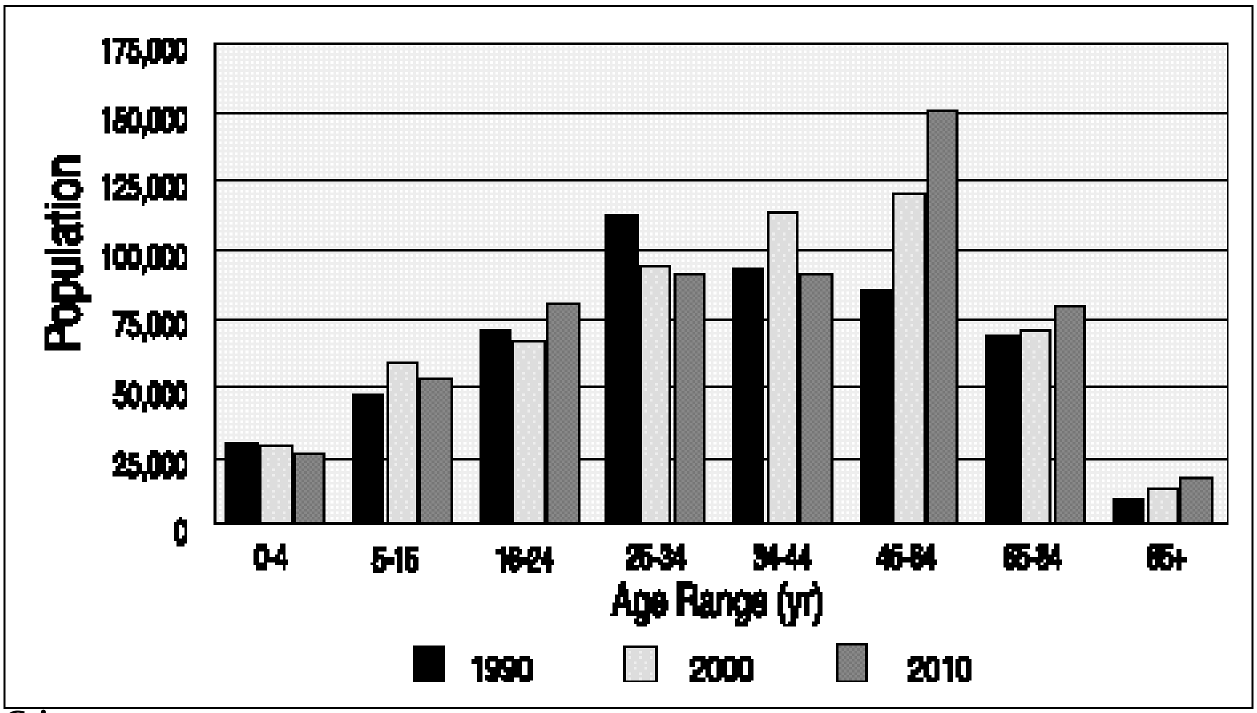
Income Distribution

In many areas, income is correlated to density – the poorest areas are often the most crowded. (See Figure 2.4) The wealthiest areas are near Lake Washington, the north end of the watershed, Jackson Park Golf Course, and the South Branch. The poorest neighborhoods are located along Lake City Way and surrounding Northgate Mall.

Age Characteristics

People of all age groups live in the Thornton Creek watershed. Figure 2.5 shows projected trends in age distribution for the City of Seattle (Seattle Comprehensive Plan, 1994). The biggest change is an increase in the number of older residents as the sizeable post-war generation grows older. A decline in the 25-34 age group is expected, possibly as young couples move to suburban areas to raise families. This is accompanied by a projected decrease in children aged 0-4.

Figure 2.5. Seattle Age Distribution 1990 - 2010



Crime

The nature and frequency of crime in the watershed is associated with socioeconomic status, zoning, and neighborhood type. Single family residential areas have the lowest crime rates in the watershed. These areas experience primarily residential theft, burglaries, and auto theft (Seattle Police Department, Part I Crimes, 1992-1997 and Shoreline Police Department Annual Reports 1997, 1998). The highest crime areas are located near Aurora Ave and Lake City Way. These areas showed the highest numbers of violent crimes and aggravated assaults. They also had higher rates for robbery, burglary, and auto theft. The higher crime areas tend to be densely populated and contain the business districts. Based on the available data, Thornton Creek, its tributaries, and adjacent parks are not at risk of becoming high crime areas where the creek and parks are generally in single family residential areas. In the Lake City business district, Thornton Creek riparian areas and parks are regularly watched and cared for by the Lake City Task Force.

Crime Prevention Through Environmental Design

Parks and natural areas, particularly those that are not staffed, may be perceived to have a higher incidence of crime. Areas that offer dense vegetation for wildlife can also provide secluded places for criminal behavior. Often neighborhood “adoption” of unmanaged parks, woods, or wetland areas can allow oversight; increase awareness, pride, and perceived levels of safety; and lead to thoughtful proposals for changes that will prevent crime in the future. Park design can also influence park safety.

The Seattle Police Department practices a concept known as Crime Prevention through Environmental Design (CPTED), which encourages the proper design and use of public spaces to decrease opportunities for crime. Some strategies applicable to watershed parks, open spaces, and natural areas include:

- Removing unnecessary structures that provide hiding places for criminal activity or increased crime risk.
- Pruning and clearing underbrush in areas designated for public gathering.
- Installing clear signs and enforcing posted rules.
- Providing adequate lighting and clear lines of sight.
- Encouraging community “adoption” and oversight of the site.

Some CPTED recommendations may increase actual and perceived public safety at the cost of wildlife. Wild animals rely on hidden places, thick shrubbery, and dark corners for their refuge and safety. Safety needs and wildlife needs require a different balance in unstaffed natural areas than in active recreation areas, and CPTED recommendations can be modified to achieve this.

Surface Water Quality Violations

The City of Seattle has a program to investigate and respond to water quality problems in creeks, lakes, and the storm drain system. City investigators respond to calls from citizens and other agencies regarding water quality problems. A typical call might report a leaking automobile, concrete washout dumped on the street, paint in a creek, or organic debris (including pet waste) in a drainage system or waterway. An investigative team promptly visits a problem site, and if a responsible party can be identified, the team informs the party of the problem, offers options for future disposal, and instructs the party to resolve the problem.

Seattle Public Utilities (SPU) has been keeping records of investigations since 1990. In the Thornton Creek watershed, 155 complaints about water quality have been investigated (1990-1998). Most problems are associated with construction, automotive fluids, and cleaning waste (soapy water):

- Construction-related complaints, including mud, paint, and drywall wastes noticeable in the creek (53).
- Automotive fluids, such as oil and antifreeze, and cleaning greasy engines and parts (35).
- Soapy water from car washes and wastewater from carpet and furniture cleaning discharging into storm drains (27).

- Other, including pet waste, excessive spraying of herbicides, swimming pool water, and sewage (40).

Approximately one-half of the water quality problems involved a storm drain, ditch, or culvert. In one-third of the cases, the problem was identified in the creek. The rest involved parking lots, dirt, or grass or were not identified.

Illegal Dumping

Seattle and Shoreline staff respond to numerous illegal dumping complaints. It is not uncommon for illegal dumping to occur along creek ravines where the material can easily disappear from sight. Watchful neighbors, street lights, and friendly “no dumping” signs can help combat this problem. No specific data was available to determine the percentage of complaints that concern illegal dumpinng along ravines or unmanaged open spaces.

Traffic

The number of cars in the watershed has grown even more rapidly than population. From 1980 to 1990 registered vehicles in Seattle increased 13%, while Seattle’s population grew only 4%. This trend is likely to continue. Currently, transit (bus) rides make up only 3% of total trips. Under the most optimistic transportation management scenario, this will rise only to 6%. (Seattle Comprehensive Plan, 1994).

Hundreds of thousands of cars, trucks, and buses pass through the Thornton Creek watershed every day. According to 1993 traffic counts, more than 187,300 vehicles travel southbound on Interstate 5 at NE 145th St on a weekday (Seattle Comprehensive Plan, 1994). An additional 60,000 cross NE 145th St on arterial and side streets. Traffic is predicted to increase 14-31% between 1990 and 2010, depending on how well the region manages population growth. This could mean 40,000 to 80,000 more vehicles crossing NE 145th St within the watershed each day.

Some typical weekday traffic counts are shown in Table 2.2, based on a 1993 traffic count.

Table 2.2. Traffic Counts

Location	Vehicles/Day
I-5 at NE 145th St	187,300
Northgate Way just east of I-5	30,700
NE 145th St just east of I-5	30,900
Lake City Way north of Northgate Way	39,100
NE 125th St just east of I-5	21,500
35th NE Ave just south of NE 95th St	14,100

Managing Growth

Seattle’s Comprehensive Plan (1994) anticipates that growth will occur within current zoning and according to historic patterns of growth in the city. Most growth will occur in the urban centers, hub urban villages, and residential urban villages that are characteristic of Seattle’s development pattern over time. Citywide, it is anticipated that there will be about 50,000-60,000 new households and 131,400-146,000 new jobs within the 20 years of the Plan. Urban centers and hub urban villages (along with Seattle’s two manufacturing and industrial centers) are expected to absorb the new jobs. Residential development is anticipated to be about 45% in the five urban villages, 30% in hub and residential urban villages, and 25% spread throughout the balance of the city.

In the Thornton Creek watershed, the Lake City area contains a hub urban village, defined by the 1999 neighborhood plan to be between about NE 123rd St and NE 135th St between about 25th Ave NE and 35th NE Ave. This area is expected to accommodate 1,400 new residential units and about 2,900 new jobs between 1990 and 2010. New and planned multi-family construction in the area is rapidly meeting this goal.

The Northgate urban center, which extends from about 86th to about 110th, and from Roosevelt Way NE to just east of I-5, is anticipated to increase in density from eight households per acre to 15, and from 28 to 50 jobs per acre between 1990 and 2010. The Northgate area, which is only just emerging as a "neighborhood," has been experiencing considerable multi-family residential growth during the past two decades, and Northgate Mall is planning a significant expansion.

Since some single family residential areas within the Thornton Creek watershed in Seattle have large lot sizes (compared to other parts of the city), there has been an observed trend to sub-divide lots and build additional single family houses in the area over the past decade. Consequently, observers in the watershed believe that there will continue to be families with children in the area in higher proportions than in Seattle's older and more crowded areas.

2.3 Watershed Survey

The Thornton Creek watershed is large, and only a small fraction of the residents live on the creek or belong to creek-based community groups. What do the majority of watershed residents think about the watershed? In 1998, SPU hired Decision Data, a marketing firm, to try and find out by conducting a telephone survey of watershed residents. Decision Data contacted approximately 1% of the households in the watershed in May 1998. The Watershed Management Committee helped develop the telephone survey. A copy of the survey questions is included in Appendix A.

Survey Objectives

The primary objectives of the survey were to assess:

- Basic awareness that there is a natural stream system in the neighborhood, recognition of the name "Thornton Creek," awareness of the terms "watershed" and "non-point source pollution," and awareness that residents are part of a watershed.
- Basic attitudes toward issues that might influence community support for or against restoration of the creek to a natural state, and support for pollution reduction.
- Reasons for interest in restoration.
- Willingness to change behavior to reduce pollution.
- Interest in supporting restoration in ways other than personal behavior.

The survey consisted of 354 interviews of a random sample of households in the watershed area. The average survey lasted 13.5 minutes. The 95% confidence interval for this survey is +/- 5.3%.

Survey Results

Basic Awareness

Awareness of Streams and Creeks. The first awareness question dealt with awareness of any natural watercourses in the area. Respondents were asked, "Do you know of any creeks or streams that run through your neighborhood or area?" Fifty percent (50%) of respondents knew of any creeks or streams and 50% did not. Individuals who did not know of any streams or creeks were asked an additional probing question, "Do you know of any place in your neighborhood where water collects and flows?" This, of course, could be any ditch or storm drain. Eighty percent (80%) responded that they knew of no such place.

Awareness of Thornton Creek. Individuals who indicated awareness of "streams or creeks" were asked to name them. Sixty-one percent of these individuals, or 31% of all respondents, were able to name Thornton Creek in this unaided way.

Individuals who were not able to name Thornton Creek were asked an aided question, "Have Another 58% (11% of all respondents) said they had, making the total awareness of Thornton Creek as a watercourse in the neighborhood equal to 42% (i.e., the total number of people who were aware of a stream or creek in their neighborhood or area and could recall the name or said they had heard of Thornton Creek). Even among individuals who did not know when asked of streams or creeks in their own neighborhood or area, 53% said they knew of Thornton Creek in the aided awareness question. Perhaps they had heard the name without realizing the stream was local, or perhaps they confused Thornton Creek with another creek. If these individuals are counted as being "aware," total awareness can be said to be 68% with more than half being of the aided variety.

Watershed Awareness. Overall, 84% of the respondents said they had heard the term "watershed," and 48% said they were aware that their "neighborhood is part of a natural watershed." There was a strong association between awareness of being part of a watershed and awareness of Thornton Creek. Seventy-four percent (74%) of individuals with unaided awareness of Thornton Creek knew their neighborhood was part of a natural watershed compared to only 24% of those who were unaware of Thornton Creek.

Source of Awareness of Creeks or Streams. Respondents who professed aided or unaided awareness of Thornton Creek were asked how they had learned about it. Approximately one third said they had always known of or lived next to the creek. Others mentioned signs (19%), newspapers articles (12%), and the recent newsletter (6%). Some said they learned of it through their children (5%) or from visiting parks (4%).

Perceptions of Thornton Creek. Respondents who were aware of Thornton Creek (unaided or aided) were asked a series of questions to determine current perceptions of the creek. They were given a list of 12 descriptions of a stream and asked if they thought each item was true or not true of Thornton Creek. For most items, 25% or more of the individuals had no opinion. This reflects the fact that the question was asked of individuals with aided awareness, and for some of these "awareness" may have been no more than a faint recollection of the name. Results are shown in Figure 2.6.

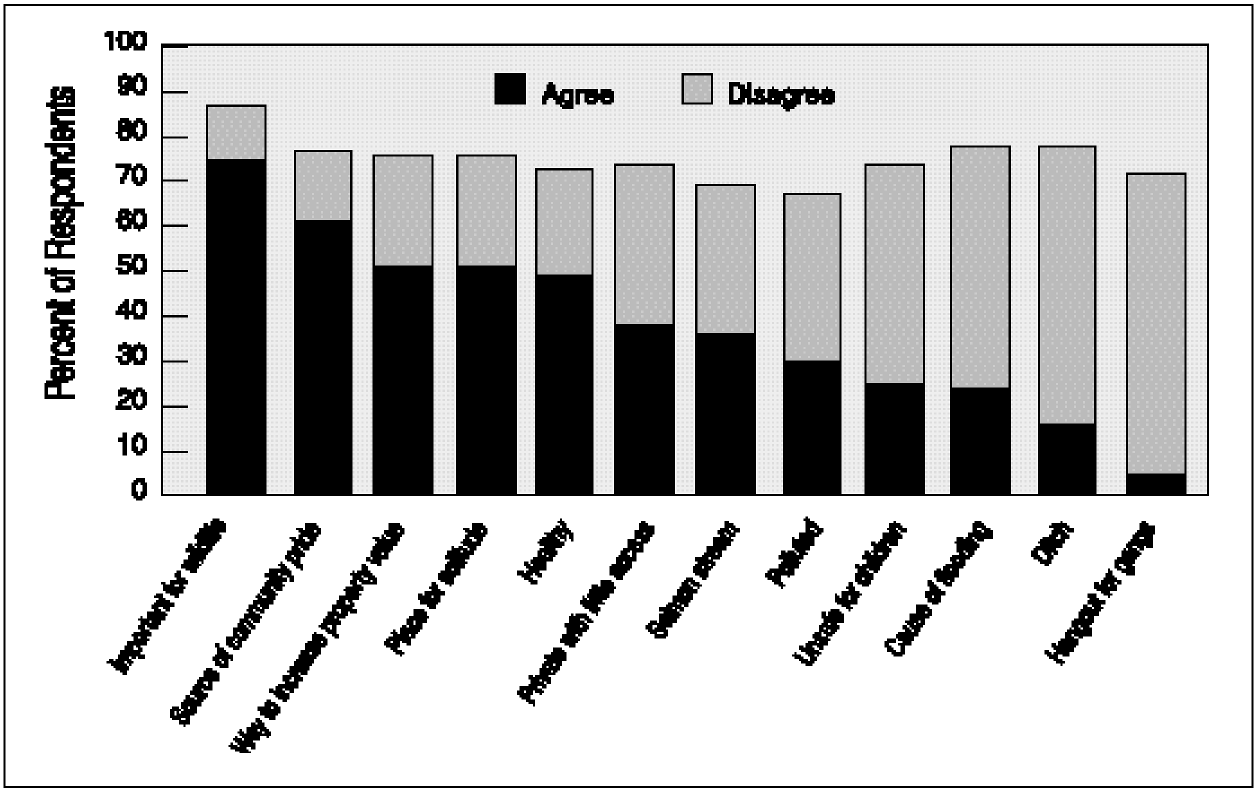
Attitudes toward Restoration Issues

This section describes attitudes toward a number of issues that may be related to opinions about restoration. The questions were presented as statements, and respondents were asked if they agreed or disagreed with each statement.

Seventy-one percent (71%) disagreed with the statement that "I'm just not very interested in it," 23% agreed and 6% withheld an opinion. This estimate of the proportion of people who are uninterested should probably be regarded as a lower bound on the true proportion because those with less interest in the watershed are less likely to have responded.

Of respondents who had an opinion, most agreed on questions about development needs and perceptions of the state of the stream. Respondents disagreed 12 to 1 that [restoration] "takes space away from needed development" and disagreed nearly 14 to 1 that [Thornton Creek] "is

Figure 2.6. Perceptions of Thornton Creek



pollution and water runoff." For the remaining four items of question 16, a significant proportion (~30%) of respondents withheld an opinion. Among three of the remaining items, opinion was approximately two to one in favor of restoration:

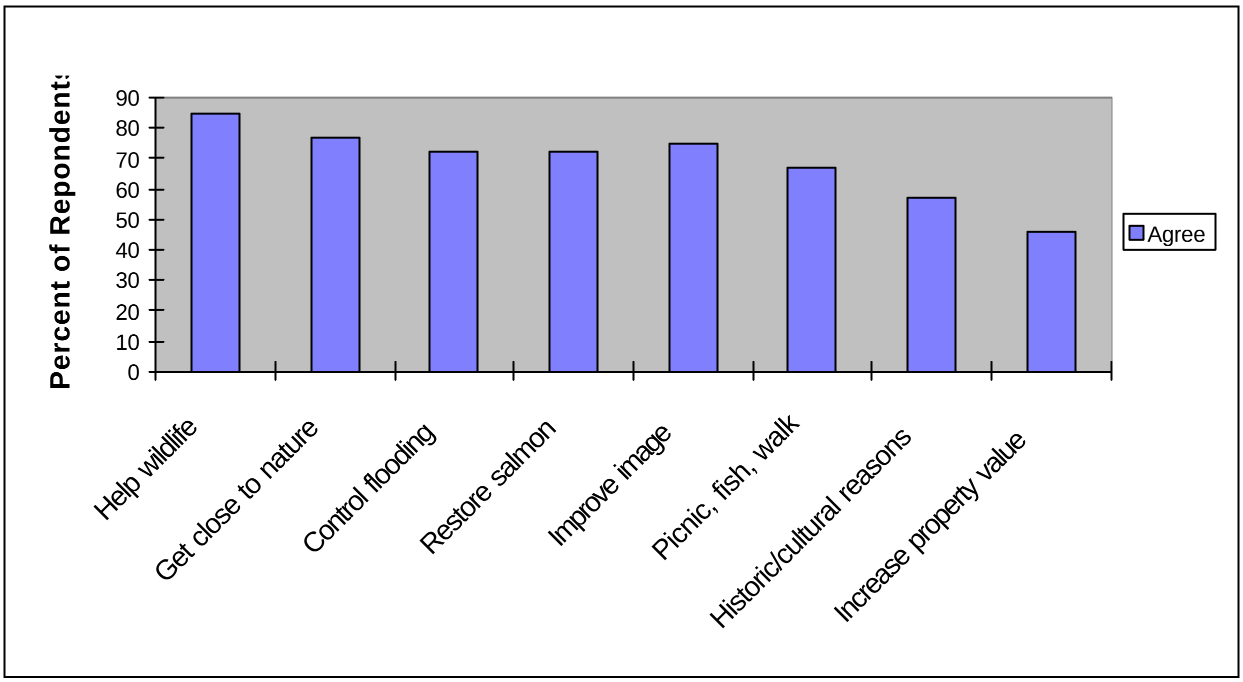
- 53% disagreed that "restoration money should be spent to protect rural creeks that have a lot of salmon, not urban creeks," and 22% agreed.
- 50% disagreed that "our city should take care of other social and economic problems before worrying about urban watersheds," and 22% agreed.
- 49% disagreed that "restoration of Thornton Creek watershed would result in too many environmental regulations and restrictions on local property owners," and 19% agreed.

Reasons for Interest in Restoration

The purpose of this section of the interview was to determine which aspects of restoration would interest the community most, given people's awareness of the nature of Thornton Creek and the watershed. Because the researchers expected many respondents to lack awareness of Thornton Creek or of being part of a natural watershed, the interview incorporated some information on these issues. Respondents were told that (1) their neighborhood was part of the Thornton Creek watershed (given a brief definition of a watershed); (2) Thornton Creek is a natural stream system; and (3) Thornton Creek had been altered by human activity. In interpreting the following data, it is important to bear in mind, as discussed in the awareness section above, that less than half the community is currently aware of these facts.

In this section respondents were asked to agree or disagree with nine statements describing reasons for restoring Thornton Creek to a more natural condition. Each description was prefaced by the statement, “It’s important to me personally to restore Thornton Creek because restoration can.…” The results are shown in Figure 2.7.

Figure 2.7. Reasons to Restore Thornton Creek



Willingness to Help

Behavior Change. The purpose of this section of the interview was to assess the potential in this community of changing a variety of behaviors contributing to non-point source pollution of Thornton Creek. Again, because of the expected lack of awareness that the stream is polluted and that residences are a source of pollution, the interview incorporated some information on these issues. Respondents were told that (1) salmon spawning and survival would increase if Thornton Creek was cleaned up; (2) much of the pollution of Thornton Creek comes from non-point source pollution; and (3) pollution of the creek comes from homes, businesses, and cars. “Examples are pet wastes that get washed into the creek, lawn and garden chemicals, soap and motor oil.” In interpreting the following data, it is important to bear in mind that many people are not aware of these concepts.

First, it should be pointed out that only 27% of the respondents acknowledged awareness of the term “non-point source pollution.” Respondents were asked to indicate their willingness to help reduce non-point source pollution in six ways after being given the information noted above. The results are shown below.

- Attend fairs and other fund raising events (32% “very appealing”).
- Participate in creek cleanups and tree planting (29% “very appealing”).
- Join a neighborhood organization that is restoring the creek (22% “very appealing”).
- Attend workshops and seminars about the creek (20% “very appealing”).

Ways of Communicating. Respondents were asked how best to communicate with them concerning watershed activities. The preferred methods were direct mail/newsletter and newspaper articles.

Demographic Characteristics of Respondents

Demographic information was collected in the last section of the interview in order to: (1) ensure that the respondents did not comprise a skewed cross section of the community and (2) determine if any particular demographic group was more or less interested in the restoration issue.

The residents surveyed we fairly comparable with 1990 census data for the watershed. Individuals with different demographic characteristics responded somewhat differently. Age appeared to be the strongest demographic predictor of responses to the survey. Awareness was somewhat lower among younger individuals (less than 35 years of age), and negative or neutral/don’t know answers were most frequent among older individuals.

To get a clearer picture of how demographic characteristics affect interest in restoration, researchers cross-tabulated groups with higher or lower interest in restoration with the demographic variables. This procedure produced a “higher interest” cluster composed of 270 individuals or 76% of the sample and a “lower interest” cluster composed of 84 individuals or 24% of the sample. Key variables were age, children in the household, and length of residence. People in the “higher interest” cluster included a greater percentage of younger individuals, families with children, and families newer to the neighborhood.

Conclusions

The information obtained in the survey about community awareness and values can be used to develop effective strategies to inform and educate the community about Thornton Creek and engage community support for restoration.

1. The effectiveness of any effort to change the behavior of residents or enlist community support will be limited by the current lack of awareness.
   - ♦ About 50% of respondents were aware of natural watercourses in the neighborhood and 31% were aware of Thornton Creek itself. Less than 50% were aware of being part of a watershed.
   - ♦ About 27% were aware of the phrase “non-point source pollution” (31% among individuals in the higher interest cluster). The low awareness of the terminology suggests a low awareness of the concept as well.
2. While awareness is low, there is a high potential for support in reducing pollution and restoring the watershed.
   - ♦ Among those currently familiar with Thornton Creek, most respondents (85%) agreed that the most important benefit of the creek was for wildlife and native plants.
   - ♦ About 61% of those aware of Thornton Creek felt it was a source of community pride. This was the second most important benefit of the creek among the items measured. Many of the respondents agreed that restoration of the creek would enhance the image of their neighborhood.
3. Among those familiar with Thornton Creek, respondents were about equally split in their perceptions that Thornton Creek is a public stream, that there is a pollution problem, or that it supports salmon. The first two issues, in particular, might represent hurdles to obtaining support from the community. People who see this as a private stream may be less likely to feel a sense of stewardship, and people who do not perceive a pollution problem may be less motivated to reduce pollution than those who do. Those who perceive Thornton Creek as a salmon stream may be more likely to view the stream as a significant natural watercourse and refuge for wildlife.

CHAPTER 3: WATER AND LAND

This chapter describes the water and land in the Thornton Creek watershed. It begins with an overview of the natural environment, the water cycle, climate, rainfall, and soils. Subsequent sections describe the creek flows, diversions for human use, sub-basins within the watershed, the riparian corridor, land use, and impervious surfaces. The flow of water through the creek and its tributaries is described, and so are the sub-watersheds.

The eastern edge of the watershed runs north from the mouth of the creek at Matthews Beach along the ridge above the west shore of Lake Washington (Sand Point Way) and extends to approximately NE 193rd St in Shoreline. The western portion of the basin extends nearly to Aurora Ave N and the southern portion to NE 80th St. The basin boundaries are shown in Figure 1.1.

Land elevations in the watershed range from 8.3 feet at the creek's mouth in Lake Washington to about 450 feet in the south (Roosevelt Way NE and NE 91st St), 500 feet in the west (of Aurora Ave N and N 145th St), and 500 feet in the north (near the Mount Vista water tank at 15th Ave NE and NE 180th St). A topographical map with 50-foot contours is shown in Figure 3.1. Most of the steep slopes are associated with the creek ravines, although some steep slopes are located near the eastern border of the watershed.

3.1 The Natural Environment

Water Cycle

A watershed is the land area drained by a particular stream, river, or other water body. Streams follow the lowest topography and form valleys that are separated from each other by ridges or divides. In a watershed, the rain, rivers, lakes, wetlands, and groundwater are all part of the water cycle (Figure 3.2). Some of the water that soaks into the ground is absorbed by plant roots and is released back into the atmosphere by the plants' leaves. The rest replenishes the groundwater, which in turn feeds streams and wetlands. In some communities, groundwater is an important source of drinking water. Surface runoff forms streams, then rivers that eventually empty to Puget Sound. Water evaporates from ponds, streams, lakes, and oceans to return to the atmosphere and eventually falls back to the earth again.

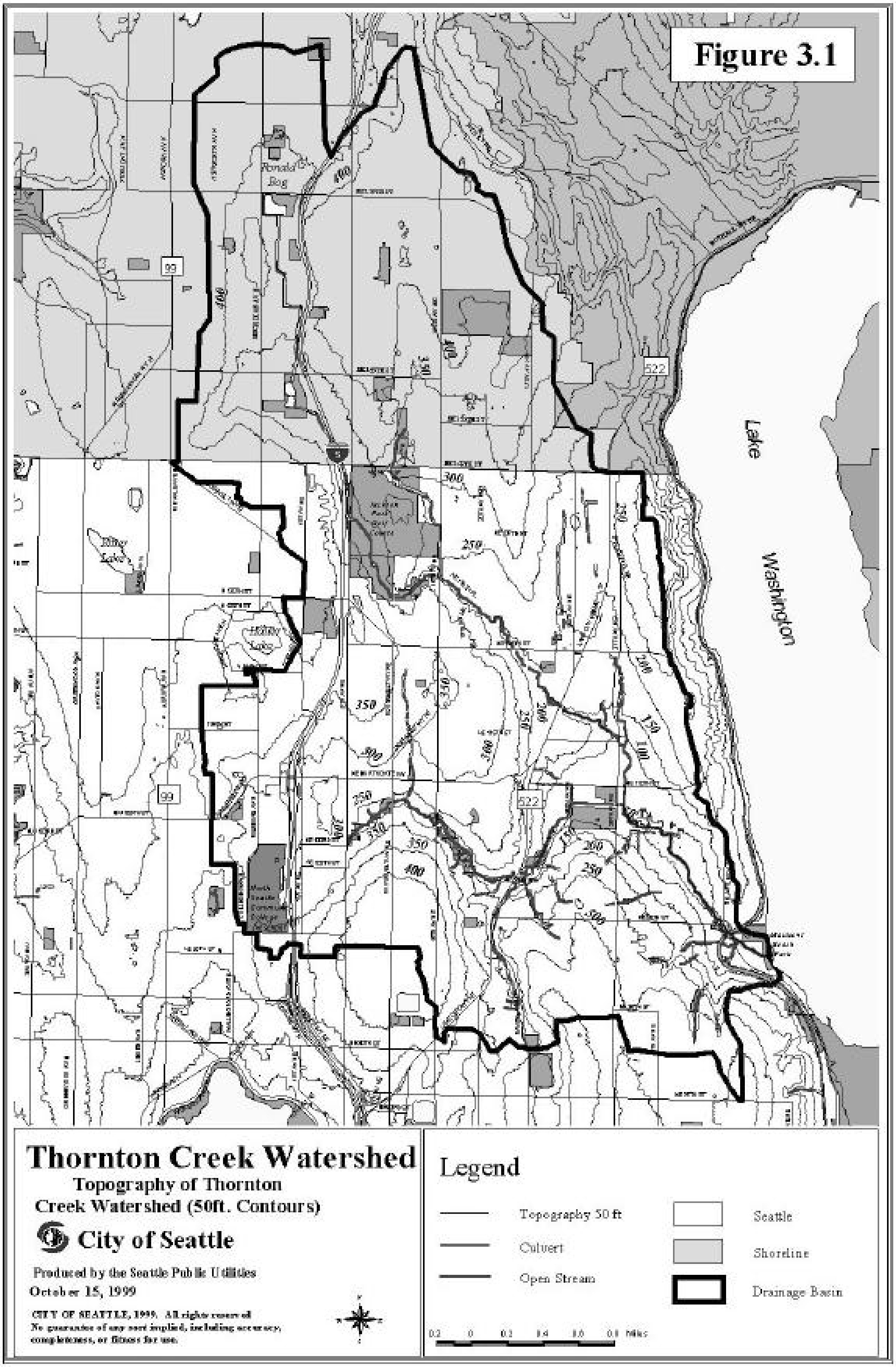
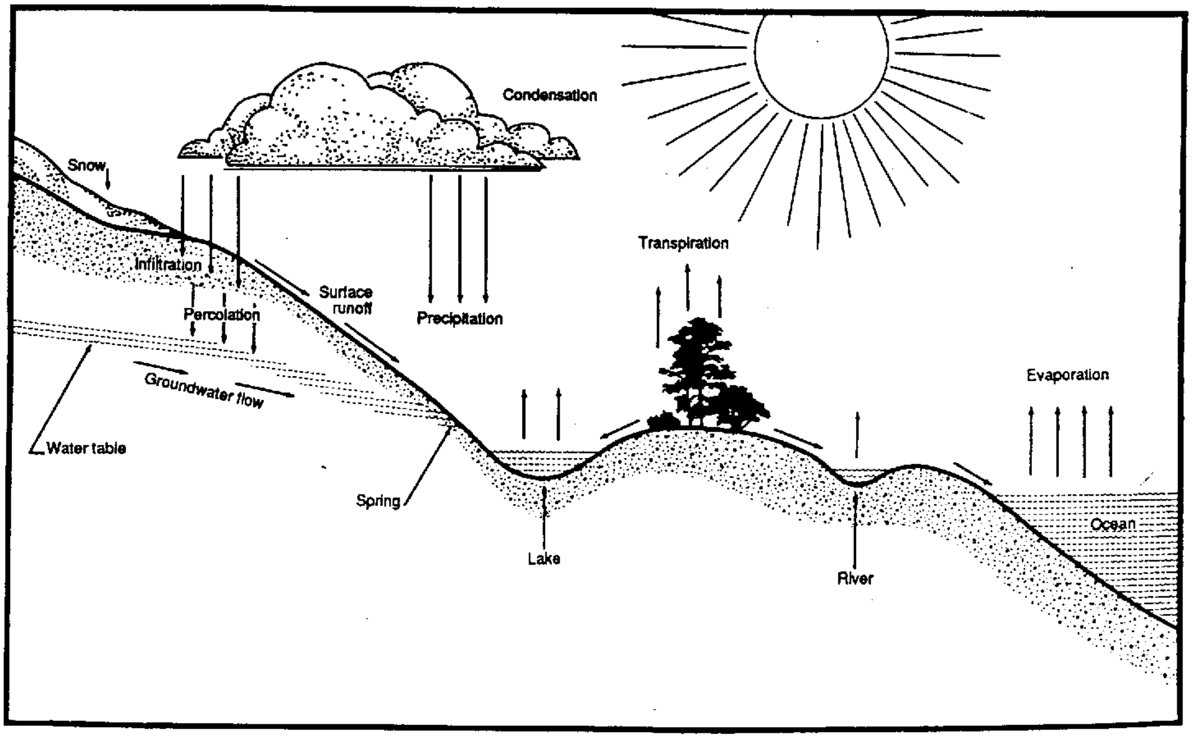


Figure 3.1
Lake Washington
Thornton Creek Watershed
Topography of Thornton Creek Watershed (50ft. Contours)
City of Seattle
Produced by the Seattle Public Utilities
October 15, 1999
CITY OF SEATTLE, 1999. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Topography 50 ft
Culvert
Open Stream
Seattle
Shoreline
Drainage Basin

Figure 3.2. The Water Cycle (Seattle Drainage and Wastewater Utility, 1992)



In urban settings, the hydrological cycle has been disturbed. When the land is covered with forests and meadows, nearly all rainwater soaks into the ground, fills wetlands and ponds, or is taken up by plants. Once the land is covered with roads and buildings, most rainwater runs off pavement, rooftops, and lawns. This urban stormwater runoff collects pollutants from these areas, finally rinsing them into ditches, pipes, and creeks.

Climate

The characteristic weather of the Thornton Creek watershed is typical of the mild, mid-latitude coastal climate of the Pacific Northwest, moderated by marine air from the Pacific Ocean. In the summer, temperatures range from the 70s to the 90s during the day, then drop to the 60s at night. In the winter, temperatures average in the 40s during the day and 30s at night, with occasional cold spells and temperatures in the low 20s. Snowstorms occur rarely, often followed by warming temperatures and rain. The frozen ground is unable to absorb the snowmelt and rainfall, which can cause severe flooding, as during the 1996 holiday storm. Most of the rain falls during the wet season, approximately October to May, usually with low intensity but long duration. Very little precipitation falls as snow in this watershed. While the prevailing winds come from the southwest, there are occasional severe storms from the north.

Rainfall in Seattle is measured by tipping bucket gauges. These gauges electronically record rainfall in 0.01-inch intervals. The City of Seattle operates three tipping bucket rain gauges in the vicinity of the Thornton Creek watershed. They are located at Haller Lake (RG01), Maple Leaf Reservoir (RG04), and Matthews Beach (RG02).

Figure 3.3 shows the annual precipitation totals for the three stations located in the watershed from 1978-97. Precipitation in the watershed averages 34.9 inches, slightly more than the City average of 34 inches per year.

Figure 3.3. Annual Rainfall in Thornton Creek Watershed (inches) (Seattle Public Utilities, 1998)

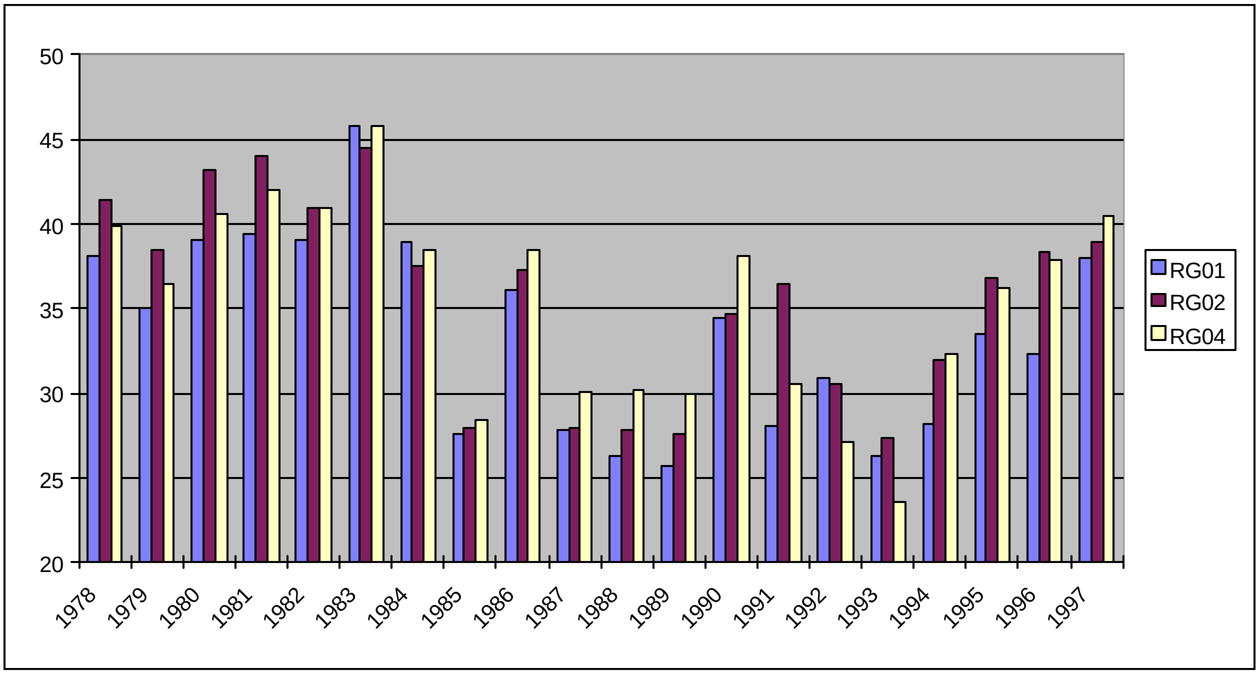


Table 3.1 compares rainfall during the wet and dry seasons based on rain gauge data from the Thornton Creek watershed.

Table 3.1. Average Monthly Precipitation by Season (Inches)

Station	Dry Season Monthly Average (Jun - Sep)	Wet Season Monthly Average (Oct - May)
RG01	1.25	3.57
RG02	1.32	3.78
RG04	1.30	3.77

Groundwater

Groundwater is rainwater that has flowed onto the land and into streams, wetlands, and lakes, then filtered into the ground where it stays beneath the surface like water in a wet sponge. All soil materials fill with water, although we usually think of groundwater being located in coarser soil materials such as sand or gravel, in zones called aquifers where the groundwater can easily be obtained and used. Finer soils, like silts, clays, and intact rocks (confining beds), yield water only very slowly. Groundwater can be observed when it fills a well to a level called the water table. Groundwater moves from areas with a high water table to areas with a low water table, but at a very slow rate, usually only inches per day even in the most productive aquifers. In periods of one year or longer depending on the depth of the groundwater, this groundwater eventually discharges to surface water bodies such as lakes, wetlands, streams, rivers, and the ocean. Thus, groundwater not only receives water from surface water sources, but it also recharges these areas by providing "base flow" for rivers and streams – therefore they keep flowing after the rain has stopped in the drier months.

Although groundwater is the major source of drinking water for many parts of King County, residents of the Thornton Creek watershed get drinking water from the Cedar and Tolt watersheds and do not rely on groundwater sources within Thornton Creek. Therefore, available groundwater in Thornton Creek is the source of much of the flow in this watershed during dry seasons, and is essential for fish and wildlife. Groundwater is also a factor in landslides, which are often caused by groundwater forces pushing on saturated and unstable soil. The process of groundwater collection and movement can be altered by the impervious surfaces and the removal of vegetation that cycle water.

Groundwater is threatened by several common human activities. As the region develops and paved surfaces continue to increase, water is less able to soak into the soil and replenish groundwater. Instead, stormwater runoff flows overland quickly through ditches and storm drains. Besides being depleted, groundwater can be contaminated by landfills, septic systems, improper disposal of hazardous materials, and leaking underground fuel tanks. Human activities have the potential to affect both the quantity and quality of groundwater.

Geology and Soils

The geology and soils found in the Thornton Creek watershed are a legacy of its glacial past. Over the past tens of thousands of years, glaciers have advanced and retreated. This movement scoured out and polished the earth’s surface. During the last ice age, about 10,000 years ago, glaciers scoured out what is now Puget Sound. As the climate warmed and melted the glaciers, deposits were pushed and mounded by the receding ice, leaving temporary ice dams. These dams created shallow lakes where fine, unconsolidated sediments were deposited.

With each successive retreat, materials were scoured, moved, and redeposited. This left Puget Sound with many layers of varying geological deposits. The Thornton Creek watershed has a variety of soils originating from different geological layers, all of which have different levels of stability, erode at different rates, and absorb water at different rates. Figure 3.4 shows the soil types found in the watershed according to US Geological Survey (USGS) soils data mapped in the 1960s. Seattle Public Utilities (SPU), the University of Washington, and USGS are working together to develop a more recent and accurate soils survey map from which preliminary data should be available within a few years.

During the most recent glacial period, the Pleistocene era, the Vashon glacier left behind thick deposits of clay, sand, silt, and gravel, called Vashon Till. Vashon Till, also known as hardpan, covers most of the watershed. The immense weight of the glacier caused the deposits to become very dense and compact. Vashon Till does not infiltrate water very well. Vegetation is more difficult to establish in Vashon Till than in some other soil types. Areas that are underlain with Vashon Till, and do not have mature trees growing on them to absorb water, tend to have naturally higher runoff rates than areas containing outwash soils.

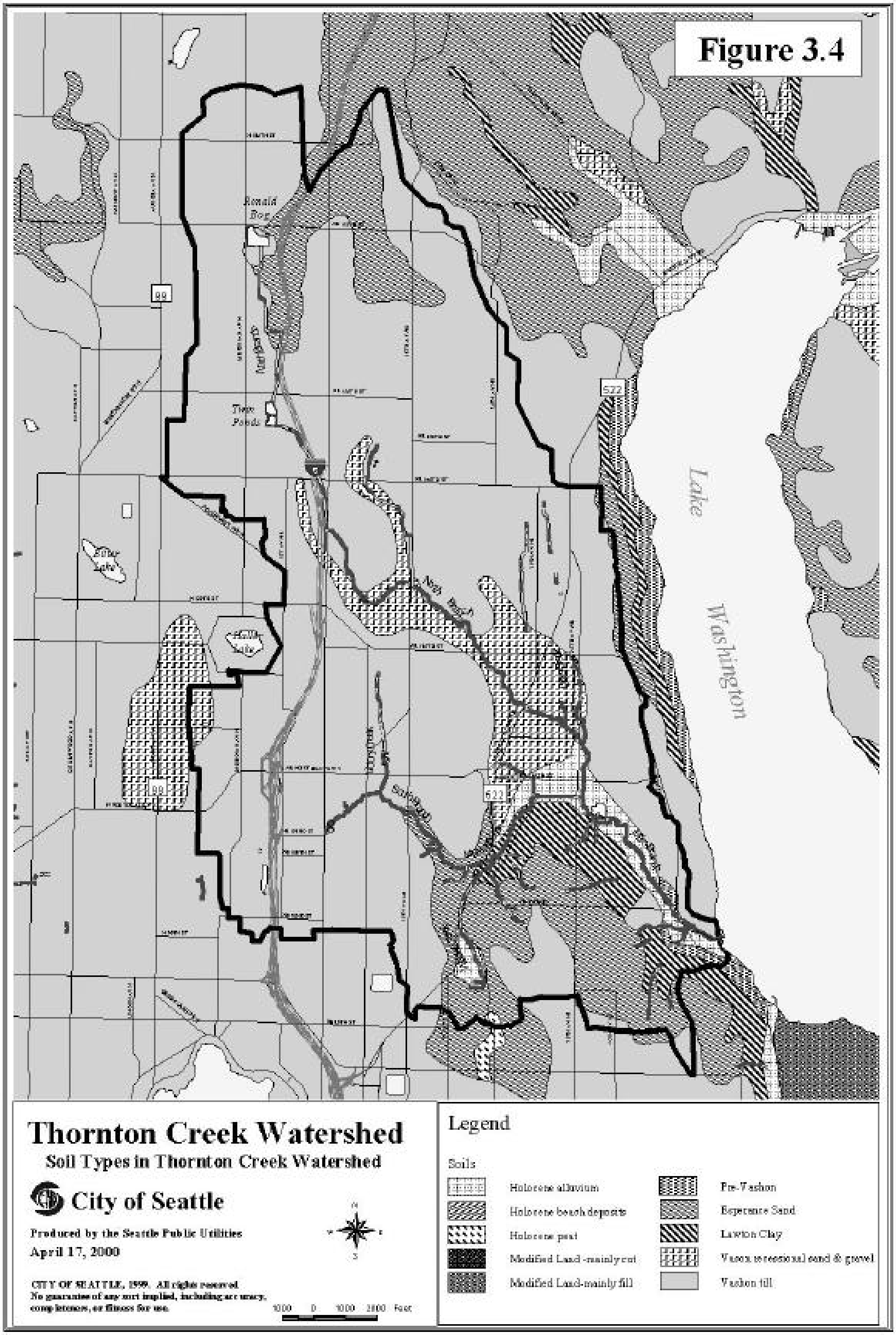


Figure 3.4
Thornton Creek Watershed
Soil Types in Thornton Creek Watershed
City of Seattle
Produced by the Seattle Public Utilities
April 17, 2000
CITY OF SEATTLE, 1999. All rights reserved.
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Soils
Holocene alluvium
Holocene beach deposits
Holocene peat
Modified Land -mainly cut
Modified Land-mainly fill
Pre-Vashon
Esperance Sand
Lawton Clay
Vashon recessional sand & gravel
Vashon till
Lake Washington
Ronald Bog
Twin Ponds
99
522
1000 0 1000 2000 Feet

Areas with outwash deposits are capable of infiltrating and storing water and are useful to store stormwater, provided the water is treated before being infiltrated into these soil types. Outwash, or alluvium, typically consists of silt and sand with embedded clay and peat. These deposits are relatively young and unconsolidated and have a very low resistance to erosion. Holocene era alluvium is found along the floodplain near the downstream portion of Thornton Creek. A sandy topsoil, called Esperance Sand, is located near the central north portion of the basin and the southeastern section. Lawton Clay is located southwesterly of the Main Branch and South Branch. Smaller patches of Pre-Vashon soils are found near the southern end of the Main Branch.

Erosion

As a stream changes course to flow around obstacles, it develops pools and riffles, and meanders as the flow, course, and velocities change over time. The process of soil erosion and transport is a natural balanced process. However, in Thornton Creek – like other urban streams – the process is out of balance due to urbanization. In some areas erosion has been severe and in other areas the streambed has gained elevation with excessive deposits of fine and coarse material (a process called aggradation). Some sections of the creek have been straightened, and some streambanks have been cleared of vegetation and armored with riprap or concrete. This has resulted in faster flows, which have accelerated erosion in downstream areas. Eroded soil from construction sites also has washed into the stream, increasing water turbidity levels, filling in pools, transporting pollutants, and embedding spawning gravels.

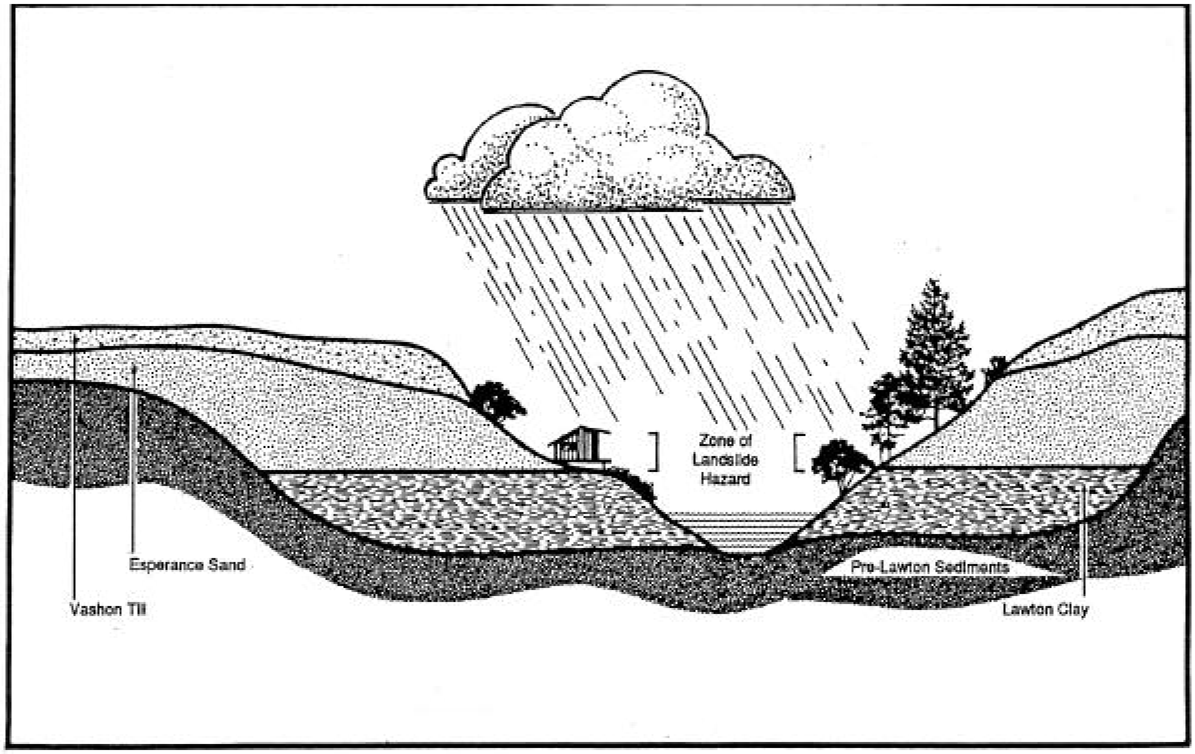
As fine soil particles settle in a creek, they fill in the small gaps between the rocks in the creek bed. This reduces the flow of water through the creek bed and lowers the dissolved oxygen level, which can smother life forms such as insect larvae and fish eggs. Soil particles also transport pollutants, such as pesticides and other toxic organic compounds, metals, nutrients, and petroleum hydrocarbons, from the urban landscape into the stream. For example, heavy metals and petroleum products bind themselves to the surface of the soil particles. Soil eroded from yards and gardens and newly landscaped areas can contribute pollutants such as nitrogen, phosphorus, and pesticides.

Landslides

Conditions within this watershed make the land susceptible to landslides. The typical soil combinations – a layer of fairly sandy soil over a layer of more impermeable deposits such as clay – are vulnerable to slides and earthquake damage. Landslides are often triggered by large storms that saturate the ground on steep slopes and lubricate the soil, allowing the surface material to slide downhill. Natural springs and unique characteristics of the underlying soils may cause or contribute to the landslide. Pipes and/or ditches that discharge water onto unstable soils can also trigger landslides. During the winter storms of late 1996, a considerable number of landslides occurred throughout the Puget Sound region due to saturated soil conditions resulting from a heavy snowfall followed by a large rainfall. These storm events are known as “rain-on-snow” events and are uncommon in the Thornton Creek watershed. Figure 3.5 shows the soil conditions that can contribute to landslides. Erosion problems and landslides are common throughout Puget Sound, particularly in areas where buildings have been constructed on steep slopes. Figure 3.6 shows steep slopes and the locations of known landslides in the watershed.

Although slides certainly occurred before urban development, human activity has increased their frequency and severity. Stripping slopes of vegetation, removing the toes of slopes, using fill dirt to build houses or streets, directing roof drains down slopes – all of these actions can contribute to landslides. Much of the Thornton Creek watershed was developed before the area was incorporated into Seattle in the 1950s and stormwater management systems were not built to meet Seattle City standards. City of Shoreline regulations have been in place only a few years. Historically, in the Thornton Creek watershed, stormwater was managed by conveying the water away from development as quickly as possible without detaining the water first and releasing over time, as most new developments are required to meet City standards.

Figure 3.5. Geological Features Contributing to Landslide Hazards (Seattle Drainage and Wastewater,



1992)

3.2 Thornton Creek Flows

Thornton Creek and many of its tributaries flow year round. In the headwaters, water collects in pipes and ditches and flows into larger and larger creek channels. During dry weather, the creek is fed by groundwater. During storms, vast amounts of stormwater runoff enter the creek.

Stream Flow Monitoring

USGS and SPU routinely monitor flows in Thornton Creek. Figure 3.7 shows the USGS and SPU flow monitoring stations. For several years, USGS monitored flows at Matthews Beach. SPU monitors flows at numerous locations along the creek. With this data, SPU calibrates complex computer flow models, which are used to help design facilities such as detention ponds and storm drains. SPU flow meters record water level at two-minute intervals. The water level can be converted to flow rate by means of equations (for piped stations) or field calibrations (open channel stations). The water level-to-flow conversions are shown in Appendix B. The locations of the flow meters are shown in Figure 3.7; equipment installation and removal dates are shown in Table 3.2, starting with the downstream station.

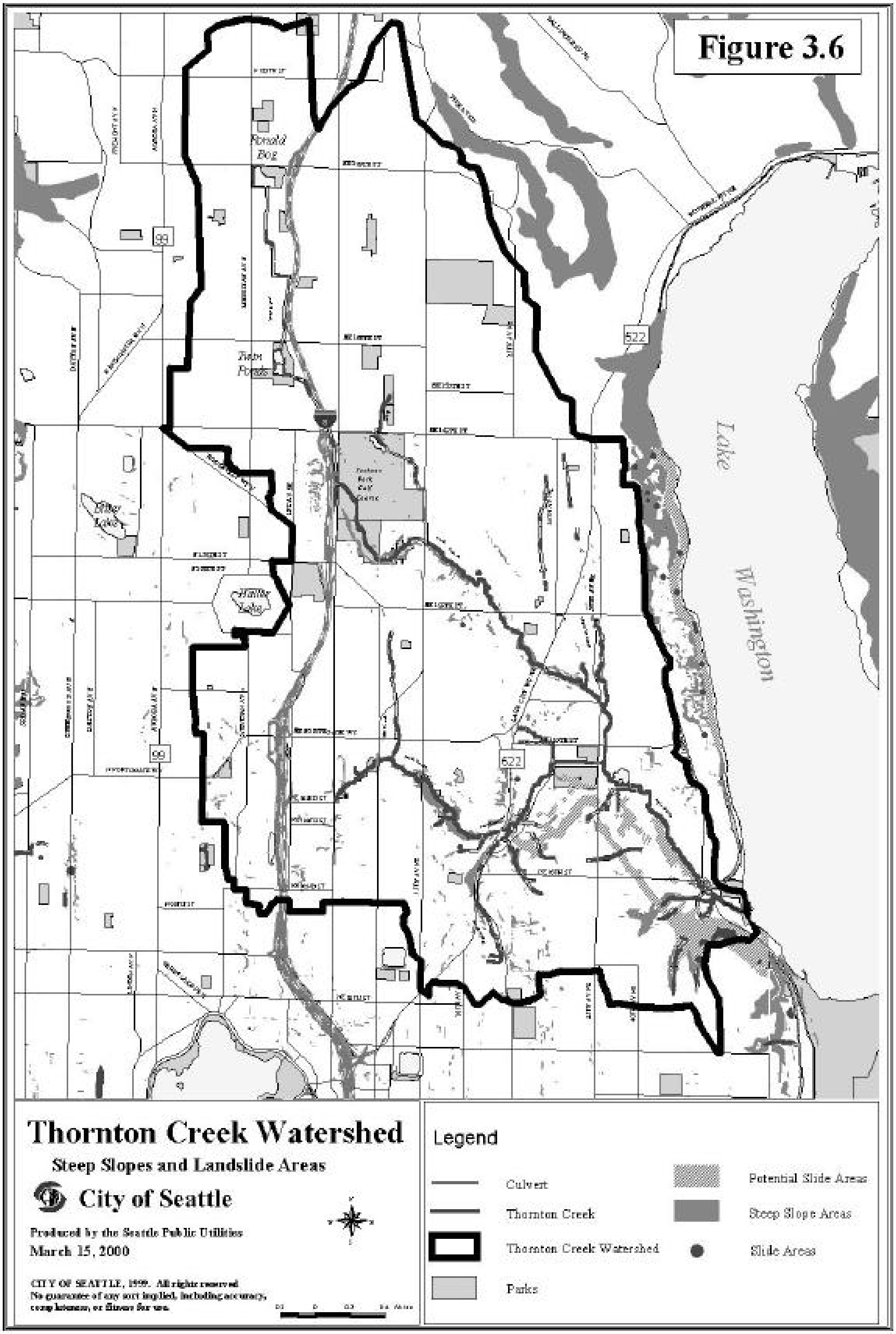


Figure 3.6
Ronald Bog
Twin Ponds
Bitter Lake
Haller Lake
Lake Washington
99
522
Thornton Creek Watershed
Steep Slopes and Landslide Areas
City of Seattle
Produced by the Seattle Public Utilities
March 15, 2000
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Legend
Culvert
Thornton Creek
Thornton Creek Watershed
Parks
Potential Slide Areas
Steep Slope Areas
Slide Areas

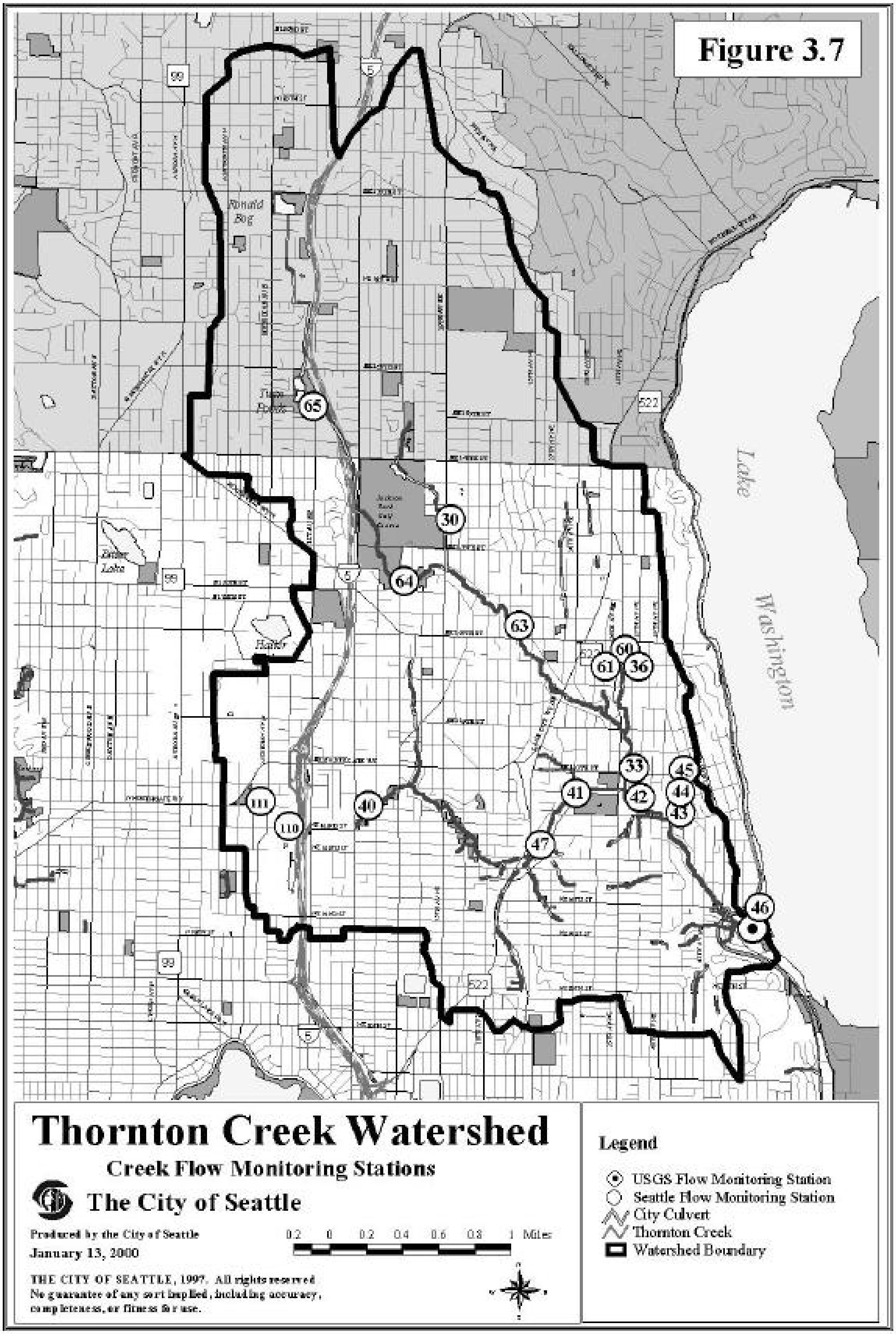
Figure 3.7
Thornton Creek Watershed
Creek Flow Monitoring Stations
The City of Seattle
Produced by the City of Seattle
January 13, 2000
0.2 0 0.2 0.4 0.6 0.8 1 Miles
THE CITY OF SEATTLE, 1997. All rights reserved
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Legend
USGS Flow Monitoring Station
Seattle Flow Monitoring Station
City Culvert
Thornton Creek
Watershed Boundary
Lake Washington
Ronald Bog
Twin Ponds
Bitter Lake
Haller
65
30
64
63
60
61
36
33
45
44
43
42
41
47
40
111
110
46
99
5
522

Table 3.2. Flow Monitoring Locations on Thornton Creek

Branch	Sta. ID	Location	Duration
Main Branch	46 Creek	Sand Point Way at Matthews Beach (mouth)	1999 – current
Main Branch	USGS Creek	Matthews Beach (same as Sta 46)	1961 – 1968 1945 – 1946 1996 – 1998
Main Branch	43 Creek	NE 105th St & 39th Ave NE (downstream of Meadowbrook Pond)	1997 – current
Main Branch	42 Creek	NE 107th St & 35th Ave NE (upstream of Meadowbrook Pond)	1997 – current
Main (bypass pipe)	44 Pipe	10524 41st PL NE	1999 – current
Tributary to bypass pipe	45 Pipe	N of NE 105th St & W of 41st Pl NE	1999
North Branch	33 Creek	NE 110th St & 35th Ave NE (lower North Branch)	1991 – current
North Branch	63 Creek	2441 NE 125th St (middle North Branch)	1999
North Branch	64 Creek	NE 130th St & 10th Ave NE (downstream of golf course)	1999 – current
North Branch	65 Creek	14920 1st Pl NE (near Twin Ponds)	1999 – current
Littles Creek (North Branch tributary)	30 Pipe	NE 137th St & 10th Ave NE	1991 – current
Little Brook (North Branch tributary)	36 Pipe	NE 120th St & 35th Ave NE	1991 – 1999 intermittent
Little Brook (North Branch tributary)	60 Pipe	NE 125th St & 33rd Ave NE (detention pond 60" outflow)	1998 – current
Little Brook (North Branch tributary)	61 Pipe	NE 125th St & 33rd Ave NE (detention pond 30" outflow)	1998 – current
South Branch	41 Creek	NE 105th St & 30th Ave NE (lower South Branch)	1992 – 1997 1999 – current
South Branch	47 Creek	NE 100th St & Lake City Way	1999 – current
South Branch	40 Creek	NE 103rd St & 8th Ave NE (in Thornton Creek Park #6)	1992 – 1997 1999 – current
South Branch	111 Pipe	N 105th St & Meridian Ave N (near North Seattle Community College)	1994 – current
Tributary to South	110 Pipe	N 103rd St & I- 5 (culvert under I-5)	1994 – current

Branch			

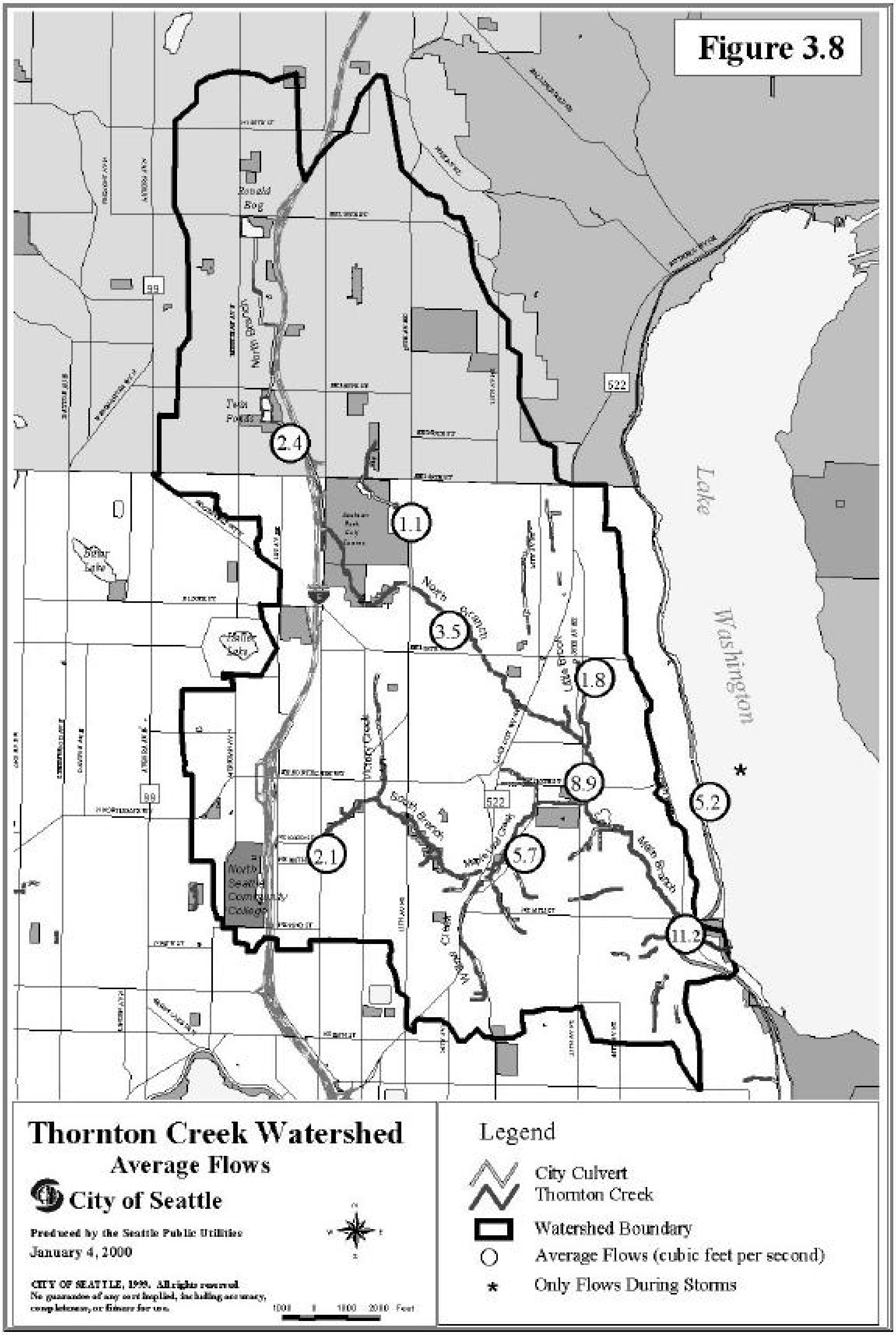
Figure 3.8
Thornton Creek Watershed
Average Flows
City of Seattle
Produced by the Seattle Public Utilities
January 4, 2000
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Legend
City Culvert
Thornton Creek
Watershed Boundary
Average Flows (cubic feet per second)
Only Flows During Storms
Lake Washington
North Branch
South Branch
Little Brook
Maple Leaf Creek
Willow Creek
Victory Creek
Main Branch
North Seattle Community College
Twin Ponds
Ronald Bog
Bitter Lake
Haller Lake
2.4
1.1
3.5
1.8
8.9
5.2
2.1
5.7
11.2
522
99

Flow Modeling

SPU has hired a consultant, Entranco, to develop sophisticated computer models to simulate flow through Thornton Creek during a variety of dry weather and storm conditions. Several models will be used to evaluate level and flow using continuous and event modeling. Information derived from this study will be used to guide future drainage capital improvement projects in the watershed that will reduce flooding and better manage flows.

Three separate models were selected to simulate the runoff response of the Thornton Creek basin and the routing of flows through the principal conveyance system (Entranco, 1999). The three models used are the Expert Storm Water Management Model (XP-SWMM), the Hydrologic Simulation Program – Fortran (HSPF) and the Hydraulic Engineering Center – River Analysis System (HEC-RAS). Each of these models has unique advantages that were used to help identify existing flooding conditions as well as evaluate proposed solutions. XP-SWMM is well suited to simulate a wide variety of complex hydraulic situations, including pipes, open channels, culverts, detention ponds and diversion structures. HSPF is useful for performing long-term hydrologic simulations in a watershed. This model estimates long-term continuous flow, which is useful in evaluating resource issues such as fish passage, instream erosion, and wetland inundation. It is also helpful for evaluating the performance of proposed improvements because it addresses multiple storm events, rather than a single design storm. The HEC-RAS model is better suited to simulate flow conditions through open channels, culverts, and bridge openings that XP-SWMM. It contains more options for bridge and culvert hydraulics, including over-topping simulations.

Table 3.3 compares average flows with peak flows for various size storms in several tributaries (personal communication with Ralph Nelson, Entranco 10/99). Figure 3.8 shows estimated average flows. Average flows include storm measurements. The amount of water flowing through the creek at any given time depends on a number of factors including weather, season, recent precipitation, water diversion, and groundwater levels. During storms, the flows in the creek swell dramatically as stormwater runoff enters the creek.

During large storms, up to two-thirds of the flow in the Main Branch are diverted directly to Lake Washington via the bypass pipe. The entrance to the bypass pipe is located in Meadowbrook Pond. The bypass pipe reaches maximum capacity at the approximately the 10-year event. These estimates, shown in Figure 3.8, have been predicted by computer models. These estimates are given in cubic feet per second (cfs). One cfs is approximately 449 gallons per minute.

Table 3.3. Estimates of Flows (HSPF Modeling Results)

Branch	Average Flow* (cfs)	2 Year Storm Peak Flow (cfs)	10 Year Storm Peak Flow (cfs)	25 Year Storm Peak Flow (cfs)	100 Year Storm Peak Flow (cfs)
Upper South Branch (Sta 40)	2.1	69	117	150	214
Lower South Branch (Sta 41)	5.7	159	271	362	556
Upper North Branch (Sta 66)	2.4	27	34	37	41
Middle North Branch (Sta 64)	3.5	60	94	112	138
Lower North Branch (Sta 33)	8.9	167	260	323	441
Littles Creek (Sta 30)	1.1	20	41	64	132
Little Brook (Sta 36)	1.8	37	67	99	182
Bypass pipe (Sta 44)	5.2 **	286	350	350	350
Main Branch (mouth) (Sta 46)	11.2	65	155	260	576

Note: This table is based on draft research and is subject to change when the final report is available.

*Average flow is the total annual volume of water divided by the number of seconds in a year. It includes dry weather and storm flows.

** Water only flows through the bypass pipe during storm events.

Flooding

Flooding is common along much of Thornton Creek. Flood-prone areas are shown in Figure 3.9 (Seattle) and Figure 3.10 (Shoreline) and listed in Table 3.4. The Seattle data comes from Thornton Creek Hydrologic and Hydraulic Modeling Technical Memorandum (Entranco, 1999). The Shoreline information comes from the Shoreline Comprehensive Plan. These areas either have a history of flooding or are likely to flood based on computer model predictions. Notable flood-prone areas include Ronald Bog, Serpentine Place, Paramount Park, Jackson Park Golf Course, the confluence of the North and South Branches, and much of the Main Branch. Many of Seattle's and Shoreline's drainage capital improvement projects are designed to reduce flooding (see Chapter 8).

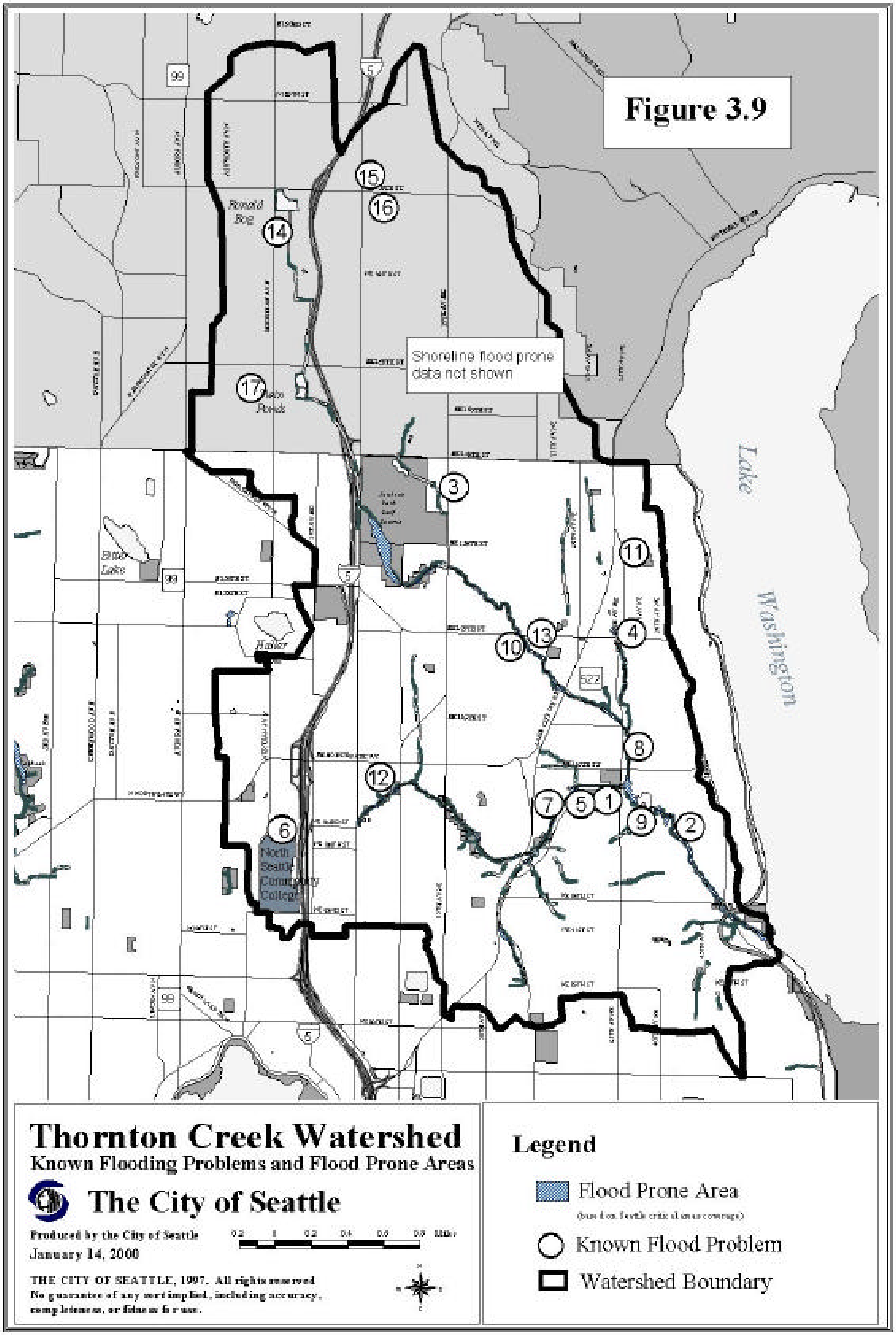
Figure 3.9
Shoreline flood prone data not shown
Ronald Bog
Lake Washington
Bitter Lake
Haller Lake
North Seattle Community College
Thornton Creek Watershed
Known Flooding Problems and Flood Prone Areas
The City of Seattle
Produced by the City of Seattle
January 14, 2000
THE CITY OF SEATTLE, 1997. All rights reserved
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Legend
Flood Prone Area
Known Flood Problem
Watershed Boundary

Figure 3.10. Surface Water Drainage Incidents in Shoreline

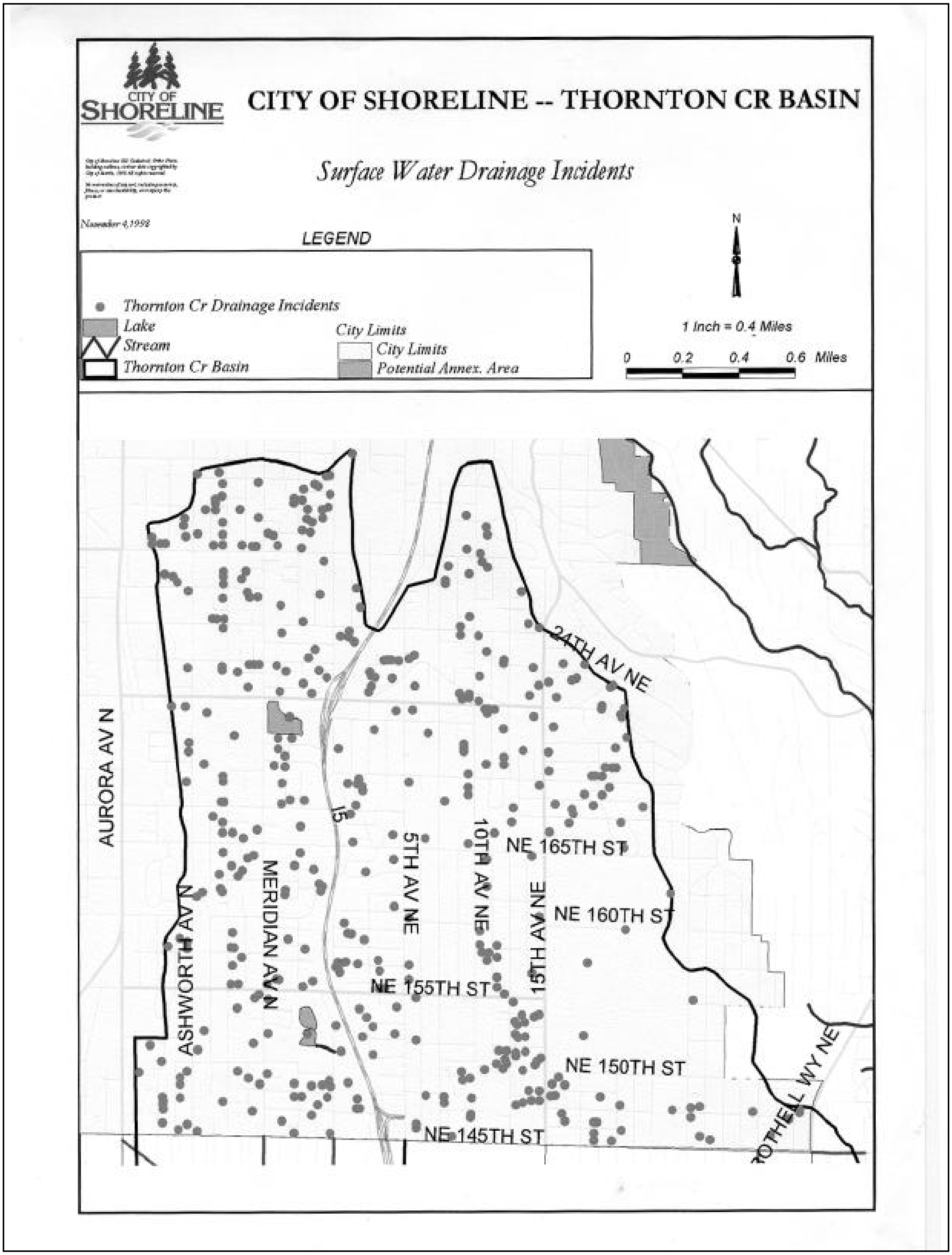


Table 3.4. Flood-Prone Areas in Thornton Creek Watershed Since 1995

ID	Location	Description	Source
1	South Branch at 35th Ave NE	Culvert lacks capacity and periodically causes flooding of 35th Ave NE.	Local resident
2	Main Branch at NE 105th St	Bank overtops and yard floods.	Local resident
3	Littles Creek at 12th Ave NE & NE 140th St	Condos flooded due to undersized culvert.	Seattle (1995)
4	Little Brook at NE 125th St & 33rd Ave NE	Undersized storm drain floods 33rd Ave NE, parking lots, and several buildings.	Seattle (1995)
5	South Branch at 30th Ave NE & NE 107th St	30th Ave NE flooded.	Seattle (1995)
6	South Branch at NE 103rd St & I-5	Culvert immediately downstream of the I-5 culvert is higher than the I-5 culvert, so stormwater backs up in the I-5 culvert during heavy runoff.	Seattle (1995)
7	South Branch at NE 107th St & 33rd Ave NE	Culvert lacks capacity (probably due to sediment accumulation).	Local resident
8	North Branch at 35th Ave NE south of NE 110th St	Stream channel overtops and floods private property.	Local resident
9	Main Branch at 35th Ave NE upstream of Meadowbrook Pond	Stream channel overtops and floods private property.	Seattle staff
10	North Branch west of 25th Ave NE	Culvert has surcharged during recent storms.	Seattle staff, drainage complaint records
11	Storm drain in 35th Ave NE, south of NE 130th St, tributary to Little Brook	A bottleneck in the storm drain (15" to 12") causes backups and floods 35th Ave NE	Seattle (1995)
12	South Branch at NE 105th St	Creek reportedly caused flooding of NE 105th St.	Drainage complaint records
13	North Branch at 25th Ave NE	Creek reportedly rose quickly in Jan 1997 storm and flooded a garage.	Drainage complaint records
14	Ronald Bog	Culvert downstream of Ronald Bog frequently floods.	Shoreline CIP
15	N 175th St & Serpentine Pl	This area frequently floods.	Shoreline CIP
16	NE 175th St & 11th Ave NE	This area frequently floods.	Shoreline CIP
17	NE 155th St & Corliss Ave N	Existing conveyance system doesn't handle the needed capacity.	Shoreline CIP

3.3 Diversions for Human Use

Under Washington law, most water is publicly owned. With few exceptions, farmers, businesses, and other users must obtain a permit or water right from the Washington Department of Ecology (Ecology) to divert and use water. This is true for water in Thornton Creek. Landowners with water flowing across their property do not automatically have the right to divert and use the water.

In most Western states, including Washington, water law is based upon the prior appropriation doctrine. According to this doctrine, rights for withdrawal of water are given priority based on the date they were acquired. A water right is valid as long as it is used at least once every five years. After five consecutive years of non-use, the right is considered forfeited.

Quite commonly streams become over-appropriated; that is, permits are issued for water diversions that exceed the flow available at certain times. When this occurs, Ecology closes the stream to further appropriation. Thornton Creek and its tributaries are closed to further appropriation.

Water rights to Thornton Creek are shown in Table 3.5 (Ecology's Water Rights Application Tracking System, 1998). The largest water right belongs to Seattle Parks and Recreation. Water is removed from the North Branch of Thornton Creek during the spring, summer, and fall to irrigate the Jackson Park Golf Course. A brief study conducted by SPU in 1994 confirmed that the golf course diverts approximately 1.2 cfs, slightly less than the permitted amount.

Ecology relies on queries and complaints from citizens to investigate potential water rights violations. Some of the rights listed in Table 3.5 may have been forfeited. Ecology does not keep a record of forfeited claims.

3.4 Three Major Creek Sections

Thornton Creek can be broadly divided into three distinct creek sections, the North, South, and Main Branches. This section gives the reader a brief overview of the Thornton Creek watershed. These branches and their associated drainage areas are shown in Figure 3.11.

North Branch

The North Branch of Thornton Creek and its tributaries drain 4,445 acres of land in Shoreline and Seattle. The major tributaries are Littles Creek and Little Brook.

The headwaters of the North Branch originate from Shoreline's Ronald Bog (N 175th St and Meridian Ave N) and the surrounding residential neighborhoods. The pond at Ronald Bog was created in the 1950s when peat deposits were excavated from this site. The area downstream of Ronald Bog has a tendency to flood. Water leaves the pond and flows southerly past a residential area through a series of culverts and open channels to Twin Ponds (Corliss Ave N and N 155th St). Twin Ponds, which was also mined for peat, is located in a park and has open water year round. After the creek leaves Twin Ponds, it passes through a private detention pond and eventually into a 72-inch pipe that conveys the water under I-5. The creek emerges as an open channel and flows through the Jackson Park Golf Course, a wetland, a wooded area (Thornton Creek Park #1), and a condominium complex before meeting the Littles Creek tributary. This section of Thornton Creek is also known as Jones Creek.

Table 3.5. Water Rights to Thornton Creek

Type	Business/Person	Priority Date	Flow (cfs)	Purpose
CL	Andrews, E			Domestic, general
CE	Argus, A G	8/14/56	0.5	Fish propagation
CL	Bird, T D			Domestic, general
CL	Henry, S M	1974		Domestic, general
CE	Kinder, L M	6/7/49	0.01	Recreation Domestic, single
CE	Lamont, D V	3/29/62	0.01	Domestic, single
CE	Lloyd, F W	1917		Domestic, general
CE	Martin, F L	10/13/44	0.01	Domestic, single
CL	Myher, W E			Irrigation
CE	Near, H P	10/19/53	0.075	Wildlife, Recreation
CE	Obeirn, K M	8/14/45	0.05	Fish propagation, Domestic, single
CE	Ohland M	12/2/26	0.50	Irrigation, Fish propagation, Domestic, single
CE	Olympic Riding Club	7/10/26	0.50	Irrigation
CE	Ritchie, G D	6/21/50	0.02	Irrigation
CL	Rogers, W E			Irrigation
CL	Rogers, W E			Irrigation
CL	Rogers, W E			Irrigation
CL	Rogers, W E			Irrigation
CE	Sanders, L	6/9/34	0.05	Irrigation
CE	Scott, E R	10/2/51	0.01	Irrigation
CE	Seattle City Parks	5/14/27	1.3	Irrigation
CE	Solberg, A W	7/29/53	0.11	Recreation
CE	Solberg, H K	8/14/45	0.05	Fish propagation Domestic, single
CL	Taylor, J L	1963		Domestic, general
CE	Watanabe, S L	3/1/73	0.02	Recreation
CE	Wood, M R	4/2/28	0.15	Domestic, single Irrigation

CL	Youngberg, J	1912		Irrigation

CE - Water right certificate

CL - Statement of claim. Claims older than 1917 are considered vested water rights. Claims later than 1917 have not been granted water rights, but potentially could be in the future.

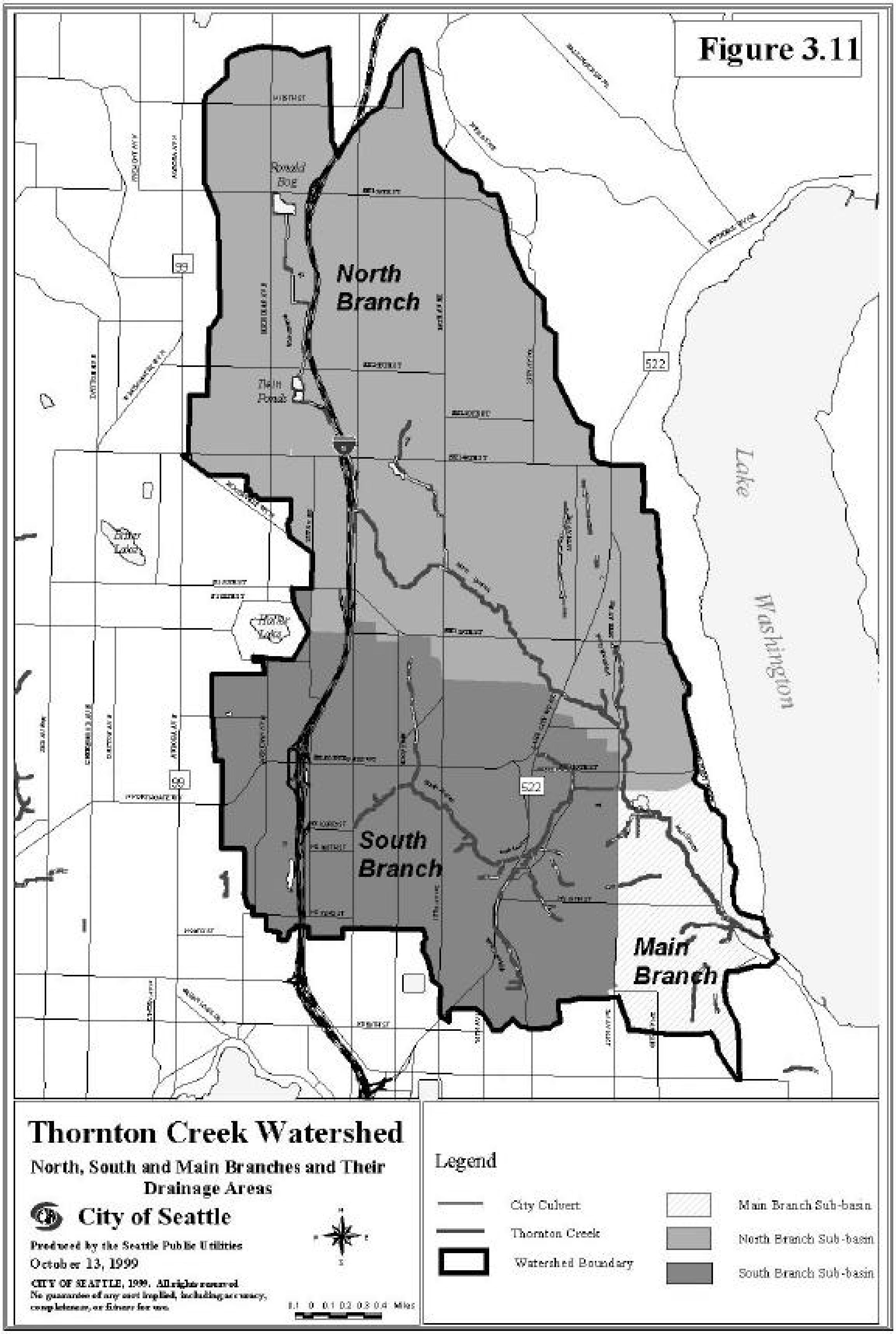


Figure 3.11
North Branch
South Branch
Main Branch
Lake Washington
Ronald Bog
Twin Ponds
Bitter Lake
Haller Lake
99
522
Thornton Creek Watershed
North, South and Main Branches and Their Drainage Areas
City of Seattle
Produced by the Seattle Public Utilities
October 13, 1999
CITY OF SEATTLE, 1999. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
City Culvert
Thornton Creek
Watershed Boundary
Main Branch Sub-basin
North Branch Sub-basin
South Branch Sub-basin

On the east side of I-5, Littles Creek flows south along 12th Ave NE, collecting groundwater and runoff from a residential area. Littles Creek passes through Paramount Park and associated wetlands before crossing under NE 145th St and flowing through the Jackson Park Golf Course. During storms, some flows are diverted into a detention pond that also serves as a water hazard for golfers. After exiting the golf course, this tributary passes through some commercial property, and then enters a 30-inch pipe along 10th Ave NE. Littles Creek joins the North Branch at NE 130th St and 10th Ave NE.

The North Branch flows through backyards for approximately one and a half miles until it reaches an area near 35th Ave NE, where it is joined by the Little Brook tributary. Little Brook begins near the City limits at NE 145th St and flows south, mainly through pipes and culverts, as it passes through the Lake City business district. It flows above ground at several sites, usually adjacent to apartment buildings. Little Brook enters a stormwater detention pond, then flows through a steep ravine for several blocks before it joins the North Branch near NE 113rd St. The North Branch flows south for several more blocks before joining the South Branch.

South Branch (Maple Leaf Creek)

As of March 2000 the character of this branch of the creek is under legal dispute.

The South Branch of Thornton Creek drains 2,332 acres in Seattle. This branch is also known as Maple Leaf Creek. Victory Creek, Willow Creek, and Kramer Creek are tributaries to this branch.

Water begins its flow to the South Branch west of I-5 near the Evergreen-Washelli Cemetery, Seattle North Precinct Police Station, and North Seattle Community College. Historically the college and Northgate area was a large cranberry bog. Based on topography, Licton Springs, which is located just west of the college, may once have been part of this watershed. A storm drain along Meridian Ave N picks up groundwater and surface runoff, and discharges it to a ditch leading into a storm surge pond at the college. Some of this water will be diverted to a recently constructed wetland on the college campus. Water exits the surge pond, then crosses under I-5 and is joined by a small tributary and runoff from I-5 and the Northgate shopping area.

The creek emerges near NE 103rd St and 5th Ave NE (near the Pacific Medical Building) and flows northeasterly through Thornton Creek Parks #6 and #2, a group of park properties adjacent to the creek. Numerous storm drains feed into the creek, some of which flow year round. At 12th Ave NE, a small tributary called Victory Creek joins the South Branch.

The South Branch flows southeast through a residential area. More storm drains feed into the creek. The South Branch picks up water from Willow Creek and several minor tributaries, including a small creek recently restored near the Meadowbrook Community Center, before joining the North Branch at NE 107th St and 35th Ave NE.

Main Branch

Here, where the North and South Branch join at NE 107th St and 35th Ave NE, the two tributaries become the Main Branch of Thornton Creek. The Main Branch receives runoff and groundwater from another 627 acres, in addition to water draining from all of the tributaries described above. Just downstream of the confluence of these streams, there is a dam and diversion structure at Meadowbrook Detention Pond, located at the site of the former Lake City Sewage Treatment Plant. The diversion structure in the pond diverts high flows directly to Lake Washington via a 72- to 90-inch diameter pipeline. The remainder of the stream flow continues along the Main Branch of Thornton Creek to Matthews Beach where the creek enters Lake Washington. Mock Creek and Maple Creek are tributaries to the Main Branch.

Lake Washington

Thornton Creek discharges into a large freshwater lake, Lake Washington. In turn, Lake Washington is connected to Puget Sound through Lake Union and the Ship Canal. Prior to 1916 and the creation of the Ballard Locks, Lake Washington used to drain into the Black River, which subsequently drained into the Green River, through the Duwamish River, and out into Elliott Bay. In general, the water quality of Lake Washington is good for a large lake surrounded by urban development. Key factors include:

- Generally good water quality in the Cedar River, which provides half of its inflow.
- A rapid flushing rate, with average water residence only 2.3 years.
- The lake depth, which causes waters in the lake to mix from top to bottom annually. There are, however, water quality concerns in the lake, including:
- A long-term trend of increasing alkalinity, the causes and effects of which are unclear.
- Spring algal blooms in 1995 and 1996 that were the worst in more than a decade.
- High fecal coliform counts in some localized areas.

The size, quality, and low elevation of the lake are critical for fish habitat – particularly for Sockeye salmon, which rear in lakes rather than rivers and which grow unusually large in Lake Washington. Despite the lake's large size and clean water, survival rates for young Sockeye in the lake appear to have been below normal ranges since the mid-1980s, the last period when adult Sockeye returns to the lake were consistently high. Improving lake survival rates is critical to ensure that investments in protecting and restoring habitat in lake tributaries provide the greatest return.

3.5 Minor Thornton Creek Watersheds (Sub-basins)

For ease of planning, SPU staff have divided the watershed into 33 smaller units called sub-basins, which drain to ponds, tributaries, and storm drains. The sub-basins are shown in Figure 3.12 and listed in Table 3.6. Sub-basins that do not drain to a point in a tributary, pond or storm drain system have been labeled "miscellaneous" North, South, or Main sub-basins in Table 3.6. Entranco divided the watershed into even smaller units to develop the hydraulic model. The Entranco sub-basin map shows 108 sub-basins (Entranco, November 1999).

3.6 Land Use

Current and Future Land Use

The Thornton Creek watershed covers 7,402 acres of northeastern Seattle and eastern Shoreline. Single family homes are the dominant land use, comprising 50% of the watershed. Roads, highways, and their associated rights-of-way are the next largest land use, covering 24% of the watershed. Other land uses are: commercial properties (8%), parks and golf courses (4%), schools (4%), vacant land (4%), and mixed use, industry, utilities and unidentified parcels (6%). One abandoned landfill is located in the watershed. Land use distribution is shown in Figure 3.13. Table 3.7 shows the area associated with each land use and its relative percentage. This information comes from 1999 King County's database of economic land use.

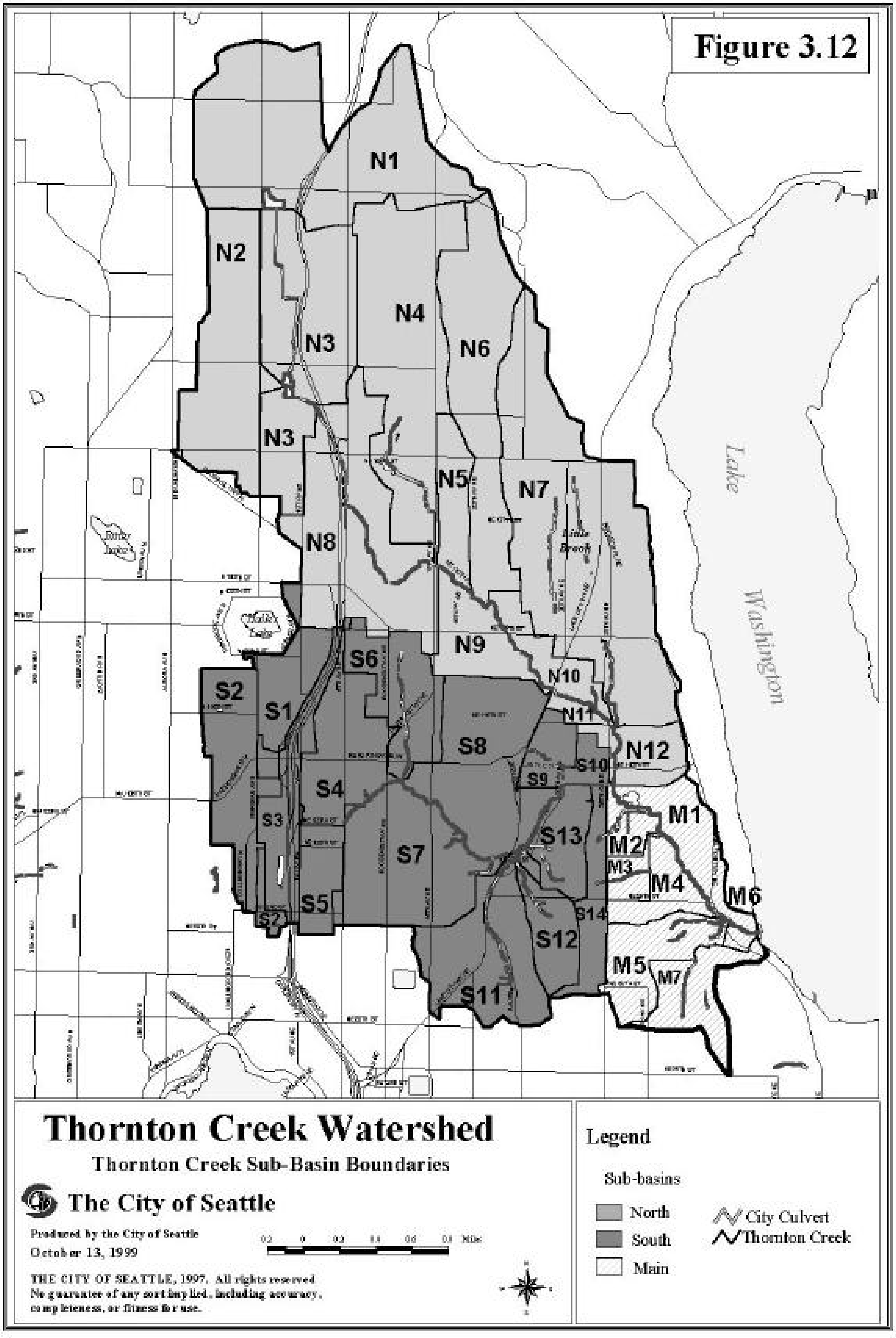


Figure 3.12
N1
N2
N3
N4
N6
N3
N5
N7
N8
N9
N10
N11
N12
S6
S2
S1
S8
S10
S9
S4
S3
S7
S13
S5
S2
S14
S12
S11
M1
M2
M3
M4
M6
M5
M7
Lake
Washington
Bitter Lake
Haller Lake
Little Brook
Thornton Creek Watershed
Thornton Creek Sub-Basin Boundaries
The City of Seattle
Produced by the City of Seattle
October 13, 1999
THE CITY OF SEATTLE, 1997. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Sub-basins
North
South
Main
City Culvert
Thornton Creek

Table 3.6. Thornton Creek Sub-basins (City of Seattle GIS database, 1999)

Sub-basin ID	Name	Acres
M1	East Side of Main Branch Sub-basin	139
M3	Mock Creek Sub-basin	44
M5	Maple Creek Sub-basin	154
M7	Matthews Beach Creek	139
M2 M4 M6	Miscellaneous Main Branch Sub-basins	51 87 13
N1	Ronald Bog Sub-basin	716
N2	Evergreen Creek Sub-basin	364
N3	Twin Ponds Sub-basin	463
N4	Littles Creek Sub-basin	543
N6	Hamlin Park Sub-basin	405
N7	Little Brook Sub-basin	829
N8	Jackson Park & I-5 Sub-basin	504
N5 N9 N10 N11 N12	Miscellaneous North Branch Sub-basins	107 273 112 40 90
S1	North Acres Sub-basin	129
S2	Meridian Ave N & North Seattle Community College Sub-basin	246
S3	Lower I-5 Sub-basin	167
S4	North Northgate Sub-basin	220
S5	South Northgate Sub-basin	94
S6	Victory Creek Sub-basin	197
S9	Kramer Creek Sub-basin	69
S11 S12	Willow Creek Sub-basins	293 103
S14	35th Ave NE Sub-basin	103
S7	Miscellaneous South Branch sub-basins	213

S8		350
S10		38
S13		111

Figure 3.13. Land Use Distribution in Thornton Creek Watershed (King County Economic Land Use Database, 1999)

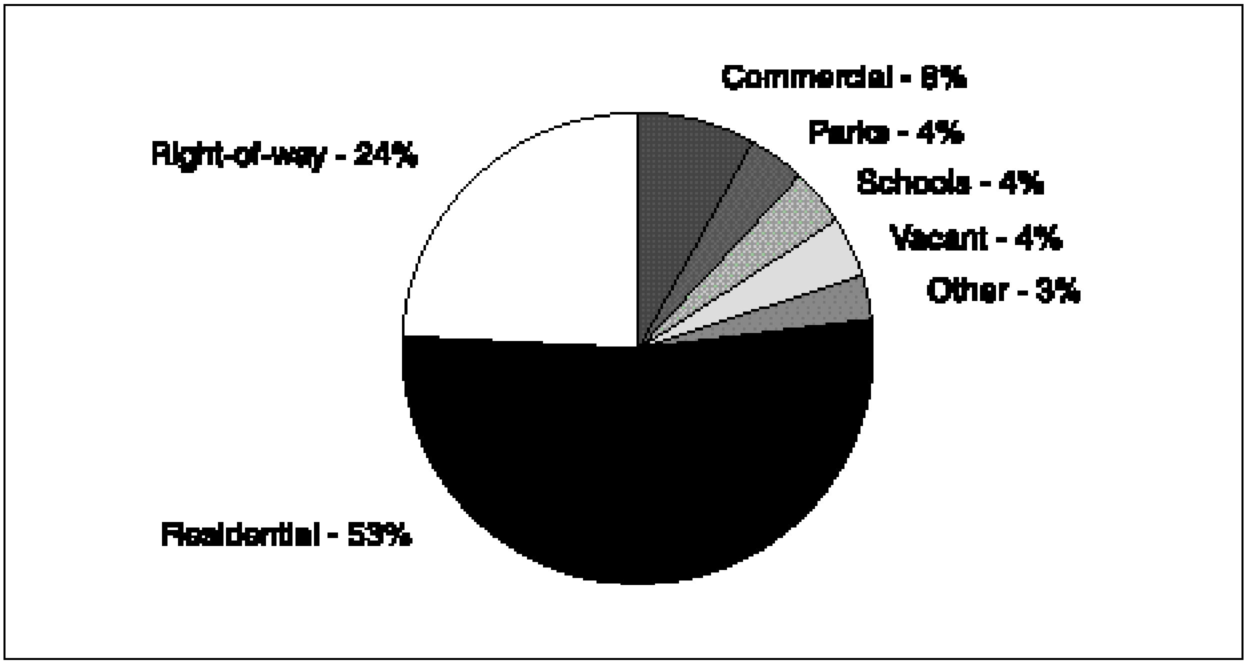


Table 3.7. Current Land Uses in Thornton Creek Watershed (King County Economic Land Use Database, 1999)

Current Land Use	Area (acres)	Area (% of total watershed area)	Seattle Averages (% of total area)
Residential – single family	3,738	51%	40% (single and multi)
Residential – multi-family	254	3	
Commercial	597	8	13
Industrial and utility	87	1	Included in commercial
Parks and golf courses	320	4	9
Schools	309	4	n/a
Right-of-way (road and shoulder)	1,682	23	26
Vacant	302	4	6

Unidentified	115	2	6

The Thornton Creek watershed can be broadly divided into three sections – the areas draining to the North, South, and Main Branches of Thornton Creek. Land uses within these three areas are compared in Table 3.8. There is very little difference between them, except that the area near the Main Branch has less commercial and more residential land use than the North and South Branch areas. Land uses associated with tributaries and smaller areas are presented later in this chapter.

Table 3.8. Comparison of Land Use by Major Sub-basin (SPU, 1999)

	Residential (SF)	Commercial *	Industrial	School	Parks/ golf	Right-of-way	Vacant	Unidentified
Main Branch	401 ac 64% of Main	12 ac 2% of Main	2 ac 0% of Main	9 ac 1% of Main	25 ac 4% of Main	141 ac 22% of Main	35 ac 6% of Main	1 ac 0% of Main
North Branch	2,293 ac 52% of North	431 ac 10% of North	67 ac 1% of North	173 ac 4% of North	273 ac 6% of North	940 ac 21% of North	208 ac 5% of North	63 ac 1% of North
South Branch	1,044 ac 45% of South	409 ac 18% of South	17 ac 0% of South	127 ac 5% of South	23 ac 1% of South	602 ac 26% of South	59 ac 3% of South	50 ac 2% of South

* Multi-family and mixed use land uses have been included in Commercial.

Figure 3.14 shows current land use and Figure 3.15 shows current zoning. The zoning map indicates future land use by identifying areas where future retail and multi-family development will be directed.

Residential

Single family residences account for 50% of the land use in the watershed. Multifamily housing and mixed use (retail and housing) accounts for 3%. Single family homes comprise two-thirds of the households, yet they account for nearly 95% of the residential land. Thornton Creek flows through more than 700 backyards and apartment building grounds. Many creekside property owners use the creek as an integral part of their landscaping.

Commercial

Approximately 580 acres of land in the watershed are used by commercial enterprises. In addition to Northgate Mall, Seattle’s principal regional shopping facility outside of downtown, several major employers are clustered in the Northgate area. These include Northwest Hospital and North Seattle Community College. In 1994, the Northgate area employed approximately 11,366 people, largely concentrated in service jobs. Shopping centers account for 63 acres; offices and medical centers cover 93 acres. The remaining 424 acres are occupied by retail establishments, restaurants, banks, and other businesses. Most businesses provide parking lots for their customers.

Lake City Way is another established commercial area with significant employment. Other neighborhood business areas provide services needed by people living nearby, such as food, entertainment, and professional, personal, or business services. These neighborhood business districts are generally located along arterial streets.

Figure 3.14. Existing Land Use

Figure 3.15. Existing Zoning

Industry and Utilities

Industrial areas and utilities comprise about 1.3% of the watershed. Almost one-third of the total industrial area is located near Twin Ponds and includes a King County solid waste transfer station, a King County bus barn; and a Seattle City Light electric sub-station. In 1994, the King County solid waste transfer station handled about 250 tons/day of waste delivered by commercial haulers, businesses, and self-haulers (residents) (King County, 1994). The site also provides a location for drop-off recycling. The Metro Regional Transit Authority bus barn is located near the transfer station. Over 200 buses receive routine maintenance and repairs at this site.

Although the Meadowbrook Pond looks like a park, it is a stormwater detention facility situated on the site of a former sewage treatment plant, and is considered industrial. Natural gas lines serve homes throughout the watershed.

Parks and Open Space

The Thornton Creek watershed has over 300 acres of parkland. Parks of significant size include: Hamlin Park, Ronald Bog Park, Ridgecrest Park, Twin Ponds Park, Paramount Park, North Acres Park, Jackson Park Golf Course, Meadowbrook Playfield, and Matthews Beach Park. In addition, Seattle Parks and Recreation owns contingent properties adjacent to the south branch of the creek, collectively known as Thornton Creek Parks #1 and 6. The North Seattle Community College campus includes a sizeable amount of undeveloped property. Parks in Seattle and Shoreline are listed in Table 3.9 (active use parks) and Table 3.10 (passive recreation parks), and shown in Figure 3.16. Parks comprise only 4% of the watershed, compared to the Seattle average of 9%. Magnuson Park, one of Seattle's largest parks is located along Lake Washington just outside of the watershed boundaries. School yards also provide open space.

Roads and Highways

Rights-of-way for roads and highways are the second largest land use in the watershed (24%). Rights-of-way are the publicly owned areas designated for roads and alleys and their adjacent sidewalks, ditches, utilities, planting areas, and/or shoulders. Unopened rights-of-way are undeveloped streets. Two large transportation corridors run through the watershed – over 4.5 miles of I-5 and about 3.5 miles of State Route 522 (Lake City Way). The freeway accounts for 212 acres (about one-tenth) of the right-of-ways in the watershed. Along highways and commercial areas, the entire right-of-way may be used for streets and sidewalks. In most residential settings, about half the width of the right-of-way is used for the roadway; the remainder is planting strips, parking areas, sidewalks, and front yards.

Schools and Community Services

Every year, approximately 25,000 students attend one of the 20 public schools and seven private schools located in or adjacent to this watershed. North Seattle Community College is in the southwest corner of the basin. These schools are shown in Figure 3.17. Schools and their playfields account for 4% of the land use in the watershed.

Also located in the watershed are three fire stations, two police stations, two hospitals, three community centers, and two libraries.

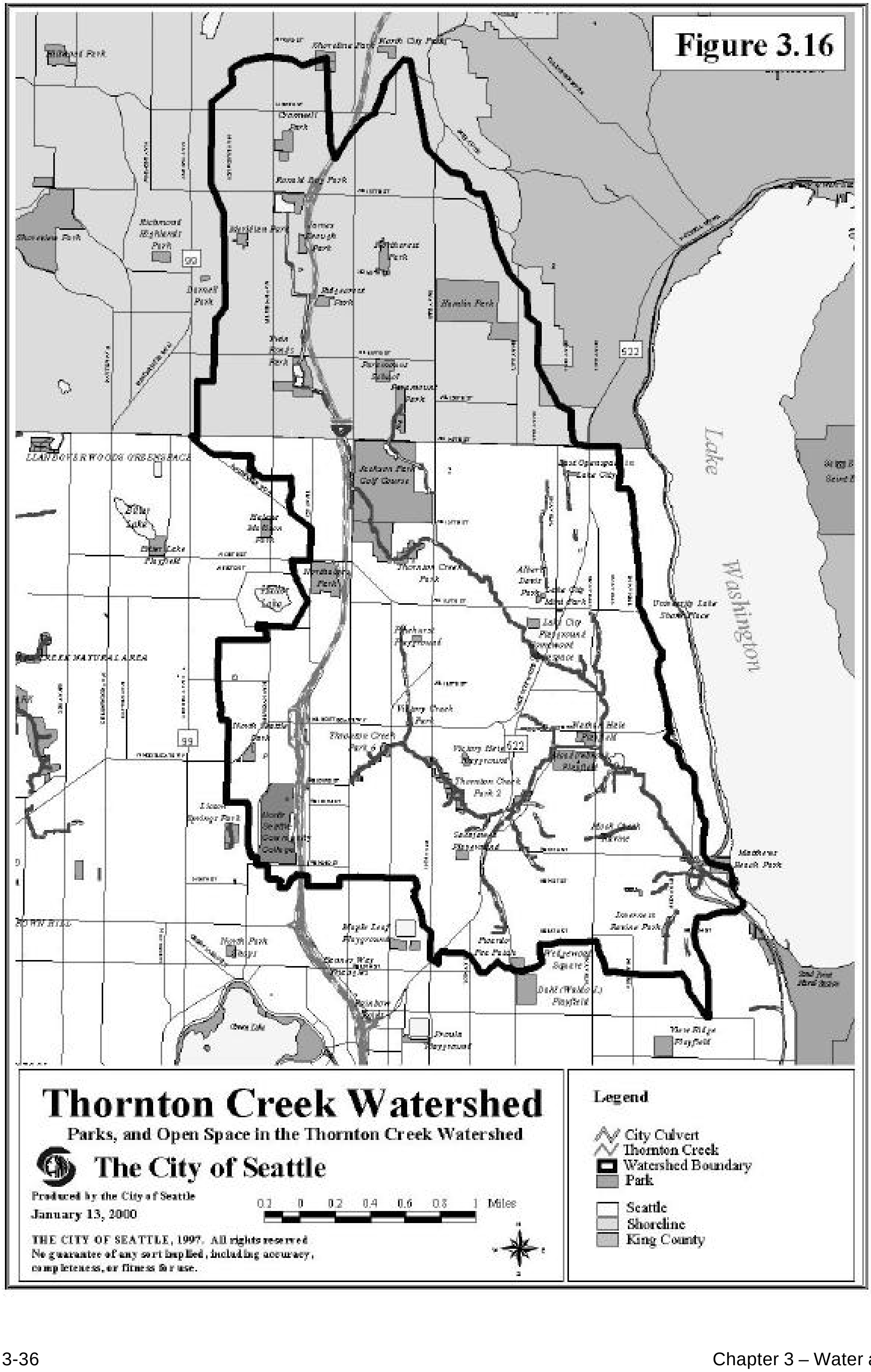


Figure 3.16
Lake
Washington
Thornton Creek Watershed
Parks, and Open Space in the Thornton Creek Watershed
The City of Seattle
Produced by the City of Seattle
January 13, 2000
0.2 0 0.2 0.4 0.6 0.8 1 Miles
THE CITY OF SEATTLE, 1997. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
City Culvert
Thornton Creek
Watershed Boundary
Park
Seattle
Shoreline
King County

Table 3.9. Active Use Parks (Ball Fields, Playgrounds, Beaches) (Seattle Department of Parks and Recreation, 1999 and Seattle GIS database 1999)

Name	Location	Acres	Amenities
Albert Davis	12526 27th Ave NE	1.2	
Burke-Gilman Trail	Near Lake Washington	n/a	Trail, wildlife corridor.
Cromwell Park	Meridian Ave N & N 180th St	2.1	Playground, ball fields, wetland.
Hamlin Park	15th Ave NE & NE 160th St	73.0	Forest, trails, wildlife habitat, children's play area, tennis, baseball fields, football field.
Jackson Park Golf Course	15th Ave NE & NE 130th St	160	Golf, trails, woods (in lower undeveloped portion).
James Keough Park	N 170th & Corliss Ave N	3.1	Field.
Lake City "Last Open Space"	14043 32nd Ave NE	0.9	Proposed creek connection, meadow and playground.
Lake City Mini-Park	NE 125th St/Lake City Way	0.2	
Lake City Playground	2750 NE 125th St	2.8	Children's play area, picnic area.
Matthews Beach	9300 51st Ave NE	22.0	Children's play area, basketball hoops, picnic area, swimming, trails, creek.
Nathan Hale Playfield	10750 30th Ave NE	5.6	Soccer/football fields, basketball, playground, creek and wetlands.
North Acres Park	12718 1st Ave NE	20.7	Children's play area, picnic, soccer/football fields, softball/baseball fields, tennis courts, trails, woods.
North Crest Park	165th St & 10th Ave NE	7.3	
North Seattle Park (Frisbee Park)	10556 Meridian Ave N	4.0	Woods, frisbee, golf.
Paramount Park (upper)	11th Ave NE & NE 152nd St	3.6	Ballfields, playground.
Pinehurst Playfield	12029 14th Ave NE	1.3	Children's play area, basketball hoops, softball/baseball fields.
Ridgecrest Park	1st Ave NE & N 161st St	3.6	Playground, handball, baseball.
Sacajawea Playground	1726 NE 94th St	2.6	Children's play area, picnic, wetland.
Twin Ponds Park	NE 155th St & 1st Ave NE	21.6	Picnic area, soccer fields, pond, woods, trail
Victory Creek Park	1059 NE Northgate Way	0.2	Children's play area, woods, creek.

Victory Heights Playground	1737 NE 106^{th} St	1.6	Children's play area, tennis courts.

Table 3.10. Passive Use Parks (Wildlife Parks and Natural Areas)

Name	Location	Acres	Amenities
Hamlin Park	See Table 3.9		
Homewood Open Space (North Fork)	11736 Daniel Pl	1.0	Woods, creek, trail.
Meadowbrook Pond	10710 35th Ave NE	10	Ponds, trails, sculptures, wetlands, creek.
Meridian Park	N 170th St & Wallingford Ave N	3.2	Wetland, woods, creek.
Mock Creek Ravine	3500 block of NE 97th St	1.0	Woods, creek.
North Acres Park	See Table 3.9		
Paramount Park (lower park)	11th Ave NE & NE 152nd St	3.6	Woods, creek, wetlands, trail, fields.
Ravenna/Blindheim Open Space (LaVilla Dairy)	10028 Fischer Place NE	3.8	Woods, creek.
Ronald Bog Park	N 175th St & Meridian Ave N	13.6	Picnic area, pond, wetlands, artwork.
Sand Point Way Open Space	West of NE 95th St & Sand Point Way NE	2.4	Woods, creek.
Thornton Creek Park #1 (North Fork)	N of NE 130th St west of 15th Ave NE	7.7	Woods, wetland, creek, trail.
Thornton Creek Park #2 (South Fork)	String of parcels between NE 100th St & NE 105th St south of 15th Ave NE	11.9	Woods, wetland, creek.
Thornton Creek Park #6 (South Fork)	String of parcels east of Northgate Mall	6.4	Woods, creek.
Twin Ponds Park	See Table 3.9		
Willow Creek Open Space	Along NE 95th St, series of parcels	1.9	Woods, creek, ravine.

Vacant Land

Only 4% of the land in the watershed remains undeveloped. Much of this vacant land is too steep to build on, contains sensitive wetland areas, or is oddly shaped and doesn't lend itself to development. Some citizens consider this land ideal for conversion to open space areas, wetland or natural area restoration sites, public parks, future water detention pond sites, and other useful purposes that would enhance the communities where they are located.

Abandoned Landfills

One abandoned landfill is located in the watershed near the existing King County solid waste transfer station. Buried refuse is located east of Thornton Creek in the vicinity of 1st Ave NE and

Corliss Ave N between N 163rd St and N 165th St. The site was used by King County as a sanitary landfill serving north King County from about 1946 until it was closed when I-5 was constructed in 1959. Portions of the landfill site are located on peat soils. When the site was in

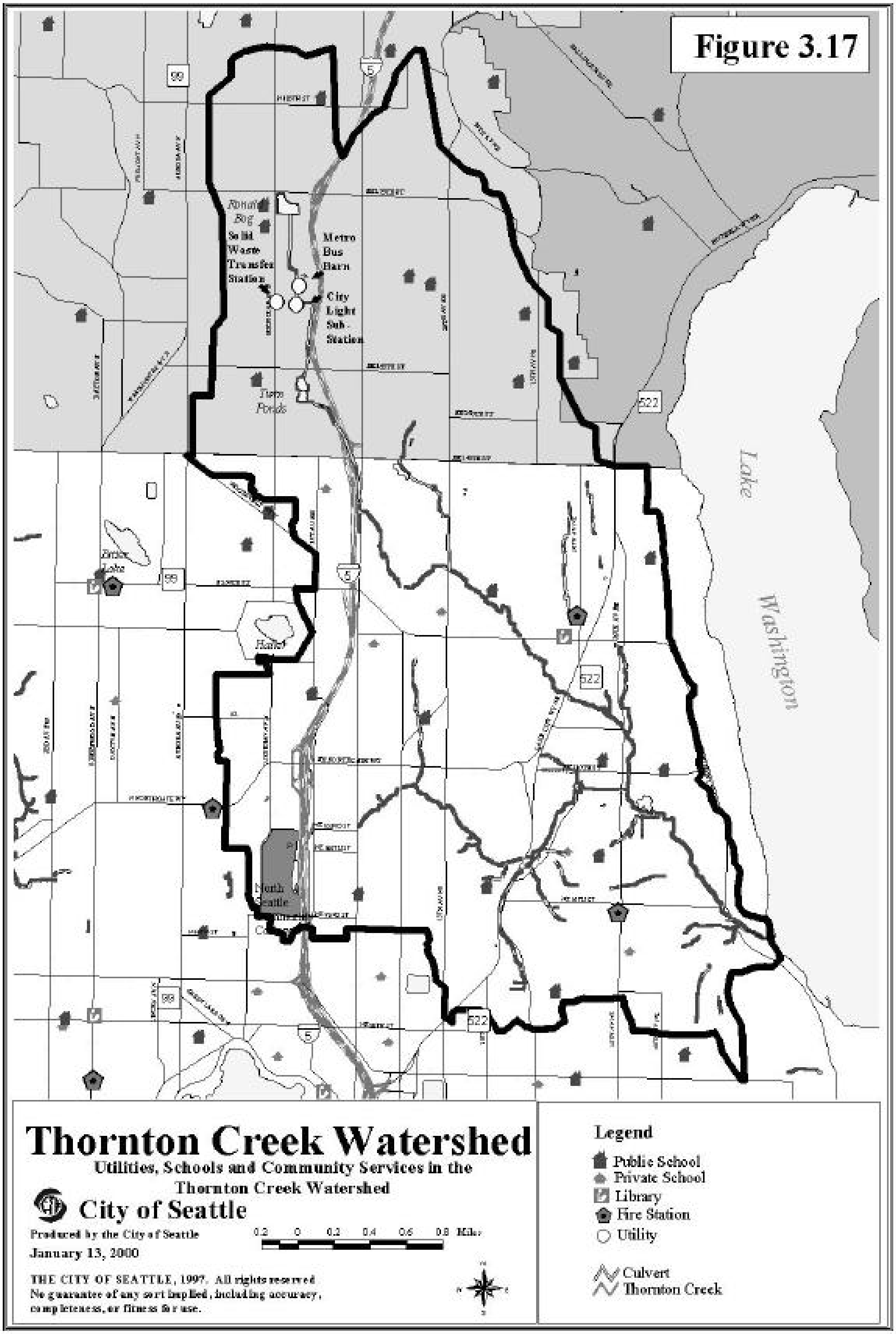


Figure 3.17
Thornton Creek Watershed
Utilities, Schools and Community Services in the
Thornton Creek Watershed
City of Seattle
Produced by the City of Seattle
January 13, 2000
0.2 0 0.2 0.4 0.6 0.8 Miles
THE CITY OF SEATTLE, 1997. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Public School
Private School
Library
Fire Station
Utility
Culvert
Thornton Creek
Ronald Bog
Solid Waste Transfer Station
Metro Bus Barn
City Light Sub-Station
Twin Ponds
Bitter Lake
Haller Lake
North Seattle CC
Lake Washington
99
5
522

operation, it handled about 60,000 cubic yards of waste a year and was the primary north King County disposal site (First Avenue Northeast Transfer Station Full Development Conceptual Alternative Report, 1994, King County).

A portion of the buried refuse was removed during the construction of I-5. When the Metro north operating bus base was constructed, about 126,000 tons of waste were excavated and removed. As part of the Health Department's Abandoned Landfill Study in 1984-85, several test holes were installed at the site and tested for combustible gas. Combustible gas was detected above the lower explosive limit in 5 of 20 test holes sampled at the site. Subsequent testing in 1986 confirmed the presence of combustible gas above the lower explosive limit.

Land Use by Sub-basin

The Thornton Creek watershed can be divided into smaller watersheds or sub-basins, as shown previously in Figure 3.12. These sub-basins are described in detail in Section 4.7. The land use for each sub-basin is shown in Table 3.11.

3.7 Impervious Surfaces

Impervious surfaces, such as roads, parking lots, sidewalks, and buildings, cover much of the land in the watershed. Impervious surfaces have altered the water cycle. More impervious surfaces mean fewer forests, meadows, and gardens. Less rainfall soaks into the soil and more runs quickly through pipes and ditches to the creek. In turn, urban streams may be overwhelmed during storms, and underfed by groundwater in the summer. Different land uses have different levels of imperviousness. At one extreme, a commercial property with stores and parking lots covering the entire lot could have an impervious rating of 95%. This means almost all of the rain falling on this property runs off into a storm drain or ditch. Some of the rainfall might remain in puddles, soak through cracks in the asphalt, soak into landscaping, or evaporate. At the other extreme, an undisturbed forest could have an impervious rating of nearly zero. In this case there would be almost no runoff; all water would be transpired from the forest vegetation or absorbed by the forest floor.

Impervious ratings are not exact. For example, within residential areas the amount of imperviousness can vary from lot to lot depending on the building footprint, driveway size, slope, type of landscaping, and size of yard. In 1989, SPU developed a table that assigns a level of imperviousness to certain land uses (Table 3.12). Many common land uses were selected and a sizeable sample area was reviewed parcel by parcel. These measurements were then extrapolated for the entire Seattle area. For this report, the 1989 land use categories were modified to correspond with the land use categories in the King County tax assessor's database.

Table 3.11. Land Use by Sub-basin (Acres) (Seattle GIS database, 1999)

		Single family residential.	Multi-family residential	Shop-ping Centers	Office/medical	Other commercial	Industrial/Utility	Mixed Use	Schools	Parks/golf	Right-of-way	Freeway	Vacant	Unknown	Total
M01	Main Branch – E side	81	0	0	0	1	2	0	6	6	31	0	12	0	139
M02	Old Maple Leaf School	34	0	0	0	0	0	0	0	0	14	0	3	0	51
M03	Mock Creek	30	1	0	0	1	0	0	0	0	10	0	1	0	44

M04	Main – misc. west	62	1	0	0	0	0	0	4	0	19	0	2	0	87
M05	Maple Creek	105	1	1	0	5	0	0	0	0	36	0	6	0	154
M06	Matthews Beach	7	0	0	0	0	0	0	0	1	3	0	1	0	13
M07	Matt. Beach Creek	83	0	0	0	0	00	0	0	18	0	28	10	1	139
N01	Ronald Bog	414	9	0	4	41	6	0	28	2	142	22	34	14	716
N02	Evergreen Creek	228	13	0	0	5	5	0	20	0	76	0	12	3	364
N03	Twin Ponds	252	7	0	1	9	31	0	0	27	73	41	19	4	463
N04	Littles Creek	256	25	0	2	32	2	0	14	76	98	0	27	10	543
N05	East of golf course	53	5	4	0	9	0	1	0	0	22	0	2	11	107
N06	Hamlin	153	6	0	0	69	0	0	39	64	56	0	16	1	405
N07	Little Brook	408	56	3	12	51	16	3	41	6	185	0	39	10	829
N08	Jackson Park & I-5	173	10	0	2	14	3	1	27	96	79	59	34	8	504
N09	Middle S side	210	6	0	0	5	2	1	0	0	29	0	18	2	273
N10	Middle N side	60	8	0	3	8	1	1	0	1	27	0	3	0	112
N11	North-lower S side	22	2	0	0	2	0	0	4	0	10	0	0	0	40
N12	North – lower E side	64	1	0	0	0	0	0	0	0	21	0	2	0	90
S01	North Acres	82	4	0	0	3	0	0	5	0	26	2	4	1	129
S02	Meridian & NSCC	58	11	0	12	80	0	0	28	0	40	0	5	12	246
S03	I-5 (lower)	1	13	0	18	3	0	0	35	0	7	87	1	3	167
S04	Upper Northgate	49	17	54	6	33	3	1	1	0	36	0	6	14	220
S05	Lower Northgate	24	2	1	20	19	2	0	0	0	18	0	0	7	94
S06	Victory Creek	108	15	0	2	7	1	1	7	1	46	0	4	4	197
S07	South – north central	110	3	0	3	4	1	1	8	0	75	0	7	1	213
S08	South – south central	214	11	0	4	7	5	2	0	3	90	0	13	1	350
S09	Kramer Creek	40	2	0	1	3	1	2	0	0	16	0	2	0	69
S10	Nathan Hale	3	1	0	0	0	0	0	29	0	5	0	0	0	38
S11	Willow	155	25	0	3	10	3	1	1	0	79	0	10	6	293
S12	Willow Tributary	69	0	0	0	0	0	0	4	0	26	0	3	0	103
S13	Ravenna/30th	66	0	0	0	0	0	0	5	13	22	0	3	0	111
S14	35th Ave NE	63	1	0	0	3	0	0	3	6	25	0	1	0	103
All	Total	3,738	254	63	93	424	86	17	309	320	1,470	212	302	115	7,402

Table 3.12. Impervious Surface Ratings for Various Land Uses (SPU, 1999)

Land Use Category / Description	Variability Factors	% Impervious
Residential – single family	Building, driveway, yard	45
Commercial, multi-family, mixed use	Building, parking lot, landscape, setbacks	75
Industrial (light)	Building, parking lot, landscape, setbacks, unpaved lots	70
Parks, open space	Vegetation, paths, parking	10
Right-of-way	Paved roadway, sidewalks, unimproved shoulders	60
Vacant	Same as park	10
Unknown	Average value	45

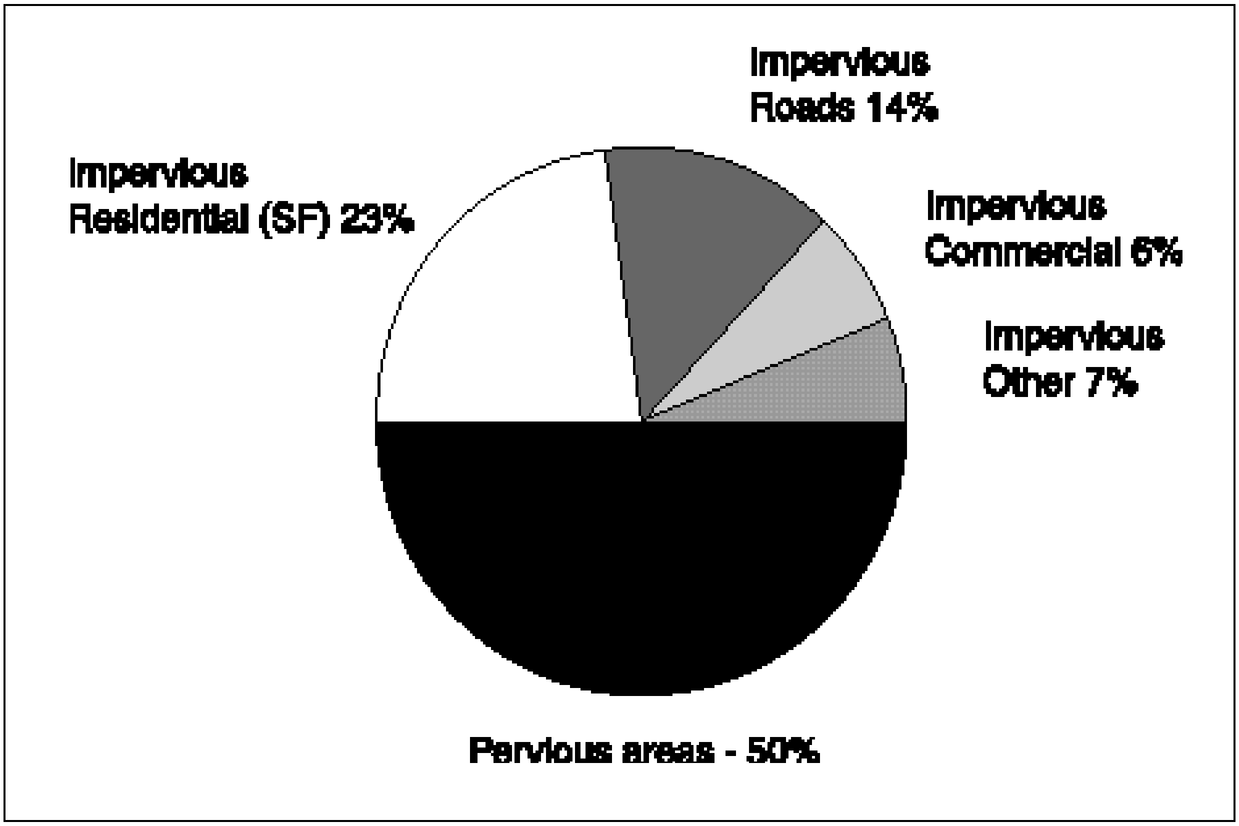
Based on Table 3.11 and Table 3.12, SPU calculated the amount of effective impervious area generated by each land use in Thornton Creek watershed. For example, residential property has an area of 4,237 acres with a 45% impervious rating; the effective amount of impervious area is 1,907 acres. These results are shown in Table 3.13.

Table 3.13. Amounts of Impervious Surface in Thornton Creek Watershed (by Land Use) (SPU, 1999)

Land Use	Area (acres)	% Impervious	Effective Impervious Area (acres)
Residential – single family	3,738	45	1,682
Residential – multi-family/mixed use	271	75	203
Commercial	580	75	435
Industrial	87	70	61
Parks, open space	320	10	32
Schools	309	45	139
Right-of-way	1,682	60	1,009
Vacant	302	10	30
Unknown	115	45	52
Total	**7,402**		**3,642**

By this method, nearly half, 49% of the Thornton Creek watershed is covered by impervious surfaces. As shown in Figure 3.18, residential uses account for half the impervious surfaces, roads cover 14% of the watershed with impervious surfaces, and commercial and other uses cover 13% of the watershed with impervious surfaces. In the future, SPU will be able to use Geographic Information Systems (GIS) data on building footprints and pavement edges to develop more accurate impervious ratings for various land uses.

Figure 3.18. Comparison of Pervious and Impervious Surface Area Sources (SPU, 1999)



Summary

Chapter 3 has painted a picture of the watershed's basic geographic features, the land, water, and changes brought about by human habitation. This information is the basic for the following chapters, which complete the watershed characterization: the aquatic and terrestrial habitat for fish and wildlife (Chapter 4) and water quality (Chapter 5).

CHAPTER 4: AQUATIC AND TERRESTRIAL RESOURCES (FISH, WILDLIFE, AND HABITAT)

Stream corridors and adjacent uplands play a key role in the natural environment. Their diverse micro-environments are habitat for birds, mammals, reptiles, and amphibians. Stream corridors also are essential for aquatic habitat; for example, they regulate water temperature, sediment, and flow, and provide food and shelter. Some of these species live permanently in the stream corridor while others visit it periodically for food, water, and cover. Stream corridors are often the only links between parks and open spaces. Because stream corridors are so important to fish and wildlife, their degradation can have a disproportionately serious effect on the ecology of an entire watershed.

This chapter focuses on the aquatic and terrestrial species and their habitats in the watershed with special attention to salmon. This chapter also summarizes the findings of the habitat assessment of Thornton Creek, recently completed by Seattle Public Utilities (SPU), and evaluates habitat problems.

4.1 Overview of Watershed Habitat

The watershed's vegetation and habitat have been greatly altered since the time European settlers first arrived, with consequences for its fish and wildlife resources. The entire watershed was likely covered with large Douglas fir, hemlock, and cedar trees before white settlers arrived. Several of these forests were cut for timber between 1859 and 1897 and were never replanted. There were remnant areas of forest in the watershed that were not logged. According to Lucille McDonald (1979), "Lake City was still covered with tall timber at the turn of the century and it was about 1916 before the last of it around 145th St was cut."

Large wetlands were drained and land was cleared for agriculture, which in turn was replaced by residential and commercial development. For example, historical land conditions near the Thornton Creek watershed included Mud Lake at Sand Point, a wet depression that was filled when it became part of the Naval Station at Sand Point (McDonald, 1979). As noted previously, most streams and wetlands in the watershed have been altered by channeling, piping, and filling. The end result is that fish and wildlife habitat in the Thornton Creek watershed has been greatly reduced. Remaining habitats are often in isolated sections, or are fragmented. These habitats are limited because many fish and wildlife species cannot or will not move far to seek them. Most of the remaining open spaces are found in parks and school campuses where often the habitat is significantly different from the historic coniferous forest.

Watershed parks were previously identified in Figure 3.16. The following discussion of wildlife and habitat in the Thornton Creek watershed is taken from Seattle Parks and Recreation Urban

Wildlife and Habitat Management Plan (Seattle Parks, 1994), which describes the environment in Seattle parks. The inventory of wildlife resources was derived from existing information, aerial photo interpretation, and limited field surveys. In addition, information on the occurrence of wildlife and wildlife habitats was obtained from focus group meetings with environmental groups, biologists, and other interested people.

The habitat categories are shown below. A description of the plants and wildlife found within each category follows. For the purpose of this report, more emphasis is given to aquatic habitat and the riparian corridor.

Dusk on Matthews Beach on Lake Washington

Terrestrial Habitats

- Conifer forest
- Deciduous forest
- Conifer hardwood mixed forest
- Grass and shrub land
- Beaches (non-vegetated areas)
- Agricultural areas
- Developed areas

Freshwater Aquatic and Riparian Habitats

- Open water
- Wetlands
- Stream
- Riparian corridor

4.2 Terrestrial Habitat and Wildlife

Conifer Forest

Conifer Forest in Hamlin Park

The isolated patches of conifer forest and stands of trees in the Seattle area provide habitat for many native species. For many residents, they represent the quintessential Pacific Northwest ecosystem. Conifer forests contain Douglas fir, Grand fir, Western hemlock, and Western red cedar. In many locations, the remaining conifer forests have been invaded by English ivy and holly. A large conifer forest is located within Hamlin Park. Small stands of mature conifers are also found in North Acres Park.

Conifer forests provide primary breeding and feeding habitat for more than 70 wildlife species. Typical bird species found in conifer forests include Red-tailed hawk, American crow, Varied thrush, Swainson's thrush, Chestnut-backed chickadee, Steller's jay and Northern flicker. Bird use varies throughout the year with more birds found in fall and winter. Common mammal species include Deer mice, Mountain beaver, Townsend chipmunk, Short-tailed weasel, opossum, and raccoon. Several amphibians are expected; these include Northwestern salamander, *Ensatina,* Western garter snake, and Pacific tree frog.

Many parks in this watershed contain mature deciduous trees with patches of immature conifers. An essential part of forest succession in the Pacific Northwest is the conifer replacement of deciduous trees in the canopy. However, due to the cumulative effects of urbanization, this is not happening. Conifer seedlings, which should sprout up, are missing – partially due to a shortage of seeds and partially because blackberry and ivy out-compete conifer seedlings in the understory. The North Seattle Community College campus has several small stands of conifers that are next to open grassland and serve as perching sites for Red-tailed hawks and the occasional Bald eagle (Seattle Parks, 1994).

Deciduous Forest

Deciduous forest is a common habitat in parks, ravines, and undeveloped areas in Seattle and Shoreline. Much of the deciduous forest grew after conifer forests were logged and cleared. The deciduous forest overstory is usually dominated by Red alder and Big leaf maple and may also include Bitter cherry, Pacific dogwood, Sitka willow, and Vine maple. The understory is often overrun by exotic invasive plants such as Himalayan blackberry, English ivy, and English holly. Where they exist, native plants such as Swordfern, Indian plum, Oceanspray, Pacific blackberry, Oregon grape, Red elderberry, Salmonberry, Stinging nettles, and horsetail are often found.

Red-alder dominated forests provide primary breeding and feeding habitat for 60 vertebrate wildlife species and secondary habitat for an additional 100 species. Typical species using this habitat include American robin, Black-capped chickadee, Northern flicker, Downy woodpecker, Deer mouse, opossum, and raccoon. Great blue heron and Downy woodpeckers have been spotted in Thornton Creek watershed.

Deciduous forests are found in Thornton Creek Parks #1, 2, and 6, Ravenna Open Space, Paramount Park, Homewood Open Space, and Sand Point Open Space. Thornton Creek Park #6 has many alder and Big leaf maple and a number of other deciduous trees. In recent years, volunteers have planted a large number of conifers in this park to shade out blackberries. These volunteer efforts assist the natural progression of forest growth from deciduous to coniferous cover. Blue heron and Downy woodpeckers have been seen in Thornton Creek Park #6, the Homewood Open Space site (near NE 125th St and Lake City Way), and in the Little Brook ravine.

Thornton Creek Park #1 provides outstanding habitat for an urban setting. There is a significant contiguous stretch of riparian forest. Its proximity to undeveloped open space near the Jackson Park Golf Course adds to its value (Seattle Parks, 1994).

Conifer Hardwood Mixed Forest

The conifer hardwood mixed forest is dominated by Red alder, Big leaf maple and Madrona. This system may often contain Douglas fir, Western red cedar, and Western hemlock in the overstory canopy. The understory may contain Salmonberry, Red huckleberry, Red elderberry, Indian plum, and Oceanspray. Stands of mature conifer hardwood mixed forest are found in North Acres Park and Paramount Park. This type of forest supports wildlife species similar to conifer and deciduous forests. Bald eagles and coyote have been spotted in the woody area south of Jackson Park Golf Course (Seattle Parks, 1994).

Grass and Shrub Land

Non-forested areas such as meadows and shrub lands are located throughout the watershed. Grassland plants often grow several feet in height. At North Seattle Community College, there are several meadows in the Bartonwood Sanctuary. The campus meadows are maintained to control invasive plants such as Scotch broom and Himalayan blackberry, which can rapidly overrun urban meadows.

Grassland areas provide habitat for insectivores such as Townsend moles, rodents such as Deer mice, and many ground foraging birds such as American robin, Dark-eyed junco, and Brewer's blackbird. The meadows at the college attract hawks that perch in the tall trees overlooking the site, as they scan the field below for rodents and other prey. Pheasant and California quail occupied the greenbelts of the campus until the mid-1980s. Pheasant recently were spotted again on the campus, but it is not clear if the birds are resident. Coyotes are occasionally spotted in the meadows and the surrounding sanctuary. Researchers suspect they enter the city via the nearby I-5 corridor.

Shrub lands frequently occur in open spaces. Many non-native species have aggressively colonized native shrub lands, which are now often dominated by weeds. For example, Scotch broom dominates some areas near I-5 with dense stands six to eight feet tall. Weed-dominated shrub lands in the park system and other developed or disturbed areas are likely to support far fewer native wildlife species than native shrub lands. Exotic, monotypic plant communities seldom support many native wildlife species. Native shrubs such as Vine maple and Salmonberry tend to grow well at creek edges (Seattle Parks, 1994).

Beaches

A sandy beach is located along the shores of Lake Washington at Matthews Beach, at the mouth of Thornton Creek. This is a freshwater beach and is not subject to tides. However, the water level in the lake can fluctuate by several feet during the year due to the operation of the Ballard Locks.

Matthews Beach is used by many species for foraging and nesting. Canada geese, crows, Mallard ducks, American coots, American widgeon, Ring-billed gulls, and Glaucous-winged gulls are often seen on sandy beaches. Blue heron and Bald eagles also have been seen at Matthews Beach (Seattle Parks, 1994).

Agricultural Areas

Four community gardens, known as P-Patches, are located within the watershed. These are Picardo Farm (98,000 sq. ft) located at 26th Ave NE and NE 82nd St; the Jackson Park P-Patch (9,000 sq. ft) located at 10th Ave NE and NE 133rd St; the Pinehurst P-Patch (5,000 sq. ft) located at 12th Ave NE and NE 115th St; and the Haller Lake P-Patch located at 13045 1st Ave NE.

P-Patches are usually small (less than one acre) and contain flowers, vegetables, and herbs. Many types of wildlife use the community gardens. Following is an incomplete list of wildlife found at P-Patches. (Source: Julie Bryan, P-Patch coordinator, results of informal phone survey of gardeners.)

Birds. Sandpipers, killdeer, woodpeckers, eagles, goldfinches, hummingbirds, Red-winged blackbirds, crows, hawks, starlings, eagles, Stellar's jays, Blue jays, robins, swallows, Nuthatches, Titmice, ducks, pigeons, chickadees.

Insects. Dragonflies, Honey bees, Orchard mason bees, Hover flies, ladybugs, Lacewings, Paper wasps, other wasps, butterflies, moths, ants, Rove beetles, other beetles, aphids, cutworms, craneflies, flies.

Mammals. Opossum, raccoons, rats, mice, cats, dogs, voles.

Developed Areas

Developed areas dominate the watershed and are found in the headwaters, uplands, lowlands, wetlands, and along the creek itself. Typically, residential properties and active use parks have lawns interspersed with patches of tended shrubs and flowers. The landscaping may contain a diverse mix of native and exotic species. Landscaped grassland, shrub land, and forest habitat are simpler than their non-landscaped counterparts. The most common species found in these areas are the Northern flicker, robin, crow, Steller's jay, Dark-eyed junco, Black-capped chickadee, Song sparrow, and House sparrow.

Developed areas also include extensive roads, commercial buildings, and parking lots, which provide little or no habitat. These heavily developed areas contain sparse vegetation and are subject to noise and disturbance from traffic and other human activities. Garbage provides a significant food source for scavengers. Depending on the amount of vegetation and food, species such as crow, starling, robin, opossum, raccoon, and Norway rat use these habitats. Domestic pets and their feral relatives are commonly found in developed areas.

4.3 Aquatic Habitat

Open Water

Several ponds in the watershed provide valuable open water habitat for resident and migratory birds. The larger ponds are located at Ronald Bog, Twin Ponds Parks, the North Seattle Community College, and Meadowbrook Pond. Several other small ponds exist.

Students at Evergreen School have been monitoring birds at Twin Ponds for several years. They have spotted Oregon junco, Spotted towhee, Song sparrow, Mallard ducks, American coot, Pied-billed grebe, American widgeon, Ring-necked duck, Belted kingfisher, Red-tailed hawk, Cooper's hawk, Downy woodpecker, and others.

A stormwater detention pond was constructed at North Seattle Community College in the late 1960s. This pond is an extension of a small natural wetland located at the north end of the pond. It provides habitat for both migratory and resident birds. Over 95 different species of birds have been sighted around the campus, and many of those are seen near the pond. The banks of the pond are planted with thickets of willow, pine, and Salmonberry, interwoven with Himalayan blackberry. These plants form a thick barrier to the pond, creating safe and secure nesting, resting, and feeding opportunities for waterfowl. In addition to the common water birds found in Seattle, an occasional flicker, Green heron, and Wood duck have been spotted. Great blue heron frequently hunt in the boggy north end of the pond.

Meadowbrook Detention Pond and the small nearby creek and wetlands are providing habitat for a number of species. Nathan Hale High School students spotted a River otter in the pond in 1998, and beavers in Meadowbrook pond have created dams in 1999 and 2000. Pacific chorus tree frogs reside in Paramount Park wetland and pond area, at North Seattle Community College, and around the Meadowbrook ponds and wetlands.

Wetlands

Wetlands are one of the most productive ecosystems in the world. Some 212 species of wildlife – ranging from salamanders and juvenile salmon to Great blue herons – and many species of plant life depend on western Washington's wetlands for survival.

The intertwining roots, leaves, and fibers of the dense plant life filter sediment and pollutants from the slow-moving water. When floodwaters overflow the banks of streams and rivers, the porous soils and plants of wetlands soak up tremendous amounts of the excess water. Water in wetlands seeps back into streams and recharges the groundwater. During dry periods, wetlands are fed by groundwater and/or adjacent streams. Wetlands are characterized by the presence of water, hydric soils, and hydrophytic (water loving) vegetation. Wetlands often contain significant amounts of decaying organic debris, which forms a silt-like layer on the floor of a wetland. Hydric soils are often dark gray to black and may have a mottled appearance. Hydric soils are formed when there is a lack of oxygen in the interstitial soil spaces. Not all wetlands have standing water and some are dry during summer months (King County DNR, 2000).

Emergent, scrub-shrub, and forested wetlands are found in the Thornton Creek watershed (see Figure 4.1).

- **Emergent wetlands** are often found along the edges of small ponds and are commonly known as marshes, wet meadows, and bogs. Marshes contain small lakes and ponds full of cattails, Pond lilies, Yellow iris, and many other types of plant life. Wet meadows often look like soggy pastures of grasses, rushes, and sedges, though they may dry out during the summer. Bogs have a thick mat of Sphagnum moss encircling or covering a small lake or pond containing cranberry, Labrador tea, and/or Bog laurel. Emergent wetlands are frequently used by waterfowl such as Mallard ducks and Canada geese. They are also home to amphibians including Pacific tree frogs, Rough-skinned newt, and Northwestern salamander. These areas contain aquatic invertebrates and frogs, which serve as prey for Great blue heron and raccoon. Three-spine Stickleback fish and Red-winged blackbird may also be found. Wetland areas contain willows, Skunk cabbage, cattails, horsetail, Reed canary grass, and bulrushes (King County DNR, 2000)..
- **Scrub-shrub wetlands** are covered by dense native shrubbery such as dogwood, crabapple, Salmonberry, Hardhack, willow thickets, and Black cottonwood, as well as non-natives like Himalayan blackberry and Purple loosestrife (King County DNR, 2000). Community members have observed Red-tailed hawk, Bald eagle, Great blue heron, and numerous songbird species using the created emergent and scrub-shrub wetlands at Meadowbrook Playfield.
- **Forested wetlands** contain Alder and may also include Sitka spruce, Western red cedar, Oregon ash, and cottonwoods in the overstory; Salmonberry, Skunk cabbage, Water parsley, and Piggy back are common in the lower layers (King County DNR, 2000).

Historically, wetlands covered an extensive area in the Thornton Creek watershed. The area around Northgate Mall and North Seattle Community College was once a large bog. Twin Ponds and Ronald Bog were peat bogs. With urbanization, these wetlands were gradually lost and today only remnants remain.

The location of wetlands in the watershed has been documented on the US Department of Interior, Fish and Wildlife Service national wetland inventory maps, on Seattle's Environmentally Critical Areas maps, and by residents. The location of watershed wetlands is shown in Figure 4.1.

USFW took high altitude aerial photographs of the watershed in 1971 and 1980. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography and stereoscopic analysis in accordance with Classification of Wetland and Deep Water Habitats of the United States (December 1979). The most recent National Wetland Inventory Map was produced in 1987 based on the 1980 flyover. The identified wetlands are listed and classified in Table 4.1.

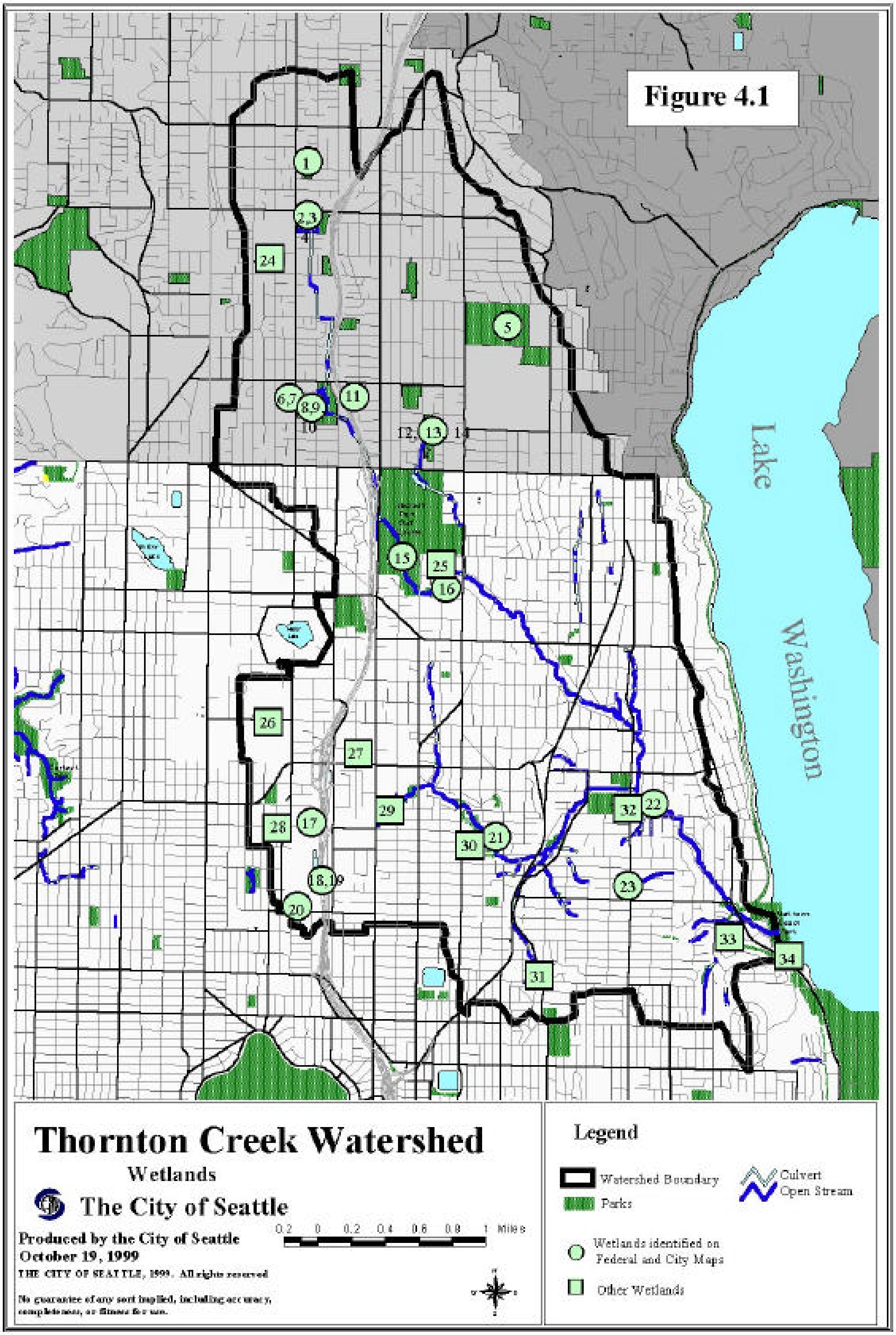


Figure 4.1
Lake Washington
Thornton Creek Watershed
Wetlands
The City of Seattle
Produced by the City of Seattle
October 19, 1999
THE CITY OF SEATTLE, 1999. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
0.2 0 0.2 0.4 0.6 0.8 1 Miles
Legend
Watershed Boundary
Culvert
Open Stream
Parks
Wetlands identified on Federal and City Maps
Other Wetlands
1
2,3
4
5
6,7
8,9
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11
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Table 4.1. Wetlands in Thornton Creek Watershed (from South to North) (USFW, 1987; City of Seattle, 1999)

Number in Fig. 4.1	Shown on National Wetland Maps	Shown on Seattle Maps	Shown on Shoreline Maps	Location	National Wetland Inventory Description (if available)
1	X			Ronald Bog (3 blocks N of pond) Cromwell Park	Palustrine Scrub-shrub Seasonally Flooded
2	X		X	Ronald Bog (N end of pond)	Palustrine Scrub-shrub Seasonally Flooded
3	X			Ronald Bog (E of pond)	Palustrine Scrub-shrub Seasonally Flooded
4	X			Ronald Bog (pond)	Palustrine Open Water Artificially Flooded Excavated
5	X			Hamlin Park	Palustrine Open Water Permanently Flooded Excavated
6	X		X	Evergreen School	Palustrine Forested Seasonally Flooded
7	X		X	Evergreen School	Palustrine Scrub-shrub Seasonally Flooded
8	X		X	Twin Ponds	Palustrine Open Water Permanently Flooded Excavated
9	X		X	Twin Ponds (SW of ponds)	Palustrine Forested Temporarily Flooded
10	X		X	Peverly Pond	Palustrine Open Water Permanently Flooded diked/impounded
11			X	East of I-5 and Twin Ponds	
12	X		X	Paramount Park	Palustrine Open Water Permanently Flooded Excavated
13	X		X	Paramount Park	Palustrine Scrub-shrub Seasonally Flooded
14	X		X	Paramount Park	Palustrine Forested Temporarily Flooded
15	X			Golf Course (pump-out site)	Palustrine Open Water Permanently Flooded Excavated
16	X			SE of Golf Course (Thornton Creek Park #1)	Palustrine Forested Seasonally Flooded

Table 4.1. Wetlands in Thornton Creek Watershed (continued)

Number in Fig. 4.1	Shown on National Wetland Maps	Shown on Seattle Maps	Shown on Shoreline Maps	Location	National Wetland Inventory Description (if available)
17, 20		X		Two pocket wetlands at the north end of the NSCC campus and two pocket wetlands at the south end	
18	X	X		North Seattle Community College (surge pond)	Palustrine Open Water Permanently flooded Excavated
19	X	X		North Seattle Community College (border of pond)	Palustrine Scrub-shrub Seasonally flooded Excavated
21	X			Thornton Creek Park #2	Palustrine Forested Seasonally flooded
22	X			NE 105th St & 40th Ave NE (no longer a wetland)	Palustrine Forested Seasonally flooded
23		X		Headwaters of Mock Creek at NE 96th St west of 40th Ave NE	

The majority of wetlands have not been delineated. Local residents have identified many wetlands that do not show up on either the National Inventory or Seattle and Shoreline Environmentally Critical Area maps. Seattle's Design, Construction, and Land Use department has recorded some of the following wetlands, while Resource Development staff and area residents have informally recorded others:

- Two small and one large (16,700 sq ft) wetlands at Evergreen-Washelli cemetery. (The cemetery staff plan to fill the two small wetlands and mitigate this by creating a 7,100 sq ft wetland next to the large existing wetland in 1999.) (Shown as 26 in Figure 4.1.)
- Small wetland adjacent to the North Police Precinct at N 105th St and Meridian Ave N, owned by the Seattle Police Department. (Shown as 26 in Figure 4.1.)
- Sizeable wetland located at the south end of Meridian Park, south of N 170th St east of Ashworth Ave N, located on Shoreline Park property. (Shown as 26 in Figure 4.1.)
- Small wetland areas recently constructed in association with the Meadowbrook Creek and the Meadowbrook Detention Pond owned by SPU. (Shown as 32 in Figure 4.1.)
- A 4,000 sq ft wetland along the Burke-Gilman Trail at the 9000 block of 46th Ave NE, owned by King County/Metro. (Shown as 33 in Figure 4.1.)
- Small wetland area in Matthews Beach Park on the south side of the creek. (Shown as 34 in Figure 4.1.)

- Wetland located behind 318 NE 115th St, on private property. (Shown as 27 in Figure 4.1.)
- Small wetland at the southwest corner of NE 86th St and Ravenna Ave NE. (Shown as 31 in Figure 4.1.)
- Six small wetland meadows in Thornton Creek Park #2. (Shown as 30 in Figure 4.1.)
- Wetland areas in Thornton Creek Park #6. (Shown as 29 in Figure 4.1.)
- Additional wetland areas in Thornton Creek Park #1. (Shown as 25 in Figure 4.1.)
- Wetland at Waldorf School in Seattle (not shown).
- Small wetland near NE 98th St and Ravenna Ave (not shown).

Streams

Streams are dynamic, constantly changing, shaped by the interaction between wood, water, sediment, and energy within the stream and from the surrounding landscape. The Thornton Creek system includes the main branches of the creek and its tributaries, including the seasonal ones.

Thornton Creek formerly supported coho salmon, Sockeye salmon, steelhead, and Cutthroat trout (Williams et al., 1975). chinook have also been documented in Thornton Creek (Ken Milton, 1998). Habitat degradation, deteriorating water quality, barriers to fish passage, and overfishing have contributed to the severe decline of these fish from Thornton Creek. Strong populations of Cutthroat trout have been reported in Thornton Creek. coho fry are released into Thornton Creek by various schools participating in the Salmon in the Classroom program run by Washington Department of Fish and Wildlife (WDFW). In 1998, participating schools received 3,350 coho eggs and 1,050 chinook eggs. It is likely that not all of these eggs survived to the fry stage; however, those that did were released into Thornton Creek. (See Chapter 11 for a list of schools that participated in this program in 1998.) The source of these fish is from either the University of Washington hatchery on Lake Washington or the WDFW hatchery on Issaquah Creek.

Stream Corridor (Riparian Zone)

The zone of vegetation that lines Thornton Creek and its tributaries, called the riparian zone, is of particular importance to creating and maintaining habitat and is described in detail in Section 4.7. The current riparian zone along Thornton Creek may contain forest, shrub land, wetlands, or landscaped yards. The canopy of shrubs and trees that fully covers the creek provides shade to cool the air and water temperature, as well as falling leaves and insects that are food for other aquatic insects, crayfish, and salmon. Branches and trunks of fallen trees slow the water, form eddies and pools, trap sediment and detritus, and shelter salmon and trout. Roots anchor streambanks, holding the soil in place so that it doesn't enter the stream. The habitat functions of riparian zone vegetation are summarized below:

- **Bank stabilization and water quality protection.** The roots of riparian trees and shrubs help hold streambanks in place, preventing erosion. Riparian vegetation also cools the water, and traps sediment and pollutants.
- **Thermal cover.** Riparian vegetation shields streams and rivers from summer and winter temperature extremes that may be very stressful, or even fatal, to fish and other aquatic life. The cover of leaves and branches brings welcome shade, ensuring that the stream temperature remains cool in the summer and moderate in the winter. Cooler,

shaded streams have less algae and are able to hold more dissolved oxygen, which fish need to breathe.

- **Fish habitat.** As dying or uprooted trees fall into the stream, their trunks, root wads, and branches break up the flow of water and create pool habitat by scouring out the streambed. These trees also provide cover for fish and aquatic insects in the stream. Salmon use pools for resting, rearing, and refuge from predators, summer low flows, and winter storms. Many of the aquatic insects that salmon eat live in riffles, the shallow gravelly sections of the stream where water runs faster. Salmon also require riffles for spawning. The absence of fallen trees limits the natural creation of pools and riffles, which provide fish habitat.
- **Wildlife habitat.** Over 80% of all wildlife species in western Washington use riparian areas during some part of their life cycle. Riparian vegetation provides food, nesting, and hiding places for these animals. Forested riparian areas account for the smallest percentage of forested land in Washington.
- **Food chain support.** During the freshwater stage of their life cycle, salmon and trout eat mainly aquatic insects, which feed on leaves and woody material such as logs, stumps, and branches that fall into the water. Standing riparian vegetation is also habitat for other insects that sometimes drop into the water, providing another food source for fish.
- **Flood control.** During high stream flows, riparian vegetation slows the speed of the water. This helps reduce erosion that damages fish spawning areas and aquatic insect habitats.

4.4 Aquatic Wildlife

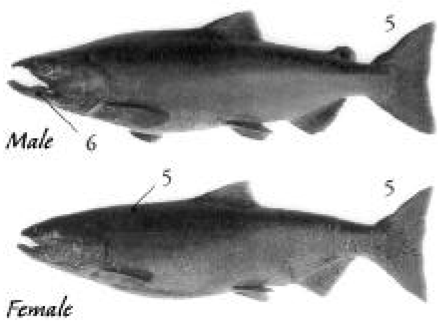
In the Northwest, salmon link the land with the sea. Born and reared in rivers and streams, most juvenile salmon species feed on aquatic insects such as Mayflies, Stoneflies, and Caddisflies. These insects feed upon the detritus of decaying leaves, wood, and other stream life. The decayed carcasses of adult salmon, returned from the ocean to spawn and die, are transformed into nutrients for the stream and food for their own offspring.

Fish and other aquatic species are biological indicators that provide a measure of the health of a creek. Their presence answers the question, “Do living things survive and thrive in this water?” Since they spend most or all their lives in the creek, they are impacted by the cumulative effect of changes in water flows, water quality, sediment transport, food availability, and the amount and quality of instream habitat. The Thornton Creek fish resources have been severely affected over time by the loss of critical instream habitat, high flows, and poor water quality. The creek has a history of use by chinook and coho salmon; however, the best current information suggests only trace numbers of fish can be seen returning to spawn in the stream (WDFW, 1993). steelhead have been observed in the stream, and most sections of the creek contain populations of resident cutthroat trout. Every year hundreds of coho and chinook fingerlings are released into the creek by school children in the watershed (Stinson, personal communication, January 2000).

Salmonid Species Found in Thornton Creek

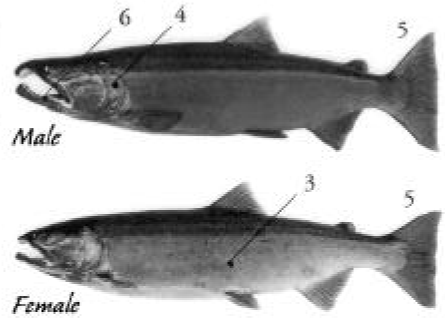
The following paragraphs describe the salmonid species reported in the Thornton Creek watershed (see Figure 4.2). These descriptions are taken from the WDFW website (www.wa.gov/wdfw/).

Figure 4.2. Coho, Chinook, Steelhead, and Cutthroat Trout



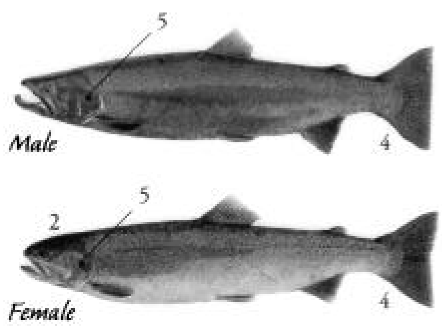
CHINOOK ("King", "Blackmouth")
(Oncorhynchus tshawytscha)

1 Largest salmon
2 Spawns September through mid-December
3 Olive-brown to dark brown, almost black on back and sides
4 Spots on back and BOTH upper & lower tail fin
5 Lower gumline is black
6 Length range 24-60 inches



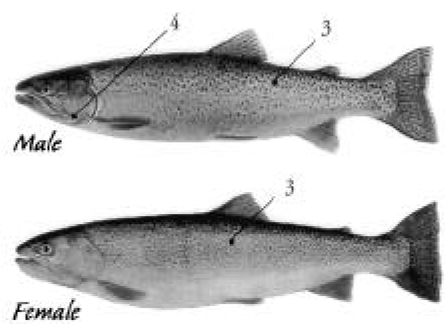
COHO ("Silver")
(Oncorhynchus kisutch)

1 Spawns mid-October through early January
2 Back and head dark bluish-green
3 Lower sides brilliant red to wine color
4 Gill cover reddish
5 Spots on back and UPPER lobe of tail fin only
6 Lower gumline is light colored
7 Length range 17-38 inches



STEELHEAD
(Oncorhynchus mykiss)

1 Spawns late March through early June
2 Head blunt, jaw short - does not extend past eye
3 Distinct dark spots on dorsal fin
4 Square-shaped tail fin with radiating pattern of spots
5 Often has reddish stripe along sides, gill cover reddish
6 Length up to 45 inches



CUTTHROAT TROUT
(Oncorhynchus clarki)

1 Spawns February through May
2 Head blunt, jaw long - extends past eye
3 Small black spots on head & body extending well below lateral line, and on all fins
4 Red to yellow streaks on underside of jaw
5 Faint to no red on sides of spawning fish
6 Length up to 30 inches

KING COUNTY
Department of Natural Resources

Produced by: Visual Communications and GIS Unit
File: 9906 Salmon ID card.p65

Coho Salmon (*Oncorhynchus kisutch*)

This species uses coastal streams and tributaries, and is often present in small neighborhood streams. Coho can be found throughout most of the larger Lake Washington watershed and are common in urban streams if their year-round needs for cold, clean water are met. Coho spend at least one full winter in the small streams of the Puget Sound lowlands. (steelhead and cutthroat do also; overwintering by chinook is not known.) Coho tend to spawn in small coastal streams and tributaries of larger rivers and travel far up these streams if suitable spawning habitat is available, often traveling during the daytime (Sandercock, 1991). They generally arrive at the Ballard Locks in the summer and enter Lake Washington as early as mid-August. They may continue entering the lake through early fall (Williams et al., 1975). Returning adult coho often gather at the mouths of streams and wait for the water to rise, as after a rainstorm, before heading upstream. The higher flows and deeper water enable the fish to pass obstacles, such as logs across the stream, that would otherwise be impassable (Sandercock, 1991). Once in the stream, they spawn from October through December (Williams et al., 1975). They prefer spawning areas of mid-velocity water with small to medium-sized gravel.

The fry emerge from the gravel in the late winter and early spring, and in their second spring go to sea, about 18 months after being deposited as eggs (Williams et al., 1975). Coho fry are usually found in the pools, wetlands, side channels, ditches, and other areas that have low water velocities during the winter. Coho fry can also be found in pools that are large enough to contain enough water and oxygen. Coho smolts begin their outmigration journey between early March and early July (Williams et al., 1975). The smolts mature in salt water for one to three years before returning to their natal streams as adults.

Chinook Salmon (*Oncorhynchus tshawytscha*)

Chinook salmon are the largest of the Pacific salmon, averaging 10 to 15 pounds. Most chinook spawn in large rivers such as the Columbia and Snake, although they also use smaller streams with sufficient water flow. They tend to spawn in the main stem of streams, where the water flow is high. Because of their size, they are able to spawn in larger gravel than most other salmon.

There are two races of chinook: stream-type and ocean-type. Stream-type chinook tend to spawn in the spring and ocean-type chinook tend to spawn in the fall; however, there is a lot of variation, even within one river system (Healey, 1991). In the Lake Washington basin, the present chinook population is considered to be the fall variety of ocean-type chinook (Williams et al., 1975). Adult chinook arrive at the Ballard Locks in summer and enter Lake Washington in early July, continuing into early November (Williams et al., 1975). Generally, spawning begins in September and is usually completed by November (Williams et al., 1975). Adult chinook tend to spawn in mainstem rivers and larger tributaries, but may also spawn in the lower portions of smaller tributaries, like Thornton Creek and Kelsey Creek. As a result, their redds, or nests, are susceptible to winter floods and streambed scour.

Chinook fry rear in freshwater for three months to a year, depending on the type of chinook and the location (Williams et al., 1975). When the fry emerge from the gravel, they generally swim or are displaced downstream, normally at night (Healey, 1991). Some fry may continue to head out to sea through the Locks, while others may spend time in Lake Washington, feeding and preparing for outmigration (Healey, 1991). Regardless of their freshwater rearing, juvenile chinook spend a substantial amount of time in estuaries where they feed and grow into smolts. The estuary at the other end of the Ballard Locks is artificial and very limiting for juvenile chinook from the Lake Washington system. Juvenile chinook migrating out to sea leave the freshwater and immediately enter into saltwater, without much of a transitional habitat area that is common to other estuaries. The smolts reside in saltwater and mature for two to four years before returning to their natal area.

Steelhead Trout (*Oncorhynchus mykiss*)

Steelhead and rainbow trout are the same species, but rainbow reside in freshwater and do not mature in the ocean, while steelhead trout are anadromous. Unlike most salmon, up to 40% of steelhead can survive spawning and can spawn in multiple years. Adult fish are usually eight to 11 pounds, but can reach up to 40 pounds.

Steelhead spawn in the winter and spring. They tend to spawn in rivers and streams and travel farther upstream than chinook or coho. These streams have areas of steep gradient and large substrate, the perfect rearing combination for steelhead fry. The adults spawn between these steep areas, where the streambed is flatter and the substrate small enough to dig into.

Like chinook, steelhead have both summer and winter runs. steelhead in Lake Washington tend to be the winter run.

steelhead fry emerge from the gravel in summer and rear in the stream for one to four years, depending on the productivity of the stream. In Washington, most wild steelhead rear for two years. Fry use areas with fast water and large substrate for rearing. They wait in the eddies behind large rocks, allowing the river to bring them food in the form of insects, salmon eggs, and small fish.

Cutthroat Trout (*Oncorhynchus clarki clarki*)

Thirteen subspecies of cutthroat trout are indigenous to North America, but only the coastal subspecies is anadromous. This subspecies is also known as sea-run cutthroat, harvest trout, and blueback. Resident cutthroat trout live in streams for their entire life and do not migrate out to sea. cutthroat are smaller-bodied than coho and the average size for adults is one to four pounds. cutthroat are abundant throughout most streams in the Lake Washington basin and have displayed remarkable resilience in the face of development. They are able to survive in all but the most heavily impacted streams.

Like steelhead, cutthroat are considered spring spawners. Location may have more to do with it than timing, especially if they spawn in the winter. These small fish seek the headwaters of coastal streams where the flow is minimal and the substrate is small, almost sand. They prefer headwaters and low-flow areas that are too shallow for coho and steelhead, since their emerging fry are less than an inch long, and poorly able to compete with larger fry.

The vast majority of cutthroat rear instream for two to four years before venturing into saltwater. Unlike other salmon species, which spend years feeding far out to sea, cutthroat always winter in freshwater and feed at sea only during warmer months. Even then, they remain within a few miles of their native stream. Protected estuaries and Puget Sound bays are excellent cutthroat habitat and are often quite productive.

Other fish species that might be found in Thornton Creek are listed below (Wyndoski):

- Western brook lamprey
- Redside shiner
- Longnose dace
- Speckled dace
- Large-scale sucker

- Three-spine stickleback
- Smallmouth bass
- Shorthead sculpin
- Torrent sculpin
- Peamouth
- Prickly sculpin
- Reticulate sculpin

Fish Surveys in Thornton Creek

The health and abundance of fish such as salmon and trout can be used to indicate the condition of the stream and its watershed. However, using salmon as an indicator species has its drawbacks. The number of salmon that survive to spawn can be easily impacted by factors outside the watershed, such as El Niño weather effects, fish harvesting, and operating procedures at the Ballard Locks. Electroshocking surveys are one of the best tools used to determine distribution of juvenile fish. Electrofishing is becoming increasingly regulated. As of late 1999, It cannot be done in areas where listed species are found, for example, the mainstem of Thornton and the lower sections of the north and south branches. The method may harm fish only if performed incorrectly. Washington Trout used electrofishing to spot check upper ranges of salmon and trout distribution outside of restricted areas. Adult salmon distribution is usually determined by counting live fish (spawner surveys) and redds. Both of these survey methods are traditionally used by WDFW and the Muckleshoot Indian Tribe. However, in recent years, volunteers, consultants, and other resource agencies like SPU also are conducting such surveys.

The most recent data comes from a study conducted by Washington Trout for SPU.. In 1999 SPU hired Washington Trout to assess fish distribution in the urban watersheds. Washington Trout is performing fish distribution surveys that include several components: water (stream) typing, fish presence/absence surveys using electrofishing equipment to spot check an area, fish passage assessments, spawning surveys, and habitat surveys. The work is still in progress, and preliminary mapping results are shown in Section 4.5. This data is subject to change as further data is collected. Preliminary results require further research and a full report has been initiated.

Adult Salmon (Spawning) Surveys

Adult surveys are conducted in the fall to count the number and location of salmon returning to spawn. Thornton Creek spawning surveys have been conducted by WDFW, Washington Trout, and volunteers. Many survey techniques rely on spot-checking the creek for presence/absence, rather than counting every fish.

WDFW/Muckleshoot Surveys (1976, 1981, 1984). Every year, WDFW and the Muckleshoot Indian Tribe conduct spawning surveys of selected streams in the Lake Washington basin to estimate the number of salmon spawning in the basin. This information is used to estimate the future salmon runs from those spawning salmon. In 1981 and 1984, WDFW staff surveyed Thornton Creek and did not find any adult salmon in either year. Apparently, after 1984 Thornton Creek was dropped from the list of creeks surveyed (WDFW, 1997).

Washington Trout Urban Creek Salmon Spawning Surveys (1999). Washington Trout, under a contract to SPU, conducted weekly spawning surveys in Thornton, Pipers, Longfellow, Taylor, and Fauntleroy Creeks from mid-September through late December 1999. Thornton Creek had a total of three chinook and about ten coho. The numbers of coho are probably underestimated for Thornton because the fish would have more places to hide in this larger system, and because some of the surveys were cancelled due to reduced visibility on rainy days.

Volunteer Salmon Spawning Survey (1996 – 1999). In 1996, King County, the City of Seattle, Snohomish County, Bellevue, WDFW, and the Muckleshoot Indian Tribe began a volunteer observer program, Salmon Watchers. The purpose of the program is to document the location and extent of fall spawning salmonids throughout the Cedar River/Lake Washington system, including Thornton Creek. Volunteers are trained to identify adult spawning salmon and document their findings. Between August 1996 and March 1997, 41 streams and beaches were surveyed. In general, few fish were found in the urbanized creeks. Salmon were generally found only near the mouths of those creeks. Thornton Creek was checked weekly between October and December using a combination of spot checks and creek walks. In the 1996 survey, volunteers spotted two chinook, one coho and one Chum salmon. The fish were spotted at the mouth of the creek, near Meadowbrook Detention Pond, and near Nathan Hale High School. In the 1997 survey, no salmon were spotted by volunteers in the program, although many residents reported seeing adult salmon in the Main Branch. Volunteers continued to observe Thornton Creek in 1998 and 1999.

Citizen Reports (1997, 1998). In 1997, community members observed a run of 20-30 coho from Matthews Beach to Meadowbrook and up Littlebrook to NE 113th St. Sockeye were seen in the Meadowbrook Pond and chinook were seen in the Main Branch stream between Matthews Beach and Meadowbrook Pond.

Juvenile Salmon Surveys

Juvenile surveys are often conducted in the summer, after eggs have hatched and when juveniles are rearing in the creek. Different salmon species migrate out of creeks at different times of the year. The results of several surveys are listed below.

Washington Department of Game (1983). In 1983, the Washington Department of Game conducted a distribution survey of game fish throughout the Lake Washington Drainage Basin. On July 21, 1983, the surveyors electroshocked various sites in the mainstem and North and South Branches of Thornton Creek, Maple Leaf Creek, Little Brook, and tributaries 0031 and 0042. This survey found Cutthroat, Rainbow, and unidentified trout in Thornton Creek and Maple Leaf Creek. Fish were not found in the other sampled tributaries (Muto and Shefler, 1983). The crew noted that they found fish up to 1st Ave NE and NE 155th St but not above I-5 due to the impassable culvert at the inlet to Twin Ponds. The crew also found salmonids as far as River Mile 1.5 on Maple Leaf Creek (08.033).

WDFW Survey of Maple Leaf Creek (1990). In the early 1990s, WDFW staff surveyed a section of the South Branch, also known as Maple Leaf Creek (Ron Whitney, personal communication, 6/8/98). Whitney electroshocked the South Branch from Nathan Hale High School to Lake City Way, and found many Sea-run and resident Cutthroat trout ranging in size from two to nine inches. He observed a “high density” of trout; that is, several trout were found in every pool he examined. Only one salmon was found at that time.

SPU Fish Habitat Survey of Lower Thornton Creek (1998). As part of SPU’s evaluation of salmonid habitat conditions along the lower reach of Thornton Creek, the Main Branch of Thornton Creek was electroshocked by Resource Planning Associates and Aquatic Resource Consultants in five locations on June 30, 1998. The objectives of the electroshocking were to determine the presence or absence (not census) of fish, their general health, and habitat usage.

The species and numbers observed are summarized in Table 4.2. The captured fish appeared very healthy. The fish were always observed near rocks or woody debris; the larger fish (200 mm and greater) were only found in the deep pools (Aquatic Resource Consultants, SPU, 1998).

Miscellaneous Salmon Sightings and Reports. Steelhead were observed in Thornton Creek in 1991 and 1995 (personal observations, Robert Fuerstenberg, SWM Division, in 1994 Annual Report North Lake Washington by King County Surface Water Management). A fisheries biologist observed a steelhead in the North Fork at NE 130th St and 17th Ave NE in March 1992 (Bob Vreeland).

Table 4.2. Results of June 1998 Electroshocking (Aquatic Resource Consultants, SPU, 1998)

Location	Habitat Description	Observations
End of 49th Ave NE	Lower section is a glide with a pool at the head of the glide.	Only Sculpins found in the glide. Large (150 to 200 mm) Cutthroat found in the pool.
Western boundary of Matthews Beach Park	Good pool on the right bank created by moderate-sized willow, and small rocks in riffle just upstream of this pool.	Ten Cutthroat and eight Sculpin were found. Larger Cutthroat (138 to 205 mm) found in pools only. Small Cutthroat found behind rocks in riffle area.
Downstream end of culverts under Sand Point Way NE	Lower end has a wide shallow pool, then a riffle with large cobbles and a dam pool	Two chinook smolt (100 mm), one coho (60 mm), and eight small Cutthroat (44 to 82 mm). chinook smolts and coho found in a pool. Cutthroat found in riffles.
Between Sand Point Way and Burke - Gilman Trail	1' to 2' rocks with pool just downstream of culvert. Woody debris and large rock in and around pool.	One rainbow (207 mm), one chinook smolt (112 mm), 11 Cutthroat (75 to 216 mm), six Sculpin. Several other fish not captured.
Upstream of Burke - Gilman Trail	Homogenous channel, shallow riffle, small-sized substrate. Patches of small woody debris and one shallow pool.	One chinook smolt (114 mm), 19 Cutthroat (52 to 110 mm).

Washington Trout Fish Presence / Absence Survey (1999)

In July 1999, under contract to SPU, Washington Trout surveyed the presence or absence of fish in Seattle streams, including Thornton Creek. The results of this single, initial survey were used to create preliminary stream reach categories . (See Section 4.5.) Washington Trout staff used visual observations and electroshocking to determine fish presence. The following preliminary observations, coupled with more thorough research and analysis by Washington Trout, will be published in a report. Currently the report is a work-in-progress. The following information represents a single sampling event, therefore the reader is cautioned as to the inappropriate use or citation of the data due to its preliminary nature.

- Main Branch – 6 - 8" chinook, 3 - 10" rainbows, sculpin, cutthroat.
- Maple Creek (Main Branch tributary) – 3" rainbows.
- North Branch between confluence and golf course – cutthroat, rainbow; near Twin Ponds – chinook fry (most likely a released fry because of the presence of adult passage barriers downstream), rainbow; Ronald Bog – carp, sunfish.

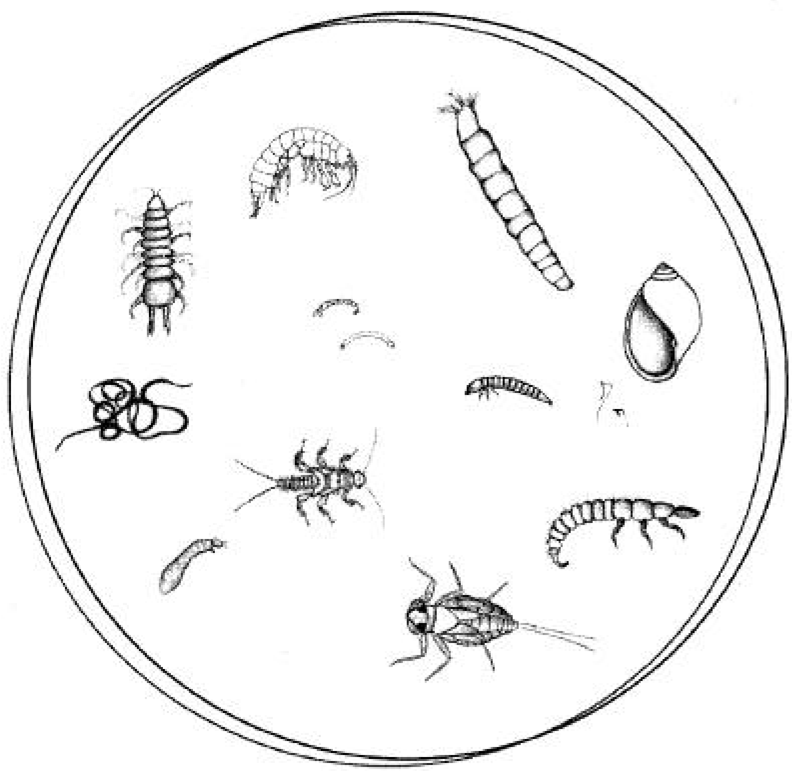
- Littles Creek (North Branch tributary) – no fish observed.
- South Branch between confluence and 5th Ave NE – cutthroat, rainbow; North Seattle Community College pond – sticklebacks.
- Kramer Creek (South Branch tributary) – cutthroat.
- Willow Creek (South Branch tributary) – rainbow, cutthroat.

Benthic Macro-invertebrates (Aquatic Insects)

Benthic macro-invertebrates are small creatures that live in the sediments at the bottom of a creek or lake. Common freshwater invertebrates, illustrated in Figure 4.3, include insect larvae, worms, leeches, small crustaceans, snails, and small clams. Many insects spend the majority of their life as aquatic larvae and are winged adults for only a short period. Benthic invertebrates are an important food source for fish.

Macro-invertebrates commonly found in Thornton Creek are worms, crustaceans, mollusks, snails, and insect larvae (including Black flies, Caddisflies, Craneflies, Dragon flies, Mayflies, Stoneflies, midges, beetles). Additional information about benthic macro-invertebrate monitoring is presented in Section 5.6.

Figure 4.3. Common Freshwater Invertebrates



Petri dish of invertebrates illustrates their approximate, relative size.

Illustrator: Annabel Wildrick

Amphibians

The Thornton Creek Project researches and records student data on amphibians in Thornton Creek. The following information is taken from the Thornton Creek website (www.thorntoncreek.org).

Amphibians are considered indicators of environmental and wetland health. Twelve species of frogs, toads, and salamanders are commonly found in the Puget Sound lowlands. These include:

- **Salamanders *(caudates).*** Northwest salamander, Long-toed salamander, Pacific giant salamander, Western red-backed salamander, *Ensatina,* Rough-skinned newt.
- **Frogs and toads *(anuarans).*** Western toad, Chorus frog, Red-legged frog, Bullfrog, Spotted frog, Cascades frog.

Amphibians lay their eggs in wetlands with stagnant or very slow moving water during February through May. The amphibians attach their egg masses to or among small plants in shallow areas, 0.5 to 3 feet (10-60 cm) in depth. Adult amphibians live on dry land in areas of trees and shrubs. They need dense vegetation, leaves, and logs for protection.

4.5 Habitat Assessments

Seattle Parks and SPU have conducted several habitat assessments of Thornton Creek, each building on the previous ones. Presented below in chronological order are: Seattle Parks' Thornton Creek Forest Restoration Plan, SPU's citywide Creek Restoration Study, a habitat survey of the Main Branch in 1998, and a stream-typing assessment in 2000.

Thornton Creek Forest Restoration Plan (Seattle Parks Department, 1994)

In 1994, Seattle Parks developed a forest restoration plan for five open space parks in the Thornton Creek watershed: Thornton Creek Park #1, 2, and 6, Ravenna Ave/Blindheim, and Sand Point Open Space. These parks are part of the open space area and won't be developed for ball fields or playgrounds. Staff investigated the conditions within the parks, documented existing conditions, and mapped out restoration activities for each site. In general, the existing forest canopy contains mature Big leaf maples and alders reaching the end of their life span. Although deciduous trees should be naturally replaced by conifers, this isn't happening due to a lack of conifers to provide a seed source, as well as competition from invasive plants such as blackberry and ivy. The work described in this plan is slowly being completed primarily through the Adopt-a-Park program. The forest restoration plan outlines specific problems and restoration strategies for habitat units within each of these parks.

SPU's Creek Restoration Study (1993-1998)

SPU recently completed work on a creek restoration program funded in 1993 by Washington Department of Ecology's Centennial Clean Water Fund. The goal of this program is to improve water quality by minimizing the impact of urbanization on Seattle's creeks. The restoration program has three phases:

- Creek identification and documentation
- Physical and habitat assessments
- Creek restoration plan development and implementation

Prior to this project, only the largest creeks in Seattle were well documented. Little or no Information was available on the smaller creeks. During the study, 42 smaller creeks were mapped and seven, including Thornton Creek, were selected for detailed assessment and restoration planning. Based on these assessments, many Capital Improvement Projects (CIPs) projects were identified. See Section 10.6 for a description of these projects.

Creek Identification and Documentation. SPU staff began with a review of existing maps, historical records, and aerial photographs. They augmented this information with data from Seattle's newly developed Geological Information System (GIS). Using 1994 orthographic images, they created a hydraulic coverage layer within the GIS, which included all identified water features. Some data was fragmented or missing due to heavy vegetative cover in many areas. To fill these gaps, staff conducted field investigations, aided by a Global Positioning System (GPS). Creek locations were digitized into a new creek coverage based on the field investigation maps. Each creek section was identified as culvert or open channel and classified according to definitions in Seattle's Critical Areas Ordinance.

Physical and Habitat Assessments. In the second phase, SPU selected Thornton Creek and six others for a comprehensive habitat assessment. These creeks were selected based on size of drainage basin, amount of remaining open channel, potential for habitat rehabilitation, and community involvement. The assessment documented current conditions relating to channel geometry, substrate composition, instream habitat, and riparian and flow characteristics. Table 4.3 shows the criteria and measurements used by SPU for the physical and habitat assessment. Measurements were recorded at 200-foot intervals. The assessment is modeled on protocols developed by the University of Washington entitled Physical Habitat Assessment Protocols for Puget Sound Lowland Streams (University of Washington,1994).

Table 4.3. Assessment Criteria and Measurements for Habitat Survey (University of Washington,1994)

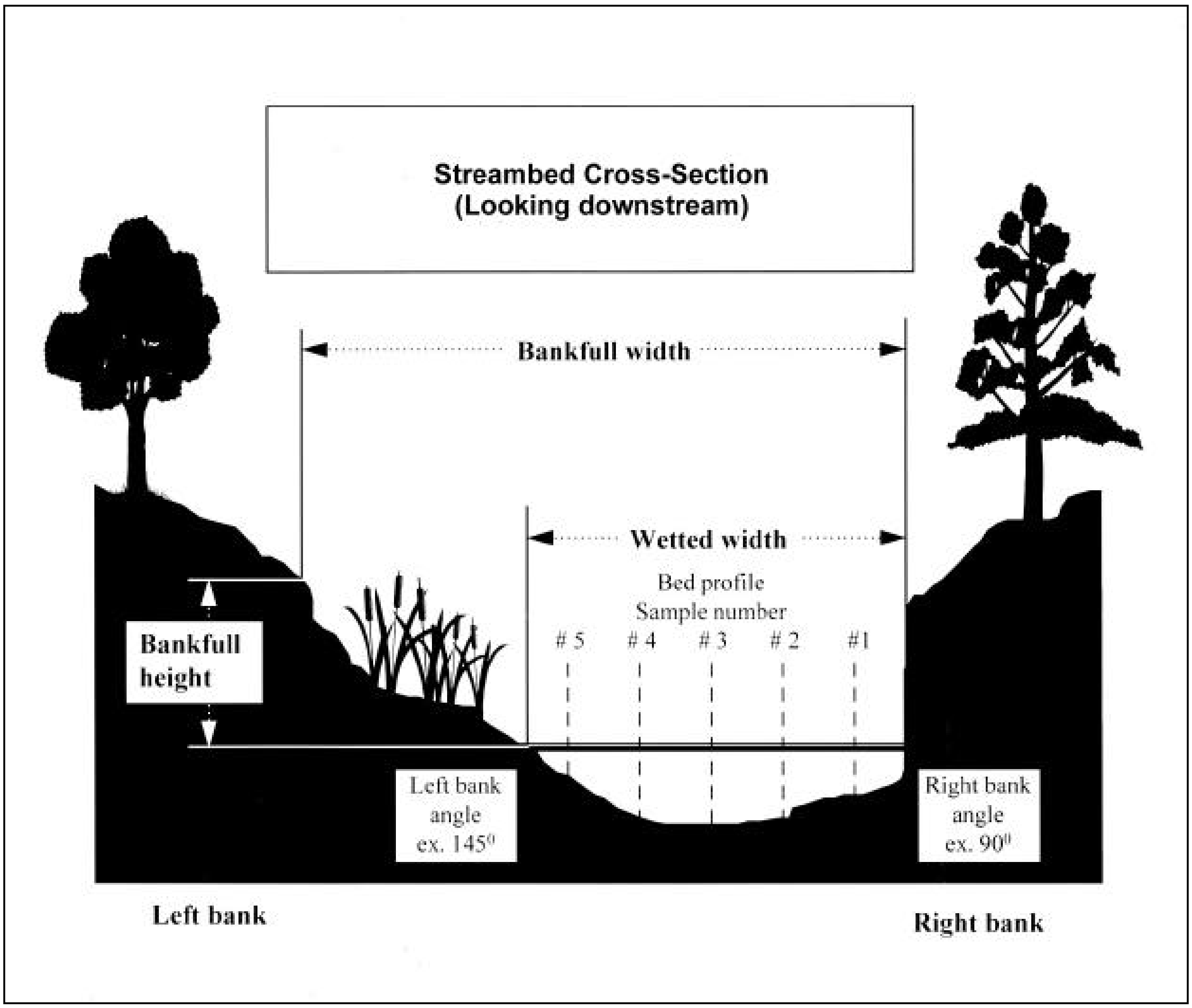
Criteria	Measurements
Vegetation	Canopy cover type and abundance Understory type and abundance Ground cover type and abundance Overall cover density
Channel Geometry	Percent slope Bank angle Bank full height Bank full width Back sight compass reading
In-channel Characteristics	Channel type classification Amount of large woody debris (LWD) Amount of small woody debris (SWD) Amount of aquatic plants Amount of boulders or large cobbles
Substrate Characteristics	Water depth Substrate size Degree of embeddedness

Several characteristics are shown in Figure 4.4. Distinctive features such as tributaries, outfall locations, bank erosion, slides, or other failures, pools, large woody debris (LWD), structures over the creek, and pipe crossings were also documented.

These survey methods are different than those used traditionally by fisheries biologists to assess habitat, such as Timber, Fish and Wildlife (TFW) Ambient Monitoring and Hankin-Reeves methods. In general, the analysis shows that Thornton Creek lacks pool habitat and woody debris. The pools that do exist are too shallow and far apart to provide good habitat for salmon. The in-channel wood is small and infrequent. (See Appendix C to review the analysis results.)

Creek Restoration. This creek assessment identified numerous problems in Seattle streams. Many instream projects were started in 1999. See Section 10.6 for a description of Thornton Creek projects.

Figure 4.4. Instream Physical Characteristics (Seattle Drainage and Wastewater Utility, 1992)



University of Washington Habitat Survey (1996)

As part of a larger study looking at the cumulative effects of urbanization on streams, Dr. Chris May and other researchers surveyed three places in Thornton Creek. The findings of this study were summarized in Section 1.4. The raw data relevant to Thornton Creek is included in Appendix D.

SPU Habitat Survey along Main Branch (1998)

In 1998, SPU hired Resource Planning Associates and Aquatic Resource Consultants to evaluate the salmonid habitat conditions in the lower mile of the Main Branch of Thornton Creek (Johnson and Minton, 1998). The consultants concluded that this stretch of the creek has the following characteristics:

- Most pools are too shallow.
- The few pools with adequate depth lack complexity and cover.
- Little woody debris is of notable size.
- Much of the channel bank is hardened by streamside property owners.
- Several large culverts may hinder fish passage.
- Seventy percent of the lower creek is glides, 20% pools, and 10% riffles.

The stream substrate is mostly sands and small gravels (0.25 to 0.75 inch diameter). Many of these gravels are partially cemented by fine particles, making it difficult for salmon to spawn in them. Areas of larger gravel, suitable for large fish such as salmon, are found in very few low gradient riffles scattered throughout the lower creek.

Few pools have more than a 12-inch residual water depth, which arguably is the minimum depth for desirable rearing conditions for larger cutthroat. However, Washington Trout documented one 8” cutthroat in a pool less than 12” deep. With a few exceptions, these few pools have little cover. The rearing of salmonids (coho in particular) at the fry stage is likely limited because of the lack of suitable pools. Pools that do exist may be limiting for juvenile salmon because the water velocities in them may be too high. Several culverts may become velocity barriers for migrating fish during high flow conditions. See Section 10.6 for a list of Johnson’s recommended projects.

Washington Trout Water Typing Survey (2000)

Water typing as a Washington State classification system was developed by the Washington State Departments of Natural Resources, Fish and Wildlife, Ecology and Washington Indian tribes under the State Forest Practices Act to establish the amount of legal protection afforded to a stream to protect it from potentially adverse forestry land use practices. Washington Trout was hired by SPU to water type Seattle streams. Water types 1 - 3 designate gamefish-bearing streams, or streams that support significant human use, such as drinking water. Types 4 and 5 are not considered gamefish bearing. Fish presence and physical parameters, such as stream width, gradient, and flow are evaluated. King County and the Washington Department of Fish and Wildlife have adopted the Department of Natural Resources emergency rules (1/2000), which include stream typing, to identify potential fish-bearing streams for the purpose of regulatory protection. The water typing observations included in Figure 4.5, coupled with more thorough research and analysis by Washington Trout, will be published in a report. Currently the report is a work-in-progress and all data shown is subject to further analysis and refinement. The following information represents a single assessment, therefore the reader is cautioned as to the inappropriate use or citation of the data due to its preliminary nature.

Washington Trout evaluated Seattle streams and classified them according to stream type. The group examined the total lengths of potential fish-bearing habitat based on a water typing survey as shown in Figure 4.5.

Although this survey was designed for setting forestry protection zones, SPU hopes to use the information as part of the process to assess stream conditions and prioritize and guide future CIP work.

Washington Trout Fish Passage Assessment (2000)

Currently, Washington Trout is evaluating fish passage barriers in Thornton Creek and other Seattle streams. Culverts and other barriers are being evaluated to determine if they pose barriers for returning adults and for juveniles. A number of characteristics are being assessed such as culvert slope, width, streambed, vertical drop, location, and depth of pool. The fieldwork will be completed in Fall 2000.

Watershed-wide Habitat Problems

Thornton Creek watershed has many of the problems found in urban watersheds. The general upland habitat problems were previously listed in the introduction and were taken from available data and scientific studies to date. They include:

- Lack of habitat diversity and fragmentation of existing habitat.
- Limited connection or linkage between riparian habitats and upland habitats and between channel and adjacent flood plain.
- Disturbance due to the proximity of housing, domestic animals, and recreational uses.
- Encroachment of non-native vegetation that out-competes native species used by wildlife.
- Lack of dead wood, either as standing snag trees or down as woody debris.
- A general lack of species and structural diversity within all habitat types (e.g., few tree species and no shrub layer).
- Narrow and degraded stream corridors, often less than 20 feet wide, lacking in shrub layers and having a sparse canopy.
- A lack of native conifer trees that historically grew on the site; instead, the remaining forests have a predominance of deciduous trees that function differently than conifer trees.
- High percentage of impervious surface area.

Streamside Erosion

Some habitat problems exist throughout each stream section, including:

- Lack of instream habitat complexity and cover.
- Excessive storm flows and high velocity flows.
- Low base flows.
- Channel straightening and bank hardening.
- Little functional floodplain and limited off-channel refuge habitat for juveniles.

- Poor water quality: high temperature, turbidity, and hydrocarbons from road runoff.
- Insufficient habitat complexity: pools, riffles, and glides.
- Inadequate or non-existent riparian buffers.
- Silted streambeds, including increased rates of erosion and channel aggradation.
- Fish passage barriers.
- Little or no treatment of stormwater (except for catch basins).
- In summer and fall, stream flow is reduced in some sections and some dry up completely.

4.7 Sub-basin Description and Specific Habitat Problems

This section describes over 30 tributaries or creek sections along Thornton Creek. For each creek section and tributary, a brief narrative description of the creek tributary and surrounding landscape is provided along with a list of habitat problems and proposed solutions. Specific habitat problems are outlined in this section. The Main Branch, North Branch to NE 145th, and South Branch have been formally assessed, while the rest of the creek and its tributaries have not received technical study. Most assessments were gathered informally by Watershed Management Committee (WMC) members and creek advocates. When possible, the group that identified the problem is listed; for example, SPU, WMC, Thornton Creek Alliance (TCA), Johnson and Minton, resident. Identified problems have largely been limited to public property (parks, ditches, road crossings) and commercial property. Reference to individual residential lots has been avoided except in a general sense.

The description starts at the mouth of the Main Branch and heads upstream. The North and then South Branch are described. Tributaries for these three areas are also described. Maps referred to in the text are published as a collection of 11 x 17-inch maps, both GIS printouts and orthographic (aerial) photographs. This companion document, Thornton Creek Riparian Corridor Maps (TCRC), is available from SPU (SPU, 1999).

Main Branch

Mouth to NE 93rd St (0 to 1,000 ft) – TCRC Map #1

Thornton Creek flows into Lake Washington at Matthews Beach Park near NE 92nd St in Seattle. At the mouth of the creek, a delta has formed. In 1998, a small creek was diverted to Thornton Creek within the park. (See Matthews Beach Creek description below under Main Branch tributaries.) Water levels in this reach are affected by changes in water depth in Lake Washington. During the winter, the lake level is lowered by three feet to help prevent flood damage to developed properties caused by winter storms. Prior to construction of the Chittenden Ballard Locks in 1916, much of this section of the creek was underwater. Many fish, including chinook, cutthroat trout, rainbow trout, coho, and sculpin, can be found in the Main Branch.

Figure 4.5. Water (Stream) Typing

From the mouth of the creek to NE 93rd St, the creek is generally a long glide with one notable riffle and no notable pools (Johnson and Minton, 1998). Within Matthews Beach Park, the banks are low, the slope is gentle, and the channel is relatively deep and wide. The substrate is sandy, and numerous aquatic plants grow in the stream. Upstream of the park, most streambanks are armored with riprap on both sides, which keeps the creek from moving laterally and often prevents vegetation from growing along the creek. Near NE 93rd, a tributary, Maple Creek, joins the Main Branch. (See Maple Creek at the end of this section.)

Identified habitat problems:

- Most pools are too shallow (Johnson and Minton, 1998).
- There are few pools with adequate depth, complexity and cover (Johnson and Minton, 1998).
- Little woody debris is of notable size (Johnson and Minton, 1998).
- There is more sediment and algae and less gravel in the last few years than at any time in the past (residents).
- Sediments near the mouth contain elevated levels of PCBs, pesticides and heavy metals (US Geological Survey; see Section 5.4).

NE 93rd to NE 95th St, Sand Point Open Space (1,000 to 2,000 ft) – TCRC Map #1

Between NE 93rd St and NE 95th St, the creek banks are more natural with few hardened areas. The creek crosses under Sand Point Way and the Burke-Gilman Trail. The Sand Point Natural Area, a 2.4-acre park, is located along this section. Within this park, the stream meanders and has good canopy cover along both banks. The stream gradient is steeper, and most pools of notable depth or complexity in the Main Branch are located in this reach. There is reasonably good cover over the pools. A few riffles and a long graveled run may provide suitable spawning habitat.

Identified habitat problems:

- Same as previous section.
- Japanese knotweed has invaded the northwest corner of this site.
- Conifer trees are not replacing mature and old deciduous trees in the forest (Parks).
- Several large culverts may hinder fish passage (Johnson and Minton, 1998).

NE 95th St to 39th Ave NE, downstream of Meadowbrook Pond (2,000 to 6,000 ft) – TCRC Map #1

The creek flows through a residential neighborhood from NE 95th St to NE 105th St. Except for the first 600 feet downstream, streamside property owners have hardened the channel with various materials such as concrete blocks, boulder walls, or grassy vegetation. There is little or no overhanging streamside cover and the canopy is sparse for much of the reach. The longest reach is a U-shaped channel due to the actions of streamside owners. This section of the creek is essentially one long run during the summer that is occasionally broken by a scour pool, a riffle or a short glide. During the winter the reach becomes essentially one long glide because of the higher base flows. Several storm drains discharge street runoff into the creek. One storm drain connects Mock Creek to the Main Branch near NE 103rd St. (See Mock Creek at the end of this section.) Numerous footbridges and driveways cross the creek. An unnamed tributary joins the Main Branch on the west side of 39th Ave NE. This water drains from the area near the old Maple Leaf School (NE 100th St and 32nd Ave NE).

Identified habitat problems:

- Hardened streambanks along private property (Johnson and Minton, 1998).
- Shortage of pools, riparian vegetation, and refuge from storm flows. (Johnson and Minton,1998).
- Erosion and sewer crossing, NE 97th St and 46th Ave NE (SPU).
- Intermittent, recurring detention.

Meadowbrook Pond to Confluence (6,000 to 7,300 ft) – TCRC Map #2

Thornton Creek flows beside and through Meadowbrook Pond. Built in the late 1990s, the pond was constructed to provide flood relief, habitat for wildlife, and a retreat for human guests. Meadowbrook Pond provides open water habitat, and many types of wildlife have been spotted in the pond. A small wetland is located on the west side of the pond. The surrounding park area has been planted with native vegetation. During construction, the adjacent stream corridor was enhanced with plants, logs, and boulders.

During dry weather, a portion of the creek flow is diverted into the pond, while the rest of the water continues along the creek channel. During storms, a greater portion of the flow is diverted into the pond, which is designed to store four acre-feet of stormwater. Water levels within the pond may rise from four to eight feet. The stored water is later released back into Thornton Creek at a controlled rate. Excess stormwater exits the pond and enters a large bypass pipe that diverts the water directly into Lake Washington. The substrate is composed of large-sized material cobble and gravel, and the banks are lined with large boulders throughout most of this reach. Canopy cover and understory is limited, since vegetation planted during construction of the pond will take several years to reach maturity.

Another small wetland was created just northwest of the Meadowbrook Pond as part of the pond construction. A few hundred feet upstream of the pond, the North and South Branches join at right angles. The upper 50 feet of the Main Branch flow through a concrete walled channel.

Identified habitat problems:

- The Meadowbrook Pond may cause temperature, dissolved oxygen, and fecal coliform problems in the Pond and the creek (TCA).
- Shortage of downstream gravel (resident).
- Too much litter collected at the pond (resident).
- Concern that fish could get into the pond or bypass pipe. No structure to prevent this from occurring.
- Wetland at southwest corner is too dry (resident).
- Hardened streambanks (SPU).
- Shortage of pools and refuge habitat (SPU).
- High percent of fines in pond and creek sediment (SPU).

Main Branch Tributaries

Matthews Beach Creek – TCRC Map #1

In 1998, the Matthews Beach Creek was diverted from the south end of Matthews Beach Park to flow north and join Thornton Creek near its mouth. Prior to the diversion, this creek flowed directly into Lake Washington. The creek was relocated to provide rearing habitat for small salmonids. Several pools were created to provide rearing habitat for juvenile fish. Upstream of the park, the creek is piped and flows through storm drains. The creek flows in an open channel briefly in the Inverness neighborhood near an undeveloped park site. Water flows through this creek year-round. Notable landmarks in the upper watershed include the Sand Point Country Club and golf course and the affluent Inverness neighborhood.

Identified habitat problems:

- ♦ Most of the stream is contained in pipes.
- ♦ Vegetation around the creek is recently planted and still immature.

Maple Creek – TCRC Map #1

Maple Creek joins the Main Branch at NE 93rd St, just one block east of Sand Point Way. Maple Creek and its tributaries drain 154 acres of the Wedgwood and Inverness neighborhoods. The creek flows in a narrow, grass-lined ditch beside NE 93rd St. Nearby residents report seeing fish in Maple Creek. Several tributaries cross under the Burke-Gilman Trail and feed into Maple Creek. The two larger tributaries are described here. The smaller south tributary, called Inverness Creek, travels across flat, landscaped backyards. It first emerges out of a pipe near a wetland just west of the Burke-Gilman Trail. In the past, a large amount of sand and fine sediment has washed down this branch, allegedly from construction of homes in the Inverness neighborhood.

The north tributary of Maple Creek travels briefly through flat, landscaped backyards between Sand Point Way and the Burke-Gilman Trail. Upstream of the trail, the character of the riparian corridor changes dramatically. Here Maple Creek flows through a steep, woody ravine with numerous tall conifers. Several neighbors in this area have voluntarily created permanent conservation easements to protect the creek. There are several open space park properties along the ravine. For the most part, the ravine is undeveloped.

Identified habitat problems:

- ♦ A lot of sand travels down the south tributary (resident).
- ♦ Parks (open space) properties have declining deciduous forests and lack conifers (Parks).
- ♦ Coho last seen many years ago; residents concerned about creek's ability to support fish (resident).

Mock Creek – TCRC Map #2

Mock Creek joins the Main Branch near NE 103rd St just west of 40th Ave NE. Mock Creek drains 44 acres of single family residential neighborhoods. Mock Creek flows year round. The lower 1,250 feet of the creek are located in a storm drain along 40th Ave NE. The creek drops into the storm drain near NE 98th St.

Upstream of NE 98th St, the stream flows in an open channel through backyards with sections of bare, steep slopes. Further upstream is a steep wooded ravine. The understory contains grasses, shrubs, and ferns. Numerous small waterfalls are found in the stream, created by stream gradient and woody debris. A Parks Department Open Space park is located along NE 97th St just east of 35th Ave NE. The ravine continues to 35th Ave NE. The headwaters of this stream are located in a wetland on private property half a block east of 35th Ave NE.

Identified habitat problems:

- The first 1,250 feet of the creek are in a pipe, creating a fish barrier and a poor connection with Thornton Creek.
- The creek drops about 10 feet from open channel to pipe, creating a fish passage barrier (SPU).
- The Parks-owned property is overgrown with blackberries.

North Branch

Confluence to NE 115th St (7,300 to 9,500 ft) – TCRC Map #3

Upstream of the confluence with the Main Branch, the North Branch travels north-south through backyards for several blocks between the confluence and NE 115th St. This area is a floodplain and the creek is relatively wide with a rocky substrate. There are several check dams and notable areas of erosion. Vegetation along the creek varies due to differences in homeowner landscaping and usage. Frequent algal growth has been noted. Little Brook joins the North Branch just south of NE 115th St. (See Little Brook in description of North Branch tributaries.)

Identified habitat problems:

- The channel bed is armored (SPU).
- There are areas of bank erosion near NE 113th St (SPU).
- Potential fish passage problems at man-made weirs north of NE 113th St (SPU).

NE 115th St and 35th Ave NE to Lake City Way (9,500 to 12,000 ft) – TCRC Map #3

In 1999, SPU modified the check dams and culvert under 35th Ave NE to improve fish passage. Upstream of 35th Ave NE, the creek passes through landscaped backyards. Upstream of 34th Ave NE, the creek flows through a woody ravine for about six blocks before reaching Lake City Way. This stretch of the creek is characterized by faster flows, a rockier substrate, and a steep woody ravine. Most of the riparian corridor is privately owned. Numerous pools are located in this tree-covered area (SPU).

Just downstream of Lake City Way, an old fish ladder may be an obstacle to migrating fish as one or more waterfalls are over a foot high. The North Branch of Thornton Creek crosses Lake City Way near NE 117th, next to Denny's Restaurant and Kentucky Fried Chicken.

Identified habitat problems:

- Culvert upstream of Lake City Way at 25th Ave NE is fish barrier (SPU, WDFW).
- Erosion along streambanks on private property.

Between Lake City Way and NE 130th St (12,000 to 18,000 ft) – TCRC Map #3 and 4

Just upstream of Lake City Way, the North Branch flows through the Homewood Open Space. The creek meanders through a flat-bottomed woody ravine. Numerous pools, check dams, and footbridges are found here. This ravine is undeveloped and contains mature deciduous and conifer trees as well as invasive plants such as Japanese knotweed. Upstream of the park, homes have been set back from the creek and the riparian corridor is still lined with trees. The culvert under 25th Ave NE has a 2.5-foot drop and may present a barrier to migrating fish. Several storm drains discharge into this section of the North Branch. Several areas of bank erosion have been noted.

Upstream of NE 125th St to NE 130th St and 15th Ave NE, the creek continues to flow through a wooded ravine. The homes tend to be set back from the creek. Numerous pools and check dams are present. Large conifers, ferns, and other native plants are common in the ravine. A tributary, Hamlin Creek, joins the creek from the north along 20th Ave NE. This tributary flows mainly through ditches. Access to the creek is limited because there are only a few public access points.

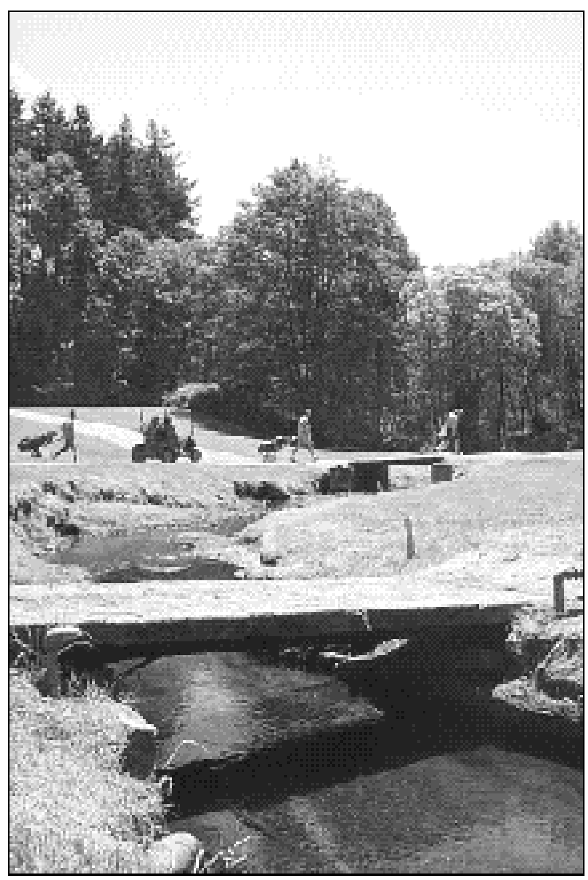
Identified habitat problems:

- ♦ Invasive plants in Homewood Open Space (TCA).
- ♦ Lack of off-channel refuge areas and wetlands (TCA).
- ♦ Potential fish barrier at culverts under 25th Ave NE, 15th Ave NE and NE 125th and 24th Ave NE.
- ♦ Bank erosion along private property, especially near NE 120th St (SPU).
- ♦ Erosion and bank undercutting near Hamlin Creek outfall near 20th Ave NE and NE 127th St (SPU).

15th Ave NE to 5th Ave NE - Thornton Creek Park #1 and Jackson Park Golf Course (18,000 to 21,000 ft) – TCRC Map #5

East of 15th Ave NE, Littles Creek joins the North Branch. (See Littles Creek under North Branch tributaries.) Upstream of 15th Ave NE, the creek travels through lawns at the Bridge Haven Condominiums. There are no shrubs or trees shading the creek through the condominium property.

Upstream of the condominiums, the creek flows through Thornton Creek Park #1. Small wetlands and wet meadows are present. Numerous small seeps feed the creek. This area provides excellent wildlife habitat (Seattle Parks, 1994). The park has a good riparian corridor and a moderately dense canopy cover. The substrate materials are composed of sand, and larger sized gravel. Several small trails crisscross the park. The creek crosses under 10th Ave NE and enters the Jackson Park Golf Course property. The southern end of the golf course is wooded and undeveloped. The riparian corridor is similar to that found in Park #1. The channel widens through this reach and small wetlands are found on either side of the creek. In 1999, SPU created a small backwater refuge near 10th Ave NE and planted native trees and shrubs beside the channel.



Upstream of the woods, the creek crosses the playable areas of the golf course. Through this section, grass grows to the edge of the creek. Two-thirds of the channel are lined with concrete slabs. Bank failures are found in several spots. The substrate is composed of sand, smaller-sized gravel, and concrete slabs in some sections.

Four hundred feet upstream of the wooded area, water is diverted to an off-channel irrigation pond. Municipal Golf of Seattle withdraws creek water to irrigate the grass during the warmer, drier months of late spring through early fall. The City of Seattle has a water right dating back to the 1920s that permits taking up to 1.3 cfs of water from the creek. According to SPU estimates, the golf course withdraws slightly less than the permitted amount during watering hours, which is up to two-thirds of the creek flow at this point. At the upstream end of the golf course, the creek travels through a wooded area flowing through a braided channel on the east side of 5th Ave NE.

Identified habitat problems:

- Little vegetation along privately owned streamside at Bridge Haven Condominiums.
- Mature forest in Park #1 is not being replaced by conifers (Parks).
- Limited amphibian habitat outside of Park #1(TCA).
- Limited LWD and instream habitat in Park #1 (SPU).
- Trash rack at the upstream end of 10th Ave NE culvert may be a barrier to fish (SPU).
- Lack of off-channel refuge, particularly through golf course (SPU).
- Potentially inadequate detention (undergoing study by Entranco, Inc.).
- Golf course has an irrigation pond and removes up to two-thirds of summer low flows (SPU).
- In the golf course, much of the creek is lined with concrete and has little or no cover (SPU).
- Exposed sewer pipe crossing at Jackson Park Golf Course (SPU).
- High concentrations of pesticides and fertilizers in water (resident).

5th Ave NE to 1st Ave NE - I- 5 and Peverly Pond (Upstream of 21,000 ft) – TCRC Maps #5 and 6

The North Branch crosses diagonally under I-5 in two culverts with a few small openings. Along the highway right-of-way, the banks are lined with grass. Upstream of I-5, the creek travels through a concrete trough. The creek also flows through a privately owned pond, Peverly Pond; in this area the banks are densely overgrown with blackberries and small trees.

Identified habitat problems:

- Concrete pipes under I-5.
- Poor streamside vegetation along I-5, mainly Himalayan blackberry, rip-rap, grass, and concrete.
- Peverly Pond is privately owned and its features may not be protected from future development.

Twin Ponds Park – TCRC Map #6

Upstream of Peverly Pond, the creek flows through a culvert under 1st Ave NE and into Twin Ponds Park. The two ponds were created in the 1950s when peat was excavated from the site.

The ponds have open water year-round. Several wetlands are located near the edge of the pond. Trees surround the ponds and provide wildlife habitat. The west side of Twin Ponds Parks is forested and extends to Meridian Ave North, and many birds are seen in this area. Evergreen Creek enters the southwest corner of the ponds. Twin Ponds has benefited from active neighborhood efforts to re-vegetate the park with native species of trees and plants. (See Evergreen Creek under North Branch tributaries.)

Identified habitat problems:

- Sections of the stream are in culverts or lack good streamside management (SPU on-site observations).
- Degraded wetland exists on the east side of I-5 near NE 155th St.
- Invasive plants in Twin Ponds Park (volunteers).
- Poor riparian corridor along the creek at north and south ends of Twin Ponds Park (Shoreline).

Flora and Fauna at Twin Ponds Park

Between Twin Ponds and Ronald Bog – TCRC Maps #6 and 7

Between Twin Ponds and Ronald Bog, the North Branch of Thornton Creek flows through pipes under the Metro bus barn and electric substation. Further upstream the creek passes beside the solid waste transfer station and through backyards, roadside ditches, and culverts. The gradient is flat and flooding is common. The creek channel is fairly narrow and most open sections of creek are overgrown with blackberries and other vegetation. Tree canopy cover is limited along most of this reach. The creek banks in the residential section are lined with grass, concrete, or boulders. There is very little flow in this reach and residents of the area report rare, yet undocumented, fish sightings. The substrate contains a lot of unconsolidated, organic debris similar to the peat found in Ronald Bog and Twin Ponds park.

Water flows out of the south end of Ronald Bog pond through a 30-inch diameter 1,000-foot culvert. The culvert is flat and flooding is common in the adjacent residential area. The creek mainly flows through culverts, but there are a few stretches of open channel (estimated ratios of culverted to unculverted creek aren't available for this stretch).

Identified habitat problems:

- The open channel near the solid waste transfer station lacks a buffer.
- A fish barrier is located at the weir south of the bus barn (SPU observation).
- Much of the connection between Ronald Bog and Twin Ponds is piped (estimated ratios of culverted to unculverted creek aren't available for this stretch).
- Poor riparian corridor features along the privately owned sections of the creek (SPU observations and GIS maps indicate approximately 50% of open creek in this stretch is privately owned).

Ronald Bog and Headwaters – TCRC Map #7

Ronald Bog, located two blocks west of I-5 at NE 175th St, is usually considered the headwaters of the North Branch of Thornton Creek. It drains over 716 acres of land, primarily residential neighborhoods. A row of trees surrounds the pond, which is frequented by ducks and other waterfowl. Carp are found in the pond. Historically, the area around Ronald Bog, Twin Ponds, and Meridian Park was a large peat bog. The pond at Ronald Bog has straight edges, evidence that it was created by excavation of peat deposits in the 1950s.

A 17.6 acre section of I-5 drains into Ronald Bog (WSDOT database, 2000). Several wetlands are located nearby. Meridian Park wetland is located a few blocks west, near Meridian Park School. The park contains a wetland, wet forests, and meadow. Much of the area is overgrown with reed canary grass. Cromwell Park, located several blocks north of Ronald Bog, has evidence of historical wetlands.

Identified habitat problems:

- Invasive plants around the Ronald Bog, especially in the southeast corner.
- Potential water quality problems due to fecal coliform from waterfowl.
- Untreated runoff from I-5.
- Shortage of good habitat in this area.
- Meridian Park Wetland overgrown with Reed Canary grass.
- Degraded wetland at Cromwell Park: wetland filled and cleared of most vegetation. (Areas of park become soggy during wet seasons) (SPU).

North Branch Tributaries

Little Brook – TCRC Maps #3, 8, and 9

Little Brook drains 829 acres of some of the most densely populated areas in the entire watershed. In addition to single family homes, there are many multi-family homes and businesses in this area. This basin includes much of the Lake City business district and a large section of Lake City Way. Over half of Little Brook is piped.

Little Brook joins the North Branch in a backyard south of NE 115th St. Upstream of NE 118th St, the creek flows through several vacant parcels and a steep woody ravine, which offers good riparian habitat. Some homes along the lower reach of Little Brook were built within the 100-year floodplain, and flooding has been a concern.

Upstream of 35th Ave NE near NE 125th St, the creek passes through a stormwater detention pond. The banks of the pond have meadow grasses and flowers. Upstream of the detention pond, most of the creek is piped. Little Brook passes under the heart of Lake City. It flows through an open channel near the back of AA Rentals before flowing into pipes again. At this point the stream is often far below the road surface, sometimes more than 30 feet below ground.

Between Lake City Way and NE 143rd St, Little Brook flows through a series of culverts, with brief sections of open channel between apartment buildings. Erosion is noticeable in a few locations. Little Brook first appears just north of the Little Brook Park, formerly known as the "Last Open Space," a recently acquired park property near NE 143rd St and 32nd Ave NE

Identified habitat problems:

- Lack of detention.

- Limited habitat in lower Little Brook where creek runs through residences. Lacks vegetation buffer, complexity (SPU).
- More than 60% of upper reach is piped (North of NE 125th St), limiting upstream habitat.
- A double-perched culvert in this creek at NE 115th Street creates a fish passage barrier.

Hamlin Creek – TCRC Map #4

Hamlin Creek joins the North Branch near 20th Ave NE just south of NE 130th St. This sub-watershed covers 405 acres. It includes Hamlin Park, a large forested park, the adjacent commercial and educational facilities, and the surrounding residential neighborhood.

Hamlin Creek flows year-round, most of its length has been ditched along 20th Ave NE. There is little quality habitat along Hamlin Creek ditch. Residents along 20th Ave NE have asked the City to install a culvert along this road. Further upstream in Hamlin Park, the creek flows underground. Much of the runoff from above the park soaks into the sandy soils within Hamlin Park.

Identified habitat problems:

- Most of lower Hamlin Creek flows through a ditch 1' to 3' deep along 20th Ave NE, with little vegetative cover.
- Much of Hamlin Creek flows sub-surface, some of it through pipes.
- Limited areas of good riparian corridor because creek is ditched along 20th Ave NE.
- Forested land near Hamlin Park is available for development.

Littles Creek – TCRC Maps #5 and 10

Littles Creek joins the North Branch near NE 133rd St and 15th Ave NE. Littles Creek drains 543 acres. The upper watershed is primarily single family housing. The lower watershed includes Jackson Park Golf Course, condominiums, and apartment buildings.

The creek flows through a 1,600-foot culvert along 15th Ave NE. It flows through several backyards and apartment complexes and a pond. Further upstream, the creek passes through an 800-foot pipe under the north end of the Jackson Park Golf Course. Upstream of the pipe, the creek flows through a wooded area near NE 145th St. Some of the high flows are diverted out of the creek into a detention pond, which also provides a water hazard for golfers. The creek leaves Seattle as it crosses under NE 145th St in a culvert that is a partial fish passage barrier.

In Shoreline, the creek flows through lower Paramount Park, which contains mature forests, small ponds, grassy meadows, and wetland areas. In the park, community groups have been active in creating amphibian ponds, removing invasive plants, and planting native vegetation. The year-round stream flow is low relative to the Main Branch; the channel is narrow, and the slope gentle. Canopy cover is moderately dense in Paramount Park. The substrate consists of fine sediments, pea gravel, and small-to-medium gravel. The headwaters of Littles Creek are located in residential areas north of Paramount Park. Here, the banks are mostly lined with grass, although they have been reinforced with concrete or large rocks in some places.

Identified habitat problems:

- 1,500-foot culvert connecting Littles Creek to Thornton Creek.
- Limited riparian cover where the creek flows through neighborhoods.

- Creek is piped through approximately 50% of the golf course.
- The existing detention pond may be a heat source and might trap fish.
- The culvert under 145th St is a barrier to fish passage.
- Wetlands near Paramount Park open space could be developed.
- Invasive plants are common in lower Paramount Park.
- Forested area north of Paramount Park could be developed.
- Reduction of wetlands to act as water detention areas.
- Open, grassy areas attract large flocks of geese, which produce fecal coliform.
- Poor to non-existent native plant and animal habitat where creek runs through Executive Estates condos.
- Lack of creek bank vegetation in Executive Estates attracts creek-polluting waterfowl.
- Creek flows in culverts in some sections east of Jackson Park Golf Course.

Evergreen Creek – TCRC Map #2

Evergreen Creek feeds into the southwest corner of Twin Ponds. It drains a 364-acre watershed, which is primarily residential and includes Evergreen School.

West and upstream of Twin Ponds, the creek flows through approximately 700 feet of wooded parkland before crossing under Meridian Ave N. Volunteers have planted many trees along the banks. The creek passes by Evergreen School and students use the creek as an outdoor classroom. Many birds are found near Twin Ponds and Evergreen Creek. Upstream of the school, the creek flows through backyard culverts and stretches of open channel and ditches. This small tributary may originate from a wetland at Meridian Park (N 170th St and Wallingford Ave N). However, it is difficult to locate the upper reaches of Evergreen Creek because the creek is either in backyard culverts or other subsurface flow.

Identified habitat problems:

- Stream is in a straight channel, not much large woody debris.

South Branch (Maple Leaf Creek)

Confluence to the West Side of Nathan Hale High School, 30th Ave NE (0 to 1,500 ft) – TCRC Map #2

From the confluence with the North Branch, the South Branch flows through an open channel lined with vertical concrete walls. These walls protect the adjacent residential properties from severe erosion and flooding. The creek flows through a large culvert under 35th Ave NE, which is prone to flooding. The section of creek running through Meadowbrook Playfield and Nathan Hale High School flows in a straight channel. A row of poplar trees shades the creek; the understory is mainly grass. Meadowbrook Creek joins the South Branch at the east end of the playfield. (See Meadowbrook Creek under South Branch tributaries.) The stream substrate material is composed of medium-to-large gravel, small cobbles, and small boulders that do provide some instream complexity for fish. Few pools are found in this reach yet small, cascading steps approximate small pools. Many Cutthroat trout adults and juveniles are found between Nathan Hale high school and 30th Ave NE (White, 1999).

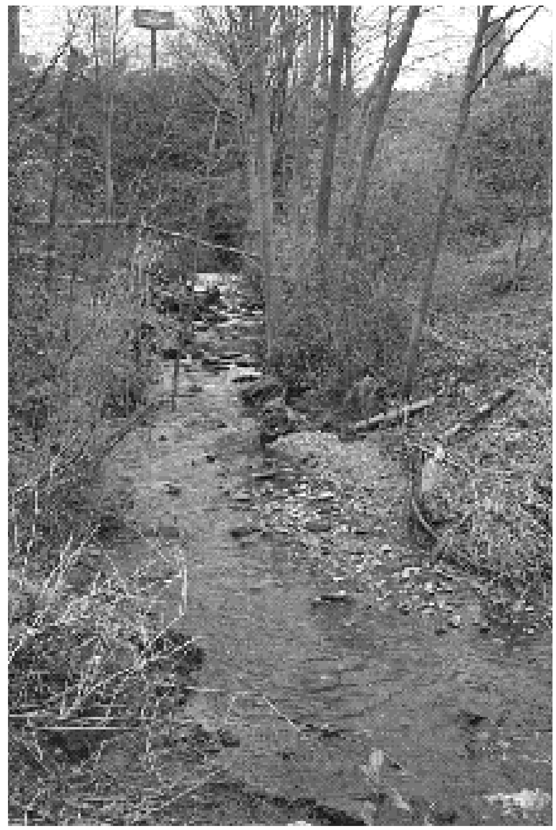
Identified habitat problems:

- There is little refuge from high flows, although potential exists in select areas; the channel is straight, with little vegetation or large woody debris.

30th Ave NE to Lake City Way, includes Ravenna Open Space (1,500 to 4,500 ft) – TCRC Map #11

Between Nathan Hale High School and Lake City Way NE, the creek travels through backyards on the west side of Ravenna Ave NE. Kramer Creek joins the South Branch near 30th Ave NE. (See Kramer Creek under South Branch tributaries.) Four storm drains flow into this section of the South Branch.

Upstream of NE 103rd St, the creek passes through the Ravenna/Blindheim Natural Area, a 3.8 acre wooded open space. Willow Creek and an unnamed tributary join the South Branch in this park. (See South Branch tributaries.) This reach has a low-to-moderate gradient and a moderately wide channel. There are significant areas of erosion in this stretch of the creek. SPU recently reinforced the banks of the South Branch at the Willow Creek confluence to reduce erosion problems. Volunteers have removed blackberries and planted evergreen trees in this park. The canopy cover within the park area is moderate to dense, and limited in the residential area. The substrate contains many large cobbles and gravel.



South Branch (Maple Creek) at Lake City Way

The stream crosses under Lake City Way near Upenick's Tires (9801 Lake City Way NE). The culvert under Lake City Way currently poses a barrier to migrating fish. The culvert has a flat bottom and the water is shallow. In addition, there is a one and half foot drop to the creek. SPU anticipates correcting this problem in 2000 by adding baffles to the culvert and putting in weirs downstream.

Identified habitat problems:

- Possible fish barrier at concrete check dam series upstream of NE 105th St culvert (SPU).
- Bank erosion near NE 100th St and Ravenna Ave NE.
- Lack of instream habitat diversity (SPU).
- Fish barrier at Lake City Way culvert (SPU and WDFW).

Lake City Way to Roosevelt Way NE at Thornton Creek Park #2 (4,500 to 8,000 ft) – TCRC Maps #11 and 12

Upstream of Lake City Way, erosion problems exist in the steep ravine. Sacajawea Creek joins the South Branch about one block west of Lake City Way. The South Branch travels through several backyards, which are prone to flooding. Between 25th Ave NE and Roosevelt Way NE, the South Branch crosses a string of park parcels, collectively known as Thornton Creek Park #2. Park #2 covers approximately 12 acres of riparian deciduous forest habitat and emergent wetlands. Several small wet meadows are located on the west side of Thornton Creek Park #2.

Several small tributaries flow into the creek from the south side. The park is located in a steep ravine. SPU has identified a number of fish barriers and needed repairs in this area (see sites 6, 7, 25, and 26 in Table 10.1). Numerous natural debris dams are found throughout the park sections of the creek. Habitat in Park #2 is generally good; however, significant areas of bank erosion are found throughout this entire section.

Upstream of the park, the creek flows through backyards and the banks are reinforced along most of the residential areas with boulder riprap and concrete walls. The gradient is steeper. Substrate material consists of small to large-sized gravel. Canopy cover is moderate through the residential sections and high within the parks. Significant bank erosion is found throughout this entire section. The only road crossings in this stretch are the 15th Ave NE bridge and NE 105th St.

Identified habitat problems:

- Bank erosion upstream of culvert at Lake City Way (SPU).
- Bank erosion at NE 100th St & 20th Ave NE (TCA).
- Invasive plants in Park #2.
- Fish passage issue at boulder dams near NE 104th St & 17th Ave NE and NE 105th St & 15th Ave NE.
- Bank erosion and creek bed scoured down to bedrock near NE 104th St & 17th Ave NE.
- Sewer crossings and erosion near NE 103rd St & Ravenna Ave NE and NE 105th St & 12th Ave NE.

Roosevelt Way NE to 5th Ave NE, including Thornton Creek Park #6 (9,000 to 10,500 ft) – TCRC Maps #12 and 13

Upstream of Roosevelt Way, the South Branch flows for approximately 12 blocks to reach 5th Ave NE. The South Branch crosses Thornton Creek Park #6. Park #6 is a 6.4-acre wooded park with some wetland areas. Several small tributaries feed into this reach, as do numerous storm drains. The park areas are wooded and the creek banks tend to be overgrown with blackberries. The park contains many mature Big leaf maples and Red alder. Local community groups removed invasive vegetation and replanted conifers and other native species.

Northeast Park #6, downstream of 8th Ave, receives flow from the Northgate Mall storm drain and an unnamed piped tributary. There is ample evidence that this park is used as a play area for nearby residents, contributing to the already frequent bank erosion along this stretch of creek. Several community restoration projects, including construction of a frog pond, have taken place here. Toward Roosevelt Way NE, the gradient is steep; there are numerous small cascades and large rocks, and the substrate material is composed of small to medium-sized gravel. Closer to 8th Ave NE, the creek flows through a muck-lined channel with few pools or riffles. Trash and debris are commonly seen in lower branches near the storm drain outfalls.

Several private homes are located between upper and lower Park #6. Southwest Park #6, upstream of 8th Ave NE, has a slightly different character. There is less flow, the gradient is flatter, and the banks are lower. The creek frequently overflows its banks and inundates parts of the park. Park #6 contains numerous trees, seeps, trails, bridges, and blackberries. Volunteers have been active throughout Park #6 planting native trees, shrubs, and ferns, and removing blackberries and ivy. Much of Park #6 provides informal stormwater detention.

Identified habitat problems:

- Invasive plants in Park #6.

- High flows from Northgate area storm drains scour the creek.
- The stream channel in parts of lower Park #6 is one long glide with sandy/mucky bottom and undercut banks.
- Lack of large woody debris, riffles, and pools near 8th Ave NE.

5th Ave NE to Headwaters – TCRC Map #13

As of March 2000 there is a legal dispute over the character of this area within the watershed. Drainage features are shown in Figure 4.6.

Upstream of 5th Ave NE, water flows under the Northgate Mall south parking lot and NE 100th St between 5th Ave NE and 1st Ave NE in a series of 60 to 72-inch pipes. The pipe containing the water is located 15 to 30 feet underground. A number of storm drains from the mall, transit center, Executive Park, and streets feed into the pipe.

Two branches west of the South Fork join in the pipe under 1st Ave NE and NE 100th St. One of these tributaries comes from the north and the other from the south, both running between and parallel to 1st Ave NE and the I-5 freeway (see Freeway tributary under South Branch tributaries).

The branch to the south of NE 100th St flows through a ditch on the west side of 1st Ave NE between 1st Ave N and the Park-and-Ride lot east of I-5. The water emerges from a 30-inch culvert passing under the freeway at about NE 98th St. The culvert comes from the North Seattle Community College Surge Pond immediately to the west of the freeway. The pond serves as stormwater detention for the college and surrounding area to the west and northwest. The pond is several feet deep and surrounded by a thick border of vegetation. The surge pond provides wildlife habitat. There are small seasonal wetlands on the north and south ends of the campus. SPU is working with the college and community groups to re-establish these wetlands by removing fill and directing groundwater into the wetlands.

The area located to the west and northwest of the college contributes to the South Branch. A storm drain along Meridian Ave N collects water from Evergreen-Washelli Cemetery and wetland, and parts of Haller Lake neighborhoods. Groundwater from these areas feeds into the Meridian Ave pipe. There is a prominent wetland near the King County Department of Health building, and wetland remnants are found at the North Seattle police precinct and at the southeast edge of the cemetery.

Identified habitat problems:

- NSCC wetland not connected to the N 103rd St culvert.
- Degraded wetlands at North Seattle Community College, North police precinct, and Evergreen-Washelli Cemetery.
- Poor human and wildlife connection/linkage across I-5.

South Branch Tributaries

Kramer Creek – TCRC Maps #11 and 12

Kramer Creek joins the South Branch near NE 108th St on the west side of 30th Ave NE, across from Nathan Hale High School. Fish surveys have found abundant Cutthroat trout in lower Kramer Creek. This stream drains 69 acres, which include a section of Lake City Way and nearby homes. This tributary flows year-round. A ditch one to two foot deep along 30th Ave NE is interrupted by driveway culverts. The substrate of the open channels is composed of fine sediment and sand. Nearby residents report flooding from stormwater overtopping the ditch. Very little shade is available along the ditches. At NE 110th St, the creek flows west to east in a steep ditch, where aquatic plants grow.

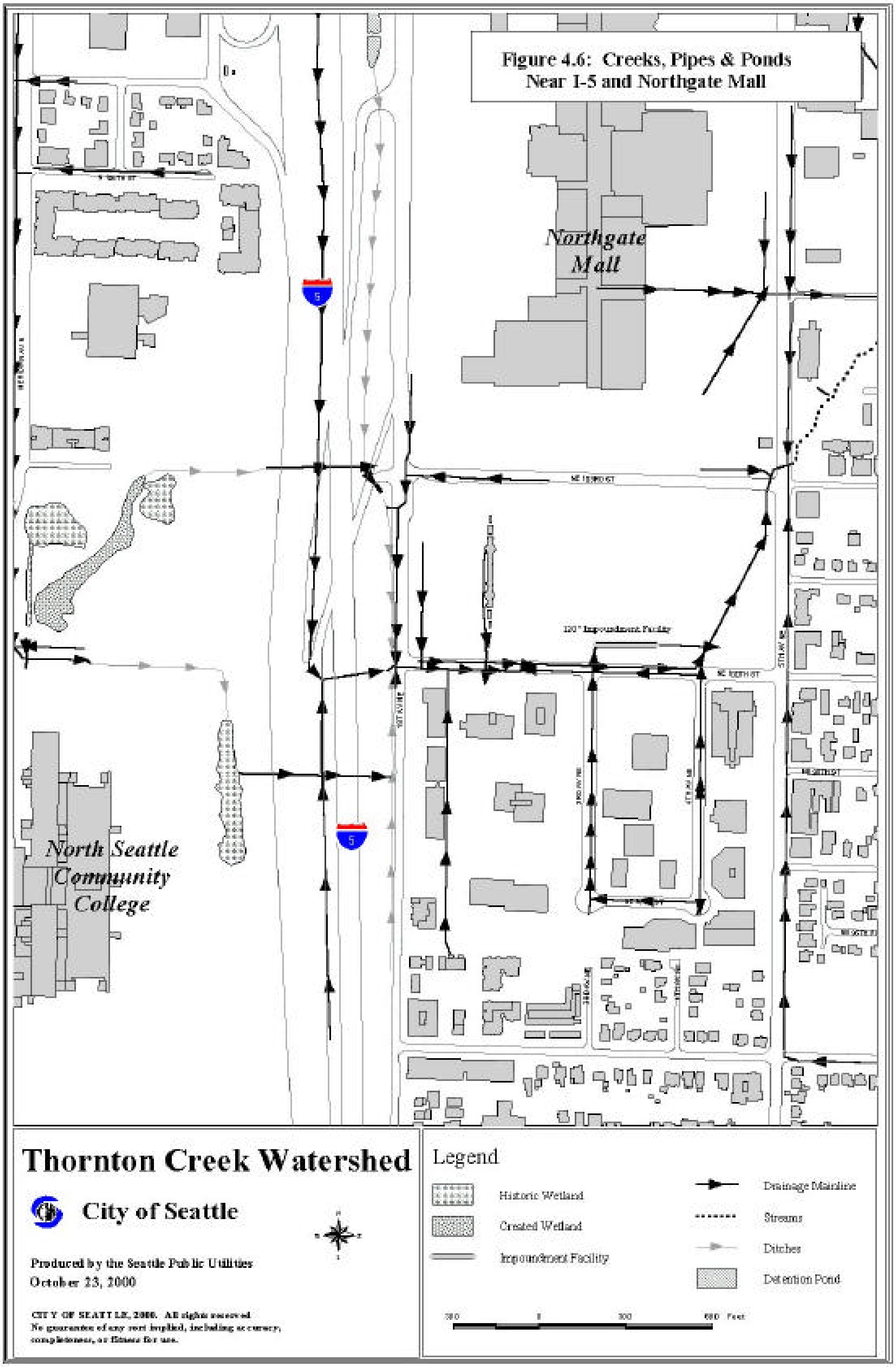


Figure 4.6: Creeks, Pipes & Ponds
Near I-5 and Northgate Mall
Northgate Mall
North Seattle Community College
120" Impoundment Facility
Thornton Creek Watershed
City of Seattle
Produced by the Seattle Public Utilities
October 23, 2000
CITY OF SEATTLE, 2000. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Historic Wetland
Created Wetland
Impoundment Facility
Drainage Mainline
Streams
Ditches
Detention Pond
Feet

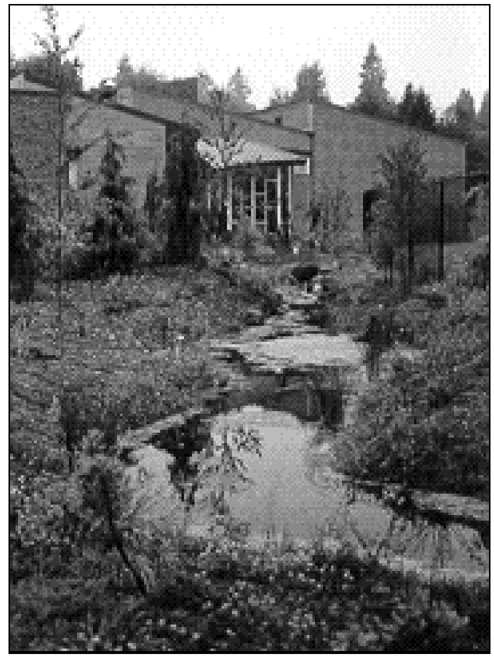
There are three short branches to Kramer Creek that join near NE 110th St and 28th Ave NE. The north tributary flows behind Big Foot Car Wash on Lake City Way through a steep wooded ravine. The headwaters of this branch are probably located west of Lake City Way. The middle branch starts behind Kemo's General Store (11050 Lake City Way) and travels through backyards. The southern branch originates from a groundwater spring along a driveway near Lake City Way and NE 110th St.

Identified habitat problems:

- Limited creek-like characteristics along the ditch on 30th Ave NE; little to no vegetative cover.
- Erosion problems and undercutting banks along north tributary, east of Lake City Way.

Meadowbrook Creek – TCRC Map #2

A few years ago, volunteers daylighted a small creek located at the bottom of a hill just west of the Meadowbrook Community Center. This creek flows through a series of small ponds and wetlands before joining the South Branch near 35th Ave NE. This tributary provides rich habitat for insects, birds, amphibians, and small fish. Volunteers are planting native trees and shrubs along the bank, creating a diverse and complex riparian corridor. Habitat problems have not been identified for Meadowbrook Creek.



Meadowbrook Creek

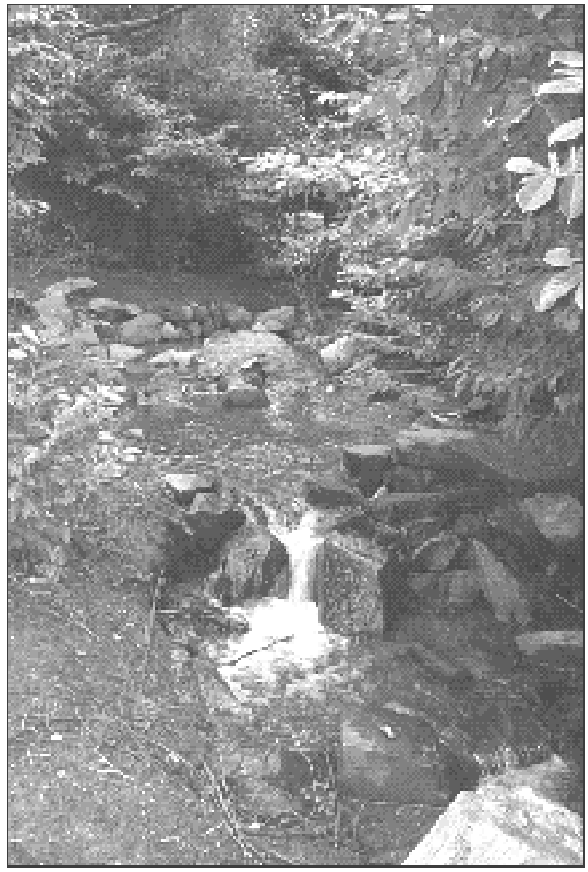
Unnamed Tributary near Waldorf School – TCRC Map #11

A small tributary joins the South Branch 200 feet downstream of the confluence with Willow Creek. Most of the tributary is contained in two pipes totaling 700 feet in length; however, there is one open channel section through a private backyard. The headwaters of the tributary are located near the Waldorf School. The remaining part of a wetland connected to this tributary is located east of the school building. Habitat problems have not been identified for this tributary.

Willow Creek – TCRC Maps #11 and 14

Willow Creek and its tributary drain 396 acres, including a portion of Lake City Way and Ravenna Ave, many single family homes, a few businesses, and several schools.

Willow Creek joins the South Branch in the Ravenna/Blindheim Natural Area, about a half-block north of NE 100th St between Lake City Way and Ravenna Ave NE (near LaVilla Dairy and the Shutter Shop). The lower reach has noticeable erosion along the streambank. The gradient is steep and water tumbles over small rocks and chunks of concrete slabs. The park has dense tree cover. On the vacant lot upstream of NE 100th St, where the creek previously flowed in a ditch, SPU last year created a small backwater channel with more natural gradient and replanted the lot with native vegetation.



Willow Creek

Near NE 98th, Willow Creek splits into two branches. The west branch of Willow Creek crosses under NE 98th St, with a 3-foot drop from the culvert under NE 98th St to the vacant lot. Upstream of this culvert the creek travels in a woodsy ravine beside the Weight Watchers building (9700 Lake City Way). The remainder of the creek flows in and out of culverts along Lake City Way and Ravenna Ave NE. There is a 300-foot culvert near the Ryther Child Center. The creek flows in a blackberry-lined channel for a few hundred feet near NE 95th St. Upstream of NE 95th St is a 880-foot culvert to NE 92nd St. The creek flows in a woodsy area west of Ravenna. Upstream of NE 90th, the creek flows through backyards for several blocks. The creek is narrow and shallow and often looks like a wet ditch. A small wetland is located at the southwest corner of NE 86th and Ravenna. The headwaters of this Willow Creek branch begin around the Picardo Farm P-Patch at NE 80th St and 25th Ave NE.

Near NE 98th St, the east branch crosses Ravenna Ave in a 200-foot culvert. Upstream (southeast) of Ravenna Ave NE, this tributary travels approximately 1,000 feet through a steep woody ravine. This section of ravine is Parks Department Open Space and includes several unopened rights-of-way. In 1996, a washout occurred on the steep bank on the east slope of the ravine at NE 96th St. SPU plans slope stabilization and instream habitat improvements in this area. Upstream of NE 95th St, the stream travels through short (100 to 200-foot) stretches of culvert and open channel. The headwaters of this Willow Creek branch are located in backyards near NE 92nd St and 27th Ave NE.

Identified habitat problems:

- Excessive storm flows create severe bank erosion at downstream end.
- Several culverts are fish barriers (SPU).
- Invasive plants are found along creek banks.
- Much of the tributary along Lake City Way is piped.
- Landslide along tributary.
- Lack of instream habitat and diversity.
- Wetland not officially designated near NE 98th and Ravenna.

Victory Creek – TCRC Map #12

A small tributary, Victory Creek, joins the South Branch between Parks #2 and #6 near NE 108th St, one and a half blocks east of Roosevelt Way NE. Victory Creek drains a 197-acre area, which includes many commercial businesses, apartments, and single family homes.

The culvert under NE 107th St is a barrier to fish passage; the culvert is several feet above the stream. Upstream of NE 107th St and Northgate Way, the creek flows through backyards. The canopy and ground cover are dense and conifers, maples, and ivy are conspicuous.

Victory Creek flows under Northgate Way through a culvert that is a fish passage barrier at the north end. A small park is located just north of Northgate Way. There are large boulders and rocks in spots throughout Victory Creek Park and south. At the north end of the park, the creek bed consists of small pebbles and a footpath runs near the creek. At its headwaters near NE 123rd St, Victory Creek flows through a residential area. The channel has a ditch-like appearance and the canopy cover is low to moderate.

Identified habitat problems:

- Several fish barriers are present.
- Much of the upper creek is piped.

Unnamed Piped Drainage Trunk Line in Northgate Area – TCRC Map #12

A piped tributary joins the South Branch in Thornton Creek Park #6, approximately 200 feet north east of 8th Ave NE and NE 105th St. Only the lower 300 feet or so of this tributary flows above ground. This tributary provides a steady, low-volume year-round flow of water to the South Branch. The 36-inch storm drain travels 1,300 feet between Park #6 and Northgate Way. It picks up drainage from the Park and Ride located north of Northgate Way. The pipe extends another 4,000 feet along 5th Ave NE to NE 125th St. This pipe conveys groundwater and stormwater runoff. Two wetlands are located near this piped tributary (one north of the Northgate Park and Ride and the other a few blocks to the east).

Identified habitat problems:

- Tributary is piped.
- Nearby wetlands are isolated from the riparian system.
- Historic wetlands are buried beneath asphalt.

Freeway Tributary – TCRC Map #13

A small tributary flows along the east side of I-5 in the Northgate Mall vicinity. This tributary joins the South Branch at NE 100th St east of I-5, upstream of the pipes under NE 100th St and the Northgate Mall lower parking lot. It provides a year-round flow to the South Branch. This tributary flows along the east side of the freeway between the off-ramps and 5th Ave NE. Some sections of streambank are lined with thick vegetation. The headwaters of the creek are located west of I-5 and north of Northgate Way; the tributary crosses under I-5 in a culvert north of Northgate Way. This area was at one time a boggy, spring-fed area, but over the years it was filled and developed, and underground perforated pipes were installed to route the groundwater under the freeway (KCM, 1998).

Identified habitat problems:

- Some of the vegetation planted during the Northgate off-ramp construction has not survived (TCA).
- Parts of the tributary are piped.

CHAPTER 5: WATER AND SEDIMENT QUALITY

This chapter begins with a brief description of the Federal framework for protecting water quality. This is followed by a presentation and evaluation of data based on samples of surface water, sediments, fish tissue, macro-invertebrates, and groundwater. The chapter concludes with a summary of exceedances of water quality standards and an overview of water quality trends.

5.1 Stream Uses and Standards

As required under the Federal Clean Water Act, Washington State has adopted standards for fresh and marine waters. These standards are found in Chapter 173-201A of the Washington Administrative Code (WAC) and apply to all surface waters, including wetlands. Washington State has several freshwater classifications with differing standards. Thornton Creek must meet Class AA standards. Water quality standards consist of three components:

- Designated and existing uses of a water body.
- Water quality criteria necessary to protect these uses; criteria can include numerical limits, as well as narrative statements.
- Antidegradation policy (40 CFR part 131.6).

Washington State has not yet adopted freshwater sediment standards, although marine sediment standards have been adopted.

The Washington State Department of Ecology (Ecology) is currently working on proposed changes to chapter 173-201A of the WAC. Modifications include changing water body designations from a class to a use-based system, expanding implementation of the anti-degradation policy, and changing other criteria, such as specific temperature needs for various life stages of salmonids.

Designated Uses

Ecology has defined the following beneficial uses for Class AA streams some of which should be supported in Thornton Creek (WAC 173-201A, 1997):

- Water supply (domestic, industrial, and agricultural).
- Fish and shellfish rearing, spawning, and harvesting.
- Wildlife habitat.
- Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).

- *Stock watering.
- *Commerce and navigation.

*Thornton Creek does not support beneficial uses related to stock watering, commerce and navigation due to its urban nature and small size.

Water Quality Criteria

Water quality criteria have been set to protect public health and enjoyment of waters, and to propagate and protect fish, shellfish, and wildlife. Table 5.1 identifies the freshwater numeric standards that apply to Thornton Creek and other Class AA streams (WAC 173-201). The freshwater standards also prohibit toxic, radioactive, or deleterious materials in concentrations that could adversely affect beneficial uses. In addition, the aesthetic values of the waterway should not be impaired by the presence of materials or their effects, excluding those of natural origin, that offend the senses of sight, smell, touch, or taste.

Table 5.1. Washington State Freshwater Standards for Class AA Streams

Parameter	Washington State Standard
Dissolved oxygen	> 9.5 mg/L
Fecal coliform	Geometric mean <50 organisms/100 ml and no more than 10% of samples >100 organisms/100 ml
pH	6.5 - 8.5 units
Temperature	<16°C
Turbidity	<5 NTU over background
Metals	Two standards: acute and chronic; each standard varies with the hardness (WAC 173-201A)

Common Chemical Analysis

Chemistry has been used for many years to assess water quality and to determine if water quality standards are being met for numeric criteria. Chemical analysis of water and sediments provides reliable, repeatable, and precise results. Chemical data lends itself well to developing numerical standards. Pollutant concentrations in water and sediment can be studied to determine threshold concentrations above which acute or chronic exposure can harm living organisms.

Some common parameters routinely used to test creeks are shown below. Many additional analyses can be performed. Concentrations are often reported in milligrams/liter (mg/L), which is the same as parts per million (ppm).

Conventional parameters:

- Physical tests: temperature, pH, and conductivity.
- Nutrients: phosphorus, ammonia, nitrates.
- Sediment/particle tests: turbidity, total suspended solids (TSS).
- Oxygen: dissolved oxygen (DO) level, biological and chemical oxygen demands.
- Oil/grease.

Bacteria:

- Fecal coliform: bacteria found in the gastro-intestinal tracts of birds and mammals.
- Enterococcus: bacteria found in the gastro-intestinal tracts of birds and mammals, associated with increased risk of disease in humans.

Metals:

- Total metals: copper, lead, zinc, chromium, cadmium, mercury.
- Dissolved metals.

Narrative Criteria

Narrative criteria are required where numerical criteria cannot be established, or to support numerical criteria (40 CFR part 131.11). Narrative criteria are general statements designed to protect a specific designated use or set of uses. Washington's water quality standards apply narrative criteria to all beneficial uses for all water classes (DOE, April 1996). An example of a narrative criterion is the "no toxins in toxic amounts" statement generally found in most State standards. Criteria based on biological monitoring methods are used by a few states. While elements of fish habitat may be protected through numeric criteria, other aspects of fish habitat are better protected by narrative criteria.

Biological Indicators

Biological indicators provide a way to assess the health of a creek and are a form of narrative criteria. Any numeric values identified (e.g. 70%), have not been adopted as numeric standards in the State water quality standards; therefore they are not rules. The narrative standards have not been clearly identified in Washington State, nor have the existing narrative standards been consistently applied. The abundance and variety of fish and aquatic insects answer the question, "Do living things survive and thrive in this water?" Since fish and aquatic insects spend a significant portion of their lives in the creek, they are impacted by the cumulative effect of many small recurring inputs of pollution. Their survival depends on more than clean water; they also require food, cool temperatures, refuge from predators, and favorable conditions for spawning and rearing. Different organisms can be used as biological indicators. Depending on the type of study, the organisms may be counted, collected, examined, dissected, or used as lab specimens.

Benthic macro-invertebrates are the small creatures that live in the sediments at the bottom of creeks and lakes. They include insect larvae, worms, leaches, small crustaceans, snails, and small clams. The insect larvae may include Mayflies, Stoneflies, Caddisflies, Dragonflies, beetles, midges, Black flies, or Crane flies. Many insects spend the majority of their life as aquatic larvae and are winged adults for only a short period. Benthic invertebrates are an important food source for fish.

Benthic macro-invertebrates and bio-assays are commonly used as biological indicators and can be used as a barometer of overall bio-diversity in aquatic ecosystems. Benthic macro-invertebrates are small, easy to catch, abundant, and non-migratory. Invertebrate communities respond to changes in water and habitat quality, and integrate impacts over time because of their extended residency in the stream.

Habitat Protection

Washington State uses surface water quality to assess whether or not designated uses are supported. The designated use support statements can be interpreted to include the narrative criteria for habitat; however, there is no clear mention of habitat protection in the State surface water quality standards other than the definition of "damage to the ecosystem." Chapter 173A-201A-020 WAC (November 1997) defines "damage to the ecosystem" as:

> Any demonstrated or predicted stress to aquatic or terrestrial organisms or communities which the department reasonably concludes may interfere in the health or survival success or natural structure of such populations. This stress may be due to, but is not limited to, alteration in habitat or changes in water temperatures, chemistry, or turbidity, and shall consider the potential build up of discharge constituents or temporal increase in habitat alteration which may create such stress in the long term.

Currently, the phrase "damage to the ecosystem" is generally applied only to mixing zones (areas where water is agitated and turbulent) downstream of outfalls as allowed under National Pollutant Discharge Elimination System (NPDES) permits, including stormwater permits.

The standard for determining impairment of designated uses, including habitat (Department of Ecology, June 1997, Water Quality Program Policy 1-11), is as follows:

- ♦ Documented environmental alteration using a generally accepted method based on site specific information, with literature thresholds appropriate to the situation or with reference sites, and
- ♦ Documented impairment of a characteristic use on the same water body segment, and
- ♦ Identification of a direct human caused contribution to the environmental alteration.

This policy guidance has been used to list habitat-impaired water bodies on the State's draft 1998 section 303(d) list; however, the list does not include all potentially habitat-impaired water bodies, such as Thornton Creek.

Antidegradation Policy

Under the Clean Water Act, every state is required to develop and adopt a statewide antidegradation policy (40 CFR part 131.12). Washington State's adopted policy (WAC 173-201A-070) has five main components:

1. Existing beneficial uses shall be maintained and protected and no further degradation which would interfere with or become injurious to existing beneficial uses shall be allowed.
2. Whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria.
3. Water quality shall be maintained and protected in waters designated as outstanding resource waters in WAC 173-201A-080.
4. Whenever waters are of a higher quality than the criteria assigned for said waters, the existing water quality shall be protected and waste and other materials and substances which will reduce the existing quality shall not be allowed to enter such waters, except in those instances where:
    a. It is clear, after satisfactory public participation and intergovernmental coordination, that overriding considerations of the public interest will be served;

b. All wastes and other materials and substances discharged into said waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment by new and existing point sources before discharge. All wastes and other materials and substances discharged into said waters from nonpoint sources shall be provided with all known, available, and reasonable best management practices; and

c. When lowering of water quality in high quality waters is authorized; the lower water quality shall be still of high enough quality to fully support all existing beneficial uses.

5. Short term modification of water quality may be permitted as conditioned by WAC-173-201A-110.

As stated previously, there are several numeric criteria for water quality parameters that are exceeded in the Thornton Creek watershed. As a result, some beneficial uses are not supported in the watershed; therefore, some aspects of the antidegradation policy do not apply (i.e., outstanding resource waters). However, the requirement to protect existing uses on or after November 28, 1975 would apply to the Thornton Creek watershed. The antidegradation policy is not well suited to restrict land uses or surface discharges in urban watersheds. The most likely application of the antidegradation policy for Thornton Creek would be during the issuance of NPDES permits for point and non-point sources. At this time, Ecology would have to determine whether or not the permit in question has the potential to protect or harm existing beneficial uses. However, most NPDES permits in the Thornton Creek watershed are general permits issued on an industry-wide basis and do not take into account site-specific conditions of the receiving water. The two NPDES permits with the greatest potential impact on Thornton Creek are the City of Seattle Municipal Stormwater Permit (which is the basis for the City's stormwater program) and the Washington State Department of Transportation Stormwater Permit (which applies to the section of I-5 in the watershed).

5.2 Review of Government Water Quality Data

A substantial amount of water quality data has been collected from the main branch of Thornton Creek, while collections in upper reaches have been fewer. King County has collected the bulk of the information since the mid-1980s as part of its Water Quality of Small Lakes and Streams program.

In 1998, SPU hired Gary Minton of Resource Planning Associates to evaluate water quality data from Seattle creeks. This section summarizes Minton's report, Review of Water and Sediment Quality Data in Thornton Creek (Minton, 1998; Appendix E), and the more recent data from Seattle Public Utilities (SPU, 1998; Appendix G), and King County (Appendix F).

Sources of Information

The existing water quality data comes from King County/Metro, SPU, USGS, and Ecology. Sampling stations and locations are listed in Table 5.2 and shown in Figure 5.1. All samples were collected in accordance with the agencies' sampling plans, which include quality assurance and quality control measures, and were analyzed by Washington State accredited laboratories. A description of the data follows. The raw data is available from the public agencies listed above.

Since 1985, King County/Metro has collected a monthly grab sample from the mouth of Thornton Creek, including base flow and storm samples. These have been analyzed for conventional water quality parameters, nutrients, and bacteria. Some additional data comes from samples collected on the North and South Branches by Metro in the late 1970s and early 1980s. These were analyzed for conventional parameters and nutrients.

SPU collected five stormwater samples in 1992 and 1993 from the Main Branch of the creek (see Table 5.2 for the exact location). These samples were taken to gain background information for the design and construction of the Meadowbrook Detention Pond. SPU analyzed mainly conventional parameters, metals, and dissolved metals. In a separate study in Summer 1998, SPU sampled ten locations along the creek to examine bacteria levels, temperature, and dissolved oxygen levels on hot sunny days. The SPU Thornton Creek Summer 1998 report is included in Appendix G.

In joint studies, USGS and Ecology evaluated pesticides in Puget Sound creeks (USGS, 1997 a,b; 1998) as part of a nationwide pesticide assessment. In these studies, water, sediment, and fish tissue samples were analyzed.

Table 5.2. King County and Seattle Sample Stations

Branch	Address	Agency	Sta. ID	Dates	# Samples
Main – mouth	Matthews Beach park	King County	434	1985 – 1997	160
Main – mouth	Matthews Beach park	USGS	USGS1	1992 – 1998	3
Main – mouth	NE 95th St & 48th Ave NE (mouth)	SPU	TC35M3	1992, 1993, 1998	65
Main – downstream of overflow pipe	NE 107th St & 36th Ave NE	SPU	434	1998	6
Main – downstream of overflow pipe	NE 109th St & 35th Ave NE	SPU	M1	1998	5
Main – upstream of overflow	NE 105th St & 39th Ave NE	SPU	M2	1998	5
Main – upstream of overflow	NE 107th St and 36th Ave NE	SPU	TC34	1992, 1993	5
South – upper	NE 100th St and 1st Ave NE	King County	O434	1970s and 1980s	14
South – middle	NE 108th St & 11th Ave NE	King County	K434	1970s and 1980s	65
South – middle	NE 105th St & 8th Ave NE	SPU	S1	1998	5
South – lower	NE 100th St & Lake City Way	SPU	S3	1998	5
South – lower	NE 107th St & 30th Ave NE	USGS	USGS2	1998	2
Willow Creek	NE 100th St & 25th Ave NE	SPU	S2	1998	5
North – upper	NE 130th St & 10th Ave NE	King County	T434	1970s and 1980s	Unable to determine
North – upper	NE 130th St & 10th Ave NE	USGS	USGS3	1998	2
North – upper	NE 143rd St & 5th Ave NE	SPU	N1	1998	5
North – lower	NE 116th St & 34th Ave NE	SPU	N4	1998	5
Littles Creek	NE 140th St & 15th Ave NE	SPU	N2	1998	5
Little Brook	NE 115th St & 35th Ave NE	SPU	N3	1998	5

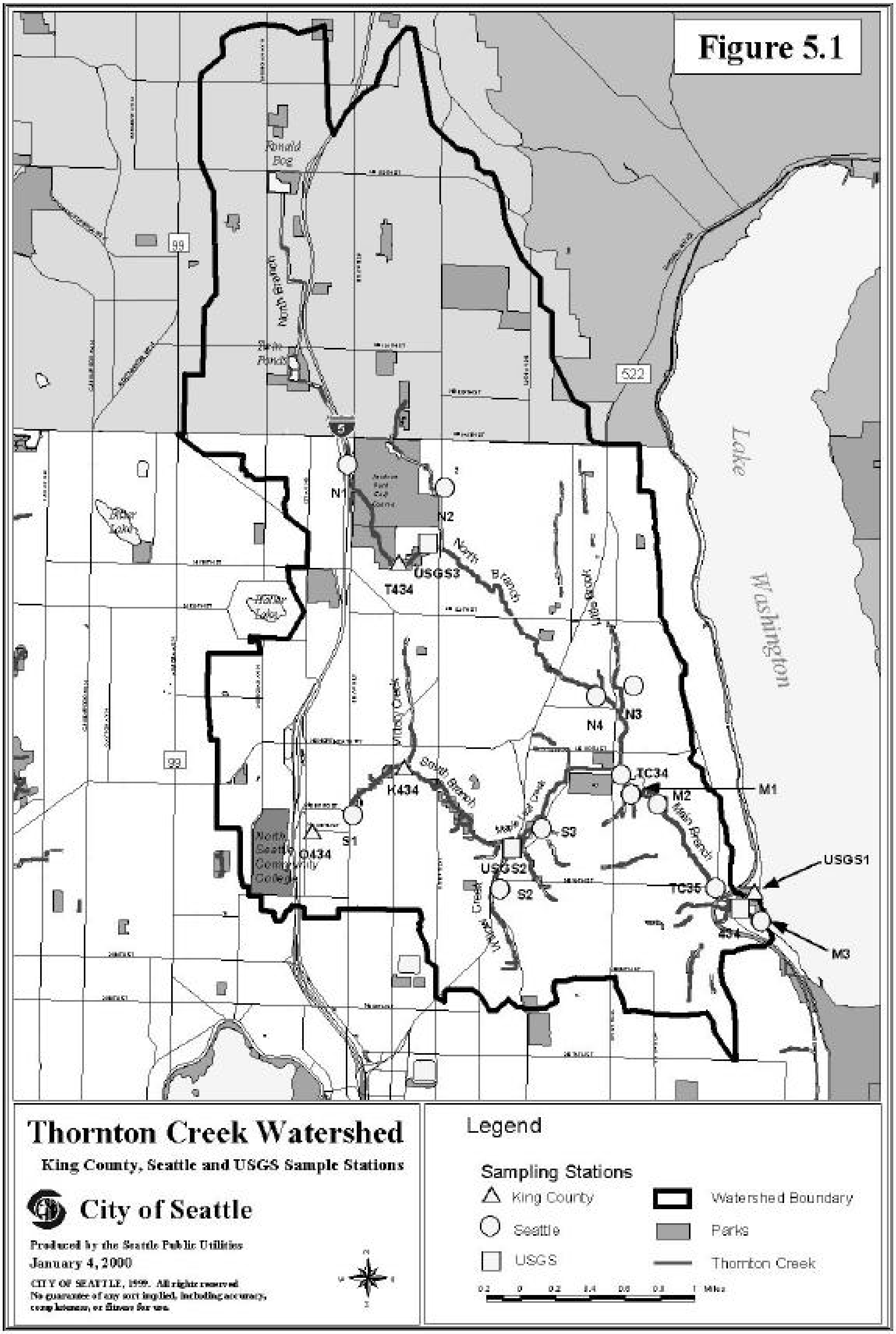


Figure 5.1
Thornton Creek Watershed
King County, Seattle and USGS Sample Stations
City of Seattle
Produced by the Seattle Public Utilities
January 4, 2000
Legend
Sampling Stations
King County
Seattle
USGS
Watershed Boundary
Parks
Thornton Creek
Lake Washington
North Branch
South Branch
Main Branch
N1
N2
N3
N4
USGS3
T434
K434
S1
S2
S3
USGS2
O434
TC34
TC35
M1
M2
M3
USGS1
434
99
522
5

Water Quality Problems during Dry Weather

During dry weather, the creek is fed from groundwater sources, and the water is usually clear and odorless. Currently, Thornton Creek has numerous water quality problems including fecal coliform bacteria, dissolved oxygen, temperature, and pesticides in summer; and turbidity, total suspended solids, zinc, total phosphorus, and nitrogen during storm events. Fecal coliform levels almost always exceed State standards. During warm summer afternoons, temperature and dissolved oxygen levels frequently violate standards as well. Base flow water chemistry data is summarized in Tables 5.3 through 5.6. The raw data for these tables is presented in Appendix F.

Coliform Bacteria

Fecal coliform bacteria is used to indicate the presence of harmful pathogens in water bodies. Coliform bacteria are commonly found in the intestinal tracts of warm-blooded animals. The presence of high numbers of fecal coliform bacteria in a water body can indicate the release of untreated wastewater and/or the presence of unfiltered animal waste, and may indicate the presence of pathogens. Bacterial contamination can adversely affect swimmers and consumers of fish taken from contaminated areas. Presently, no effective treatment is available to remove the bacteria, and the best known remedy is source control.

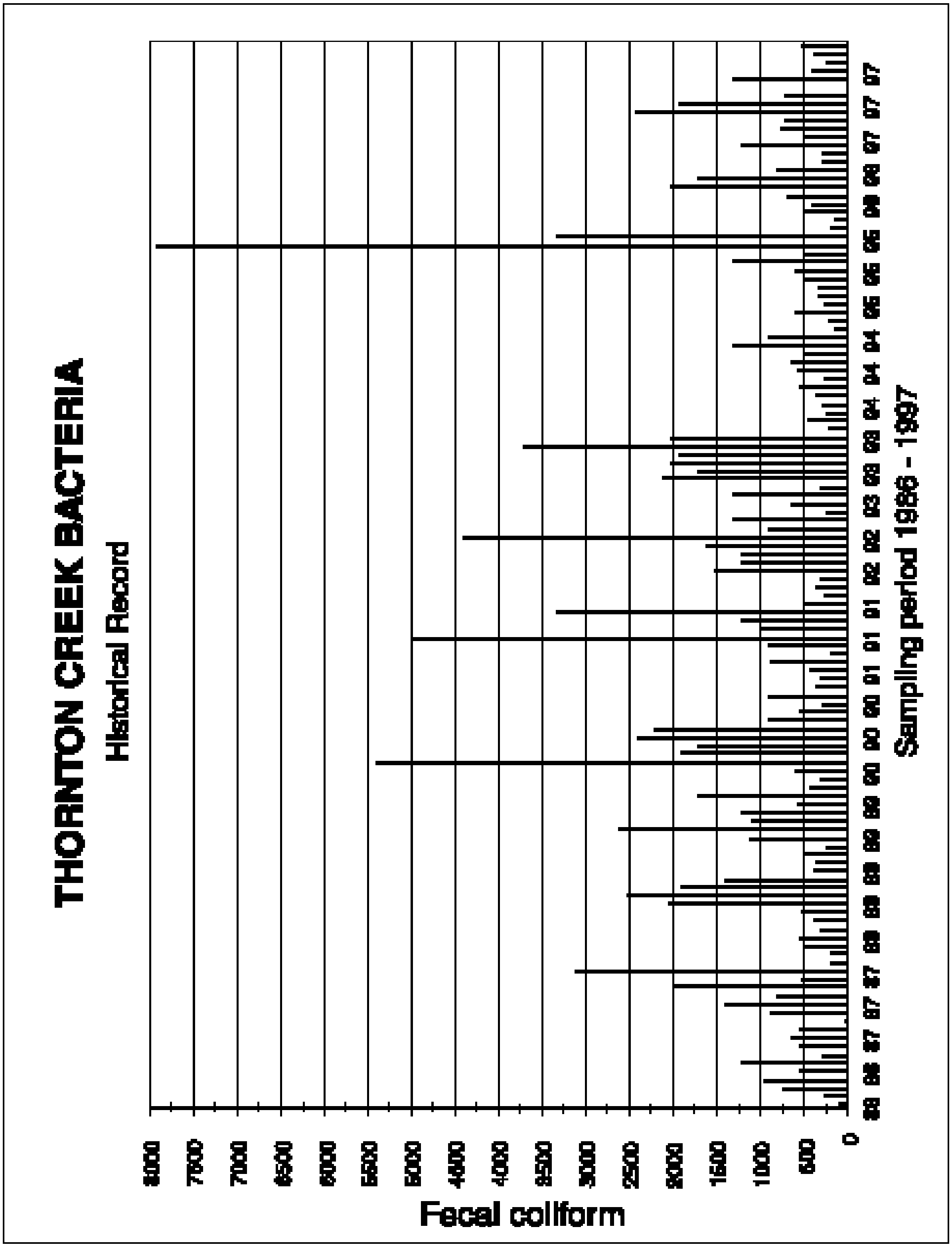
Fecal coliform levels have been routinely measured in Thornton Creek since 1985. Of 128 dry-weather flow samples from 1985 to 1997 taken from the stations in the Main Branch, 126 (98%) exceeded both aspects of State standards (geometric mean of 50 and 10% not exceeding 100 colonies/100 ml) as shown in Figure 5.2. The geometric mean, 1,053 colonies/100 ml, is significantly above State water quality standards. The highest recorded level is 7,900 colonies/100 ml. Thornton Creek is on the 1996 303(d) list for fecal coliform. For water bodies listed on the 303(d) list, Total Maximum Daily Load (TMDL) allocations are required; levels of bacteria above these measured daily fecal coliform threshold levels are considered excessive and unhealthy.

Prior to 1998, it was not known whether fecal coliform levels were high throughout the creek or just at the mouth. SPU's study in 1998 found bacterial levels to be high throughout the creek system. The only exception was the North Branch upstream of Jackson Park Golf Course.

Although Ecology has not adopted a standard for Enterococci (a type of coliform bacteria), the US Environmental Protection Agency (USEPA) has recommended a standard of 31 colonies/100 ml to protect human health. For Thornton Creek, all 91 samples, most from the mouth of the creek, have exceeded this recommended standard. The geometric mean is 613 colonies/100 ml.

The sources of contamination in Thornton Creek remain unknown, but could be from domestic and wild animals, as found in a previous bacterial analysis conducted in Seattle's Pipers Creek. Seattle's Drainage and Wastewater Utility conducted a study in 1992 to track the source of fecal coliform in Pipers Creek (Seattle Drainage and Wastewater Utility, 1993). The study examined ribonucleic acids (RNA) found in fecal coliform from creek samples and compared it to fecal coliform from a variety of sources including excrement of humans, dogs, birds, and small mammals. This bacterial study concluded that the fecal coliform found in Pipers Creek was not human in origin. It came from a number of sources; of the approximately 40% that could be traced, the primary sources were cat and dog wastes. A study is needed to identify the sources of bacterial contamination in Thornton Creek and the health concerns for humans.

Figure 5.2. Fecal Coliform Levels in Thornton Creek Samples in Colony Forming Units (CFU)/100 ml.



Source: King County Data from Station 434, Thornton Mouth. See Section 5.8.

Dissolved Oxygen

Dissolved oxygen (DO) is required by all aquatic life. In natural streams, oxygen is gradually consumed by bacteria as leaves, algae, and other vegetation decay. It is replaced by oxygen at the air/water interface, and by photosynthesis from aquatic plants. Oxygen can often become depleted in deep, slow moving streams, or in streams with warm temperatures or excessive nutrients. Dissolved oxygen is more soluble in cold in water than in warm water. High levels of nutrients, such as yard waste or fertilizers, cause algae to thrive; as algae dies and decomposes, dissolved oxygen levels are lowered.

For most of the year, dissolved oxygen levels in Thornton Creek are satisfactory. From 1985 to 1997, the average level in the Main Branch was 10.6 mg/L, above the 9.5 mg/L Washington minimum standard. However, during summer, low dissolved oxygen levels are a problem. Dissolved oxygen has violated the standard for each summer sampling has occurred and at every sampling station; approximately 30% of the samples have been below the standard.

In SPU's 1998 study (1998), depressed levels of dissolved oxygen were found to be a problem on hot afternoons at locations throughout the creek. SPU measured dissolved oxygen levels during the worst case scenario (weather conditions yielding the most depressed levels in past measurements), hot afternoons in July and August. On afternoons when air temperatures were over 70 degrees, SPU recorded five readings from ten locations; each time dissolved oxygen levels were below the 9.5 mg/L standard. The mean dissolved oxygen value was 6.7 mg/L and the lowest reading was 4.2 mg/L (See appendix G).

Additional information about dissolved oxygen levels is needed because there can be a significant difference in dissolved oxygen levels within a watershed, as well as the dissolved oxygen level at the surface and the dissolved oxygen level in the streambed gravel. The dissolved oxygen available to incubating eggs in gravel is often lower than dissolved oxygen available to adults in surface water (State of Oregon, 1995). The lethal limit of intergravel dissolved oxygen for Coho is 7.1 mg/L (State of Oregon, 1995). Also, field studies have shown that low oxygen levels can delay development and reduce the size of alevins at hatching; at intergravel dissolved oxygen concentrations of 5 mg/L or less, there is poor survival from the redd, whereas survival is greater at intergravel concentrations of 8.0 mg/L or greater (State of Oregon, 1995). A surface water measurement of 6.7 mg/L suggests that the intergravel dissolved oxygen could be below 3.7 mg/L based on USEPA's recommendation for assuming a loss of 3 mg/L from surface water to gravel (State of Oregon, 1995). It is likely that dissolved oxygen levels in Thornton Creek are having at least a sub-lethal effect on Coho and potentially other salmon and trout.

In streams, dissolved oxygen problems are frequently caused by organic matter decomposition, high water temperatures due to urban runoff and lack of vegetative cover, and low rates of agitation. Bacteria decompose organic matter including aquatic plants, which can be stimulated by fertilizers and other sources. Low agitation rates occur due to the lack of instream habitat features like large woody debris that serve to agitate the water and replace the oxygen in the water column.

To determine if dissolved oxygen levels are a limiting factor for fish, dissolved oxygen data is needed. This information can be obtained by deploying probes at several locations that can measure and record dissolved oxygen levels at regular intervals in the surface water and the intergravel area.

Temperature

Water temperature depends on a number of factors including the source of stream water, the flow rate, weather conditions, and the amount of shading. Temperature is important because certain fish species, such as trout, salmon, and some micro-invertebrate species, prefer a certain temperature range and may not survive in warmer conditions.

High water temperatures have been found in Thornton Creek. Between 1985 and 1997, recorded temperatures exceeded the Ecology standard of 16 degrees centigrade on nine occasions near the mouth of Thornton Creek and once each at Stations K434 and T434 (King County monthly data 1985-97 and SPU 1998). The infrequent exceedances suggest temperature is of minor concern. However, the data were usually collected during the morning and do not fully represent peak summer temperatures. It is possible that exceedances of the temperature standard are much more frequent than indicated by the record.

In SPU's 1998 study, SPU recorded temperatures during worst-case conditions, hot summer afternoons (weather conditions yielding the most depressed levels in past measurements). During this study, temperatures throughout the creek system frequently exceeded 16 degrees centigrade and maximum temperatures were recorded as high as 22 degrees centigrade; the average temperature was 19 degrees centigrade. This study did not gather enough information to determine how often temperatures exceed criteria.

Although the creek flows through pipes and wooded park and ravine areas, much of the creek flows through backyards, where the canopy cover is often limited. Any efforts which successfully lower water temperature will also benefit dissolved oxygen levels.

Nutrients

Phosphorus and nitrogen are important chemicals for aquatic and terrestrial plant growth and are also indicators of organic pollutant loads. If high levels of these two nutrients are present, excessive aquatic plant growth can choke a stream. Sources of excess nutrients include leaves, grass clippings, pet waste, sewage, and fertilizers.

There are no Washington State standards for phosphorus or nitrogen. Phosphorus levels in the lower stations average 0.068 mg/L, well below the guideline (USEPA, 1986) of 0.10 mg/L. The average concentration during the summer months (June through September) is not statistically different from the annual average. The average phosphorus concentration at the lower stations was 0.068 mg/L for data collected between 1986 and 1997. At the upper stations (Stations 0434, T434, and K434), the phosphorus concentration in 1974 was consistently higher, on the order of 0.1 to 0.2 mg/L. Phosphorus concentrations dropped noticeably at these two stations beginning in late 1976 and remained consistently lower through the end of the record in 1982 – generally in the range of 0.06 to 0.10 mg/L. This range is similar to that observed at the lower stations between 1986 and 1997. It is not known whether the change reflects water quality conditions or a change in the laboratory method of analysis.

Sediments

All streams transport sediments as they erode streambanks and create sandbars. The sand and gravel-sized sediments tend to settle along the banks and create bars and/or deltas. Fine sediments may be so small that they remain suspended in the water column. These suspended sediments are not regarded as a pollutant unless they are present in excess. High levels of suspended sediment can carry metals and other contaminants, directly injure fish, and smother gravel beds needed for spawning. Suspended sediment levels are often used as an indicator of turbidity. The standards call for turbidity levels to be no more than 5 NTU above background. During dry weather, the mean value of the Main Branch was 2.2 NTU. The King County and

Seattle turbidity readings varied from 0.1 to 20 NTU. The record shows occasional exceedances above 7.2 NTU. In addition to instream sources, fine sediments come from construction sites, street sanding for snow and ice, recently landscaped areas, and other areas with exposed soils.

Metals

Metals can be harmful to aquatic life. Metals enter Thornton Creek by a number of paths. They tend to bond to fine sediment and air particles and enter the stream through stormwater runoff and precipitation. The sources of metals include vehicle emissions, brake pad dust, paint, roofing materials and some garden chemicals. Metal concentrations may be measured as total metals and as dissolved metals. Data on total metal concentrations are included in Table 5.3. The concentration of dissolved metals correlates more closely to aquatic health than total metal concentrations. However, during dry weather, dissolved metal concentrations are often below the detection limit.

Washington State has two standards for dissolved metals, chronic and acute. The acute standard represents the average concentration over one hour, and the chronic standard represents the average condition over four days. Although data from dry-weather flows are grab samples, it is not unreasonable to compare the data to acute and chronic standards since the metals concentrations are not likely to vary significantly within the four-day period surrounding the time of the grab sample in the absence of a storm. Only two samples of dry-weather flow have been analyzed for dissolved metals, at Stations T34 and T35 in 1991. Only zinc was detected and at very low levels, 0.004 and 0.010 mg/L. The dissolved metal data are not included in Table 5.3.

Table 5.3. Summary of Base Flow Water Quality Data for Thornton Creek, 1985 to 1997 (Main Branch)

Parameter	Period	No. of Samples	Minimum	Maximum	Mean	Median	SD
pH	3/86-12/97	119	6.83	8		7.7	
DO	3/86-5/97	114	8.9	14	10.6	10.3	1.2
Turbidity	3/86-12/97	120	0.1	20	2.2	1.8	1.4
TSS	3/86-12/97	121	0.60	73	4.6	3.4	4.4
Total Phosphorous	3/86-12/97	121	0.0074	0.273	0.068	0.071	0.020
Ammonia	3/86-12/97	106	0.001	0.12	0.031	0.022	0.022
Nitrate	5/86-12/97	119	<DL	2.03	1.27	1.24	0.21
Chromium	3/93-10/97	3	<DL	0.055			
Copper	3/93-10/97	3	0.0047	0.010			
Zinc	3/93-10/97	3	0.021	0.056			
Temperature	9/85-12/97	196		17.6			
Fecal coliform	3/86-12/97	128	2	7,900	1,058	600	1,146
Enterococci	1/89-12/97	92	29	7,900	613	370	1,038

Samples taken on the Main Branch at Stations TC34/TC35/434
SD = Standard Deviation
DL = Detection Limit.
Fecal coliform and Enterococci are geometric means.
Metals are total metal concentrations.
Too few samples for the metals to calculate means and medians.
Temperatures for dry-weather and storm flows are combined.
All data are in mg/L except pH, temperature (^oC), bacteria (colonies/100ml), and turbidity (NTU).

Table 5.4. Summary of Base Flow Water Quality Data for Thornton Creek, 1974 to 1982 (South Branch)

Parameter	Period	# of Samples	Minimum	Maximum	Mean	Median	SD
pH	3/74-6/82	68	7.2	8.5		7.5	
DO	"	65	7.6	12.2	9.8	9.5	0.0
Turbidity	"	68	0.7	20	3.2	2.5	3.0
TSS	"	67	0.5	30	3.9	2.3	4.4
Total Phosphorus	"	67	0.007	0.24	0.11	0.075	0.06
Ammonia	"	68	0.007	0.09	0.033	0.03	0.019
Nitrate	"	66	0.46	3.2	1.51	1.5	0.42

Samples taken on the South Branch at Stations O434/K434
SD = Standard Deviation
All data are in mg/L except pH and turbidity(NTU)

Table 5.5. Summary of Base Flow Water Quality Data for Thornton Creek, 1974 to 1982 (North Branch)

Parameter	Period	# of Samples	Minimum	Maximum	Mean	Median	SD
pH	3/74-6/82	58	6.8	8.1		7.5	
DO	"	55	8	12.5	10.2	10	0.9
Turbidity	"	58	0.8	11	2.7	2.2	2.1
TSS	"	56	0.7	26	4.6	3	4.6
Total Phosphorus	"	57	0.041	0.23	0.10	0.072	0.056
Ammonia	"	58	0.002	0.12	0.034	0.03	0.026
Nitrate	"	56	0.59	2.57	1.41	1.39	0.27

Samples taken on the North Branch at Station T434
SD = Standard Deviation
All data are in mg/L except pH and turbidity(NTU).

Pesticides

Pesticides in the aquatic environment are a concern because of possible toxic effects on fish, wildlife, and human health. Pesticides include chemicals designed to kill weeds (herbicides), insects (insecticides), and fungi (fungicides). USGS and Ecology have conducted studies to assess the occurrence of pesticides in streams and streambed sediments in the Puget Sound basin; this section describes the findings on pesticides in streams and stormwater in Puget Sound, including specific results for Thornton Creek. Findings on pesticides in sediments are presented later in this chapter.

1995 Ecology and USGS Findings for Puget Sound. From 1987 to 1995 Ecology and USGS monitored pesticide concentration in streams. Various land uses around Puget Sound streams were evaluated.

Table 5.6. SPU Summer 1998 Sample Data (See Figure 5.1 for sample station location)

Station ID	pH Units		Temperature (°C)			Dissolved Oxygen (mg/l)			Fecal Coliform (CFU/100ml)		
	min	max	min	max	mean	min	max	mean	min	max	mean
TC-N1	7.1	7.8	15	17	16.6	4.24	7.68	5.63	25	138	55
TC-N2	7.4	8.0	19	22	20.3	4.7	7.47	6.03	690	3,000	1,860
TC-N3	7.8	8.1	19	20	19.5	6.1	9.41	7.36	186	600	339
TC-N4	6.4	8.3	18	20	19	4.93	8.12	6.47	320	1,020	477
TC-S1	7.4	8.0	18	22	19	5.14	7.54	6.51	300	2,400	720
TC-S2	7.8	8.2	16	20	17.8	5.94	8.36	7.42	160	620	357
TC-S3	7.7	8.4	18	19	18.4	5.79	7.93	7.2	150	420	306
TC-M1	8.0	8.4	18	21	19.3	5.79	6.9	6.4	460	850	669
TC-M2	8.0	9.1	19	22	20.3	6.24	8.06	7.4	380	2,600	1,174
TC-M3	6.5	8.5	19	21	20.5	6.11	8.11	7.28	440	4,600	983
All Sta.	6.4	9.1	15	22	19.1	4.24	9.41	6.7	25	4,600	528

The results were summarized in a USGS fact sheet, Pesticides in Selected Small Streams in the Puget Sound Basin, 1987-1995 (Bortleson, Davis, 1997). Significant findings were:

- The most commonly detected pesticides in streams were among the most commonly used in the basin. The most frequently detected pesticide was 2,4-D, a herbicide.
- Pesticide concentrations generally were small.
- Pesticides that are currently banned in the US were found in streambed sediments.
- In general, more pesticides were detected in urban streams than in agricultural streams.

It is important to note that State or Federal freshwater aquatic life criteria have been established for only two of the detected pesticides, and neither were exceeded during this monitoring effort. Therefore, EPA, USGS, and Ecology used other tools to evaluate possible impacts to aquatic life in lieu of criteria because pesticides can be highly persistent.

1992 Thornton Creek Data. As part of the above-referenced study, Ecology analyzed water samples from Thornton Creek for pesticides. The samples were taken on June 14, 1992 (Davis, 1993). Of 162 compounds tested, the only one above the detection limit in Thornton Creek was an insecticide, diazinon, at a concentration of 0.077 ug/L. Aquatic life criteria have not been established in Washington for diazinon; however, the recommended maximum concentration (National Academy of Science, 1973) is 0.009 ug/L. The majority of streams with detectable amounts of diazinon, including Thornton Creek, had diazinon levels above the recommended maximum concentration.

Diazinon is a broad-spectrum insecticide commonly used by homeowners and pest control professionals. The primary use for diazinon is for general insect control, with the most common targets being ants, fleas, ticks, grubs, and spiders. It is also used to control crane fly larvae in lawns. Diazinon is highly toxic to aquatic life at low levels. It is very soluble and therefore mobile in the urban environment. Although it eventually breaks down in the environment, diazinon has a half-life (the point at which a substance is at half of it's original strength) of about 40 days in surface waters (Watershed Protection Techniques, Vol. 3, No.1).

1998 USGS Stormwater Pesticide Samples for Puget Sound. Earlier data from USGS studies showed that instream pesticide concentrations are highest during spring storms. USGS collected additional pesticide data from samples of stormwater entering Puget Sound streams in April and May 1998. USGS also evaluated pesticide sales information. Data from home and garden stores indicated that pesticide application rates are greatest in these two months. SPU resource planning associates have speculated a connection between increased residential use of lawn and garden chemicals and high urban creek pesticide levels during spring. Between two and four surface water samples were collected at 12 study sites in King County in ten urban or suburban watersheds and in Rock Creek, an undeveloped basin.

The results were summarized in a USGS fact sheet, Pesticides Detected in Urban Streams during Rainstorms and Relations to Retail Sales of Pesticides in King County, Washington (Voss, Embrey, Ebbert, 1999), as follows:

- Twenty-three pesticides were detected in water from urban streams during rainstorms, and the concentrations of five of these pesticides exceeded limits set to protect aquatic life.
- Pesticides used on lawns and gardens contributed to the occurrence of several pesticides in urban streams.
- Many pesticides found in urban streams might be the result of nonresidential applications, i.e., licensed applicators. Almost half of the 23 pesticides detected were not sold from home and garden stores in King County. This indicates that some pesticides are being applied to nonresidential areas such as rights-of-way, parks, and recreational areas.

1998 USGS Data for Pesticides in Thornton Creek. As part of the USGS 1998 study, stormwater samples were collected on May 14 at three sites in Thornton Creek: the South Branch (just upstream of the south/north branch confluence), the North Branch (downstream of the golf course), and the mouth of the creek (Matthews Beach Park). Thirteen pesticides were identified in Thornton Creek, as shown in Table 5.7. Only diazinon was detected at levels above freshwater aquatic life criteria, although criteria have not been established for all the detected pesticides. The samples taken downstream of the golf course (North Branch) are not very different from samples collected from the other stations. The notable differences are a higher level of atrazine (which is not sold in retail stores), and a lower level of diazinon (which is not permitted on golf courses) and trichlopyr. Approximately half of the compounds detected in Thornton Creek were found in every site in the study where pesticides were detected.

Water Quality During Storms

Storm events significantly impact water quality because stormwater runoff washes pollutants off streets, parking lots, and other surfaces. Stormwater runoff is generally untreated. In urban areas, concentrations of suspended solids, phosphorus, bacteria, and metals typically increase during storms. Levels of dissolved oxygen, pH, ammonia, and nitrate do not appear to change during storms. A summary of the stormwater data is presented in Tables 5.8 to 5.10. The storm data are from a variety of sample types such as individual grabs, timed-composites, and flow-weight composites. Conclusions about water quality during storms must be viewed with caution given the differences in collection protocols.

Total metals concentrations are likely higher during storms, although the limited amount of data for dry-weather flows prevents firm conclusions. Only zinc, lead, and copper have been detected in all stormwater samples. Arsenic, cadmium, and silver were never detected in storm flows. Chromium and nickel have been infrequently detected. Analysis for dissolved metals in

Table 5.7. Pesticides Detected in Thornton Creek Stormwater Samples, USGS 1998

Active Ingredient (Trade Name Example)	Acute[1]	Chronic[1]	RMC[2]	Main Branch (n=2)	North Branch (n=3)	South Branch (n=2)
Detected Herbicides*						
2,4-D (Weedone)	10	1	4	0.11	0.103	0.095
4-Nitrophenol				0.069	< 0.076	0.081
Atrazine (Aatrex)	70	7	2	E 0.002	0.006	< 0.001
Dichlobenil (Casaron)			37	0.079	J 0.031	J 0.41
MCPA (Kilsem)			2.6	J 0.028	J 0.042	J 0.02
MCPP (Mecoprop)				0.102	0.122	J 0.06
Prometon (Pramitol)				0.058	0.034	0.059
Simazine (Princep)	100	10	10	0.437	0.016	0.188
Tebuthiuron (Spike)				< 0.01	0.028	< 0.01
Trichlopyr (Garlon)	5600	560		0.295	J 0.036	0.116
Detected Insecticides*						
Carbaryl (Sevin)	0.17	0.017	0.02	E 0.005	**E 0.003	E 0.008
Diazinon	0.16	0.04	0.009	0.145	0.076	0.124
Detected Fungicides*						
Pentachlorophenol (Penta)	19	15	0.5	0.068	0.034	0.04

*All concentrations shown in ug/L

**Only one reading above detection

< Below detection limit. E – Estimate J – Compound present, but below detection limits

[1] Acute & chronic standards for freshwater aquatic life, Norris & Dost, 1991.

[2] RMC from National Academy of Sciences, 1973 and Ministers of Health Canada and Environment Canada, 1995.

stormwater has been limited to four events at Station T34 and three events at Station T35. However, in one of these events (June 20, 1991) the standard for copper was exceeded at both stations.

Comparison to Other Seattle Creeks

Minton compared water quality in Thornton Creek to two other Seattle creeks, Pipers and Longfellow (Minton, 1998). Land use in both the Pipers and Longfellow Creek watersheds is similar to the Thornton Creek watershed. Except for bacteria, no significant differences between the creeks were evident for dry-weather flows. Thornton Creek appears to have the highest average bacteria counts, although the most extreme events have occurred in Pipers Creek.

With storm flows, most parameters are similar in concentration when comparing the average concentrations. The exceptions (for example, ammonia) are not statistically different because of the substantial variability between storms. See Minton's report (Appendix E) for more details.

Table 5.8. Summary of Storm Flow Water Quality Data for Thornton Creek (Main Branch)

Parameter	Period	# Samples	Minimum	Maximum	Mean	Median	SD
pH	3/86-12/97	45	6.41	8.2		7.3	
DO	"	44	8.1	12.8	10.5	10.8	0.9
BOD	"	6	<10	17	11	12	4.6
Turbidity	"	49	2.1	53	16	12	13
TSS	"	50	4.75	290	54	28	13
Oil & grease	"	4	<0.5	1.2	*		
Total phosphorus	"	48	0.041	0.89	0.174	0.013	0.149
TKN	3/93-10/97	9	0.74	3.5	1.42	0.89	0.97
Ammonia	3/86-12/97	37	0.014	0.17	0.060	0.06	0.04
Nitrate	"	50	0.364	1.9	0.78	0.64	0.35
Chromium	6/91-10/97	15	<DL	0.016	<DL	<DL	
Copper	"	24	0.0041	0.028	0.013	0.009	0.007
Lead	"	14	0.003	0.067	0.041	0.040	0.016
Nickel	"	24	<0.01	0.013	*	<DL	
Zinc	"	24	0.021	0.132	0.059	0.047	0.030
Dissolved copper	"	7	0.003	0.013	0.007	0.05	0.004
Dissolved zinc	"	7	0.013	0.064	0.027	0.017	0.018
Fecal coliform	4/86-12/97	44	4,000	9,300	1,763	2,200	2,324
Enterococci	3/89-12/97	31	210	14,000	2,176	3,000	2,954

Samples taken on the Main Branch at Stations TC34/TC35/434
SD = Standard Deviation
DL = Detection Limit
Fecal coliform and Enterococci are geometric means.
Metals are total metal concentrations.
Too few samples for the metals to calculate means and medians.
TKN is total kjeldahl nitrogen, which is organic nitrogen plus ammonia.
Temperatures for dry-weather and storm flows are combined.
All data are in mg/L except pH, temperature (^{o}C), bacteria (colonies/100ml), and turbidity (NTU).

Table 5.9. Summary of Storm Flow Water Quality Data for Thornton Creek (South Branch)

Parameter	Period	# Samples	Minimum	Maximum	Mean	Median	SD
pH	3/74-6/82	11	7	8.3			
DO	“	9	7.5	11.9	9.5	9.3	
BOD	“	11	0.8	7.6	2.4	1.7	1.2
Turbidity	“	11	1.3	34	12	12	1.8
TSS	“	11	2.3	54	19	17	9
Total phosphorus	“	11	0.058	0.24	0.130	0.099	17
Ammonia	“	11	0.07	0.10	0.056	0.06	0.056
Nitrate		11	0.448	1.49	0.86	0.75	0.34

Samples taken on the South Branch at Stations O434/K434
SD = Standard Deviation
All data are in mg/L except pH and turbidity (NTU).

Table 5.10. Summary of Storm Flow Water Quality Data for Thornton Creek (North Branch)

Parameter	Period	# Samples	Minimum	Maximum	Mean	Median	SD
pH	3/74 - 6/82	7	6.7	7.7		7.1	
DO	“	5	9.4	10.57	10.1	10.05	0.4
BOD	“	7	0.9	2.4	1.8	2	0.6
Turbidity	“	7	0.7	14	7	7.3	5
TSS	“	7	4	26	12	7.3	8
Total phosphorus	“	7	0.035	0.097	0.069	0.068	0.018
Ammonia	“	7	0.015	0.102	0.051	0.044	0.03
Nitrate		7	0.68	1.45	1.04	1.01	0.28

Samples taken on the North Branch at Station T434
SD = Standard Deviation
All data are in mg/L except pH and turbidity (NTU).

Comparison to King County Creeks

Information on local creeks comes from Water Quality of Small Lakes and Streams (King County, 1994). This report covers four years of data collected from 1990 through 1993. King County evaluated data of dry-weather flows obtained in 23 sampling events at 50 sites. Table 5.11 compares Thornton Creek with median concentrations found in western King County.

Thornton Creek has higher bacterial levels than other King County creeks. Thornton Creek has slightly higher median values for nutrients such as total phosphorus levels, ammonia, and nitrate than other county streams. For dissolved oxygen, suspended solids and turbidity, Thornton Creek medians were comparable to other streams.

Table 5.11. Comparison of Dry-Weather Water Quality in Thornton Creek and King County Creeks

Parameter	Ecology Standard	King County Median	Thornton Median
pH	Between 6.5 and 8.5 units	7.5	7.7
Dissolved oxygen	Greater than 9.5 mg/L	10.4	10.3
Suspended solids	No Ecology standard	3.4	3.4
Turbidity	Less than 5 NTU above background	1.8	1.8
Total phosphorus (mg/L)	No Ecology standard	.048	.071
Ammonia (mg/L)	No Ecology standard	.015	.022
Nitrate + nitrite (mg/L)	No Ecology standard	.630	1.24
Fecal coliform	< 50 CFU/100 ml	100	600
Enterococci	No Ecology standard	53	370

CFU = Colony forming units (organisms)

Lake Data

Ronald Bog, a 6.5-acre open water wetland, and Twin Ponds (4.3 acre and 0.9 acre open water lakes), located in the City of Shoreline, are the two largest water bodies in the watershed (See Figure 1.1). Water quality data is largely unavailable for these ponds. Ronald Bog and Twin Ponds were historically bogs, which would normally have had lower pH values. They were dredged in the 1950s. Based on the limited existing data, the City of Shoreline expects these lakes to be eutrophic – that is, high in dissolved nutrients with high organic production (Shoreline, 1997). This type of lake is often shallow and seasonally deficient in oxygen. Over time, eutrophication leads to the filling of lakes as they transition to swamps, marshes, and bogs. Some data on Ronald Bog is presented in the following section.

5.3 Review of Other Water Quality Data

Several other sources of data have been presented to the Watershed Management Committee. These sources include University of Washington (UW) researchers, the students and teachers involved in the Thornton Creek Project (TCP), a UW thesis on a study of Paramount Park wetlands, and a comparison of Ravenna Creek and Thornton Creek. This section briefly summarizes some of this data presented to the Committee.

Effects of Urbanization on Small Streams

Thornton Creek was one of 22 Puget Sound lowland streams studied by the University of Washington (May et al., 1997) to assess the cumulative effects of urbanization on streams. Researchers examined instream characteristics, riparian conditions, physio-chemical water quality, and biological attributes. Thornton Creek represented the watershed with the highest level of urbanization, measured by percentage of impervious surface area within watershed boundaries. (See Section 1.4 for a summary of this work.)

Chemical water-quality constituents were monitored under base flow and storm flow conditions. Baseflow conductivity, considered a surrogate for total dissolved solids and alkalinity, was found to be strongly related to the level of basin development and impervious surface. Mean concentrations for several chemical constituents were found to be related to both storm size and basin imperviousness. However, water quality criteria were rarely violated except in the most highly urbanized watersheds, where total impervious surface area was greater than 45%. As with other recent studies, these findings indicate that chemical water quality of urban streams is generally not significantly degraded at low impervious levels such as 10%, but may be a more important factor in streams draining highly urbanized watersheds.

Biological conditions were assessed using an indicator of the integrity of the benthic macro-invertebrate population (Benthic Index of Biotic Integrity, or B-IBI) and the salmonid community (using a ratio of juvenile Coho salmon to Cutthroat trout. (See Sections 4.4 and 5.6 for Thornton Creek benthic sampling results and Section 4.4 for fish populations in Thornton Creek.) The study showed a direct relationship between percent impervious surface and biological integrity using both measures. There appears to be a rapid decline in biotic integrity when the total impervious area exceeds 10%. The researchers reported it appears unlikely that streams draining highly urbanized sub-basins (over 45% impervious) could maintain a BIBI greater than 15 (minimum score is nine, maximum is 45). Only stream reaches in undeveloped areas (less than 5% impervious) showed a B-IBI greater than 32.

Thornton Creek Project

The Thornton Creek Project (TCP) staff and students have collected data from Thornton Creek since 1991. TCP has worked with schools in the watershed to coordinate the sample collection times, analytical parameters, and analysis techniques. TCP is putting the data into a single database. The sample locations are listed in Table 5.12. TCP receives financial support from SPU, North Seattle Community College, Lakeside School, King County, and private organizations.

Unlike the data from Seattle and King County, the TCP data examines water conditions at a minimum of 12 points in the watershed. Students routinely test Thornton Creek for one or more of the following parameters: temperature, pH, conductivity, dissolved oxygen (DO), flow, turbidity, total phosphorus, total solids, nitrates, and fecal coliform. In addition to these parameters, Thornton Creek Project participants have also informally surveyed macro-invertebrates. The TCP data was not incorporated in Minton's review because an accredited laboratory did not perform the analysis and different analytical methods were sometimes used. Despite this, TCP data helps create a more full picture of watershed health

The results of the TCP data, summarized in Table 5.13, are similar to data collected by Seattle and King County. Maximum water temperatures in the creek were below 16^{o} C; some temperatures above 16^{o} C were noted in Ronald Bog pond. Students collected samples during the school year from September through June, therefore summer temperatures were not measured. The flow data are also similar to other flow information collected for Thornton Creek. Water clarity was measured using a Secchi disk, a different technique from the one used by the City and County.

TCP data showed dissolved oxygen levels in Thornton Creek were routinely below 9.5 mg/L. The results suggest it would be prudent to collect additional dissolved oxygen samples from several locations along the creek for analysis at an accredited laboratory.

The pH measurements generally fell between 6.5 and 8, except for one slightly lower reading at Ronald Bog, which should have lower pH values because of its peat based substrate. Minton (1998)found an average dry-weather total phosphorus reading of 0.07 mg/L. TCP data shows phosphorus values ranging from 0.03 to 0.2 mg/L for creek samples and up to 0.3 mg/L for Ronald Bog. Nitrate levels ranged from 0.02 to 8.8 mg/L; 8.8 mg/L is quite high and may reflect a lab error or sewage leak.

Table 5.12. Thornton Creek Project Sampling Sites (parameters vary per site and sampling group)

Location	Station ID	Creek/Tributary
Jackson Park	N 3.4	North Branch
Paramount Park	L2	Littles Creek (tributary to North Branch)
Executive Suites		Littles Creek (tributary to North Branch)
Park #6	S 2.3	South Branch
Park #6	S 2.1	South Branch
South Fork Falls	S 1.8	South Branch
South Fork Hale	S 0.2	South Branch
Weight Watchers	W 0.4	Willow Creek (tributary to South Branch)
Lower Willow	W 0.1	Willow Creek (tributary to South Branch)
Ronald Bog		Ronald Bog (headwaters of North Branch)

Paramount Park Wetlands

Students from Shoreline Community College investigated the impact of a recently constructed wetland on water quality (Cowan, 1999). Over a course of three months, students investigated water quality in the constructed wetland located in Shoreline's lower Paramount Park (See Figure 3.16). The wetland is located beside Littles Creek, a tributary to the North Branch of Thornton Creek. Nitrates, dissolved oxygen, conductivity, pH, and temperature were examined on approximately 11 occasions.

The study concluded that the constructed wetland improved water quality by increasing dissolved oxygen levels, neutralizing pH, and decreasing nitrate levels. The average upstream dissolved oxygen level was 8.06 mg/L and the downstream level was 9.17 mg/L. The average pH levels went from 6.67 to 6.86. After passing through the wetland, the nitrate levels dropped from 11 mg/L to 8.1 mg/L. The study concluded that the wetlands did have a negative impact on water temperature; the average temperature reading increased 1.8° C from 10.4° C upstream to 12.2° C downstream.

Comparison of Ravenna Creek and Thornton Creek

In spring 1999, students from the University of Washington Bothell campus compared stormwater samples from Ravenna Creek to samples from Thornton Creek. The study sought to compare the effect of road runoff on fecal coliform levels between the two watersheds. Several points in Ravenna Creek were sampled and compared to comparably sized Willow creek sub-basin, within the Thornton Creek watershed. The sample watersheds had similar sizes; however, land use and impervious surfaces varied. Land use within the two sample watersheds differs significantly. The Ravenna Creek watershed is primarily situated within a park, and it contains few roads and other hard surfaces. In contrast, the Thornton Creek watershed is well developed with many roads and homes. Very little road runoff enters Ravenna. The samples, analyzed at a certified lab, showed that most Thornton Creek water samples routinely registered high fecal coliform levels, while Ravenna Creek samples did not. The students found Thornton Creek highly responsive to storm events, showing high fecal coliform levels immediately after storms, whereas storm events did not noticeably increase fecal coliform levels in Ravenna. The students hypothesized, based on these results and previous studies, that this was due to the much higher percentage of impervious surface area in the Thornton Creek watershed sample basin. The study concluded that adjacent land use affects fecal coliform levels (Westerbeck and Fischer, 1999).

Table 5.13. Thornton Creek Project Data, Physical Parameters

Parameter	Location	Period	No.	Min.	Max.	Mean
Air Temp (C)	North Branch	2/95 - 9/97	5	11	20	15
"	Ronald Bog	9/91 - 10/96	12	-1.1	22.7	13.6
"	South Branch	11/94 - 2/95	3	6.8	9	8.1
"	Littles Creek	5/96 - 9/97	7	14.6	19.4	16.3
Water Temp (C)	North Branch	2/95 - 10/97	6	9.8	15	13.2
"	Ronald Bog	9/91 - 10/96	9	4.4	18.9	12.7
"	South Branch	11/94 - 2/95	4	7	10	8.2
"	Littles Creek	5/96 - 9/97	7	12	15.3	13
Flow (cfs)	North Branch	2/95 - 9/97	3	1.8	1.9	
"	South Branch	11/94 - 1/97	5	1.1	9.1	
"	Littles Creek	5/96 - 9/97	6	0.2	0.6	
Secchi depth clarity (in)	North Branch	9/97	2	20	20	20
"	South Branch	4/96	1	70		
"	Littles Creek	5/96 - 9/97	6	<5	>70	n/d
Turbidity (mg/L)	Willow Creek	4/96	2	70	70	
TSS (mg/L)	North Branch	9/97	3	61	81.5	72.2
"	South Branch	11/94 - 1/97	2	120.6	167.5	150.3
Dissolved Oxygen (mg/L)	North Branch	2/95 - 10/97	5	8.8	15	10.4
"	Ronald Bog	9/91 - 10/96	10	4	10	6.4
"	South Branch	11/94 - 1/97	7	8	10.6	9.4
"	Willow Creek	4/96	2	12	14	
"	Littles Creek	5/96 - 9/97	5	5	9	7.4
pH	North Branch	2/95 - 10/97	7	6.5	7.5	7.1
"	Ronald Bog	9/91 - 10/96	12	6.25	7	6.8
"	South Branch	11/94 - 1/97	7	4	8	7
"	Willow Creek	4/96	2	7	7.5	
"	Littles Creek	5/96 - 9/97	6	7	7.5	7.2
Total Phosphorous (mg/L)	North Branch	2/95 - 10/97	4	0	0.1	0.09
"	Ronald Bog	9/91 - 10/91	3	0.03	0.3	0.21
"	South Branch	2/95	1	0.1		
Nitrates (mg/L)	Ronald Bog	9/91 - 10/96	11	0	8.8	0.9
"	South Branch	11/94 - 2/95	2	8.8	8.8	
"	Littles Creek	5/96 - 9/97	5	0.1	0.3	0.2
Fecal Coliform (CFU/100ml)	Ronald Bog	9/91 - 10/91	3	18	52	31

Cfs = Cubic feet per second
CFU = Colony forming units

5.4 Sediment Quality

The limited amount of streambed sediment data available on Thornton Creek comes from King County, SPU, and USGS. King County has taken one sediment sample near the mouth of the creek each summer from 1991 through 1997. The County samples were analyzed for metals. Seattle took one sample at Stations TC34 and TC35 in 1991. The City samples were analyzed for metals and conventional parameters.

USGS collected sediment samples near the mouth of Thornton Creek in 1995. The USGS sample was taken as part of the National Water Quality Assessment program, which includes a study in the Puget Sound basin. This program is investigating trace elements and organic compounds, which accumulate in fine-grained streambed sediment and fish tissue, in relation to land use and human activities. In 1995, USGS collected sediment and fish samples from 18 sites around the Sound including Thornton Creek. Samples were analyzed for organic compounds, such as organochlorine pesticides, total PCBs, poly-aromatic hydrocarbons (PAHs), and metals. These compounds are known or suspected to cause harm to aquatic organisms.

Metals

The Puget Sound basin is naturally rich in metals. Even samples from streams in mostly forested areas with little human impact contain arsenic, chromium, nickel, zinc, cadmium, and lead.

Sampling data are shown in Table 5.14. The County and City samples were very similar; the values reported by the USGS are considerably higher. The reason for the difference is not certain; however, USGS sampled at sites that may have had a higher percentage of fine sediments. Pollutants often adhere to small organic matter in the sediment. Total organic carbon was not measured in many of the County and City sediment samples. Sediment contaminants are often reported relative to the amount of organic material (total organic carbon), rather than the total sample, which includes sand and organic material; this is called a “normalized” sample.

Since Ecology does not have freshwater sediment standards, the metal concentrations were compared to Canadian guidelines. The Canadian guidelines list two concentrations for each compound of interest. The threshold effects level (TEL) is the concentration below which adverse effects to aquatic organisms are expected to occur rarely. The probable effects level (PEL) is the concentration above which adverse effects are expected to occur frequently. Concentrations that exceed these guidelines may or may not have adverse effects on aquatic organisms.

Without the total organic carbon data, it is not possible to determine whether current metal levels exceed guidelines. According to USGS reports, the sediment values listed for Thornton Creek exceed Canadian probable effects levels and exceed the median of forest and reference conditions at sampling sites in the Puget Sound basin.

In the 1994 report on small streams and lakes (King County, 1994), the County assessed sediments collected from deltas at the mouths of 20 streams. The County report noted that differences among levels of metals, pollutants, sediments, and other contaminants in streams generally correlated with the relative level of development in the surrounding basin. In 1991 and 1992 samples, Thornton Creek had relatively high levels of metals compared to the other County streams. Thornton Creek samples had the highest levels of cadmium, lead, and zinc; the second highest level of copper; and the third highest level of nickel. Although the cadmium level was higher than other creeks (0.4 mg/kg), it was similar to the 0.5 mg/kg found in Chester

Morse Lake, a drinking water reservoir in a protected watershed, which is considered to have clean sediments.

Table 5.14. Metal Concentrations Detected in Thornton Creek Sediments

Metal	City & County Samples	USGS Samples	Canadian Guidelines	
			TEL	PEL
Arsenic	<DL - 8	19	5.9	17
Cadmium	<DL - 0.4	1.4	.6	3.5
Chromium	17.2-20.9	120	37.3	90
Copper	7 - 16.2	58	35.7	197
Lead	18-50	190	35	91.3
Mercury		.53	.17	.486
Nickel	19-29	65	No guidelines	
Zinc	62-94.2	330	123	315

All data are in parts per billion (ppb).

DL = Detection Limit.

Data sources: Seattle and King County; National Water Quality Assessment Program, USGS, 1998.

Pesticides

In its 1996 study, the USGS also analyzed Thornton Creek sediments for pesticides (Bortleston and Davis, 1997, and Voss, Embrey, Ebbert, 1999). USGS staff compared concentrations to Canadian guidelines, which list two concentrations for each compound of interest: the threshold effects level (TEL) and the probable effects level (PEL). The comparisons are best used to indicate potential sediment quality problems.

High concentrations of organochlorine compounds were detected in Thornton Creek sediments. This type of compound includes DDT and its breakdown compounds DDD and DDE. DDT (dichlorodiphenyltrichloroethane) is an organochlorine insecticide that was banned from use in the US in 1972, but is highly persistent in the environment. Organochlorine pesticides were detected at three of the 18 Puget Sound sites tested: one agricultural, one urban (Thornton Creek), and one reference site. The highest levels were found in Thornton Creek. The data is shown in Table 5.15. Several other detected compounds were found to exceed Canadian guidelines.

Poly-aromatic Hydrocarbons (PAHs)

The USGS also found poly-aromatic hydrocarbons (PAHs) in sediment samples from several study sites in the Puget Sound basin. Many PAHs are toxic and/or carcinogenic in fish and other animals. Typical urban sources include vehicle emissions and some manufacturing processes. PAHs are also produced in forest fires, which are less common in urban environments. Tons of PAHs are emitted to the atmosphere and introduced to the aquatic environment through oil spills, sewage discharge, and urban runoff, particularly via road and parking lot runoff.

Table 5.15. Organochlorine Compounds Detected in Thornton Creek Sediments

Compound	Concentration	Canadian Guidelines	
		TEL	PEL

DDT	8.1	1.19	4.77
DDD	4.6	3.54	8.51
DDE	6.9	1.42	6.75
Dieldrin	1.3	2.85	6.67
Chlordane	4.5	4.5	8.9

All data are in micrograms/kg, dry weight.

Data source: National Water Quality Assessment Program, USGS, 1998.

PAHs were most frequently detected in urban stream sediments. The highest levels were found in Kelsey Creek. Levels detected in Thornton Creek, shown in Table 5.16, exceeded the Canadian TEL, but fell below the PEL.

5.5 Fish Tissue

The USGS study included analysis of tissue from sculpin, a bottom-feeding fish. Sculpin are not usually consumed by humans, but are eaten by other fish and wildlife. Since many states, including Washington, do not have standards for fish tissues, USGS staff compared the data to New York State Department of Environmental Conservation criteria for organic compounds and metals.

Table 5.16. Poly-aromatic Hydrocarbon Concentrations Detected in Thornton Creek Sediments

Compound	Concentration	Canadian Guidelines	
		TEL	PEL
Benzo(a)anthracene	220	31.7	385
Benzo(a)pyrene	310	31.9	782
Chrysene	270	57.1	862
Fluoranthene	470	111	2,355
Phenanthrene	200	41.9	515
Pyrene	410	53	875

All data are in micrograms per kilogram.

Data source: National Water Quality Assessment Program. USGS, 1998.

Organic Compounds

Total PCBs (polychlorinated biphenyls) and/or at least one of 26 organochlorine pesticides were detected in USGS samples of fish tissue at two agricultural and six urban sites, including Thornton Creek. The highest concentrations and greatest ranges of organochlorine compounds were detected at Thornton Creek. For comparison, USGS used New York State criteria for protection of fish-eating wildlife, and found samples from Thornton Creek exceeded these criteria for total PCBs and total DDT. The data is shown in Table 5.17. Bolded values exceed criteria.

Elevated levels of DDT and PCBs are toxic to all animals. These compounds can bio-accumulate in tissue, resulting in increased concentrations at higher levels of the food chain and causing hormonal and behavioral problems and tumors. Additionally, they can suppress the immune and respiratory systems and cause abnormal development. The primary effect on aquatic communities is a reduction in the number of sensitive species, which allows domination by more pollution-tolerant species.

Table 5.17. PCBs and Organochlorine Pesticides Detected in Thornton Creek Fish Tissues

Compound	Thornton Creek Concentration	New York Criteria
Total chlordane	100	500
Total DDT	216	200
Dieldrin	27	120
Total PCB	310	110

All data are in micrograms/kg, wet weight.

Data source: National Water Quality Assessment Program, USGS, 1998.

Metals

Arsenic, lead, mercury, and PCBs were detected in fish tissue obtained from Thornton Creek. Marginally elevated levels of arsenic, cadmium, lead, mercury, and zinc may not be of concern in a naturally metal-rich region such as Puget Sound because the aquatic system has adapted to this type of environment. However, excessive amounts (varies depending on organism size) can affect the nervous, respiratory, circulatory, and reproductive systems of aquatic organisms.

5.6 Benthic Macro-invertebrate Sampling

Benthic populations vary throughout the length of a creek depending on a number of factors, including water depth, water velocity, substrate type, pollution inputs, and canopy cover. The number, variety, and types of invertebrates are important indicators of the health of a creek. Some creatures survive only in pristine conditions, while others thrive in degraded urban streams. Figure 4.3 illustrates some of the benthic macro-invertebrates typically found in Thornton Creek. The presence of creatures with a long life span suggests that conditions have been favorable for several years. Water quality can be assessed by sorting, counting, and identifying macro-invertebrates.

The University of Washington developed a method for evaluating this data called a benthic index of biological integrity (B-IBI). Samples from different creeks are rated according to several criteria including total number, number of species, species dominance, presence of pollution intolerant species (such as Stonefly, Caddisfly, and Mayfly larvae), presence of pollution tolerant species (such as worms, and black fly and midge larvae), and presence of predators and long-lived species.

Regional Sampling Protocol

Regionally there is an established protocol for collecting benthic samples:

- Samples should be collected from "ideal" sites or sites that come closest to meeting ideal conditions, such as riffles with at least three inches of water, cobbled substrate, overhead canopy, and minimal physical disturbances.
- Invertebrates should be collected in late summer, when larvae are large and have not yet burrowed deep into the sediment for winter protection.
- At each site, three samples within the same riffle should be collected with a Surber sampler with a 500-micron mesh size.

The B-IBI is developed for the protocol described above and applies only to lowland streams in the Puget Sound region (Kleindl, 1995, and Karr, 1991). Using the B-IBI, undeveloped (forested) areas often scored between 32 and 45 points. Biotic integrity rapidly declines with urbanization (May et al., 1997). Mid-range B-IBI scores are found in suburban areas with intact wetlands and wide buffers. May concluded that streams in highly urban areas are unlikely to support a B-IBI greater than 15. (See section 7.1 for more information, or go directly to www.salmonweb.org).

Thornton Creek Benthic Invertebrate Data

Benthic macro-invertebrate data has been collected from several sites along Thornton Creek by the University of Washington, King County, City of Seattle, and Thornton Creek Project participants. The University of Washington and Seattle data were collected in accordance with the B-IBI protocol. The sample locations are shown in Figure 5.3. The identity and counts of the benthic macro-invertebrates found in Thornton Creek are presented in Appendix H. Commonly found macro-invertebrates include insect larvae (such as Mayflies, black flies, midges, and Crane flies), worms, crustaceans, leeches, and small clams.

The B-IBI scores are shown in Table 5.18. The results are typical of urban streams. The B-IBI has an error margin of +/- 4 points. Thus conclusions about the “best” places along Thornton Creek should be viewed cautiously. King County does not use the protocol described earlier; however, a review of the data shows similar results for the County.

Table 5.18. B-IBI Scores for Thornton Creek Benthic Macro-invertebrate Samples

Sample Year	Main Branch	North Branch	South Branch	Willow Creek	Littles Creek
1994	10*	16*	12		
1995	14*		12		
1996	12		10		
1998	12	16	10	12	14

*UW data. All other data from SPU.

5.7 Groundwater Quality

Not much is known about groundwater quality in the Thornton Creek watershed. Groundwater testing has not been given a high priority because residents in the watershed obtain their drinking water from the City of Seattle’s Cedar River watershed. The water is piped to local reservoirs, treated, and distributed into homes and businesses. Well water is not used for potable purposes, although it may be used for irrigation. Consequently, well water is not sampled to see if it meets Washington State health standards, and this potential source of data on groundwater quality is not available.

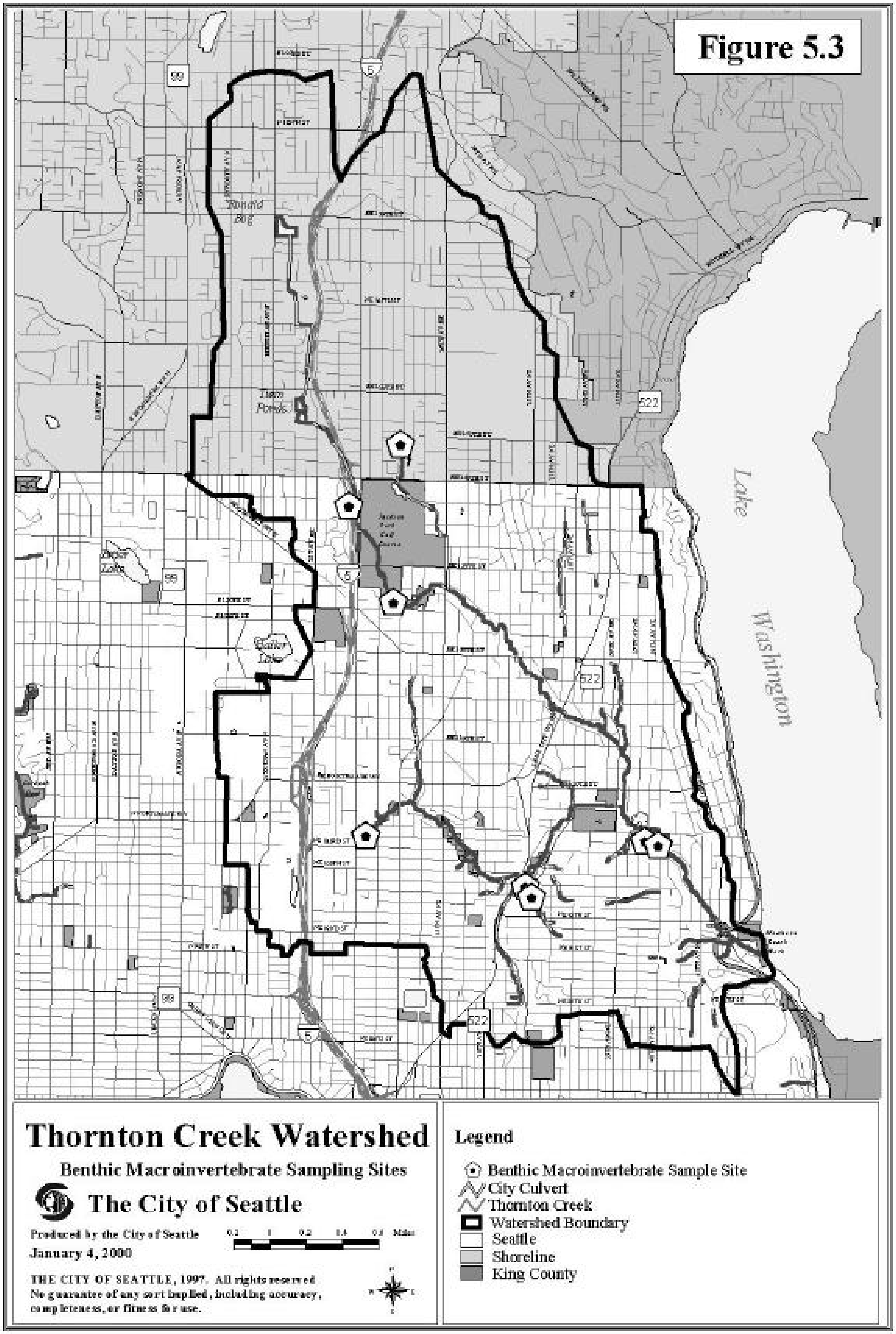


Figure 5.3
Lake
Washington
Thornton Creek Watershed
Benthic Macroinvertebrate Sampling Sites
The City of Seattle
Produced by the City of Seattle
January 4, 2000
THE CITY OF SEATTLE, 1997. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Benthic Macroinvertebrate Sample Site
City Culvert
Thornton Creek
Watershed Boundary
Seattle
Shoreline
King County

Businesses in the Seattle area do not use injection wells to pump water or waste materials into the soil. The main source of groundwater recharge is stormwater soaking into the soil. Some pollutants contained in stormwater runoff may be removed as the water filters through the soil to reach the water table.

Problems associated with groundwater probably include leaking underground storage tanks, both commercial (such as gas stations) and residential (such as home heating fuel tanks). Gas stations in the Thornton Creek watershed and throughout the State have been upgrading gas tanks and conducting soil remediation for over a decade. Ecology operates a Leaking Underground Storage Tank (LUST) program to detect problems with these tanks. A list of tanks in the watershed is included in Appendix I. Ecology is developing a program to assist homeowners with leaky home oil tanks.

5.8 Exceedance of Surface Water Quality Standards

The Clean Water Act (CWA) requires Ecology to prepare a report biennially on the overall condition of the State's waters. The 1996 Statewide Water Quality Assessment lists Thornton Creek as a water body that does not support two or more of its designated uses. The most current approved 303(d) list is the 1996 list, which included Thornton Creek for fecal coliform violations. This section summarizes the results of studies from the past five years that have shown consistent exceedences of standards for fecal coliform, dissolved oxygen, and temperature. For details, see Section 5.2.

Fecal Coliform

For Class AA streams, Washington water quality standards (WAC Chapter 173-201A) state the geometric mean for fecal coliform counts should be below 50 colony forming units (CFU)/100 ml, and no more than 10% of samples should have more than 100 CFU/100 ml. Many creeks in King County routinely exceed the standard of <50 CFU/100 ml.

During dry weather (June through September) over the last five years, water samples collected by King County from Thornton Creek routinely have had elevated fecal coliform levels, with samples having a geometric mean of 1,752 CFU/100 ml. Of 38 dry-weather samples, 100% exceeded both the aspects of the Ecology standards. SPU collected fecal coliform data at ten stations throughout the creek during the summer of 1998, and of the 56 samples collected, 52 (93%) exceeded the Ecology standard. However, it is important to note that SPU collected the data during the hottest days of the summer in an effort to characterize worst case conditions at various locations in the creek. The data collected by SPU, in conjunction with the data collected by King County, indicate that these are not likely the average conditions in the creek (see Appendices F and G for data tables).

During wet-weather (October through May) over the last five years, water samples collected by King County from Thornton Creek routinely have had elevated fecal coliform levels, with samples having a geometric mean of 1,639 colonies/100 ml. Of 65 wet-weather samples, 100% exceeded both the 50 CFU/100 ml and the 100 CFU/100 ml Ecology standards.

Dissolved Oxygen

For Class AA streams, Washington water quality standards (WAC Chapter 173-201A) state the dissolved oxygen level should not be below 9.5 mg/L.

During dry weather, over the last five years, water samples collected by King County from Thornton Creek have had depressed dissolved oxygen levels, with samples having a geometric mean of 9.63 mg/L. Of nine dry-weather samples, three (30%) were below the Ecology standard. It is not known what percentage of the time dissolved oxygen levels are depressed. SPU collected temperature data at ten stations throughout the creek during Summer 1998, and of the 56 samples collected, 55 (98%) exceeded the Ecology standard. However, it is important to note that SPU collected the data during the hottest days of the summer in an effort to characterize worst-case conditions at various locations in the creek and the data are not likely to represent average conditions in the creek. (See Appendices F and G for data tables.)

During wet weather, over the last five years, water samples collected by King County from Thornton Creek never had depressed dissolved oxygen levels, with samples having a geometric mean of 11 mg/L. Of 29 wet-weather samples, 100% were above the Ecology standard (Appendix F).

Temperature

For Class AA streams, Washington water quality standards (WAC Chapter 173-201A) state the temperature should not be below 16°C (60°F).

During dry weather, over the last five years, water samples collected by King County from Thornton Creek have had elevated temperatures, with a geometric mean of 14.8. Of 37 dry-weather samples, ten (27%) exceeded the Ecology standard. SPU collected temperature data at ten stations throughout the creek during Summer 1998, and of the 56 samples collected, 53 (95%) exceeded the Ecology standard. However, it is important to note that SPU collected the data during the hottest days of the summer in an effort to characterize worst-case conditions (conditions yielding high temperatures in past studies) at various locations in the creek, and the data are not likely to represent average conditions in the creek. (See Appendices F and G for data tables).

During wet weather, over the last five years, water samples collected by King County from Thornton Creek never had elevated temperatures, with samples having a geometric mean of 11 mg/L. Of 61 wet-weather samples, none exceeded the Ecology standard. (See Appendix F.)

5.9 Water Quality Observations

Over the past 13 years, a considerable amount of water quality data has been collected in this watershed, notably at the mouth of Thornton Creek. However, no trends in dry-weather data have been discerned. Levels of bacteria, nutrients, and other pollutants have remained fairly constant.

A possible exception is the lower phosphorus levels. Phosphorus levels at the upper watershed sampling stations dropped in late 1976 and remained consistently lower through the end of the record in 1982. It is not known whether the change reflects water quality conditions or a change in the laboratory method of analysis.

The stormwater data were not evaluated for trends. The validity of any such comparison is problematic given the various types of samples, the normal variability of concentrations of the parameters (both within and between individual storms), and the limited amount of data.

Data from pesticides, sediments, and biological monitoring is not sufficient to evaluate trends.

Perhaps this lack of clear trends is not surprising. The main source of pollution to Thornton Creek is urban runoff. Although population has increased, the watershed is almost completely built out, and land use has not changed significantly in the last 13 years.

Evaluating water quality using the antidegradation policy criteria is more difficult than using chemical and even biological criteria. The State's antidegradation policy is not designed to restrict land uses or surface discharges in urban watersheds. In the Thornton Creek watershed, there are no individual point-source industrial or municipal (sewage treatment plant) NPDES permits that could be altered to better protect water quality. Since urban runoff is the primary source of water quality degradation, the NPDES permit with the greatest probable impact in the watershed is the City of Seattle Municipal Stormwater Permit. This permit provides the basis for the City's stormwater program. In addition, the Washington State Department of Transportation (WSDOT) has a stormwater permit that covers the portion of Interstate 5 located in the watershed. Otherwise, the small industries in the watershed are covered by general permits that require best management practices, but do not regulate discharges on a site-specific basis. Consequently, activities with potential water quality impacts are regulated through the requirements of general NPDES stormwater permits, source control programs, and city development regulations. In addition to regulatory approaches, water quality problems are addressed through capitol improvement projects, operation and maintenance programs, and educational programs. These are described in Chapters 6-11.

The challenge in an urban environment is changing individual behaviors that contribute to pollution. Strategies like public outreach campaigns, tighter enforcement of existing regulations, improved stormwater management, and incentives for businesses and homeowners are intended to improve water quality and reduce pollutant levels.

PART 3
Watershed Protection Activities

Volunteers Constructing Meadowbrook Creek

CHAPTER 6: GOVERNMENT LAWS, POLICIES AND REGULATORY FRAMEWORKS

Part 3 of this document (Chapters 6 to 11) examines the community's response to the conditions described in Part 2 (Chapters 2 to 5). In this context, "community" refers to immediate neighbors, governments, schools, and non-government organizations. In the Puget Sound region, local jurisdictions develop Watershed Action Plans as a way to address non-point pollution and related concerns including stormwater, wildlife, habitat and stewardship.

This chapter examines government laws, policies and regulatory frameworks. It begins with the Federal government, then describes Tribal, State, Interjurisdictional, and County regulations and policies. This is followed by a review of the laws, policies, and regulatory frameworks of the City of Seattle and the City of Shoreline. The chapter ends with some concerns of the Watershed Management Committee about the strengths and effectiveness of these current laws, policies and regulatory frameworks.

Federal laws are the umbrella for the laws, policies, and regulations delegated to the State of Washington and the Tribes. These laws are briefly described. In turn, the State sets expectations for local levels of government. Sometimes local government sets the highest standards. Local laws have the most direct influence on the Thornton Creek watershed and they are described in the most detail. Several Native American Tribes, including the Muckleshoot, Suquamish, and Tulalip, have influence over their "usual and accustomed fishing and hunting" areas.

6.1 Federal Government

The two Federal regulations that most influence the Thornton Creek watershed are the Clean Water Act and, potentially, the Endangered Species Act. Other regulations affecting this watershed include hazardous waste management laws, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation, and Liability Act, and the Water Resource Development Act. These laws and regulations are described below.

Clean Water Act

Congress enacted the Federal Water Pollution Control Act of 1972 which set the basic structure for regulating discharges of pollutants to waters of the United States. The Clean Water Act (CWA) is a 1977 amendment to the Federal Water Pollution Control Act of 1972. The CWA gave the federal Environmental Protection Agency the authority to set effluent standards on an industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit (NPDES) is obtained under the act. The 1977 amendments focused on toxic pollutants. In 1987, the CWA was reauthorized and again focused on toxic substances, authorized citizen suit provisions, and funded sewage treatment plants (POTW's) under the Construction Grants Program. (The Clean Water Act (33 U.S.C. s/s 1251 et seq. 1977) U.S. E.P.A. 6-25-99, ww.epa.gov/region5/defs/)

The Clean Water Act established the National Pollutant Discharge Elimination System (NPDES), a regulatory program focusing on point sources such as sewage treatment plants and industrial discharges. Every point source wastewater discharge to the nation's waters is required to have a permit issued under NPDES. The NPDES program is administered by the US Environmental Protection Agency (USEPA). In Washington, the USEPA has delegated this responsibility to the Washington State Department of Ecology (Ecology).

The Clean Water Act outlined four steps to control water pollution:

- ♦ Identify the beneficial uses a water body must support.
- ♦ Set instream water quality standards that allow the desired beneficial uses.
- ♦ Set limitations for pollutant discharges that are consistent with the instream water quality standards.
- ♦ Take action to make sure pollutant discharges are controlled to the degree necessary to meet effluent limits.

Wetlands were also given protection under the Clean Water Act. Section 404 of the Act made the US Army Corps of Engineers (COE) responsible for regulating the placement of dredged or fill materials into water and wetlands. This responsibility includes wetlands and deltas found in the Thornton Creek watershed.

In 1987, Congress amended the Clean Water Act, adding new sections on stormwater, non-point sources, and estuary management. These amendments require extension of the NPDES program to address stormwater runoff from large construction sites and industries. Seattle and other municipalities with populations of 100,000 or more are required to obtain NPDES permits to discharge stormwater.

States are also required to list waters not meeting water quality standards under Section 303(d) of the CWA. States then are to develop TMDLs (Total Maximum Daily Loads) – a report describing the loadings of the pollutants involved and how they will be controlled in the future. USEPA recently issued new regulations under Phase II of the NPDES program that will require mid-size cities to apply for stormwater permits.

Section 319 of the Act required states to prepare non-point source assessments and then develop programs to control and prevent non-point source pollution. Section 320 identified four estuaries – including Puget Sound – as nationally significant and allocated funding for the relevant states to develop management plans. The 1991 Puget Sound Water Quality Management Plan was the first such plan in the country approved by USEPA.

Endangered Species Act

Under the U.S. Endangered Species Act of1973 (full text available at http://endangered.fws.gov/esa.html), a species may be listed as endangered or threatened for any of the following reasons:

- ♦ Present or threatened destruction, modification, or curtailment of its habitat or range.
- ♦ Over-utilization for commercial, recreational, scientific, or educational purposes.

- Disease or predation.
- Inadequacy of existing regulatory mechanisms.
- Other natural or artificial factors affecting its continued existence.

The decision to list a species as endangered or threatened is made solely on the basis of the best available scientific and commercial data. Economic impacts cannot be considered in the listing decision, but the protection provided by State and local programs and regulations may be considered in a decision on whether to list a species.

In March 1999, the National Marine Fisheries Services (NMFS) listed the Puget Sound estuary Chinook salmon (among several chinook runs) as a threatened species under the Endangered Species Act (ESA). This listing will have broad impacts in the Puget Sound region because of the need to protect water quantity and quality as fish habitat. Municipalities, real estate developers, hydroelectric facilities, farms, port districts, and many other interests will find their use of water resources scrutinized in terms of the ESA listing for Northwest salmon.

Once the Puget Sound Chinook were listed, the NMFS was required to develop regulations to prevent the direct taking of Chinook and regulate the incidental taking of Chinook themselves and/or their habitat. According to the NMFS (1999), any accidental or incidental "take" of an endangered species (upper Columbia River spring Chinook are listed as endangered) will require a permit after 60 days. Killing an endangered species, or harming the species or its habitat, is considered a "take." The regulation and enforcement of a "no-take" policy applies to all and is considered necessary to immediately protect and care for the endangered salmon. For species listed as threatened, Federal agencies will have to consult with NMFS to protect the species after 60 days. No new regulations will apply to non-Federal parties while NMFS works with Indian tribes, states, counties and cities on local tailor-made measures needed to save the fish that can be adopted in a customized rule under Section 4d of the ESA.

Federal agencies are consulting with the NMFS on all projects that received Federal funding or require a Federal permit such as a Clean Water Act Section 404 permit from the COE. In the meantime, Seattle and a host of other governments are working with NMFS to negotiate incidental take regulations under Section 4(d) of the ESA through the Tri-County effort. These rules will be available for public comment and can be found at www.nwr.noaa.gov/1salmon/salmesa/.

Hazardous Waste Management – RCRA and CERCLA

Two more Federal laws protect surface and ground waters by regulating the storage and handling of hazardous substances to prevent release of toxic contaminants. These laws are the Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund). In the event of a toxic materials spill or illicit discharge to the storm system, this legislation would be used to ensure cleanup by the responsible parties. At this time, these laws have had limited application in this watershed.

Water Resources Development Act (Section 1135)

The Corps of Engineers (COE) operates Chittenden Ballard Locks for navigation, flood control, and fisheries. The regional COE office is located in Seattle. The Chittenden Locks connect Lake Washington, Lake Union, and their tributaries to Puget Sound. Completion of the Lake Washington Ship Canal and Chittenden Locks in 1916 lowered Lake Washington by almost nine feet. This substantially shrank and altered the lake shoreline, affecting Thornton Creek, other lake tributaries, and wetlands. The 1986 Water Resources Development Act (WRDA), Section

1135, authorized the Secretary of the Army to modify the structure and operation of COE water resource projects, including the Chittenden Locks, to improve the quality of the environment in the public interest. Under this program, creek restoration work was conducted near the mouth of Thornton Creek in 1999. (See Chapter 10 for details.) Currently the COE is working with Seattle, King County, the Muckleshoot Indian Tribe, and others to improve fish passage at the Locks for adult fish migrating upstream and juveniles heading out to sea. The COE plans to begin construction in 2000.

River, Harbor, and Flood Control Act of 1970 (Section 216 of Public Law 91-611)

The COE is pursuing a study under Section 216 of Public Law 91-611 of the River, Harbor, and Flood Control Act of 1970. Through this Act, the COE has the authority to review the operation of projects constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes. In 1991, the US Congress allocated $279,000 to conduct a reconnaissance study to see if there was Federal interest in investigating whether conserving water at the Chittenden Locks could be used to replace additional water withdrawals from the Cedar River by the City of Seattle. The initial study was reactivated in 1994 by the City of Seattle with support from King County and the State of Washington as potential new sponsors. The local sponsors are interested in conserving water at the Locks for fish passage and habitat enhancement, as well as other ecosystem restoration opportunities elsewhere in the larger Lake Washington/Sammamish/Cedar River watershed.

The sponsors and the COE have agreed to a list of studies and investigations under Section 216. At this time, none of the studies directly involve Thornton Creek.

6.2 Tribal Government

Federally recognized Indian Tribes in Washington State are unique governments because they have authority to regulate land use and pollution control on their reservations. They also have rights to protect off-reservation habitat in areas known as “usual and accustomed areas” (U&A). These U&A areas are generally larger than the reservation areas. In the case of Thornton Creek, this watershed is part of a much larger U&A area of the Muckleshoot Indian Tribe, whose reservation is located near Auburn.

The Muckleshoot Indian Tribe has the right to harvest fish that are produced from the entire Lake Washington/Cedar River/Sammamish watershed (as well as other watersheds) as a result of the 1974 Boldt decision (*U.S. v. Washington*). This landmark decision gave Federally recognized tribes in Washington State the right to harvest up to 50% of the returning adult salmon available for harvest. This fishing right is considered to be a property right that cannot be interfered with by Federal, State, local, or other interests. As part of the decision, Boldt recognized that a tribe’s right to harvest fish would be meaningless if there is no habitat for fish. The specific details of a tribe’s right to protect habitat have not yet been fully litigated. However, State and Federal agencies that have permit authority to regulate habitat alterations generally recognize that the tribes are an “affected” jurisdiction and grant these tribes the opportunity to review, comment, and appeal permits under several of the Federal programs identified above, such as CERCLA and WRDA. Tribes are also treated as “a state” for some purposes of the Clean Water Act, enabling them to regulate water quality on their reservations and to receive grants that are available to other governments such as CWA 319 funding.

Most tribes in Washington State seek to work cooperatively with permitting governments at all governmental levels: local, State, and Federal. In the case of the Muckleshoot Indian Tribe, this work is done by the tribe’s Fisheries Department staff, who have expertise in geology, fisheries, water quality, forestry, habitat restoration, marine sediments, and land use. Through a review process, tribal staff provides input and recommended changes to programs, plans, regulations, policies, and individual projects that require permits. Staff from the Muckleshoot Indian Tribe's Fisheries Department have been involved in developing this Watershed Characterization Report and the Action Plan for the Thornton Creek watershed.

6.3 Washington State Government

In Washington, several laws and regulations govern non-point pollution, stormwater, and watershed planning. These are the Water Pollution Control Act, Growth Management Act, State Environmental Policy Act, Puget Sound Water Quality Protection Act, Hydraulic Permit Authorization, Model Toxic Control Act, and water rights. State agencies having influence in this watershed are Ecology, Fish and Wildlife, and Transportation.

The State is involved with regional coordination and planning such as the Governor's Salmon Response Plan, Puget Sound Water Quality Management Plan, and the Water Quality Consortium. The State also provides funding for numerous water quality improvement programs and projects for salmon recovery.

Water Pollution Control Act

The Water Pollution Control Act is Washington State's response to the Federal Clean Water Act. In Washington State, Ecology is designated as the State's water pollution control agency for all purposes of the Federal Clean Water Act. Ecology has been granted jurisdiction to control and prevent the pollution of streams, lakes, rivers, and other surface and underground waters within the State, except Indian reservations. Chapter 90.48 RCW, Water Pollution Control, requires maintaining the highest possible standards to ensure the purity of all waters of the State, consistent with public health, enjoyment, habitat, and industrial uses.

Ecology has developed a plan that designates the beneficial uses of all water bodies in Washington. The designated beneficial uses of Thornton Creek and other Class AA streams are: domestic, industrial, and agricultural water supply; irrigation; livestock watering; fish and shellfish rearing, spawning, and harvesting; wildlife habitat; recreation; commerce; and navigation. Beneficial uses applying to Thornton Creek are irrigation, fish rearing and spawning, habitat, and recreation.

Ecology has established regulations for instream water quality standards for freshwater streams that are consistent with the beneficial uses (WAC 173.201). These water quality standards are described in Section 5.1. Streams, or portions of streams, that remain out of compliance with instream standards after application of conventional controls to point sources are referred to as "water quality limited." Under the Clean Water Act, water quality limited streams are subject to further analysis to determine the level of control necessary to achieve compliance with instream standards. Ecology is required under Section 303(d) of the Federal Clean Water Act to prepare a list every two years containing surface waters not expected to meet State water quality standards after implementation of technology-based controls. Thornton Creek is included in Washington's 303(d) list for violating water quality parameters (see Section 5.8).

Under the State code, cities are authorized to prevent pollution of streams, punish polluters, promulgate all regulations necessary for the public health, declare what is a public nuisance, and decide what improvements are necessary and should be charged to the property owners (Chapter 35.22.280 RCW). The State code includes language stating that it is a public nuisance to pollute any spring, stream, pond, lake, or well (Chapter 7.48.140 RCW).

Under the Washington Pollution Control Act, Ecology administers the State's National Pollution Discharge Elimination System (NPDES) permits. Under NPDES there are programs to deal with point sources (sewage treatment plants and discharges from industry), urban runoff, construction runoff, and industrial runoff. Businesses and government agencies that meet certain conditions are required to submit applications for NPDES permits. Ecology has approved stormwater permits for Seattle, Tacoma, King County, Pierce County, Snohomish County, and the Washington State Department of Transportation. Ecology reviews these permits every five years on a watershed-wide basis. Thornton Creek is part of Watershed Resource Inventory Area (WRIA) 8, which includes the Cedar River and Lake Washington. There is an Ecology basin assessment for WRIA 8.

Growth Management Act (GMA)

Continuing rapid growth is expected in the Puget Sound region for the foreseeable future. Thousands of new people will live here. In 1990 and 1991, Washington State, responding to an initiative of the people, adopted a Growth Management Act with significant amendments (RCW 36.70A.020) to help the state manage future growth. The GMA seeks to balance growth with protection of the natural environment, including conservation of fish and wildlife habitat and other environmental and agricultural resources.

Under the GMA, counties that are undergoing rapid growth, and cities within those counties, are required to develop and adopt 20-year comprehensive plans. These plans must identify and protect critical areas and resource lands, set specific growth targets, demonstrate that funding is available to provide adequate infrastructure for the first six years, demonstrate consistency with neighboring city and county plans, and specifically plan for various “elements” (land use, transportation, housing, capital facilities, and utilities).

In the Puget Sound region, growth is being guided to designated Urban Growth Areas around existing urban centers by providing adequate infrastructure and continuing to improve design and construction standards so urban areas will be more attractive and livable. This strategy is intended to help rural lands remain that way and to protect, preserve, and sustain natural resources, particularly farmland and forests.

The Thornton Creek watershed is within the Urban Growth Area for the Cities of Seattle and Shoreline and King County. (See Sections 6.5 and 6.6 for GMA implementation in Seattle and Shoreline.)

State Environmental Policy Act (SEPA)

The State Environmental Policy Act, enacted in 1971 (RCW 43.21C) strives to encourage productive and enjoyable harmony between humans and their environment. SEPA was enacted by public initiative to ensure that decision makers consider environmental consequences, including cumulative impacts, before taking action and to assure the opportunity for public review of development plans and projects. The environmental review occurs early in the development process and asks critical questions about possible impacts on the environment and the actions that can be taken to avoid or mitigate those impacts for several alternatives. Some activities are exempt from SEPA, and do not undergo environmental review. SEPA is administered locally by county and city governments. State agencies, affected Indian Tribes, property owners, and the public are solicited for their comments and concerns through a notification and review process. (See Sections 6.5 and 6.6 for SEPA implementation in Seattle and Shoreline.)

Puget Sound Water Quality Protection Act

The State legislature has designated the unique resources of Puget Sound as worthy of protection and assumed the preservation of Puget Sound as an obligation of the State. In 1985 the legislature created the Puget Sound Water Quality Authority, intending it to be a single entity with adequate resources to address the cumulative, wide-ranging impacts contributing to the degradation of Puget Sound. The Authority was mandated to produce the Puget Sound Water Quality Management Plan to restore and protect the water quality and biological resources of Puget Sound. One of the first such regional plans in the country, the Management Plan was adopted by the legislature in 1986 and has been revised several times, most recently in 1996. This plan identifies Federal, Tribal, State, and local government agencies responsible for implementing recommendations covering 13 programs.

In 1996, the Authority was replaced by a 13-member Puget Sound Water Quality Action Team. The Action Team – a sub-agency of the Governor's Office – brings together the heads of ten State agencies, a city and a county representative, a representative of Federally recognized tribes, and ex-officio non-voting representatives of three Federal agencies to lead and coordinate efforts to protect Puget Sound. The Action Team develops and oversees a biennial work plan based on implementing sections of the Puget Sound Plan.

Under Chapter 90.71 RCW, Action Team members are responsible for:

- Developing a biennial work plan and budget.
- Coordinating the monitoring and research programs.
- Periodically amending the Puget Sound Water Quality Management Plan.
- Coordinating Puget Sound Plan implementation among agencies.

The 12-member Puget Sound Council, composed of representatives from business, agriculture, tribes, local governments, environmental groups, and the legislature, advises the Action Team. The Puget Sound Council also recommends ways to make protection efforts viable for local governments and to improve the accessibility of State and Federal services to cities, counties and tribes. A chairperson appointed by the Governor guides the work of the Action Team and Council, helps develop the work plan, and oversees how the work plan is carried out.

The 1997-99 Puget Sound Water Quality Work Plan sets priorities for State and local actions, and details “key actions” to be taken to implement these priorities. A key action identified for the City of Seattle is to “develop a watershed plan for the Thornton Creek watershed.”

The 1999-2001 Puget Sound Water Quality Work Plan coordinates State, Federal, Tribal, and local actions to restore and protect the Sound's resources and water quality. The Action Team identified seven priorities for the 1999-2001 biennium:

- Protect and restore habitat for fish and shellfish, and remove barriers to salmon passage.
- Prevent downgrades or closures of shellfish areas and reopen closed areas.
- Fix existing and prevent future stormwater problems and reduce toxic discharges.
- Fix existing and prevent future on-site sewage system problems.
- Implement watershed plans.
- Prevent the introduction of new aquatic nuisance species and control the spread of those that already have been introduced.
- Provide public education and involvement on these priorities.

Several of these priorities pertain to development of this Characterization Report and the subsequent watershed action plan.

Drainage and Flooding Control

State codes authorize cities to construct, maintain, and operate storm or surface water sewers with full jurisdiction and authority to manage, maintain, regulate, and control the rates and charges for their use (Chapter 35.67 RCW). The State has also recognized the damage and cost associated with increased surface runoff flows which may occur from development or alteration of the existing drainage. Chapter 90.03.500 RCW permits the construction of public improvements for stormwater control and imposition of special assessments, or charges for the cost of these improvements. Both Seattle and Shoreline assess a drainage fee on properties to fund stormwater management services. (See Chapter 8 for more details.)

Hydraulics Permit Authorization (HPA)

The Washington Department of Fish and Wildlife (WDFW) reviews applications and issues hydraulic permits for work in or near streams. To minimize project-specific and cumulative impacts to fish, the WDFW reviews proposals for projects that will use, divert, obstruct, or change the natural flow or bed of any of the salt or freshwaters of the State (RCW 75.20 and WAC 220-110). Permits, called Hydraulic Project Approvals (HPAs), include conditions to minimize or mitigate impacts. Projects that require HPAs include those which will alter flows by changing stormwater runoff, alter streambeds by causing sediments to enter water, or alter fish habitat by changing streambank vegetation. Projects with more direct effects on streams, such as culverts, bridges, bank stabilization, or changes to a channel, all need HPAs.

Hazardous Materials (MTCA)

In 1988, the State legislature passed the Model Toxics Control Act (MTCA) (Initiative I-97,RCW 70.105(D)), modeled after the Federal laws described above("Hazardous Waste Management"). MTCA is more inclusive than Federal law with respect to petroleum and hydrocarbon cleanup requirements.

Washington's Water Law - Water Rights

In most Western states, including Washington, water law is based upon the prior appropriation doctrine. According to this doctrine, rights for withdrawal of water are given priority based on the date they were acquired. However, Tribes have Federally held water rights for instream flows reserved for fish that are a result of their treaties with the Federal government.

Washington's water law includes a principle that a water right is perfected, defined, and maintained through beneficial use. The expression "use it or lose it" is sometimes applied to describe this Western water law principle. Put simply, a water right may be wholly or partially lost through extended periods of non-use. A water right is valid as long as it is used at least once every five years. After five consecutive years of non-use, the right is considered forfeited. The return of unused water to the State is called relinquishment. The purpose of relinquishment is to ensure that Washington's limited water sources are put to maximum beneficial use for all of the State's citizens.

With some minor exceptions, farmers, businesses, and other users must obtain a permit or water right from Ecology to divert and use water. This is true for water in Thornton Creek. Landowners with water flowing across their property do not automatically have the right to divert and use the water. There are about 65,000 authorized diversions from surface water systems throughout Washington State. (See Table 3.5 for water rights on Thornton Creek.) In the early 1970s, Washington State set broad policy that base flows for surface water systems will be retained in perennial rivers and streams of the State, a measure taken to protect the quality and quantity of water for all uses.

Ecology is required by law to protect instream flows by adopting regulations and to manage water uses that affect stream flows. One way to do that is to adopt an instream flow rule for a stream or river. The volume of water required for an instream flow is developed by considering existing data, the hydrology of a stream, its natural variations in stream flow and base flow over the course of the year, the need for fish habitat, and many other factors. For some watersheds, minimum flows and lake levels have been established through administrative rules. These include major rivers such as the Cedar River. State-issued permits and certificates issued after base flows or minimum flows were set may contain provisions instructing water users to stop diverting water when the river drops below a certain flow.

Quite commonly, streams become over-appropriated; that is, permits are issued for water diversions that exceed the flow available at certain times. When this occurs, Ecology closes the stream to further appropriation. Thornton Creek and its tributaries are closed to further appropriation.

Centennial Grants and Loans

The Washington State Centennial Clean Water Fund has been a major source of funding for Seattle programs over the last ten years. Administered by Ecology, the Centennial Fund finances the planning, implementation, design, acquisition, construction, and improvement of water pollution control facilities and related activities. The Centennial fund provides grants and low-interest loans to local governments and Indian tribes for water pollution control facilities and water pollution control activities designed to prevent and control water pollution to the State's surface and groundwater.

The Thornton Watershed Action Plan is funded by a Centennial Clean Water Fund loan. SPU has also received numerous Centennial Clean Water grants. Although many of these projects were located outside the Thornton Creek watershed, the techniques and information developed by these programs can be applied to Thornton Creek. The following projects were (or are) funded by grants:

- **Pipers Creek Watershed Action Plan.** Development of an Action Plan for Pipers Creek watershed in northwest Seattle. The plan was adopted in 1990, one of the first local watershed plans in the region.
- **Longfellow Creek Watershed Action Plan.** Development of an Action Plan for Longfellow Creek in West Seattle. The plan was adopted in 1992.
- **Lake Union Source Control.** Focused on the Lake Union watershed. Activities included collecting stormwater and sediment data, inspecting businesses, cleaning catch basins, and stenciling storm drains. (Underway, SPU.)
- **Elliott Bay/Duwamish River Source Control.** Similar to the Lake Union source control grant, focusing on areas in Seattle that drain to Elliott Bay and the Duwamish River. (Underway, SPU.)
- **Best Management Practices (BMP) Assessment.** Will pay for installation, testing, and evaluation of several devices that remove pollutants from stormwater runoff. (Underway, SPU.)
- **Drainage Maintenance Program.** Designed to improve water quality by improving the drainage maintenance system. As part of this grant, all catch basins in the city were

identified, mapped, and put into an automated work order program to make sure they were routinely scheduled for cleaning. The grant also funded training for drainage maintenance workers to ensure that they understand and appreciate the role of drainage maintenance in protecting water quality. (Underway, SPU.)

- **Creek Assessment Program.** Identified and mapped all creeks within the city, conducted physical assessments of seven creeks, and will pay for several instream improvements. (Underway, SPU.)

Grants and loans for watershed protection are available from other sources including private foundations and all levels of government (see Appendix K).

6.4 Interjurisdictional Approaches

Water Quality Consortium

King County, Seattle, Bellevue, Tacoma, and Ecology are members of the Water Quality Consortium. These agencies combine financial and technical resources to develop regional ad campaigns. A recent campaign featured four scenes about car washing, motor oil, dog excrement, and pesticides getting washed into a lake. The Consortium paid for regional advertisements on television and in newspapers.

Regional Water Quality Committee and Watershed Forums

The Regional Water Quality Committee, which is composed of representatives from the Suburban Cities Association, the City of Seattle, water and sewer districts, and the Metropolitan King County Council, directed King County to prepare a Regional Needs Assessment analyzing problems related to water and fish in five watersheds. The County produced a report in 1995 and subsequently conducted an assessment of funding needs and options. The Committee recommended establishing local forums for five King County watersheds to develop and coordinate regional actions that address problems related to fish, water quality, and flooding in the watersheds. The Thornton Creek watershed is in the area covered by the Lake Washington/Cedar River Watershed Forum. Four other forums have been created for watersheds of the Sammamish, Green/Duwamish, and Snoqualmie Rivers, and watersheds draining directly to Puget Sound.

The watershed forums developed visions for their watersheds and prioritized projects and programs of regional importance to reach those visions. Some of the projects and programs relating to Chinook salmon were submitted as early actions under the ESA, and the rest will likely be included in the region's response to listings of Puget Sound salmon under the Endangered Species Act (see Section 10.1 and below). As part of its response to the listing of Chinook salmon, the County began planning by Water Resource Inventory Area (WRIA) . The forums continue to meet and are also working with Ecology to coordinate watershed-level responses to requirements of the Clean Water Act, including development of TMDLs.

Tri-County Endangered Species Response

In March 1999, the Puget Sound Chinook salmon was listed as a threatened species under the Endangered Species Act. King, Pierce, and Snohomish Counties, Seattle, Bellevue, Tacoma, and Everett are leading what is known as a Tri-County response to the listing. This involves a detailed salmon recovery planning process by WRIAs, proposed programmatic changes, and restoration and acquisition projects. In 1999, agencies submitted early action proposals to the National Marine Fisheries Service (NMFS), and in January 2000, NMFS issued a draft rule under

Section 4(d) of the Act for the affected West Coast areas. NMFS will issue another 4(d) rule in April 2000, which will include more details for the Puget Sound Evolutionarily Significant Unit (ESU), particularly in the tri-county region. Proposed actions are expected to include improvements in implementation and enforcement of stormwater and land use regulations, monitoring, and road management practices.

Interagency Regulatory Analysis Committee (IRAC)

IRAC was formed in 1993 to address issues of regulatory conflict and to improve coordination between municipal, County, and State regulatory agencies. IRAC is a forum for exchanging ideas and addressing mutual concerns of different agencies and jurisdictions. IRAC has several hundred members from agencies whose interests include fire, hazardous materials, water quality, air, code enforcement, health, and safety issues. The committee's mission is "to create a more effective and efficient means of protecting public health and safety through coordination of regulatory agencies."

6.5 King County

King County has limited legislative authority in this watershed, since the watershed is located within the incorporated city limits of Seattle and Shoreline. In the context of watershed action plans, King County's legislative authority is primarily limited to sanitary sewers. The County does operate public transportation services such as Metro transit and Park and Rides. However, the County does have an influence on regional issues such as the Endangered Species Act response and Lake Washington salmon.

Basin Steward Program

The King County Water and Land Resources Division (Department of Natural Resources (DNR)) works with area residents to develop basin management plans for many of the County's most complex and resource-rich watersheds. To help implement these plans, Water and Land Resources has assigned basin stewards to specific watersheds, where they:

- Respond to citizen inquiries concerning their watershed
- Coordinate efforts among diverse public agencies
- Facilitate watershed improvement projects
- Provide assistance to monitoring programs
- Provide public education opportunities

The basin stewards focus most of their efforts in unincorporated King County. Thornton Creek watershed residents do not receive significant benefit from this program.

Funding Support Opportunities

King County offers Waterworks Grants for projects in the County that protect or improve watersheds, rivers, lakes, wetlands and tidewater. Projects must provide opportunities for stewardship. Individual grants up to $50,000 are available. Waterworks grants have funded projects in Paramount Park and Thornton Creek Park #6. See Appendix K for a full listing of grant and loan programs.

6.6 City of Seattle

This section reviews the Seattle ordinances and regulations, plans, and policies that most affect water quality and habitat in the Thornton Creek watershed. These have been continually refined and strengthened over the past three decades, both in response to changes in Federal and State law and as a reflection of the high value that Seattle's citizens place on a clean and healthy environment. Early land use controls and building regulations were based on broad goals of promoting general health, safety, and welfare of citizens, nuisance abatement, and mitigating property damage associated with development activities. In the 1970s and 1980s, Seattle adopted a series of increasingly stringent land use controls and regulations specifically intended to protect the remaining natural environment. During the 1990s policy and regulatory changes first focused on meeting requirements of the 1990 Growth Management Act and, more recently, on State and Federal mandates related to salmon recovery.

Growth Management Plans

Comprehensive Plan (1994)

Future development in Seattle is guided by the Seattle Comprehensive Plan, Toward a Sustainable Seattle, adopted in 1994 under the state GMA. The City of Seattle's growth management strategy directs growth to urban centers and urban villages, which already have strong infrastructure. Areas not designated as an urban center or urban village will likely retain their single family character for the foreseeable future. The City of Seattle Comprehensive Plan is amended annually, usually in July. For the most recent information or to participate in the amendment process, one may contact the City of Seattle Strategic Planning Office and/or check the City of Seattle on-line Public Access Network.

The Northgate area has been designated an urban center under the King County Countywide Policies and Seattle Comprehensive Plan and will be permitted to increase housing densities and commercial services. The Lake City area is designated a hub urban village. The Comprehensive Plan includes a neighborhood planning element that offered an opportunity for each "neighborhood" or community designated by the Plan as an "urban village" to create neighborhood-specific plans.

Seattle's Neighborhood Planning Program (1995-1999)

The Seattle Neighborhood Planning Program was a special approach to growth management planning. From 1995-1999, the Neighborhood Planning Office (NPO) was established to support community-created neighborhood planning groups in developing neighborhood plans consistent with the Seattle Comprehensive Plan. The neighborhood plans addressed issues of growth in their specific localities and as many plan "elements" as seemed appropriate to their particular situation. These plans were as representative as possible of all stakeholders' interests. A neighborhood planning group was formed in each of the potential neighborhood planning areas.

Funds were made available to neighborhood planning groups by contract in two phases: Phase I to reach out to community stakeholders and create both a planning committee and a scope of work for their planning; and Phase II where planning committees hired consultant assistance and developed a neighborhood plan and an "adoption and approval matrix" of recommend-ations for City action. Many City staff from various departments have been involved in developing and implementing neighborhood plans.

North District Neighborhood Plan, 1999. The North District Neighborhood Plan focuses around the Lake City Hub Urban Village. This planning area covers about one-third of the watershed. The vision for this plan is "to protect and enhance the residential neighborhoods that surround the Lake City commercial district while the area designated for a hub urban village is developed with a unique, positive image." The plan has identified 12 goals, listed below. Goals 7 and 8 deal with issues addressed in the Watershed Action Plan.

1. Establish a comprehensive, multi-use neighborhoods-oriented transportation network that integrates with regional and intra-city transportation systems and services.
2. Improve Lake City Way to create a pleasant, safe boulevard that accommodates both local and through traffic and transit as well as pedestrian use.
3. Develop a cluster of community public facilities, conveniently located and capable of serving the area's projected population.
4. Attract new businesses and employers to the Lake City business district and stimulate private commercial investment.
5. Provide opportunities for effective civic involvement by individuals and organizations throughout the planning area.
6. Create the perception and reality of security and safety throughout the planning area.
7. Preserve and improve the area's watershed, green areas, and habitat corridors.
8. Provide parks, public recreation facilities, and community areas that are safe, clean, multi-use wherever possible, and responsive to local needs.
9. Create and allow for development of a unique urban area that fosters business vitality, sense of community, and strong connections to surrounding neighborhoods and businesses.
10. Provide opportunities for development of a mixture of high quality housing while protecting established residential areas from the encroachment and impacts of other uses.
11. Provide public services adequate for current and future populations.
12. Develop and implement design review guidelines to enable significant community influence over the quality, function and appearance of future development.

Northgate Plan, 1993. The Northgate Area Comprehensive Plan (Seattle, 1993) was initiated in 1989 to plan for projected dramatic growth in the Northgate area and to address continued deterioration of traffic congestion. Creating this plan provided an opportunity for residents, business people, and landowners of the Northgate area to study emerging growth and to shape the future of the area. This plan addresses the period between 1992 and the anticipated initial operations of a regional high capacity transit system (after 2002).

The Northgate Plan is intended to manage growth so as to provide an opportunity for changing the character of the commercial core while enhancing the surrounding single family neighborhoods. It guides public and private investments regarding future land use, transportation, and open space in the Northgate area. In addition, it offers greater predictability concerning future conditions for property owners, residents, developers, and City and other public agencies.

The plan developed 16 policies covering land use, transportation, open space, development plans for large sites, the potential high capacity transit station, drainage, financing, and human and community services. These are listed below:

1. A Northgate overlay district shall be created to address the special characteristics of

development in the area.

2. The land use pattern in the Northgate area should concentrate employment activity where the infrastructure and transportation system can best accommodate it.
3. A mixture of activities including commercial and residential uses shall be promoted in areas with NC (neighborhood/commercial) and RC (residential/commercial) zoning designations.
4. Additional multifamily housing opportunities for households of all income levels shall be promoted to the extent that a compatible scale and intensity of development can be maintained with adjacent single family areas.
5. To reduce conflicts between activities and to promote a compatible relationship between different scales of development, a transition shall be provided between zones where significantly different intensities of development are allowed.
6. The efficiently of the transportation system shall be maximized by accommodating more person trips rather than vehicle trips.
7. Enhance transit service and facilities to make it a more attractive travel mode for persons living and working in the Northgate area.
8. Increase pedestrian circulation with an improved street level environment by creating pedestrian connections that are safe, interesting and pleasant.
9. Manage parking supply, location and demand to discourage the use of single occupant vehicles, and to improve short term parking accessibility for retail customers, patients and visitors without undermining transit or HOV usage, or detracting from the creation of an attractive pedestrian environment.
10. Reduce the impact of increases in traffic volume by minimizing conflicts with local access streets, and improving traffic flow, circulation and safety, without increasing vehicular capacity.
11. Development of a high capacity transit station shall be designed to minimize impacts on surrounding neighborhoods by emphasizing non-motorized access, transit supportive land uses, and an attractive pedestrian environment at and near the station.
12. A system of open spaces and pedestrian connections shall be established to guide acquisition, location and development of future open space and to establish priorities for related public improvements.
13. General development plans shall be required to ensure that the development of super-blocks in the Northgate area supports and reinforces the vehicular/pedestrian balance envisioned to complement transit use in the Northgate overlay.
14. Reduce potential runoff into Thornton Creek, and restore the creek to enhance aquatic habitat and absorb more runoff.
15. Provide quality human services for all segments of the population.
16. The City should explore and develop a variety of strategies for financing the implementation of this plan.

The Northgate Plan provided the basis for modifying and guiding City policies and regulations that impact land use codes, land use maps, City SEPA process, and Seattle's comprehensive transportation program. The Seattle City Council has adopted ordinances and resolutions to implement this plan.

Laws and Regulations

The four main municipal laws and regulations affecting water quality and habitat in the Thornton Creek watershed are:

- Stormwater, Grading and Drainage Control Ordinance and related best management practices
- Permit Review Process/Seattle's Land Use Code
- State Environmental Policy Act (SEPA)
- Environmentally Critical Areas (ECA) Ordinance

The Stormwater, Grading and Drainage Control Ordinance regulates activities that affect surface waters, water courses, and related shoreline areas (Seattle Municipal Code, SMC, Chapter 22.800, Stormwater, Grading and Drainage Control Code). It was adopted in 1993, revised in1995, and revised again in 2000 (Ordinance 119965). The other three regulations affect building and land development through land use and development regulations.

The purposes of the Stormwater Ordinance include protecting life, property, and the environment against loss or damage by pollution, erosion, flooding, and other hazards; protecting surface waters, receiving waters, and the aquatic and benthic life in these waters; and protecting the public interest in drainage and related functions of drainage basins, watercourses and shoreline areas. The stormwater regulations also work to ensure that the City meets the requirements of the City's municipal permits under the NPDES permit program.

Land use and development regulations give the City an integrated set of strategies to manage development in and along Seattle's waterways, stream corridors, and upland areas. The comprehensive regulatory program the City has developed to manage land use and building activities (which includes the Stormwater Ordinance, Permit Review Process, SEPA, and ECA) addresses development that may affect Seattle's streams. These regulations apply to both new construction and redevelopment of commercial and industrial facilities, multi-family residences, and single family homes. Land use plans and regulations have been continually refined and strengthened over the past three decades, partially in response to changes in Federal and State law, and partially to reflect the high value that Seattle's citizens place on a clean and healthy environment.

Stormwater, Grading and Drainage Control Ordinance

The Stormwater, Grading and Drainage Control Ordinance contains significant regulatory authority important in the broad context of stormwater management. Activities covered by this ordinance are summarized below.

Prohibited Discharges. This section prohibits illicit discharges to the City's drainage control system. This section applies to such environmentally damaging substances as automotive and petroleum products, solid waste, grease, metals, chemicals, soaps, pesticides, herbicides, and fertilizers. The intent of this section is to prevent any discharges into the City's system that may cause a violation of the City's NPDES permit or contribute to a water quality problem.

Requirements for Existing Discharges and Land Uses. This section requires implementation of nonstructural BMPs (e.g., maintenance and housekeeping) for all existing discharges to the City's system, and allows the City to require installation of structural BMPs if additional measures are deemed necessary to protect water quality. This section also requires commercial and industrial parties to take measures to prevent spills of materials that may contaminate the environment, requires that natural drainage patterns be maintained, and prohibits the obstruction of watercourses.

Stormwater, Drainage, and Erosion Control Requirements. This section contains a provision limiting post-development runoff rates to a specific peak flow rate. The intent of this requirement is for post-development runoff rates to approximate runoff rates from undeveloped land. This section also requires taking steps during construction to control erosion and the transport of sediment or other pollutants from the site.

Maintenance and Inspection. This section requires that all private drainage control facilities be inspected and maintained by the owner(s) of the site.

Enforcement. This section includes provisions that allow the City to issue a Notice of Violation and/or a Stop Work Order if the requirements of the code are violated.

Penalties and Damages. This section provides the schedule of penalties for violations of the ordinance. The penalties are daily fines, increasing in size for each day of continued violation, up to $500 per day. Also included in this section are provisions for fines to be trebled for repeat, deliberate, or physically harmful violations. Significant violations, including violations that cause significant harm to the environment, may be assessed a penalty in excess of the daily fine and the violator may be made liable for damages caused by the violation.

The Stormwater Ordinance also impacts new construction and redevelopment. Regulatory requirements are tiered based on project size, complexity, and location of the stormwater discharge. Development coverage includes not just the specific structure under construction but any activity on the site, such as clearing, grading, alley development, sidewalks, or work in the right-of-way or on contiguous lots. All projects over 750 square feet must follow BMP erosion controls and construction BMPs.

New Information. Two “Director’s Rules” implementing changes to the Stormwater, Grading and Drainage Control Code became effective on July 5, 2000: DR 16-2000 Construction Stormwater Control Technical Requirements Manual, and DR 17-2000, Source Control Technical Requirements Manual. Two additional “Director’s Rules”, DR026-2000 Flow Control Technical Requirements Manual and DR 27-2000, Stormwater, Treatment Technical Requirements are circulated in draft form as this report goes to press. These “Director’s Rules” and the new Stormwater Ordinance can be found at the City of Seattle Department of Design Construction and Land Use.

Permit Review Process

The City regulates land use and development activities by reviewing project proposals; by issuing permits that typically impose site-specific development controls; by inspecting construction sites for compliance with regulations and special permit conditions; and by enforcement or civil action, if necessary. The Department of Design, Construction and Land Use (DCLU) is responsible for implementing and coordinating the permit review process. Once it is determined which regulations apply, the City follows a coordinated review process. The permit review process for most projects is as follows:

- The applicant prepares and submits a permit application, including a project description and detailed plans. Regulations specify the information the developer must submit (e.g., plans, geotechnical studies, SEPA checklist).

- City staff reviews the proposal for compliance with applicable regulations and policies to assess potential environmental impacts and determine appropriate mitigation.
- City staff establishes permit conditions and mitigation requirements (conservation measures) based on regulations that define substantive requirements (e.g., size requirements for buffers) and provide authority for required mitigation or project conditions.
- Staff may request additional information to clarify the proposal, its impacts, and necessary mitigating measures.
- Consultation with other government agencies, tribes, and the public occurs as part of the City's project review. City staff coordinates among the applicant, resource agencies, and affected Tribes, as needed.
- Project review may involve a public hearing. SEPA reviews and most discretionary project approvals and permit conditions can be appealed.
- Permits and approvals are issued when the project (with conditions) is determined to comply with City regulations. Inspections are scheduled at the time of permit issuance.
- Inspection is completed and enforcement action is taken if necessary. (See below for more detail.)

An important part of the City's review process involves consulting with Federal and State resource agencies and Tribes, and inviting public review and comment. The City utilizes the specialized expertise of outside agencies and Tribes to identify potential impacts on salmon and salmon habitat.

The City has the authority to inspect sites to ensure that permit requirements are met and that the developer or owner is adequately applying BMPs. City inspectors inspect even minor projects involving building permits, demolition, and grading. Key aspects of the City's inspection and enforcement program include the following:

- Construction site inspections are scheduled at the time of permit issuance.
- The City takes enforcement action if needed. Enforcement tools include issuance of stop work orders, assessment of fines and penalties, withdrawal of the permit, and abatement of damages.
- In addition, the City has inspection authority to ensure compliance with shoreline and stormwater regulations whether or not the activity requires a permit.

City Compliance with State Environmental Policy Act (SEPA)

A critical part of the City of Seattle's environmental review process is ensuring compliance with the SEPA. The City has adopted regulations to implement SEPA (Seattle Municipal Code Chapter 25.05, Environmental Policies and Procedures). SEPA establishes both procedural and substantive environmental requirements. The purposes set forth in the City's ordinance include minimizing or preventing the loss of wildlife habitat and other vegetation, and helping to protect special habitat types.

SEPA review is required for the following projects within the City of Seattle:

- All work done in or over water (including docks, piers, bulkheads, shoreline protection, and riprap).

This checklist (specified in State law and included in the City's ordinance at Chapter 25.05.960) requires the applicant to identify, to the best of his or her knowledge, any potential impacts to specific elements of the natural environment (such as earth, water, and animals) and the built environment (such as public services, schools, and traffic). The checklist requires the applicant to identify any endangered species on or near the site. In addition, the SEPA checklist asks what steps (conservation measures) the applicant intends to take to avoid or mitigate any impacts. The City reviews the SEPA checklist and identifies any additional impacts or potential impacts based on information available to the City. SEPA gives the City discretionary authority to require further information about the project (including studies) and gives authority to require mitigation beyond that identified by the applicant.

The City coordinates a notification process, which may involve the Corps of Engineers and WDFW for Hydraulics Project Approval, along with local Tribes. This notification and comment process helps to ensure that any interested agency, affected Tribe, or person has an opportunity to review and comment on projects subject to SEPA review.

Decision Options. The City's responsible official makes the SEPA decision based on review of the SEPA checklist and the project plans. The responsible official must consider two basic questions: (1) Does this project potentially have a significant impact on the environment? and (2) If so, what steps should be taken? The responsible official may request additional technical studies to augment the information provided in the checklist or may seek additional analysis and information from experts internal or external to the City.

The City's responsible official then makes a SEPA determination and notifies the applicant and other parties of this determination as required. The three possible decision options (SEPA determination) are as follows:

1. **Issue a Determination of Non Significance (NS).** No significant adverse environmental impacts; no environmental impact study (EIS) is required.
2. **Issue a Mitigated Determination of Non Significance (MDNS).** No significant adverse environmental impact, provided specific mitigation is done. Rather than undertaking an EIS, the applicant may volunteer to do the mitigation or the City may simply require mitigation or project changes in order that the project qualifies for an MDNS.
3. **Issue a Determination of Significance (DS).** Potential for significant adverse environmental impact. An EIS is required; a biological assessment or special habitat study is routinely required if habitat issues are identified. If the EIS and comments demonstrate that the environmental impacts cannot be reasonably mitigated, the application may be denied.

The City's SEPA determination is published in the State SEPA register and in the local newspapers, and notice is sent to agencies and the public as required under the City's SEPA ordinance. Typical SEPA mitigation measures include: relocating the project on the site; reducing the scale of the project; preserving specific on-site habitats such as trees or vegetated areas; limiting the uses allowed on the site; limiting times of operation, for example during spawning or mating season; and landscaping and/or retention of existing vegetation.

Environmentally Critical Areas Ordinance

Development in or abutting designated critical areas is regulated by the Environmentally Critical Areas (ECA) Ordinance (SMC Chapter 25.09, Regulations for Environmentally Critical Areas). The ECA regulations were adopted in 1992, replacing the previous interim regulations.

The purposes of the ECA Ordinance include protecting the environment and natural resources; promoting the health, safety, and welfare of the general public; and managing development in the identified critical areas. The GMA requires that critical areas be protected from adverse impacts. The GMA requires cities and counties to identify critical areas that are to be protected and where development is to be limited. The ordinance identifies six environmentally critical areas:

1. **Geologic hazard areas.** Known and potential landslide areas; steep slopes of 40% or more; areas that were formerly steep slopes that have been modified; potentially unstable areas resulting from stream incision; and liquefaction areas.
2. **Flood-prone areas.** Areas likely to be covered with or carry water as a result of a 100-year storm, or that would have a 1% or greater chance of being covered with or carrying water in any year based on current circumstances or the maximum development allowed by current zoning.
3. **Riparian corridors.** Areas within 100 feet of any stream as measured horizontally from the top of the bank or ordinary high water mark.
4. **Wetlands.** Generally swamps, marshes, bogs, and similar areas sufficiently inundated or saturated with water that they support vegetation typically adapted for life in saturated soil.
5. **Fish and wildlife habitat conservation areas.** Areas identified by the WDFW as priority habitat or urban fish/wildlife corridors. In addition, the City has designated "all bodies of water that provide migration corridors and habitat for fish, especially salmonids" as fish and wildlife conservation areas
6. **Abandoned landfills.** These include abandoned solid waste landfills that have been identified by hazard assessments and by historical research, and areas within 1,000 feet of methane-producing landfills.

The ECA Ordinance discourages building and construction in sensitive areas; if that is unavoidable, it requires stricter building codes to apply. The ECA requirements apply to development projects within any of the critical areas, including building additions or accessory structures that involve 750 square feet or more of new impervious surface, or projects involving grading of more than 25 cubic yards. However, no amount of grading may be permitted in some critical areas and their buffers.

ECA applies to some projects that are not reviewed under SEPA, such as single family homes, multi-family buildings with four or fewer residential units, commercial buildings of 4,000 or less square feet, parking for 20 or fewer cars, and projects involving grading of between 25 and 500 cubic yards. In critical areas, the SEPA threshold is lowered, meaning more (smaller) projects must complete the SEPA review process. Projects located within the critical areas defined in ECA must undergo SEPA review, except for single family homes with less than 9,000 square feet of development coverage and grading-only projects involving less than 25 cubic yards.

Exempt are additions or accessory structures that involve less than 750 square feet of new impervious surface, grading of 25 cubic yards or less, and certain utility and previous right-of-way work. The exemption for additions/accessories can be applied only one time to a parcel.

ECA Policies on Riparian Corridors, Wetlands, and Cluster Development. In riparian corridors, no development is permitted within or over water courses, unless there is no other access to the property. Riparian corridors are protected by a 50-foot buffer for Class A (year-round) streams and a 25-foot buffer for class B (intermittent) streams. The 50-foot buffer may be reduced to 25 feet for single lots if the adjacent properties have buffers less than 50 feet. The guidelines encourage restoration of riparian corridors in both open channel sections and piped reaches. To encourage wider buffers, setbacks for yards may receive variances.

The ECA also requires that a fence be placed outside the buffer to avoid any disturbance within the stream or its buffer, and requires that clearing and construction be staged on the remainder of the parcel to minimize site disturbance. Other requirements include: permanent markers to delineate buffers; retention of the existing natural state vegetation or revegetation; preservation of habitat corridors and minimizing intrusion; connection of all stormwater drainage to the City-approved system; and best management practices such as using vegetative or bioengineering methods to stabilize stream banks.

The ECA Ordinance protects wetlands greater than 100 square feet and smaller wetlands if they are part of a larger system. Wetlands currently used as lawns and playfields are exempt. However, exempted wetlands may fall under ECA provisions during redevelopment. Wetlands generally are protected by a 50-foot buffer. For wetlands of exceptional value, buffers cannot be graded, filled, or developed. Buffers around non-exceptional wetlands may be reduced to 25 feet. Non-exceptional wetlands may be altered, but compensation is required. Wetlands of exceptional value have the following features: (1) rare or unique species listed by Federal or State agencies as endangered or threatened; (2) presence of plants or groups of plants that occur infrequently in the Seattle or Puget Sound region; (3) habitat diversity; (4) sensitivity to disturbance; and (5) difficulty in replacing ecological functions unique to Seattle.

The ECA Ordinance recommends that development not occur on slopes steeper than 40% and generally requires a 15-foot buffer at the toe of the slope.

ECA policies and regulations permit clustered development in ECAs. The purpose is to encourage larger buffers, reduce impervious surfaces, and decrease encroachment into affected ECAs. The ECA regulations set strict platting standards on sites containing wetlands, riparian corridors, and steep slopes. In order to recover development credit in single family zones, DCLU permits a building applicant to cluster development on the non-critical or least critical portion of the site. Smaller-than-required lot sizes, reduced yards, and attached dwelling units may be allowed.

In some cases, DCLU modifies ECA development standards to allow reasonable use of an applicant's property. ECA exemptions are considered only after all other administrative remedies have been exhausted, such as ECA exemption, ECA yard and setback variance, and ECA conditional use. Conditions for such exemptions and variances are outlined in the ECA Ordinance.

Required Actions and Procedures. The ECA requires the applicant to file an application for the City's review. The application must include a wide range of documentation, such as information about topography, maps of any critical areas, geotechnical analysis, and habitat analysis. The ECA describes development standards to be applied whether or not the City reviews an application. Under these standards, the City may require buffers (areas in which no development, grading, or alteration of vegetation is allowed); sequencing for project construction; and/or revegetation or other restrictions on vegetation removal. The City has discretionary review and may require additional studies.

Updating Regulatory Programs

The City has demonstrated a track record of monitoring and updating its land use policies and regulations as new information becomes available and experience indicates more stringent controls are needed. City staff and elected officials use a variety of mechanisms to modify land use and regulatory programs. The following activities and tools are used to help assure effective programs for meeting environmental and other general community concerns.

Built Environment Study. The City of Seattle is currently funding a study, The Endangered Species Act and the Built Environment. The intent of the study is to identify factors within the City of Seattle which may be contributing to the decline of Chinook salmon runs, recommend solutions to address those factors, and develop a methodology to assist city decision makers in prioritizing the most cost-effective strategies for Chinook salmon recovery. The study is scheduled for completion during Summer 2000.

Comprehensive Plan Updates. The Comprehensive Plan, including the Shoreline Master Program, and implementing development regulations are regularly upgraded. The City continually reviews and amends the Comprehensive Plan and its regulatory program as new Federal, State and local laws and regulations are adopted, and in response to feedback from citizens, planners, inspectors, and enforcement cases.

New Code Development. To assure that regulations are effective and comprehensive, the City has dedicated ten permanent and four temporary employees to new code development. This staff routinely reviews the effectiveness of existing development controls and regulations, and helps develop administrative rules. When a problem with a project or development regulation emerges, City staff – representing inspection, planning, permit review, and code development – work together to solve both the short-term problem and potential similar situations that may arise in the future. DCLU periodically proposes legislation to revise/amend the Land Use Code to City Council which is then made available for public review and comment before Council acts.

Staffing Evaluation. As part of its annual budget review, the City evaluates the resource needs of staff, staff commitments, and the training needed to effectively carry out the regulatory program. In addition, special reviews are undertaken to respond to emergencies and to changing Federal and State regulations. For example, the City responded quickly to the recent ESA listing, allocating funds and hiring new staff to address emerging issues and concerns.

Citizen and Developer Feedback. The City provides a variety of forums for comments and feedback from those involved in development (the regulated community) as well from affected neighborhoods. Forums and activities include a Construction Code Advisory Board, Developer Roundtables, neighborhood meetings, citywide public meetings, and educational programs and materials.

Related City Policies

Drainage Policy Study

Seattle Public Utilities (SPU) launched an effort in 1997to re-evaluate the utility's role in drainage management for the coming decade. Previously, the drainage mission focused on alleviating serious flooding and building drainage system trunk lines. Work to accomplish his mission s nearing completion. SPU looked at options for various levels of increased services, including additional maintenance of creeks, a stronger role in stream restoration, a stronger role in endangered species response, more landslide prevention measures, and local drainage issues. New Drainage Policies were adopted by City Council (Resolution 30083) in December 1999. (See Section 9.1.)

Seattle's Endangered Species Response

In March 1999, Seattle and other agencies submitted early action proposals to the National Marine Fisheries Service. In the next year, these groups will develop a long-term recovery strategy through WRIA 8 Committees and the Lake Washington/Cedar River Forum, as well as the Sammamish Watershed Forum. For more details, see the City of Seattle's Early Action Proposal for Puget Sound Chinook (1999). The Seattle proposal addresses Lake Washington/Cedar River, Duwamish/Green River, Tolt River, and Skagit River fisheries. The proposal summarizes the status of Chinook, a scientific framework for action, limiting factors, and proposed action.

Seattle's Early Action Proposal seeks to use the City's multiple roles effectively (with thorough consideration of the scientific framework) to assist the region in crafting a chinook recovery effort. As the report details, the City has already invested significantly in specific Chinook recovery actions and projects that improve ecosystem processes, and has significant pending commitments. As an example of a pending commitment, the Cedar River Habitat Conservation Plan (HCP), when approved by NMFS, would provide for Chinook passage into 17.5 miles of pristine Cedar River spawning habitat. Seattle proposes to capitalize on four key City roles:

- **Environmental Steward.** Seattle proposes permanent protection for important Chinook spawning and rearing habitat, in-city stormwater control actions and stream and creek restoration with fish barrier removal, and Chinook research investments.
- **Regional Partner**. Seattle has a key role to play as a regional partner with other water suppliers and counties. In partnerships with other water suppliers, Seattle can manage its water system to reduce water withdrawals in streams tributary to mainstem rivers, where low flows are potentially harming Chinook and other salmon.
- **Regulator and Operator.** Through its land use, public utilities, and transportation departments, the City regulates new development within its boundaries. Projects proposed in this category increase inspection, enforcement, and education associated with existing regulations to respond to the specific habitat needs of Chinook and other salmonid species. In addition, the City is reviewing its management practices related to transportation, stormwater, and parks.
- **Catalyst for Community Action.** Saving salmon must become a community activity. Seattle can act as a catalyst for community action by engaging its citizens through a variety of involvement strategies, communication products, and continuing education

Several projects that may impact Thornton Creek fish resources are flood relief projects in the watershed, improvements to the Chittenden Ballard Locks, and instream restoration projects along Thornton Creek. These are described in more detail in Section 8.4 and Section 10.6.

Landslide Policy

Landslides resulting from the severe winter storms of 1996-1997 caused extensive damage to public and private property and raised awareness of landslide hazards. Seattle City Council appointed a Landslide Policy Group to explore ways to prevent future damage. After extensive discussion and four citizen workshops, the following recommendations were adopted by City Council in 1998 (Resolution 29774, June 1998):

- Map landslide prone areas (LPAs).
- Inform citizens of risks and responsibilities in LPAs.
- Educate citizens about hazards and best management practices (including trees and other slope vegetation) in LPAs.
- Enforce codes and policies in support of best management practices in LPAs.
- Develop policies for hillsides.
- Invest in a preventive program to protect public facilities in LPAs.
- Develop tailored street and drainage standards for residential streets.
- Address drainage problems.
- Improve coordination of emergency response and recovery services.
- Increase the drainage fee to better control stormwater runoff.
- Capitalize a hazard mitigation fund to protect public facilities.
- Contribute to a risk pool to protect public and private facilities.
- Use financing mechanisms to help residents and businesses.

Sedimentation resulting from landslides can cause considerable damage to creek habitat. In addition to reducing risk of such damage, the new landslide policies affect creek restoration strategies in several ways: they set a precedent for spending public money on private property for public benefit; they emphasize the importance of infiltration and groundwater recharge; and they change street-side drainage requirements.

Seattle Public Utilities Strategic Business Plan (1999-2000)

SPU's mission statement is: "We provide our customers with a reliable water supply and essential sewer, drainage, solid waste, and engineering services that safeguard public health, maintain the City's infrastructure, and protect, conserve and enhance the region's environmental resources." One SPU goal directly addresses the environment: "Protect, sustain and enhance environmental quality both locally and regionally." This goal is supported by a commitment to emphasize use natural solutions for flooding; to restore and preserve habitats that are threatened and for which SPU is responsible; and to help the public to be environmentally aware and encouraged to become responsible stewards.

Environmental Action Agenda

The Environmental Action Agenda, adopted in 1992 by Seattle City Council Resolution 28619, endorses preserving and protecting open space, the urban forest, and other wildlife habitat areas as a major priority for new environmental action by the City. It endorses improving environmental education, expanding community involvement opportunities, and improving environmental management and coordination.

6.7 City of Shoreline (Incorporated 1995)

This section reviews the Shoreline Comprehensive Plan policies, ordinances, and regulations that most affect water quality and habitat in the Thornton Creek watershed. As of December 1999, the City of Shoreline was in the process of revising the development regulations to implement the policy direction detailed in the 1998 Comprehensive Plan, as well as to address Federal and State regulatory requirements related to stormwater management, protection of anadromous fish, and use of best available science. Based on the policy direction contained in the Comprehensive Plan and approved by the Shoreline City Council, it is anticipated that the City will implement more stringent standards related to stormwater management, critical areas protection, and grading than those in place under current codes inherited from King County. It is also anticipated that the City will implement tree-cutting and land-clearing standards to encourage or require development practices that result in greater retention of forest cover and native soils to reduce impacts related to loss of habitat and increased stormwater runoff.

Comprehensive Plan (1998)

The City adopted its first Comprehensive Plan in November 1998. This plan contained specific policy direction calling for additional protection for native vegetation, streams, wetlands, lakes, and wildlife habitat. Examples include the following:

EN18: Allow land alteration, such as clearing, grading, and filling only for approved development proposals or approved mitigation plans. The City shall investigate regulatory means of restricting land-clearing activities that do not meet the current size and volume thresholds for obtaining a grading permit. Regulations shall exclude activities defined as routine property maintenance.

EN21: Develop educational materials, incentives, policies, and regulations to conserve native vegetation on public and private land for wildlife habitat and human enjoyment. The City shall establish regulations to protect mature trees and other native vegetation from the negative impacts of residential and commercial development, including short-plat development.

EN29: Actively participate in regional species protection efforts, including salmon habitat protection and restoration.

EN30: Critical wildlife habitat, including habitats or species that have been identified as priority species or priority habitats by the Washington Department of Fish and Wildlife, will be preserved through regulation, acquisition, incentives, and other techniques. Habitats and species of local importance will also be protected in this manner.

EN37: Maintain surface water quality as defined by Federal and State standards and rehabilitate degraded surface water through reduction of non-point source pollution and erosion and the development of stormwater system improvements.

EN38: Actively pursue State and Federal grants to improve surface water management and water quality.

EN39: Support enhanced water quality and the percolation of water at natural rates near where it falls where it won't result in soil instability or damage roadways or other improvements. Measures may include appropriate landscaping, swales, natural retention facilities, pollution control devices, and improved stormwater facilities.

EN46: Where practicable, stormwater facilities, such as retention and detention ponds, should be designed to provide multiple benefits, including wildlife habitat and opportunities for passive recreation.

EN51: Establish regulations for wetlands that:

- Recognize and protect the functions and values of all wetlands where practicable;
- Provide increasingly stronger protection to wetlands according to the ranking and classification system hierarchy;
- Recognize and protect wetlands of significant size;
- Preserve appropriate buffers to facilitate infiltration and maintain stable water temperatures, limit the rate at which stormwater enters the wetland, and provide wildlife habitat;
- Protect the natural water quality and regime;
- Preserve native wetland vegetation and allow the removal of noxious weeds; and
- Limit public access based on the importance and sensitivity of the wetland.

EN52: Achieve a no net loss of wetlands function and value within each drainage basin over the long term. Shoreline should seek to maintain total wetlands acreage over the long term.

EN56: Existing degraded wetlands should be restored where practicable. Restoration of degraded wetlands may be required as a condition of redevelopment.

EN58: Actively pursue funding for baseline monitoring and improvement of water quality in lakes and streams in the City.

EN59: Streams shall not be filled or permanently altered except where no other practicable alternative exists or for approved mitigation projects. Where practicable, streams should be allowed to return to natural channel migration patterns. In cases where stream alteration is necessary, channel stabilization techniques shall generally be preferred over culverting.

EN60: Identify surface water features with restoration potential and attempt to obtain citizen involvement and community consensus on any future attempt to restore features that have been altered. Restoration efforts may include the daylighting of streams that have been diverted into underground pipes or culverts.

EN61: The City shall work with citizen volunteers, State and Federal agencies, and tribal governments to identify, prioritize, and eliminate physical barriers and other impediments to anadromous fish spawning and rearing habitat.

EN62: The City shall take a leadership role in protecting water quality through regulation, educational outreach, and by adhering to State and Federal environmental standards in all City funded projects.

EN66: Shoreline shall cooperate with King County, Snohomish County, and other local governments and State agencies, and tribal governments in developing and implementing

Watershed Action Plans and other types of basin plans for basins that include or are upstream or downstream from the City of Shoreline.

Shoreline Laws and Regulations

The City of Shoreline regulates impacts to water quality and habitat through its development regulations. These include clearing and grading standards, stormwater management standards and design guidelines, critical area regulations, and environmental (SEPA) policies. The specific standards and requirements applied to a project are identified through the permit review process. The City's Department of Planning and Development Services is responsible for administering construction, land use, and zoning regulations for development of all properties within the Shoreline City limits. As of December 1999, the City operates under King County development regulations, including grading, stormwater management, SEPA, and environmentally sensitive areas standards adopted prior to incorporation. These standards are contained or adopted by reference in the Shoreline Municipal Code. In addition, the Building Code regulates drainage of surface water around buildings to ensure that stormwater drains away from the structure, and recommends guidelines to protect the site from erosion and shallow failures.

Stormwater Management

Shoreline adopted King County's Surface Water Management Code (Title 9) in 1995, and has amended it several times since incorporation. One amendment stiffened the rules to require drainage review when a project proposes to add 1,500 square feet of new impervious surface, rather than the previous threshold of 5,000 square feet. The City has also adopted by reference the 1990 King County Surface Water Design Manual (KCSWDM) with updates. This manual regulates proposed projects by a mixture of requirements, performance standards, and design standards. To comply with Ecology's regulatory direction, Shoreline is currently using the 1998 KCSWDM update.

The City is currently revising stormwater management development regulations to comply with Ecology's recommendations. Issues include increasing detention requirements for redevelopment projects and using a pre-incorporated natural state as the basis from which to measure redevelopment project impacts. Following public review, approval of stormwater management development regulations and guidelines is expected by Spring 2000.

In addition, the City is in the process of analyzing the existing surface water management program, including maintenance, operations, regulation, public outreach, environmental education, and other components, relative to Federal and State laws and requirements. The City will design a surface water program that is compliant with these laws and consistent with City values. The City is already in compliance with some requirements. In other areas, the City is only partly in compliance, or does not have the desired systems in place. The City expects to have this analysis completed by Winter 2000. Budget development and Council approval for the program is expected by Summer 2000, with coordinated implementation of the comprehensive stormwater management program to begin sometime in late 2000.

Critical Area Regulations

The City of Shoreline has adopted the King County Environmental Sensitive Areas Code (Chapter 21) as Chapter 18.24 of the Shoreline Municipal Code. The purpose of this chapter is to implement goals and policies of the Washington State Environmental Policy Act (43.21C RCW) and the City of Shoreline Comprehensive Plan that call for protection of the natural environment and the public health and safety. This code restricts development and controls activities relating to landslide hazard areas, seismic hazard areas, erosion hazard areas, steep slopes, wetlands, streams, flood hazard areas, and the identified buffers of these areas.

The City of Shoreline is currently revising the environmentally sensitive areas regulations. The new regulations will be known as the Critical Areas Standards and will represent the state of the art in critical area regulation. In addition to the existing categories of critical areas, the new regulations will also provide standards for Fish and Wildlife Conservation Areas based on Washington Department of Fish and Wildlife Priority Habitats and Species data as well as standards for aquifer recharge areas. Other proposed changes include more stringent standards for critical geologic hazards and less burdensome regulations on areas of minimal geologic hazard. Proposed changes also include performance-based variable buffers, elimination of standards and exemptions related to forestry and agriculture, more detailed standards related to stream and wetland mitigation, and a transition from the old King County system to the wetland and stream classification system used by the State of Washington. Following public review, Council approval of the revised Critical Areas Standards is expected by Spring 2000. The City is also expected to fund additional resource surveys to identify and classify wetlands and streams in the City to augment the critical area identification done under King County. This additional survey work is expected to occur sometime in 2001.

Environmental Procedures (SEPA)

As of December 1999, the City operated under SEPA policies developed by King County (King County Code Chapter 20.44). These regulations establish both procedural and substantive requirements to ensure that the environmental impacts of projects are identified, public comment is sought, and adverse environmental impacts of projects are mitigated. Most SEPA provisions are mandatory and determined by State law (RCW 43.21C and WAC 197-11). However, certain provisions are optional or may be augmented by agencies as stated in their adopted SEPA procedures.

SEPA is an important and flexible tool for protecting water quality and habitat. It gives the City the authority to require detailed environmental analysis of the impacts of a proposal and require mitigation to address these impacts. It also requires that adequate notice and opportunity for public comment is provided for all projects not categorically exempt from SEPA review. Under SEPA, mitigation is defined as the following:

1. Avoiding the impact altogether by not taking a certain action or parts of an action;
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;
5. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or
6. Monitoring the impact and taking appropriate corrective measures.

Council is expected to adopt revised SEPA procedures following public review. Major changes include a reduction in the flexible categorical exemption thresholds for minor new construction to the State minimums. For example, this would mean that the construction of more than four dwelling units or any fill or excavation of more than 100 cubic yards would be subject to SEPA. The current thresholds for SEPA review include the construction of more than eight dwelling units or any fill or excavation of 500 cubic yards. Under the City's proposed draft environmental procedures, the following projects would also be subject to SEPA:

- Construction of an office, school, commercial, recreational, service, or storage building with more than 4,000 square feet of gross floor area.
- Construction of a parking lot designed for more than 20 automobiles.
- Installation of impervious underground tanks with a capacity of more than 10,000 gallons (includes gas stations).
- Construction, reconstruction, or maintenance of groins, bulkheads, and similar shoreline protection structures.
- Any construction on lands wholly or partly covered by water.
- Construction activities (except certain utility maintenance and construction activities and limited other remodeling and maintenance activities) that propose to change existing conditions within a stream, wetland, or the designated buffer of these areas.

A major component of SEPA is the concept of substantive authority. SEPA substantive authority gives agencies and local governments the ability to condition or deny a proposal to address probable significant adverse environmental impacts. Under the City's draft proposed SEPA policies, the City could attach conditions to a permit or approval for a proposal so long as:

1. Such conditions are necessary to mitigate specific adverse environmental impacts identified in environmental documents prepared pursuant to the environmental procedures chapter; and
2. Such conditions are in writing; and
3. The mitigation measures included in such conditions are reasonable and capable of being accomplished; and
4. The City has considered whether other local, State, or Federal mitigation measures applied to the proposal are sufficient to mitigate the identified impacts; and
5. Such conditions are based on one or more of the documents identified as the basis for substantive authority (includes Comprehensive Plan, City of Shoreline Municipal Code, surface water management plans adopted by Council, etc.) and cited in the permit, approval, license, or other decision document.

The City could deny a permit or approval for a proposal on the basis of SEPA so long as:

1. A finding is made that approving the proposal would result in probable significant adverse environmental impacts that are identified in a Final Environmental Impact Statement or Final Supplemental Environmental Impact Statement; and
2. A finding is made that there are not reasonable mitigation measures capable of being accomplished that are sufficient to mitigate the identified impact; and
3. The denial is based on one or more of the documents identified as the basis for substantive authority (includes Comprehensive Plan, City of Shoreline Municipal code, surface water management plans adopted by Council, etc.) and identified in writing in the decision document.

Like the City of Seattle, the City of Shoreline requires all applicants to fill out a SEPA checklist unless the project is categorically exempt. The City makes the decision as to whether a project is categorically exempt. The City then makes the threshold description as described previously.

Comparison of Seattle and Shoreline Regulations

Like Seattle, the City of Shoreline has several regulatory tools to protect water quality and habitat in the Thornton Creek watershed. Key tools include clearing and grading standards, stormwater management standards and guidelines, critical areas standards, and SEPA. SEPA can be viewed as an all encompassing framework for project review and a safety net that gives the City the authority to address significant adverse environmental impacts that are not anticipated or adequately mitigated by established local development regulations or State and Federal law. The City of Shoreline is currently revising its development regulations to implement the policy direction in the adopted Comprehensive Plan, which calls for additional protections for water quality and habitat both citywide and in the Thornton Creek watershed.

A comparison of key Seattle and Shoreline development standards is shown in Table 6.1. The table also includes examples of draft proposed development standards as of December 1999. Note that exemptions to these standards may be granted.

6.8 Watershed Management Committee Concerns About the Cities of Seattle and Shoreline's Laws, Regulations and Policies Related to the Thornton Creek Watershed

The Watershed Management Committee reviewed the regulations and policies described in this chapter. The Committee chose to focus most of its effort on Seattle and Shoreline, where the group can wield greater influence on protecting the Thornton Creek watershed. The Committee's concerns are summarized below:

Regulations

- Too much development is permitted in the remaining undeveloped areas near the creek.
- Wetlands are not adequately protected.

Policies

- City policies/regulations do not encourage infiltration
- City policies/regulations do not adequately support lower levels of impervious surface.
- Existing requirements for new construction/remodel are not aggressive enough.
- Seattle's Design Review Guidelines do not include environmental concerns.

Enforcement

- Existing regulations are not aggressively enforced.
- Penalties are often not administered.
- Responses to environmental complaints are not always resolved in a timely manner.
- Citizens are not able to easily report environmental offenses.

Coordination

- Coordination between Seattle, Shoreline, and King County should be increased.
- Regional responses for endangered salmon may leave out urban streams.

Table 6.1. Comparison of Seattle and Shoreline Drainage-Related Building Codes

Code	Seattle	Shoreline (Existing)	Shoreline (Draft Proposed – Subject to change prior to Council approval)
Threshold for drainage control review	750 sq ft	1,500	1,500 sq ft
Detention required	2,000 sq ft	Approx. 9000 sq ft of new impervious surface	1,500 of new impervious surface
Detention requirements	Less than 0.2 cfs/acre in a 25-year storm	Match runoff rates for the 2 and 10 and up to 100 - year storm	Depends on site and downstream conditions. In general, match 50% of the 2 through 50-year storm using continuous runoff model and predevelopment natural rates (requires substantially more detention for re-development and more continuous attenuation rather than just smoothing out the peaks).
Buffer for riparian corridor	25 – 50' (only two categories for streams)	25 – 100' (three types)	0 – 150' (five types)
Buffer for wetland	25 – 50' (may be reduced on existing lots)	25 – 100'	10 – 100'
Single family residential minimum lot size	5,000 sq ft	7,200 sq ft	7,200 sq ft
Maximum lot coverage	Single family – varies Commercial – 100% Industrial – 100%	Single Family – 45% to 50% Multifamily – 75% to 90% Commercial and Industrial – 75% to 90%	Same
Water quality requirements for construction activities	Erosion control plan	Temporary Erosion and Sediment Control Plan as per KCSWDM	Same plus remove 90% of suspended solids
Water quality requirements for new development		5,000 sq ft of new pollution generating impervious surface	5,000 sq ft of new pollution generating impervious surface (greater choice of treatment options)

Regulated wetland size		1,000 sq ft	1,000 sq ft

CHAPTER 7: NON-GOVERNMENT ORGANIZATIONS, SCHOOLS, AND OTHER ORGANIZATIONS

Watershed protection is not limited to governments. Many non-government organizations, community groups, and schools are actively involved in restoring the health of the Thornton Creek watershed. The purpose of this chapter is to identify these groups and their missions, and explain their roles in the watershed. Specific activities and projects sponsored by these groups are described in later chapters.

7.1 Non-Government Organizations

Numerous non-profit organizations work to improve the Thornton Creek watershed. Several active organizations, such as the Thornton Creek Alliance, and the Thornton Creek Project, focus their effort mainly within the watershed. Others, such as the Seattle Audubon Society and Washington Native Plants Society, work regionally to promote issues that improve the health of all watersheds. In addition, numerous Scout groups, religious organizations, social clubs, and businesses have dedicated time to work on restoration projects within the watershed. The organizations with a strong presence are described below. For additional information on these groups, see Sections 10.4 and 10.5.

Thornton Creek Alliance

The Thornton Creek Alliance is an all-volunteer organization formed in 1992 by people living and working within the Thornton Creek watershed. They are dedicated to preserving and restoring an ecological balance in the watershed. Their goal is to benefit the creek by encouraging individuals, schools, groups, businesses, and government to work together to address the many issues associated with preserving what remains of the watershed and restoring other sections. This includes water quality and quantity, streambank stabilization, open space acquisition, community stewardship, education and awareness, advocacy, research, watershed planning, and habitat restoration and protection. They are concerned about many of the degradations faced by urban streams: pollution, flooding, habitat loss, wildlife population decline, erosion, invasive plants, and fish passage obstacles. TCA promotes neighborhood-based monitoring and stewardship of Thornton Creek through a program called Stream Care. In this program, TCA seeks to assist leaders of neighborhood-based stream groups and individuals who organize neighbors around a specific stream-related project. This is done by providing various resources, network contacts, and educational opportunities. URL: http://www.scn.org/earth/tca/index.htm

Thornton Creek Project

The Thornton Creek Project (TCP) is a cooperative educational venture among watershed schools, focusing on Thornton Creek and its watershed. TCP brings together students, teachers, residents, and other decision makers in the watershed. TCP's mission is to use mutual understanding and active care for the watershed to help students develop the habits, attitudes, skills, and knowledge of stewards, citizens, and leaders. Phone: TCP project manager 206-526-0187. URL: http://nsccux.sccd.ctc.edu/~tcp/

Some TCP projects include:

- Organizing school monitoring of various aspects of watershed health including creek health, birds, amphibians, salmon habitat, and business vitality.
- Hosting an annual confluence where students from throughout the watershed take on the role of watershed stakeholders in shaping the community's future.
- Providing teacher support for curriculums involving the creek and watershed.
- Sponsoring "Rudy's Adventure," a project in which each year students research, write, and illustrate a story about a mouse who escapes from a pet shop at Northgate Mall and travels down Thornton Creek to Lake Washington.

Adopt-a-Stream

The non-profit Adopt-a-Stream Foundation was created in 1981 to increase public sensitivity to and awareness of the importance of the 3,000 miles of creeks, streams, and rivers and the fish that inhabit them in Snohomish County, and to restore health to those waterways damaged by people or nature.

The program seeks to ensure that Northwest streams continue to provide healthy spawning and rearing habitat for wild salmon, steelhead, and trout, while also serving a growing population with clean drinking water and places for rest and relaxation.

Adopt-a-Stream's mission is to "teach people to become stewards of their watershed" through a focus on environmental education and habitat restoration. Schools, community groups, clubs, civic organizations, and individuals are encouraged to adopt their local streams and become "Streamkeepers."

Presently, Adopt-a-Stream is concentrated within Snohomish County. The program could prove valuable if expanded into King County. Phone: 425-316-8592 URL: http://www.streamkeeper.org/index.htm

Boy Scouts, Girl Scouts, and Camp Fire Girls

Boy Scouts, Girl Scouts, and Camp Fire Girls regularly participate in environmental projects throughout the watershed. They often work on restoration and planting projects with Seattle's Adopt-a-Park program, as well as completing independent projects to gain badges and recognition within their organizations.

Cascadia Quest and King County World Conservation Corps

Cascadia Quest is an international conservation group based in Seattle. King County World Conservation Corps (KCWCC) is a public-private partnership between Cascadia Quest and King County. Cascadia Quest/KCWCC also works on restoration projects in partnership with People for Puget Sound and the Student Conservation Association, among other community organizations. Their mission is to provide leadership training to young adults from King County and around the world in environmental restoration. KCWCC is involved in 40 restoration projects throughout King County. In addition to projects in the Thornton Creek watershed, they have included wetland reconstruction in the Duwamish and other watersheds, salmon stream habitat restoration in Redmond, Medina, Seattle, and Woodinville, and creek daylighting in Seattle. Phone. 206.322.9296. URL: http://www.cascadiaquest.org/

Cascade Land Conservancy

The Land Conservancy of Seattle and King County (TLC) is a non-profit, tax exempt organization working to preserve invaluable open lands, beaches, wetlands, forests, and farm-lands in neighborhoods throughout Seattle and King County. TLC enables landowners to preserve the special character of their property for present and future generations – at virtually no public expense. TLC joins with the landowner and surrounding community to design a preservation program that protects selected property, and also allows the landowner to continue to own and use the land. In addition, many of the programs can provide substantial tax benefits that may include reductions in Federal income tax, Federal estate taxes, and State and local property taxes. Phone. (206) 292-5907. URL: http://www.cascadeland.org/

Paramount Park Neighborhood Group

The Paramount Park Neighborhood Group is an independent grassroots community organization of neighbors and friends of the Paramount Park Natural Area. It was formed originally in 1989 to advocate for open space additions and then for protection from encroachment by development on its periphery. Its goals were expanded to include habitat and water quality enhancements after receiving several grants. The group has worked on wetland restoration, frog habitat, trail guides, brochures, and a book.

Salmon Web

The purpose of Salmon Web is to create, distribute, and coordinate a set of tools that support education, communication, and ecological science focusing on salmon habitat. Their tools include a web page (www.salmonweb.org) with attached database that allows access to biomonitoring data and networking opportunities, and a monitoring video showing in detail how and why to conduct biomonitoring. This organization seeks to harness and coordinate efforts of citizen and student groups in the Northwest, creating a “virtual” community aimed at preserving and restoring wild salmon and their habitat throughout the region.

Salmon Web has four connected components designed to provide educational information and training for stream monitors, educators, and decision makers about the health of Pacific Northwest Streams.

- **Benthic Index of Biological Integrity (B-IBI).** Designed by Dr. James Karr of the University of Washington, the B-IBI detects changes in the biotic community and the biological integrity of streams as resulting from human impacts such as urbanization, forestry, agriculture, recreation, and grazing.
- **Biological Monitoring Protocol.** Based on the work of Dr. Karr, the protocol provides step-by-step instructions for collecting standardized samples of invertebrates, such as insects, in streams. These samples are used to develop an index of biological integrity to measure changes in stream health.
- **A Multifaceted Website.** The website is designed as a data repository, educational site, and networking tool. The site provides a comprehensive look at individual watersheds, streams, and study sites, as well as a wealth of salmon and streamflow

data. Among its services, the site is designed to allow monitors to exchange data on the site, "walk" through watersheds, and view photos.

- **Freshwaters Flowing (educational video).** Explores the connection between humans and streams, revealing the links between human influences and the ability of a stream to support healthy biological communities.

Seattle Audubon Society

The Seattle Audubon Society protects birds and the natural environment by involving volunteers and the community in education, advocacy, preservation, science, and enjoyment. The Audubon Society hosts lectures, bird watching tours, field trips, nature camps, and educational programs. The office is located in the watershed and open to the public daily. Phone. (206) 523-4483. URL: http://www.seattleaudubon.org/. For more detail, see Section 10.1.

Seattle Community Councils and Shoreline Council of Neighborhoods

Community councils in the Seattle portion of the watershed include Wedgwood, Maple Leaf, Meadowbrook, Olympic Hills, Pinehurst, Victory Heights, and the 27th Ave Neighborhood Alliance. In Shoreline, active neighborhood associations include Ridgecrest, Parkwood, Meridian Park, Briar Crest, and North City. These community councils and neighborhood associations work with Shoreline's Council of Neighborhoods and Seattle's North District Council.

Community councils, generally staffed by volunteers, are dedicated to maintaining and improving the quality of life for residents of the community and neighborhood. Most councils have monthly meetings and are run by an elected board including a president, treasurer, and secretary.

These councils work to improve their communities in a variety of ways. Stewardship of creeks, wetlands, and natural areas is a typical issue for discussion and action, along with land use and development planning, parks, roads, and transportation, use of city funds, organizing community events, and school decisions.

Seattle Tilth

The non-profit Seattle Tilth Association began in 1978 when neighbors got together to change a paved lot to a garden. This act of real estate development has had far-reaching effects, from a local increase in diversity of beautiful insects and birds, to a heightened consciousness citywide of the benefits of composting. In working to enhance local environments and the community through education about organic gardening, Tilth members have created diverse and innovative programs that have improved the city. Tilth is known for its popular Master Composter program and Compost Hotline, as well as the CORE Volunteer program.

Seattle Tilth's vision is to introduce people to the immensely satisfying joys of gardening. They are working to make organic gardening methods the norm instead of an alternative to industrialized, chemical-intensive techniques. They seek to expand opportunities for living well while using the earth's resources more lightly, and to create opportunities for diverse people to work together in practical ways that nurture community. Phone. (206) 633-0451. URL: http://www.seattletilth.org/

Seattle Urban Nature Project (1999)

A non-profit organization, Seattle Urban Nature Project (SUNP), is surveying existing wildlife habitats and associated wildlife in Seattle's parks and green spaces to create an independent, continuously updated and refined database to be used for science, conservation, and education. SUNP completed the initial survey in 1999. This organization also aims to protect, enhance and increase understanding and stewardship of urban park natural resources. Refer to Section 10.1 for more detail.

Sierra Club

With more than 550,000 members, the Sierra Club is the largest conservation organization in the United States. Its effectiveness comes from speaking with one voice on national issues. As a grassroots organization, its power comes from thousands of creative, energetic volunteers who donate their time and talents to help protect the natural environment.

The Cascade Chapter organizes and supports the Sierra Club's grassroots conservation efforts in all but the easternmost counties of Washington State. Phone: 206.523.2147. URL: http://www.cascadechapter.org/

Student Conservation Association

The Student Conservation Association (SCA) is America's largest and oldest provider of national and community conservation service opportunities, outdoor education, and career training for youth. SCA volunteers and interns annually perform more than one million hours of conservation service in national parks, forests, refuges, and urban areas in all 50 states. Its mission is "to build the next generation of conservation leaders and inspire lifelong stewardship of our environment and communities by engaging young people in hands-on service to the land." Phone: 603-543-1700. URL: http://www.sca-inc.org/

TREEmendous Seattle

TREEmendous Seattle is a public/private partnership whose mission is to unite and coordinate the efforts of volunteers, communities, businesses, not-for-profit organizations, and government agencies to plant, preserve, and maintain a healthy urban forest in Greater Seattle.

Seattle's trees are a beloved and integral part of the city's landscape. TREEmendous Seattle members treasure urban forests and work to protect them for future generations. TREE-mendous Seattle is a key partner in Seattle's Millennium Project to plant 20,000 trees in Seattle. The millennium trees will be a living legacy to the citizens who participated in the planting – and to generations to follow. Phone: 206-985-6867. URL: http://www.seattletrees.org/. For more details, refer to Section 10.4.

Washington Native Plant Society

The Washington Native Plant Society's mission is to promote the appreciation and conservation of Washington native plants and their habitats through study, education, and advocacy. The organization is actively involved in education and conservation. Membership is made up of people interested in the native plants and vegetation of the Pacific Northwest. Members include avid gardeners, plant novices, hikers, photographers, teachers, students, and professional botanists.

The Native Plant Society has an active chapter in Seattle, run entirely by volunteers. The chapter holds regular meetings and lectures; organizes plant sales, landscaping workshops, and field trips; and publishes a monthly newsletter. In addition, members work with schools and a variety of other organizations to increase public awareness of the importance of native plants and their environment. The Education Committee is developing a native plant curriculum suitable for grades K-12. In response to many requests to speak about native plants in local schools, the chapter is developing a guideline for volunteers.

In 1996, 25 Native Plant Stewards graduated from a native plant stewardship program sponsored jointly by the chapter and Washington State University/King County Cooperative Extension. The stewards are involved in education, restoration, and other projects throughout the Puget Sound region. Phone: 206-527-3210 or 1-888-288-8022. URL: http://www.wnps.org/. For more detail, see Section 10.4.

YMCA Earth Service Corps

YMCA Earth Service Corps is a service learning program for teens ready to make a difference in their communities. Grounded on the building blocks of leadership development, environmental education and action, and cross-cultural awareness, this proven program works in diverse communities and allows teens to use their talents, develop new skills, and learn more about themselves and their surroundings. Young people in Earth Service Corps are recognized as valuable resources, working hand-in-hand with others to solve important problems. Phone: Seattle branch (206) 382-5000. URL: http://www.seattleymca.org/

7.2 Schools

A number of schools in and near the watershed have incorporated Thornton Creek and watershed activities into their curriculum. Schools in or near the watershed are listed below and school programs are described in Chapter 11.

Seattle Public Schools

Alternative School #1

Alternative School #2

American Indian Heritage High School

Eckstein Middle School.

Nathan Hale High School

Northgate Elementary School

Olympic Hills Elementary School

Olympic View Elementary School

John Rogers Elementary School

Sacajawea Elementary School

Summit School (K-12)

Wedgwood Elementary School

Shoreline Public Schools

Briar Crest Elementary School

Kellogg Middle School

Meridian Park Elementary

Parkwood Elementary School

Ridgecrest Elementary School

Shorecrest High School

Shorewood High School

Private Schools

Evergreen School

Fircrest School (all ages)

King's Schools (all ages, nearby on Boeing Creek)

Lakeside High School

Lakeside Middle School

Ryther Child Care

Seattle Waldorf School

St. Mark's Catholic School

St. Matthew's School

Shoreline Christian School

University Prep Academy

Colleges and Universities

North Seattle Community College

Shoreline Community College

University of Washington

7.3 Government-affiliated Organizations

A number of organizations rely on local residents and volunteers, but are affiliated with local and State government. These organizations are described below. Section 11.5 lists web addresses and links to these organizations.

Seattle Department of Parks and Recreation – Adopt-a-Park

Seattle's Department of Parks and Recreation runs an innovative program called Adopt-a-Park, which encourages citizens and community groups to assist Parks Department employees in caring for green spaces. The purpose is to entice volunteers to help maintain local parks and restore habitat. Hundreds of volunteers every year dedicate Saturday mornings to work parties. The program accommodates two types of volunteers: participants in one-day community restoration, re-vegetation, and maintenance projects; and long-term volunteers dedicated to the care of a specific site.

Volunteers not only help restore the beauty of their surroundings, but also plan and implement projects so today's children will have a place to bring their children in the future. Money from the Department of Neighborhoods Matching Fund program provides cash matches to neighborhood-based Adopt-a-Park projects. Programs in Seattle's Thornton Creek watershed are administered by Janine VanSanden, Seattle Department of Parks and Recreation, (206) 233-3979. URL: http://www.ci.seattle.wa.us/parks/Volunteers/index.htm. See Sections 10.2 and 10.4 for more detail.

Seattle Millennium Project

The Seattle Millennium Project unites neighborhood organizations, environmental groups, City departments, and individual volunteers in a citywide park restoration and tree planting project. Together, these groups will plant 20,000 trees in developed parks and boulevards, park open spaces and natural areas, watersheds and stream corridors, public streetscapes, and private residential, business, and institutional properties throughout the city.

The 20,000 millennium trees will greatly enhance the natural beauty of the city. Citizens of all backgrounds, from Scout troops and Seattle school children to neighborhood groups such as the Fremont Public Association, will work side by side planting and caring for these trees and transforming the urban landscape. See Section 10.4 for more detail.

Seattle Neighborhood Planning

As a part of its Growth Management Act (GMA) implementation, the City of Seattle established a Neighborhood Planning Office (NPO) to support community-created neighborhood planning groups in developing neighborhood plans consistent with the Seattle Comprehensive Plan. The neighborhood plans sought to consider all stakeholders' interests. Within the Thornton Creek Watershed two plans were developed. The Northgate Area Comprehensive Plan was adopted in 1993 and addresses preserving Thornton Creek in its open space section. The Plan for the Neighborhoods of the Lake City Community, adopted in 1999, includes preservation of the Thornton Creek watershed as a major theme throughout the Plan and addresses the creek specifically in the chapters devoted to natural systems. See Section 6.5 for details.

Seattle P-Patches

The Thornton Creek watershed is home to three community P-Patches, created and implemented by the Department of Neighborhoods, but maintained and cared for by Seattle citizens. In addition to providing a place for gardening, the P-Patch program promotes organic gardening techniques and educates gardeners about topics such as composting, worm bins, and Integrated Pest Management. The three watershed P-Patches include Picardo Farm, at the south edge of the watershed near 80th Ave NE and Ravenna Ave; Jackson Park P-Patch adjacent to Thornton Creek Park #1; and Pinehurst P-Patch at 12th Ave NE and NE 115th.

Seattle Public Utilities – Citizen Advisory Groups

Seattle Public Utilities (SPU) has established three Citizen Advisory Groups, reporting to director Diana Gale with comments on public policy and work needs. One of these, the Creeks, Drainage, and Wastewater Committee, focuses on issues pertinent to Thornton Creek that can influence decision making in the watershed.

Seattle Public Utilities – Urban Creeks Legacy

In a renewed effort to care for Seattle's vital urban creeks system, SPU began the Urban Creeks Legacy Program as part of Seattle's Millennium Project. The need for the program stemmed from SPU's responsibility to enhance degraded creek systems, recognize the need for community and business education, resolve critical water quality and quantity problems, and coordinate restoration efforts of multiple agencies, groups, and individuals across the city. URL: http://www.ci.seattle.wa.us/util/urbancreeks/

The Urban Creeks Legacy Program was developed through a collaboration of dedicated citizens, local non-government organizations, and City staff. Common themes emphasized in the program include:

- Promoting awareness of urban creeks and their watersheds.

- Educating citizens about the importance of urban creek systems and their care.
- Promoting linkages between groups and individuals working on creek projects, and providing access to creeks.
- Fostering a stewardship ethic towards urban creek systems, including hands-on restoration, enhancement, and protection activities by volunteers.
- Celebrating and appreciating all that has been done to preserve, protect, enhance, and restore Seattle's creek systems.

Shoreline Council of Neighborhoods, Seattle North District Council

Shoreline and Seattle support neighborhood associations and community councils including those listed above. Representatives from each of Shoreline's 13 neighborhood associations attend monthly meetings of the Council of Neighborhoods. Seattle's community councils participate in Seattle's North District Council.

WSU Cooperative Extension – Community Horticulture Program

The mission of the Washington State University Cooperative Extension Community Horticulture program is to provide access to research-based information and encourage its application by individuals, communities, and horticulture professionals with the purpose of promoting human well-being, protecting and enhancing the environment, and encouraging community stewardship. URL: http://gardening.wsu.edu/text/mission.htm. See Section 10.4 for more detail.

WSU Cooperative Extension – Master Gardeners

Master Gardeners are university-trained volunteers who serve as educators in their communities. In Washington State, the Master Gardener program originated in 1972 to help WSU Cooperative Extension better serve the public – specifically home gardeners. Today, 2,900 Master Gardeners are at work in Washington State. In 1995, they volunteered 101,335 hours and helped over 314,000 citizens with their gardening problems. URL: http://gardening.wsu.edu/. See Section 10.4 for more detail.

CHAPTER 8: STORMWATER MANAGEMENT

This chapter deals primarily with the quantity side of stormwater – conveyance and flood control. Although some water quality elements are discussed here, the reader is referred to Chapter 9 for more details on non-point pollution prevention and National Pollutant Discharge Elimination System (NPDES) permits.

In Seattle, the Seattle Public Utilities (SPU) and the Department of Design Construction and Land Use (DCLU) is responsible for managing stormwater; in Shoreline, the Public Works Department (PWD) is responsible. Both cities have incorporated ways to improve water quality in their storm management programs, and both are facing the challenge of habitat restoration.

8.1 Responsibility for Stormwater Management

Seattle

The City's stormwater utility, the Drainage and Wastewater Utility, was formed in 1987. Its responsibility was to regulate stormwater, manage the existing conveyance system, alleviate flooding, and mitigate water pollution. In 1997, the Drainage and Wastewater Utility merged with the Solid Waste Utility and portions of City Light and the Engineering Department to form Seattle Public Utilities. In only ten years, the environmental responsibility of the drainage utility has grown.

One of SPU's goals is to continue providing reliable infrastructure and high quality, cost-effective utility service for stormwater management. The maintenance programs minimize future costs and service disruptions and protect private as well as public property. Reducing localized flooding helps protect public health and safety and prevent property damage. A second SPU goal is to protect, sustain, and enhance environmental quality, both locally and regionally. Day-to-day City activities should demonstrate responsible environmental practices. Projects should be managed with a priority concern for the protection and sustainability of the environment. Natural solutions for flooding are emphasized. Threatened habitats for which SPU is responsible are restored and preserved, with particular emphasis on recovery of salmon populations.

In 1997, Seattle developed a comprehensive Stormwater Management Program (see Section 8.2), which outlined water quality and quantity problems, programs, and needs. The stormwater program continues to evolve. In late 1999, the Seattle City Council approved a new direction for the drainage policy to improve environmental protection, basic services, rate design, and public/private responsibilities (resolution 30093). Table 8.1 summarizes the new policy direction.

Table 8.1. Summary of Recommended Drainage Policy Improvement Actions

Program Dimension	Recommended Policy Direction	Recommended Policies
Role and Mission of Utility Current: ♦ Build trunk drainage system ♦ Maintain drainage network constructed to acceptable standards ♦ Respond to complaints	♦ Uniform service delivery ♦ Leadership for surface water management and protection—define program elements and necessary standards	♦ Expand work in creeks, addressing surface water bodies within the City that are part of the drainage system ♦ Establish coordination framework between departments to meet program needs
Environmental Protection Current: ♦ Administer stormwater permit program ♦ Respond to regulatory issues (water quality, endangered species) ♦ Use creeks for stormwater conveyance ♦ Creeks as education icons	♦ Water quality, habitat value, and environmental stewardship are program elements	♦ Develop standards for creek protection corridors ♦ Use creek health as indicator of good surface water management ♦ Apply stewardship ethic to all program elements
Basic Services/Public Purpose Current: ♦ Complaint response ♦ Property owners are responsible for local improvements; 20% of the city remains "underserved"	♦ Provide basic capacity to protect property, water quality and habitat, and public safety	♦ Ensure citywide infrastructure network with adequate base capacity ♦ Develop integrated basin planning/needs assessment methodology
Rate Design Current: ♦ Fee structure based on impervious surface and lot size	♦ Retain current rate design and develop opportunities for credits and incentives	♦ Use existing rate design, develop an allocation framework ♦ Develop credits and incentives encouraging customers to reduce impact.
Public/Private Responsibilities Current: ♦ Property owners responsible for local infrastructure improvements ♦ Property owners can adversely impact "public systems" such as creeks ♦ Problems and damages are prone to resolution through litigation ♦ Recent court decisions expose City to additional liability	♦ Clarify role of property owners, and expand outreach	♦ Provide service and features above base capacity if privately financed ♦ Expand education and outreach to include technical assistance ♦ Integrate enforcement with education ("edu-forcement")

Stormwater programs are funded by a drainage fee assessed to each parcel within the City limits. The drainage rate is collected with the County property tax. Residential properties are charged a flat rate, currently about $81 per year. The fee for other properties varies depending on the property size and percent of impervious surface. Currently, the City does not offer any rate incentives for water quality or quantity improvements. Seattle's 1997 drainage revenues totaled approximately $11 million.

Shoreline

The City of Shoreline incorporated in 1995. The Public Works Department is responsible for the City's infrastructure and the Surface Water Utility is a section of the Public Works Department.

Shoreline's Surface Water Utility manages the City's drainage system. The Surface Water Utility fee is $85 per year for residential parcels. The fee for other property varies depending on property size and percentage of impervious surface. The maximum fee is $1,318 per acre if the parcel is more than 85% impervious. The City reduces the fees for commercial property owners who maintain retention/detention facilities on their property to City standards.

Shoreline has interlocal agreements with King County to maintain drainage-related facilities and provide billing and collection services for the Surface Water Utility. A number of these services will be examined in the near future to determine if King County remains the best provider. These revenues are received from properties within the City using the County's combined Property Tax and Drainage Billing Statement. In 1997, the City received over $2 million from surface water fees.

Washington Department of Transportation (WSDOT)

WSDOT manages stormwater runoff from State roads and highways. In the Thornton Creek watershed, I-5, Lake City Way, NE 145th St, and NE 175th St are State roads. In addition to treating and conveying existing runoff, WSDOT must consider the drainage impacts associated with expanding roads. WSDOT projects and operations are affected by provisions of its National Pollutant Discharge Elimination System (NPDES) permit.

8.2 Stormwater Infrastructure

Stormwater systems are designed to transmit water, control flooding, and reduce pollution. Components of the drainage infrastructure, common to both Seattle and Shoreline, are described below.

Conveyance Channels

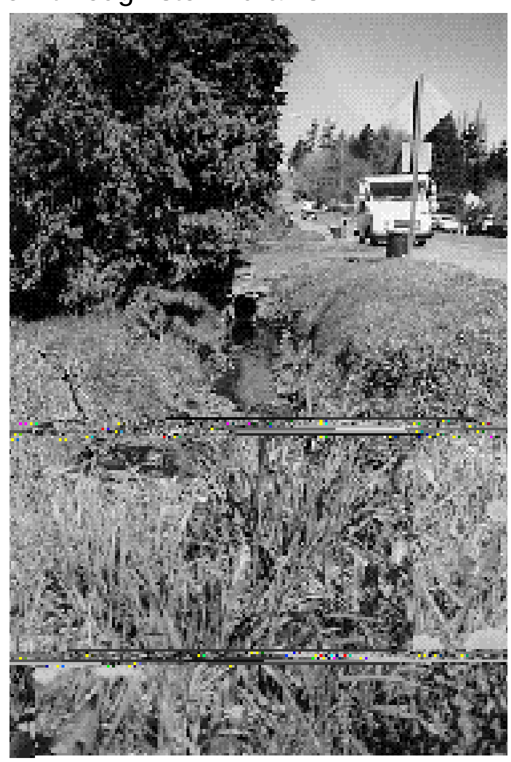
In many parts of Seattle and Shoreline, drainage from homes and businesses discharges to the storm drains under the street. These storm drains feed into larger pipes called drainage trunk lines, which carry water to receiving waters like Lake Washington or the Duwamish River. In other areas, such as the Thornton Creek watershed, the creeks serve as the drainage trunk lines. SPU and the Shoreline Public Works Department have used streams as part of the stormwater conveyance system and are now developing programs to improve and maintain them for uses other than flood conveyance. The stormwater conveyance system relies on both natural and artificial components to direct the flow of stormwater. These components are briefly described below.

In the Thornton Creek watershed, much of the stormwater runoff does not flow through the conveyance methods listed below. Instead, water flows along the shoulder of the road. This accounts for approximately 70% of the runoff in Seattle north of NE 85th St (personal communication with Darla Elswick, SPU, 2/25/00).

Natural Drainage Channels (Creeks). As water flows across undeveloped land it forms a network of natural channels, tiny streamlets that combine to form creeks. In urban areas, natural channels must be able to convey high flows through restricted channels (usually created by people placing rock or concrete along creek banks) without causing serious flooding. As a result, some streams have routed through pipes. In the Thornton Creek watershed, the larger creeks have been left to flow above ground, interrupted in places by culverts and storm drains. Creeks pass through private and public property. The water within the creek belongs to the State of Washington; the land under the creek belongs to the adjacent property owner.

Storm Drains. Storm drains are pipes that carry stormwater to natural water bodies such as creeks and lakes. Storm drains in the Thornton Creek watershed, ranging from eight inches to seven feet in diameter, are found primarily along busy roads and in commercial districts. Most residential areas do not have storm drains; instead they rely on ditches to convey stormwater runoff. (Sewage is carried in a separate set of pipes to the West Point Sewage Treatment Plant.) Storm drains in the Seattle portion of the Thornton Creek watershed are shown in Figure 8.1. Shoreline storm drains are not shown because the data is not included in the Geographic Information System (GIS) system, although it is available on maps. Some smaller tributaries have been put into storm drains; for example, sections of Little Brook, Mapes Creek, and an unnamed tributary northwest of Northgate Mall flow through storm drains.

Drainage Ditches. Drainage ditches are open channels, usually adjacent to roadways, which are lined with asphalt, rock, or vegetation. Most ditches discharge eventually to the creek. Ditches provide some environmental benefits. Generally, water flows more slowly through ditches than pipes, so they provide some storage and, in unlined ditches, some of the runoff can soak into the ground. The slower flow allows time for some sediment to settle out rather than passing into the stream. Vegetation in ditches can trap dirt and litter and prevent some oil and other pollutants from entering the surface and groundwater.



Some Thornton Creek tributaries flow through drainage ditches

In most of the Thornton Creek watershed, stormwater is conveyed through drainage ditches. The City of Seattle is in the process of mapping ditches and culverts. Figure 8.1 shows the culverts and ditches currently entered into Seattle's GIS system. Some ditches were constructed to convey only runoff. Others are channelized streams that have flowing water year-round. Some of these ditches provide important habitat for fish and wildlife. Kramer Creek and Hamlin Creek are examples of former streams that were turned into ditches.

Culverts. Culverts are short sections of concrete or corrugated metal pipe, usually used to connect ditches together. Over time, many ditches have been converted to culverts for the following reasons: easier maintenance, additional street edge parking, and improved pedestrian safety.

Figure 8.1. Storm Drains, Ditches and Culverts in Thornton Creek Watershed (Seattle Portion)

Ditches are usually located under or adjacent to roads. In some areas, culverts may extend for blocks. Culverts may be owned privately (usually roadside culverts) or by the City (usually culverts that cross under a road). Seattle culverts mapped so far are shown in Figure 8.1.

Swales. Swales are gently sloped, flat-bottomed, grass-lined ditches. They are designed to allow more water to soak into the ground than ordinary ditches. The grass increases removal of some pollutants such as sediments, metals, and oils. Swales are often a more attractive alternative than ditches and can be incorporated into the landscape. One example of a swale can be found at Victory Creek Park near 12th Ave NE and Northgate Way.

Stormwater Conveyance: Flow Control Elements

Detention Systems. Detention systems are often underground pipes or vaults that store stormwater and release it at a controlled rate. Their purpose is to prevent downstream flooding by detaining the water during storms and releasing it slowly over time. They can also provide some water quality benefits by removing some pollutants before discharging the water into a stream or wetland. The catch basins trap sediment and floating debris. While the stormwater is detained, dirt and sediment settle out and sink to the bottom. With proper maintenance, the sediments and associated pollutants are routinely removed. Private detention systems are often a requirement for new construction for projects over 2,000 square feet. There are several hundred privately owned and maintained stormwater detention systems in the Thornton Creek watershed.

City code requires commercial construction and significant remodels to provide on-site detention. New and remodeled single family homes may use detention or infiltration to reduce the rate of runoff (see Section 6.5). Detention requirements have become stricter over time. Most of the homes and businesses in the watershed were constructed before on-site detention was required. There are no City codes requiring existing buildings to retrofit and provide detention unless redevelopment is occurring.

Regional Detention Ponds. Detention ponds are constructed ponds that store stormwater and release it at a controlled rate. In this watershed, detention ponds are usually owned and operated by local government. Some provide storage for individual properties, such as the King County courthouse; others provide regional detention. Their main purpose is to prevent downstream flooding. Wet ponds contain water yearround; dry ponds temporarily fill with stormwater and then dry up. Infiltration ponds give stormwater a chance to soak into the ground. Detention ponds benefit water quality by allowing sediments to settle out of the water. However, detention ponds can also harm water quality by providing conditions that decrease dissolved oxygen and increase temperature. In addition, open water can attract waterfowl, which in turn increases fecal coliform levels. Vegetation in wet ponds may remove additional pollutants from the water. Figure 8.2 shows the six publicly owned regional detention ponds in the watershed, four in Seattle and two in Shoreline. These detention ponds are found at the following locations:

Meadowbrook Pond

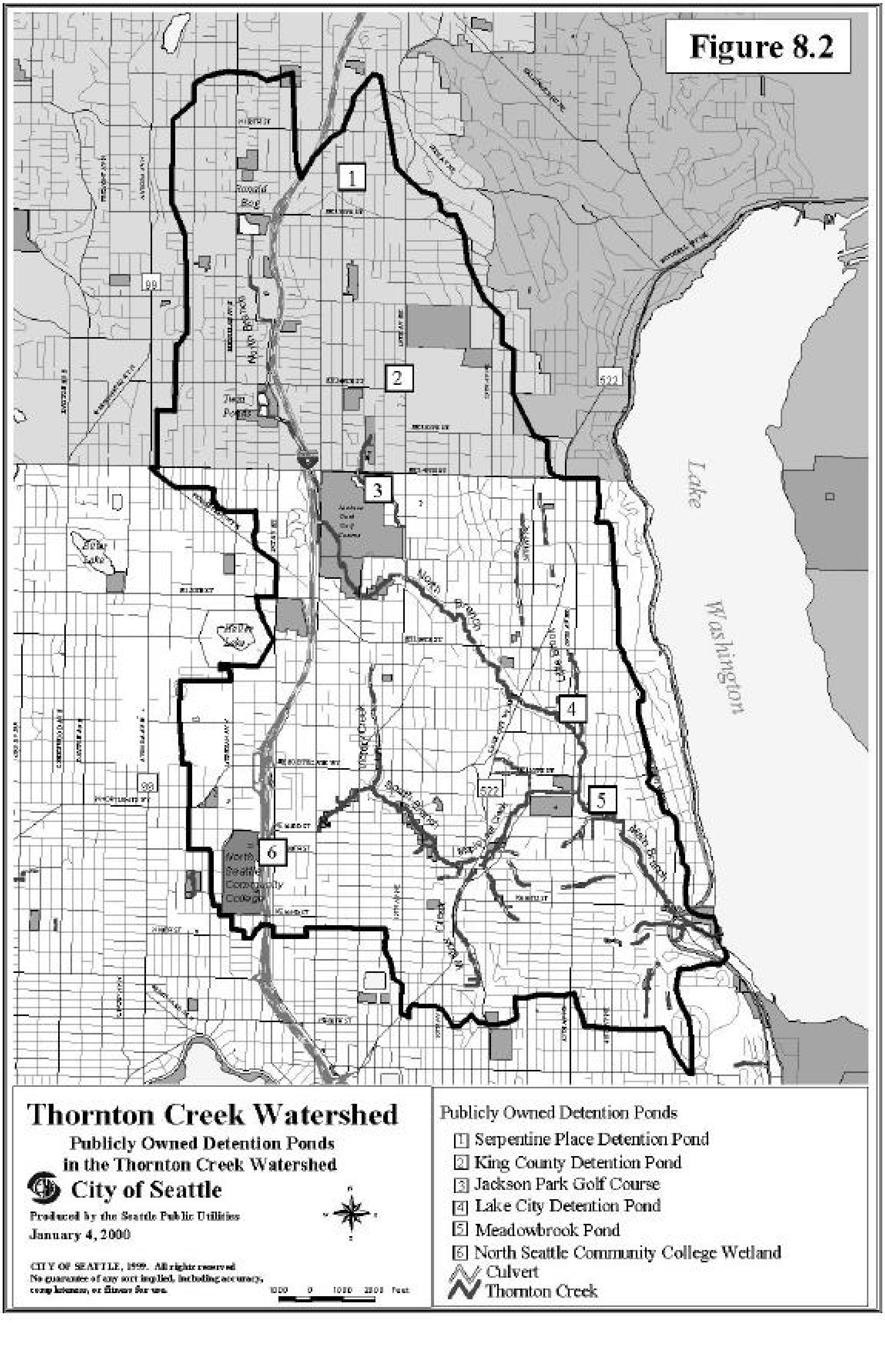


Figure 8.2
Thornton Creek Watershed
Publicly Owned Detention Ponds
in the Thornton Creek Watershed
City of Seattle
Produced by the Seattle Public Utilities
January 4, 2000
CITY OF SEATTLE, 1999. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Publicly Owned Detention Ponds
1 Serpentine Place Detention Pond
2 King County Detention Pond
3 Jackson Park Golf Course
4 Lake City Detention Pond
5 Meadowbrook Pond
6 North Seattle Community College Wetland
Culvert
Thornton Creek
Lake Washington
North Branch
South Branch
Main Branch
Twin Ponds
North Seattle Community College

- Serpentine Pl
- 15th Ave NE and NE 160th St
- Jackson Park Golf Course along Littles Creek
- NE 125th St and 30th Ave NE along Little Brook
- North Seattle Community College wetland
- Meadowbrook Pond

Infiltration Trenches. Infiltration trenches are underground structures that store water and allow it to discharge slowly into the ground. Soil type, percolation rate, potential for contamination, water table, and slope are among the factors considered in designing infiltration trenches. Some new homes direct roof runoff to infiltration pits to reduce runoff and to reduce the potential for water and sediment contamination, in lieu of providing detention. Infiltration pits are a less costly alternative to underground detention vaults or pipes.

Stormwater Conveyance: Pollution Control Elements

Several devices designed to remove pollutants from stormwater are illustrated in Figure 8.3 and described below. Proposed changes to Seattle's Stormwater, Grading and Drainage Code will require certain new construction to install treatment facilities such as wet ponds, wet vaults, media filters, and bio-swales.

Catch Basins. Catch basins are underground sumps located between stormwater inlets and the piped stormwater system. The sump at the bottom of the basin captures sediment and other debris from incoming stormwater. A trapped outlet prevents floating debris and oil from leaving the catch basin. They are vacuumed out periodically to remove captured sediment and debris.

Sand Boxes. Sand boxes are similar to catch basins; however, they are usually constructed of wood instead of concrete and are installed near ditches rather than storm drains. Water soaks into the ground through the dirt at the bottom, which filters out sediment and debris. Sand boxes are also routinely cleaned to remove this material.

Oil/Water Separators. Oil/water separators, generally located underground, are designed to trap sediments, oil, and floatable material. Some industries are required to install oil/water separators before they can discharge stormwater to the drainage system. Most oil/water separators discharge to the sanitary sewer. Several different styles of oil/water separators are available.

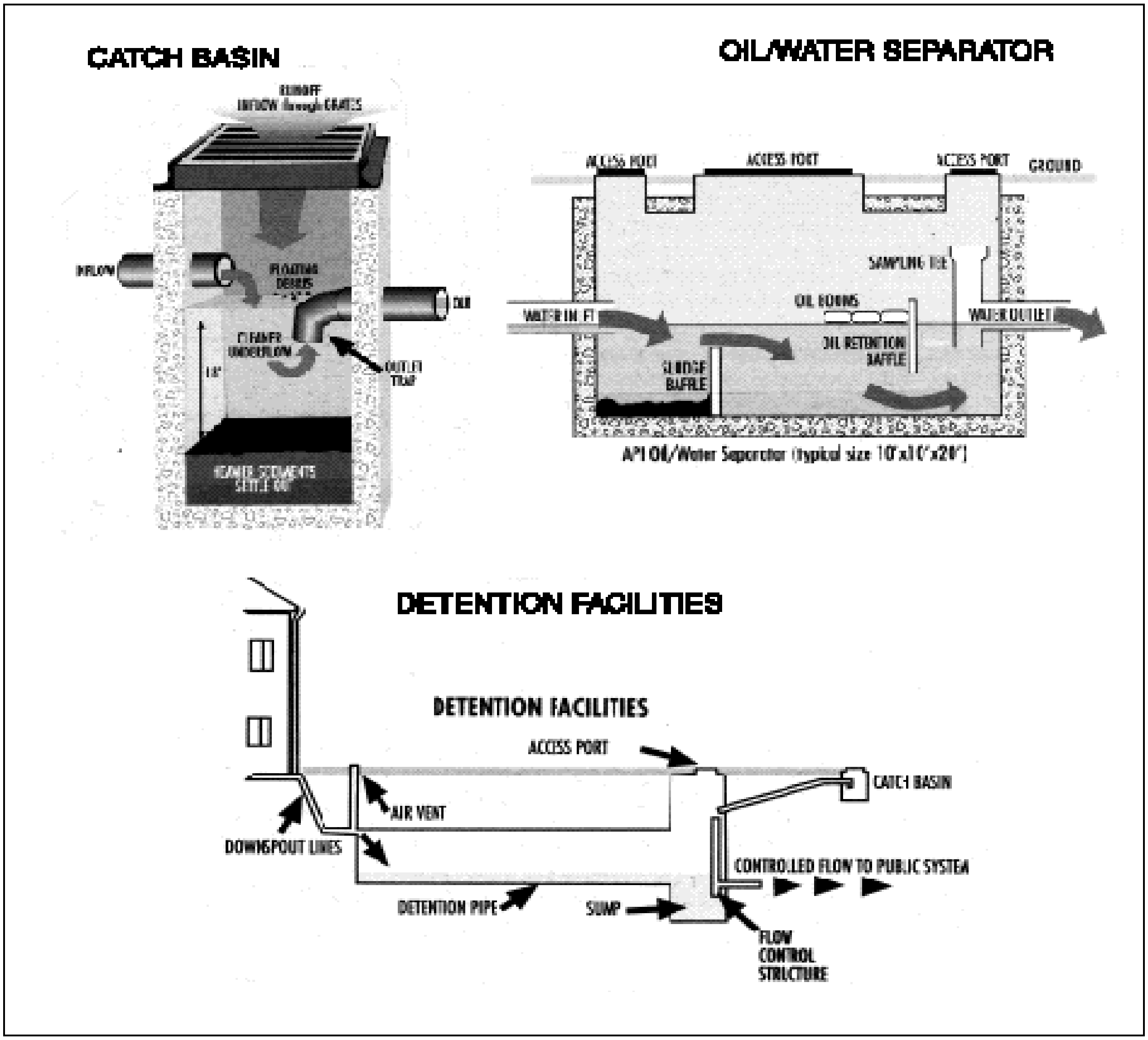
Detention Ponds. As previously stated, detention ponds benefit water quality by allowing sediments and attached pollutants to settle out of the water. Vegetation in wet ponds may remove additional pollutants from the water.

Other. A number of other pollution removal devices are available on the market, though their use is voluntary and they are rarely installed. Some rely on filters made of sand, leaves, compost, activated charcoal, and/or fabric. Others take advantage of centrifugal force to help settle solid particles and "float away" oil and some debris. Currently WSDOT is sponsoring two systems to treat runoff from I-5. One is located near Northgate; the other will be located near Ronald Bog.

8.3 Drainage Operation and Maintenance Programs

Operation and maintenance programs provide routine and corrective maintenance of the sewer and stormwater system. Storm drains, detention systems, and combined sewers are maintained in order to ensure proper operation, prolong the useful life of the system, and reduce contamination from street runoff.

Figure 8.3. Illustration of Some Drainage System Components



Seattle

Within Seattle, operation and maintenance of the public stormwater systems is the responsibility of SPU. These programs provide routine maintenance, respond to citizen requests and after-hours emergencies, and inspect private detention systems.

Routine Operation and Maintenance. The City performs maintenance on a routine basis for publicly owned catch basins, inlets, sand boxes, ditches, and other facilities that accumulate sediment, and monitors the facilities to determine when cleaning is needed. Maintenance activities in the Thornton Creek watershed are coordinated out of the Haller Lake field office located just outside the watershed. Drainage system components and a description of the maintenance they receive are shown in Table 8.2. Crews rely on citizen reports to help identify problems with the drainage system and areas that need maintenance.

Table 8.2. Drainage System Components and Routine Maintenance

Component	Service	Frequency
Natural channel	Inspect. Remove trash and debris. Conduct bank stabilization projects on public property (see Chapter 10).	As needed.
Storm drains (pipes)	Inspect. Clean lines. Repair lines. Remove roots, sand, gravel, and other debris.	As needed based on complaints.
Ditches	Inspect. Clean by hand or machine as needed. Remove sediment, trash, excess vegetation, and debris. Mow. Occasionally stabilize or reshape slopes.	Mowing once a year; other service as needed based on complaints.
Culverts	Inspect. Remove sediment, debris, and vegetation. Repair pipe (publicly owned culverts only).	As needed based on complaints.
Catch basins and sand boxes	Inspect annually. Remove sediment and debris. Repair as needed.	As needed based on annual inspection.

In Seattle the size of the drainage crew has grown from 17 people in 1997 to 39 in 1999. In 1995, drainage crews received training on water quality protection. Ongoing training is provided to new and regular employees on water quality, safety, and maintenance.

SPU operates two vactor trucks full time in the north half of the City. Vactor trucks are large trucks that vacuum up water and sediment from catch basins and sand boxes. When the sump in a catch basin is approximately one-third full, the catch basin requires cleaning. On average, catch basins are checked annually and cleaned as needed. The average catch basin requires sediment removal every three years. Excess water from pumping out catch basins is deposited in the sanitary sewer; the sediments go to a landfill or are recycled in the production of cement. Catch basin sediments often contain high levels of organic material (decomposing leaves and twigs), petroleum products (motor oil), and metals associated with automobiles. Thanks to a recent grant from Ecology, the locations of catch basins and sand boxes in Seattle have been entered into an automated program to improve regular maintenance.

Ditches are maintained as needed. The City owns one “Ditch Master,” a piece of heavy equipment capable of restoring grade to a ditch that has filled with sediment. This process leaves bare earth in the ditch, which is re-seeded by City crews. Ditches are mowed once or twice a year. The City relies on citizen reports to identify clogged ditches and culverts.

Service Requests. The City responds to requests for services and problems reported by citizens and public agencies concerning street use and drainage problems. All telephone requests for service, complaints, or reports of problems are received by a district dispatcher at (206) 684-7506, who records the information. The dispatcher refers the complaint to district crews for investigation and response. A computerized service request tracking and reporting system produces a monthly report identifying the requests and response status. SPU also investigates reports of illegal dumping and tries to get the responsible party to clean it up (see Sections 9.3-9.5). A program to reduce graffiti indirectly reduces illegal dumping.

Off-hour Emergency Maintenance. The City employs off-hour crews for inspection and emergency maintenance of street and drainage systems during nights, weekends, and holidays. They call for additional staff support as needed. Citizens can call (206) 386-1230 to reach a dispatcher after normal work hours.

Private Stormwater Detention System Inspections. City codes require private detention facilities to be maintained by the property owner. Detention systems must be correctly installed and be maintained routinely to operate properly. In 1991, the City began inspecting private detention systems. If the system is inadequately maintained or installed, the property owner is notified of the problems and told to rectify the situation per code.

In 1998, City staff completed initial inspections in the Thornton Creek watershed by inspecting 278 privately owned stormwater detention systems. Over 75% of these were in commercial developments and apartment complexes; the rest were in condominiums, townhouse developments, schools, public buildings, religious facilities, and single family homes. When all the systems are cleaned, an estimated 243 tons of sediment will have been removed from the storm drain system. The majority of inspections were for commercial and multi-family properties. Because of the relatively large parking lots and high traffic, stormwater detention systems for these properties tend to require more frequent maintenance.

The most common problems found in private systems were excessive sediment build-up and missing flow control components. Within two months of the initial inspection, 78% of the systems were in compliance. After five months, this increased to 99% compliance. SPU is planning a re-inspection schedule that allows sites to be checked every five years, consistent with anticipated Ecology requirements.

Shoreline

Routine Operation and Maintenance. Currently, the City of Shoreline has an interlocal agreement with King County to provide routine maintenance to the City's drainage system. This agreement establishes tasks and schedules for County crews. The County inspects drainage channels, cleans storm drains and catch basins, and controls vegetation in ditches. In April 1998, Shoreline hired a Surface Water Coordinator to inspect drainage facilities and create a City surface water management program. The Shoreline Public Works Department is currently evaluating alternate options for drainage infrastructure maintenance and will adopt a five-year plan to transfer at least some of the County's tasks to other providers.

Service Requests. Shoreline's Customer Response Team (CRT) employs three field customer service representatives who can be reached at (206) 546-1700. Team members respond to calls from Shoreline residents and perform tasks such as removing debris from a ditch or catch basin, cleaning up illegal dumping, painting out graffiti, and checking on flood-prone areas during storms. All requests for service from citizens are logged into a database to track the City's response. Requests can be mapped geographically by type of service, and information is analyzed to isolate growing concerns and identify trends in the types of requests. A survey is sent to citizens upon completion of service to gauge the City's responsiveness and level of customer service.

Off-hour Emergency Maintenance. There is always a Shoreline Customer Response Team (CRT) member on call after business hours at (206) 546-1700. On-call staff respond to emergencies such as traffic accidents, hazardous material spills, and flooding.

Private Stormwater Detention System Inspections. Approximately 253 detention facilities are located in the City of Shoreline. The City requires private detention facilities to be maintained by the property owner. As previously mentioned, the City's Surface Water Management (SWM) Coordinator has taken over facility inspection duties from King County. The SWM Coordinator inspects regional, commercial, and residential facilities each year to make sure they are functioning as designed. Should a commercial facility (or a facility that isn't the City's responsibility) lack proper maintenance, the SWM Coordinator notifies the owner that maintenance is necessary. The SWM Coordinator inspects the facility at a later date to make sure the maintenance was performed.

Small Drainage Projects. The City of Shoreline has spent approximately $500,000 per year in 1997 and 1998 to solve small drainage problems identified through the Customer Response Team's service request database. This extremely successful program has solved many localized flooding and erosion problems citywide. This program is budgeted to continue in 1999.

WSDOT

For WSDOT, the goal of maintenance is to retain the highway system in a condition as near as possible to the condition of its initial construction or subsequent improvement. Some of the routine maintenance activities that affect stormwater are:

- Drainage work, including catch basin cleaning.
- Vegetation management.
- Emergency maintenance, such as cleanup and repair related to flooding, accidents, and hazardous materials spills.
- Snow and ice control activities.

8.4 Drainage Capital Improvement Programs

Each year, Shoreline and Seattle approve a Capital Improvement Program (CIP), allocating funds to finance the design and construction of specific infrastructure improvements. The CIP allocates funds for construction projects and staff time for preliminary engineering, design, and construction inspection. Both Seattle and Shoreline update their CIP every year as a six-year program to facilitate cash-flow planning. The CIP includes projects that are in progress and those planned to begin during the next six years.

Stormwater CIP projects are designed to control flooding and erosion, and to improve water quality, habitat, and safety. They include funds to reduce combined sewer overflows and flooding; construct major stormwater detention facilities, new sewers, and storm drains; and restore existing facilities. Stream habitat-related CIPs, discussed in Section 10.6, include funds for habitat improvement (e.g., barrier removal and instream flow control mechanisms), restoration, and acquisition in both the creeks and major water bodies.

The Capital Improvement Program Plan reviews, prioritizes, and schedules all public infrastructure projects, including drainage and water quality projects, that are required to address existing problems.

Seattle Drainage Capital Improvement Program

Seattle's Drainage and Wastewater Utility developed the City's first Comprehensive Drainage Plan (CDP) in 1988. It analyzed drainage problems in five drainage basins, including Thornton Creek. The CDP lays out a 15-year program of capital improvements and is the principal guide for projects to be constructed under the six-year CIP. The CDP is intended to be revised every five years to take advantage of new information. In the interim, the City reviews changes made in each basin, designs solutions to previously unidentified problems, and responds to emergencies. The CDP was last updated in 1995. The next update is scheduled for 2000.

1988 Plan

In 1988, the initial Comprehensive Drainage Plan laid out a program of capital improvements and ongoing maintenance for each watershed. The CDP accomplished the following:

- Documented the existing drainage infrastructure, including stream reaches, pipe systems, and culverts.
- Defined boundaries for each watershed based on piped systems and contour lines.
- Identified existing and potential problem areas in each watershed.
- Recommended capital improvements to address flooding.

The Seattle City Council approved the CDP and work began. Projects were prioritized and scheduled to start at various times over a 20-year period. Between 1988 and 1995 over $18 million was spent on drainage improvements. Although no major drainage improvements were made in the Thornton Creek basin at that time, many of the most pressing flooding problems throughout the city were solved.

The 1988 CDP identified $40 million worth of bypass pipes in the Thornton Creek watershed. This pipe network would have extended as far north as the golf course and as far east as 12th Ave NE (between Parks #6 and 2). The 1988 CDP recommended detention ponds at Meadowbrook and Ravenna/Lake City, and in the Jackson Park Golf Course.

1995 Plan

In 1995, SPU updated the Comprehensive Drainage Plan (1995 CDP). For the areas studied in 1988, the analysis was updated to reflect system improvements, advanced modeling results, and new concerns. Five new basins were studied.

No major drainage improvements had been made to the Thornton Creek watershed prior to 1995. In 1995, SPU anticipated a major hydraulic study would be undertaken in this watershed prior to major drainage improvements scheduled for 2000 and later. Because of this, the Thornton Creek recommendations were not significantly changed at that time. The 1995 CDP recommended this strategy:

- Maximize detention storage wherever feasible
- Provide bypass pipelines around channel reaches having inadequate capacity
- Modify some culverts and sections of stream channel to reduce flooding

Instream detention sites were not included in areas thought to support salmon spawning. However, thorough studies of fish use in the creek were not available at that time. In these areas, the detention sites were located off-channel. Detention sites were located at Meadowbrook Pond, Littles Creek (in the golf course), North Seattle Community College, and in a pipe near Ravenna/Lake City Way.

Bypass pipes were recommended to reduce downstream flooding. Many sections of the creek have restrictions – culverts, road crossings, buildings – that can impede the flow of water and contribute to localized flooding. Bypass pipes were not scheduled for construction until after

2000. This recommendation was not updated in light of SPU's changing environmental policies. The bypass recommendation will be re-evaluated in the 2000 CDP update.

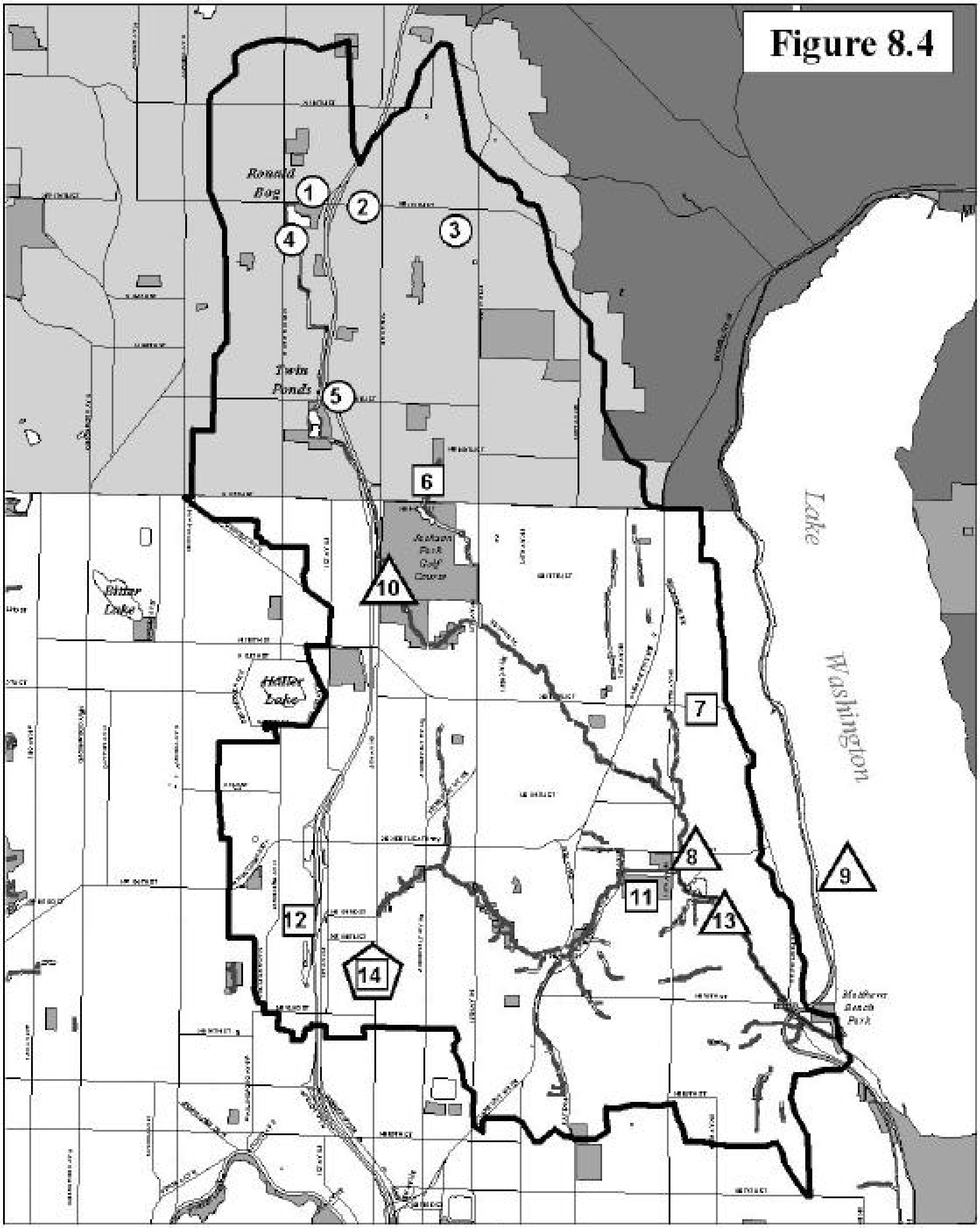
CIP Projects Completed Prior to 1999

SPU completed several stormwater detention ponds and one runoff treatment structure in 1998. They are listed below and shown in Figure 8.4.

- **Jackson Park Golf Course Detention Pond.** A four acre-foot detention pond was completed in 1997 in the golf course along the Littles Creek tributary. In addition to reducing flooding, the pond also provides a water hazard for golfers. Project shown as #6 in Figure 8.4.
- **Lake City Detention Pond.** Although not identified in the CDP Update, a one acre-foot instream detention pond was constructed in 1997 along Little Brook at NE 125th St and 33rd Ave NE. Project shown as #7 in Figure 8.4.
- **Meadowbrook Detention Pond.** This four acre pond is located at the site of the former Lake City Sewage Treatment Plant and stores up to 16 acre feet of water. The pond has an average depth of three to four feet, although the water level may reach eight feet during severe storms. The facility includes wildlife areas, artwork, and a walking trail. This project involved restoration efforts along the banks of the Main Branch of Thornton Creek. The bypass pipe diverts storm flows directly to Lake Washington (see Section 3.4). The intake to a bypass pipe is located in the pond. Project shown as #11 in Figure 8.4.
- **North Seattle Community College (NSCC) Wetland.** In 1997, SPU completed construction of a wetland at the north end of the NSCC campus. The wetland helps to reduce peak flows, flooding, and erosion in the South Branch and will also help improve water quality and enhance fish habitat downstream by providing a source of food materials. The project included pollutant removal structures to pre-treat runoff before it enters the wetland. Project shown as #12 in Figure 8.4.
- **Thornton Creek Protection BMP (Treatment for I-5 Runoff).** Stormwater from a section of Interstate 5 in the Northgate area previously entered the South Branch of Thornton Creek untreated. SPU and WSDOT worked cooperatively to install a treatment device in line with the existing storm drainage system. This structure is designed to remove particulate matter, oils, and greases from highway runoff water before it enters the creek. The underground structure is located beneath the entrance to the Northgate Park-and-Ride, west of 1st Ave NE and NE 100th St. Project shown as #14 in Figure 8.4.

Proposed Seattle Thornton Creek Watershed CIP Projects

Since 1995, SPU's environmental goals have changed. SPU now seeks to better manage projects with a priority concern for the protection and sustainability of the environment and emphasizes natural solutions for flooding.



Thornton Creek Watershed

Drainage CIPs

The City of Seattle

0 0.2 0.4 0.6 0.8 1 Miles

Produced by the City of Seattle
January 6, 2000

Legend

Drainage CIPs

- Shoreline proposed CIPs
- Seattle proposed CIPs
- Seattle recently completed CIPs
- WSDOT/Seattle recently completed CIPs

Section 3.2 describes a hydraulic and hydrologic study of Thornton Creek. Section 4.4 describes fish habitat, fish use, and spawning surveys. Information derived from these and other sources will help SPU select and refine future CIP projects. The proposed drainage CIP projects and their budgets are shown in Table 8.3 and described in more detail in the following paragraphs. Locations are shown in Figure 8.4. CIP projects located along the stream are described in Section 10.6.

Table 8.3. Seattle Drainage Capital Improvement Proposed Projects and Budgets

Project Title	2000	2001	2002	2003	2004	2005	2006
Thornton Creek Flow Study and Flood Relief (bypass pipe & detention)	470,000	2,655,000	2,827,000	2,709,000	5,112,000	5,879,000	5,727,000
Outfall (for existing bypass pipeline)	25,000	20,000	147,000				
Jackson Park Detention Phase II	700,000	250,000	3,000,000	2,250,000	750,000		
Environmental Learning Center	10,000	0	TBD	TBD	TBD	TBD	TBD
Thornton Creek Restoration Projects (incl. Thornton Creek Action Plan)	600,000	320,000	710,000	TBD	TBD	TBD	TBD
Thornton 35th Ave NE & NE 125th St	575,000	900,000	600,000				

Note: The proposed budget (March 2000) has not been adopted by City Council.

Flow Study and Flood Prevention. The 1988 CDP and 1995 CDP Update identified a need for extensive bypass pipes along the North and South Branches and essentially the entire Main Branch of Thornton Creek to minimize flooding. SPU is re-evaluating this proposal. SPU has hired a consultant to collect detailed information on flows throughout the creek, the creek channel, and upland conditions. (See the description of the Entranco study in Section 3.2.) Entranco is developing sophisticated computer models to identify flood-prone areas and simulate various flood control strategies. The strategies will include detention ponds, property acquisition, off-channel ponds, and bypass pipes. These strategies will be evaluated for flood prevention, cost, and environmental impact, among other criteria. The public will have several opportunities to comment on this proposed project. The results are expected in early 2001. Based on the results of the flow study, public comment, and staff review, future CIP projects to reduce flooding will be identified.

Outfall for Existing Bypass Pipe. One bypass pipe currently is in operation in this watershed. The intake is located in Meadowbrook Pond. During storms, this 72 to 90-inch pipe diverts excess water directly to Lake Washington, thereby reducing downstream flooding. Originally this pipe discharged treated sewage into Lake Washington from the former Lake City Sewage Treatment Plant. When the sewage treatment plant was dismantled, the pipe was used to convey excess stormwater. The existing bypass outfall, located about 300 feet offshore, is failing. Designs for the repaired outfall are currently being developed. The new outfall probably may be situated closer to shore since sewage is no longer discharged from this pipe. Proposed project shown as #9 in Figure 8.4.

Jackson Park Detention Phase II. SPU is designing a second phase of detention in the Jackson Park Golf Course. A series of detention ponds are proposed for the North Branch. Since the golf course is large, there is potential for significant storage. The existing detention pond, located on Littles Creek, provides detention for stormwater and a water hazard for golfers.

Preliminary designs show three ponds located near the stream. The total storage could be as much as 25 acre-feet. This design requires sections of the creek to be relocated. As part of this CIP, features will be incorporated to reduce the impact of water withdrawal from the North Branch. The golf course legally withdraws approximately 1.2 cfs from the creek during the daytime in the summer for irrigation. Some potential strategies to reduce water withdrawal impacts are to use more stormwater for irrigation and alter the timing of water withdrawal. Construction is scheduled for 2001. Proposed project shown as #10 in Figure 8.4.

Thornton 35th Ave NE and NE 125th. Additional work is needed adjacent to the existing detention pond. The culvert under 35th Ave NE requires repair and there is potential for adding more detention to this site. Project shown as #7 in Figure 8.4.

Thornton Creek Restoration Projects. In addition to flood prevention CIP projects, SPU has dedicated several million dollars to creek restoration work along Thornton Creek over the next few years. Rather than a single large project, this CIP project will include numerous smaller projects throughout the creek. Restoration projects will be constructed over several years. These projects, including removal of fish passage barriers, protecting eroding banks, protecting sewer lines, re-vegetating streambanks, and adding instream diversity, are described in Section 10.6.

Environmental Learning Center. SPU is currently designing an environmental learning center. This facility will be located north of the Meadowbrook Pond near NE 110th St and 36th Ave NE. The learning center will help Seattle citizens understand how everyday actions affect the health of creeks and waterways. This project is described in more detail in Section 11.3. Proposed project shown as #8 in Figure 8.4.

Spot Drainage Improvement Projects. In addition to the major CIP projects described above, SPU has allocated $2,000,000 citywide over the next two years to repair smaller drainage problems identified by Seattle residents and City employees. They range from minor drainage problems that may affect one homeowner to projects that affect several neighbors. Some examples of repairs are installing catch basins and grass swales and replacing undersized drainage structures. Historically, a large percentage of the City's spot drainage improvements have been located in the Thornton Creek watershed.

Future CIPs. SPU will continue to select and develop CIP projects based on an understanding of watershed-wide problems and priorities. Projects will be designed and implemented that are appropriate for the watershed and its conditions.

Proposed Shoreline Drainage CIP Projects

Shoreline's first six-year CIP was adopted by City Council in November 1998. The CIP includes millions of dollars worth of capital drainage improvements throughout the City. The proposed projects located in the Thornton Creek watershed are discussed below. Citizens will have opportunities to comment as project plans develop. This program is to be revised every year to account for completed projects and to address emergency situations. Figure 8.4 shows the location of all Shoreline stormwater CIP projects. The proposed budget is shown in Table 8.4.

Table 8.4. Shoreline Drainage Capital Improvement Projects and Budgets

Project	2000	2001	2002	2003	2004	2005
Ronald Bog Water Quality improvement		42,666				
Ronald Bog Drainage Improvement	935,000	3,022,500				
NE 155th St & Corliss Ave N			15,000	55,000	280,000	
Stream Rehab/Habitat Enhancement	25,000	25,000	25,000	25,000	25,000	

Note: Accurate as of February 2000.

Ronald Bog Water Quality Improvement. This project is to construct stormwater quality improvements on City park property in the vicinity of N 175th St and I-5 near Ronald Bog. The improvements include construction of a settling pond to allow particulate matter to settle out of the stormwater runoff before it enters Ronald Bog. The channel from the I-5 culvert to the pond will be reconstructed. The improvements will be based on a preliminary design done by King County Parks. This project is partially funded through a grant from WSDOT. The project location is shown as #1 in Figure 8.4.

Ronald Bog Drainage Improvements. This project is to evaluate, design, and construct drainage improvements to address flooding downstream of the outlet from Ronald Bog. In the first phase the City will complete a drainage study of the area and develop recommendations to address local flooding. After reviewing previous King County studies, the study team will model drainage conditions under existing and future development and the resulting downstream impacts. Conceptual designs and cost estimates for the recommended alternative will be developed and used to better define future costs. The study will include public involvement and coordination with other resource agencies. The study team will also evaluate interim measures that could reduce the extent of local flooding until the long-term solution can be implemented. Subsequent phases of the project include design, right-of-way acquisition if needed, and construction. The project area extends from the outlet of the pond to the Metro bus base. The project location is shown as #4 in Figure 8.4.

N 175th St and Serpentine Pl Drainage Improvements. This project will be addressed through the above-mentioned Ronald Bog Drainage Improvements and will evaluate, design, and construct drainage improvements to address flooding at the intersection of N 175th St and Serpentine Pl. This location drains to Ronald Bog, and any improvement will be coordinated with the Ronald Bog project to avoid contributing to flooding in that area. Opportunities for providing additional storage upstream of the flooding area will be evaluated. The project location is shown as #2 in Figure 8.4. Costs for this project are included in the Ronald Bog Drainage Improvements budget.

NE 175th St and 11th Ave NE Drainage Improvements. This project will be addressed through the above-mentioned Ronald Bog Drainage Improvements and will evaluate, design, and construct drainage improvements to address flooding of the area south of NE 175th St and 11th Ave NE. This location drains to Ronald Bog, and any improvement will be coordinated with the Ronald Bog project to avoid contributing to flooding in that area. Opportunities for providing additional storage upstream of the flooding area will be evaluated. The project location is shown as #3 in Figure 8.4. Costs for this project are included in the Ronald Bog Drainage Improvements.

NE 155th St at Corliss Ave N (Twin Ponds) Drainage Improvement. This project will evaluate, design, and construct drainage improvements to address flooding in the vicinity of NE 155th St at Corliss Ave N. The existing conveyance system will be upgraded to increase capacity. The project location is shown as #5 in Figure 8.4.

Stream Rehab/Habitat Enhancement Program. This project will evaluate, design, and construct improvements to enhance streams, wetlands, or other sensitive areas in locations throughout the City. The project may include education programs and improvements that will make streams more accessible to fish and enhance habitat and environmentally sensitive areas. The first phase of the program will include identifying opportunities for enhancement projects through coordination with the community and other resource agencies. The next phase will be to develop a systematic approach to prioritizing the individual projects and programming them for implementation.

Proposed WSDOT CIP Projects

SR 522 Multi-modal Project Site. State Route 522 is a significant regional and local arterial linking I-5 and I-405 around the north end of Lake Washington. The section of SR 522 known as Lake City Way NE carries local and express bus service to downtown Seattle and the University of Washington and is shown in the Regional Transit Authority's Master Plan as an RTA "trunk" bus route.

Because SR 522 is an older arterial, it has design and safety problems such as lack of sidewalks, uncontrolled driveway access, a high accident rate, peak hour congestion, and constraints due to its proximity to Lake Washington. The purpose of the Multi-modal Project is to improve safety and people-carrying capacity of the highway. This will be accomplished by undertaking technical analysis and assessments as well as working with corridor communities to incorporate local interests and requests.

A variety of actions to improve the safety and people-carrying capacity of SR 522 are being evaluated. They include improvements to pedestrian and bicycle safety, vehicle safety and operations, and transit. Some of these improvements may add additional paved surfaces. WSDOT will follow local regulations to provide the required levels of mitigation, detention, and treatment for runoff.

Ronald Bog Water Quality Improvement. See Shoreline's Drainage CIP projects. This project is partially funded through a grant from WSDOT.

Expansion of N 175th St. WSDOT is exploring plans to widen N 175th St. As part of this project, water quality treatment and detention will be provided.

8.5 Assessment of Stormwater Management Programs

Seattle, Shoreline, and WSDOT have long-term commitments to continuing their various stormwater management programs in order to address stormwater impacts on the environment. Local governments are strongly committed to continually adjusting their programs, projects, and priorities to address emerging needs and to incorporate emerging technologies and information.

The environmental added value of various stormwater projects and programs can never be fully quantified, and their significance often cannot be perceived until years after they have been implemented. As more information becomes available, capital projects related to creeks may be changed, or priorities adjusted, in order to fully meet the needs of these urban water bodies. For example, the results of scientific studies may suggest the need to more fully address riparian or sediment issues in order to better protect salmon. As capital projects on Pipers and Longfellow Creek are monitored, the new information will inform decisions about improvements in the Thornton Creek watershed. New information on BMP performance may require revising structural and nonstructural BMP directions currently given to developers, contractors, and property owners. Finally, new techniques may emerge that will significantly enhance such programs as source control, monitoring, public education, and operation and maintenance.

Seattle, Shoreline, and WSDOT provide valuable maintenance to the drainage system. The stormwater programs have made commendable recent progress. In Seattle, recent citywide accomplishments include increased drainage maintenance staff, improved training, computerized maintenance schedules, increased budget, and a re-evaluation of the drainage utility's role. Within the Thornton Creek watershed, the recent completion of four detention ponds and a current flow study are positive achievements. In Shoreline, a recently adopted CIP including extensive drainage improvements in Thornton Creek watershed and a commitment to solve problems "naturally" along with a review of the King County policies are admirable.

The Watershed Management Committee has identified these areas as needing additional investigation:

- Reducing ongoing high flows that cause flooding, degrade water quality, and damage habitat.
- Improving understanding of stormwater flow through Thornton Creek.
- Moving beyond flood prevention/control to more active stream habitat rehabilitation.
- Improving maintenance of the public stormwater conveyance system.
- Increasing the amount of detention in the watershed through tougher requirements for new development, more frequent inspections, and more regional detention ponds.
- Increasing infiltration through regulations encouraging and/or requiring infiltration and reducing the level of impervious surfaces.
- Establishing rate structures and incentives that encourage better management of private stormwater.
- Creating maps of existing storm drains, ditches, and culverts in Shoreline.
- Implementing stormwater recommendations of neighborhood plans.
- Examining the process of evaluating, selecting, and designing capital investments in Thornton Creek watershed, including project selection criteria.
- Increasing monitoring of CIP projects to evaluate effectiveness of flood control and/or habitat restoration.

The Committee realizes that many of these areas are currently being addressed by Seattle Public Utilities and Shoreline Public Works Department. These items are listed to reinforce the Committee's belief that they are the major stormwater issues facing the Thornton Creek watershed.

CHAPTER 9: NON-POINT POLLUTION PREVENTION AND CONTROL PROGRAMS

Under the Clean Water Act, Federal and State regulations have required cities to examine non-point pollution and reduce the amount that enters local waterways. Traditionally, stormwater management programs have focused on preventing flooding and maintaining the drainage infrastructure to protect life and property. More recently, stormwater programs have also sought to protect the environment from harm caused by stormwater runoff by reducing pollutants in stormwater runoff and improving habitat.

This chapter describes the various non-point pollution prevention programs operating in the Thornton Creek watershed. It begins with a description of sources of non-point pollution in this watershed. Then it describes regulatory programs that impact non-point pollution, such as the National Pollutant Discharge Elimination System permits. This is followed by a description of citizen-oriented pollution prevention programs, business programs, and government maintenance programs. The final section assesses the success of these programs. Chapter 8 dealt with the quantity side of stormwater and does include some pollution control associated with conveyance and flood control.

Also, see Chapter 6 for a discussion of regulations and policies that protect water quality. The laws previously discussed that are most relevant are the Federal Clean Water Act and Seattle's Stormwater, Grading, and Drainage Control Code.

The non-point pollution problem is sometimes compared to snow. No individual snowflake weighs very much, yet snow piled deep enough can cause a roof to cave in. Similarly, any individual source of non-point pollution, a drop of oil or a cigarette butt, may seem inconsequential. But, when such pollution is multiplied by the thousands, natural resources may be irrevocably damaged.

9.1 Sources of Non-point Pollution

In the Thornton Creek watershed there are many sources of non-point pollution. The most problematic is urban runoff that carries pollutants from roads, buildings, parking lots, parks, and other areas. Storm flows also can increase turbidity and sediment loads, which damage habitat. Stormwater enters Thornton Creek with almost no water quality treatment, although a minimal amount of treatment is provided by grassy ditches or catch basins.

Although stormwater is the biggest problem, erosion and illegal discharges (such as spills, inappropriate practices, and deliberate dumping down a storm drain) contribute to the problem. Due to the urban character and small size of the watershed, agriculture, forestry, mining, boats, and marinas do not contribute to non-point pollution problems in the Thornton Creek watershed.

No industrial discharges, such as sewage treatment plants or pulp and paper mills, are located within the watershed, although there is a sewage pump station located at Sand Point Way NE and NE 93rd. Pollutants in urban stormwater runoff come from a wide variety of sources. Non-point sources include contributions from animals (wild and domestic), decomposed plants, natural minerals, and human sources such as motor vehicles, residential land uses, illegal dumping, commercial, industrial, and construction activities. (See Chapter 5 for water quality assessment.) Major sources of non-point pollution can generally be categorized as follows:

Street and Parking Lot Deposition. In urban areas, street and parking lot deposition frequently is a major source and collector of urban runoff pollution. Such deposited materials may include street dirt and litter. Pollutants frequently bind to dirt particles. Street dirt may arise from traffic, road deterioration, vegetative residue, and decomposed litter. Litter includes cans, glass, paper, cigarette butts, and garbage. Vegetation, animal excrement, dead animals, automotive fluids, and spilled or improper disposal of solid and liquid wastes generated from household or commercial activities onto the streets are picked up when it rains and contribute to polluted or contaminated runoff.

Vehicles. Internal combustion engine exhaust emits primarily dust-sized particles containing hydrocarbons. Many other pollutants are deposited into the environment by automobiles and trucks. Fluids such as oil and antifreeze leak onto roadways, worn metals and brake pads deposit toxic mineral dusts onto roads, tires wear and deposit rubber particles, poorly maintained vehicles drip oils and other automotive fluids onto street surfaces, and various solids and fluids are rinsed from vehicles and the loads they transport. These fluids and solids are rinsed from roadways and other impervious areas when precipitation falls, which results in polluted creeks and tributaries. Residential car washing also contributes soap and other chemicals to the storm system and Thornton Creek.

Landscape Maintenance. In urban areas, vegetative inputs exceed their undeveloped counterparts. Trees and the associated leaf-fall contribute organic residues that are high in nutrients. Such inputs occur primarily in autumn. Improper yard waste disposal, such as dumping lawn clippings into ditches or over ravines, can cause nutrient problems in the stream. Landscaping practices, such as the use and overuse of fertilizers, herbicides, and pesticides, can also result in pollution of stormwater and Thornton Creek.

Construction/Erosion. Erosion of exposed soils during clearing and construction activities contributes significantly to the sediment content of urban runoff, especially when erosion controls are not properly used. Improperly planned landscaping projects can leave bare soils subject to erosion. This is especially true during the rainy season, October to May. In some areas of the Thornton Creek watershed, erosion occurs in steep ravines where uncontrolled runoff can cause soil loss and side slope instability.

Excessive Storm Flows. High levels of impervious surface contribute to high storm flows in the stream. Streambanks and beds and ditches also erode due to increased stream velocities during periods of heavy rainfall. Turbidity and sediment problems are caused.

Uncovered Outdoor Material Storage. Materials such as oily parts, old cars and engines, messy or leaking dumpsters, storage drums, and soil and compost stockpiles can come into contact with stormwater. When it rains, the pollutants are washed off the surface of these objects and are carried into the storm system and Thornton Creek.

Illicit Discharges. Materials are illicitly discharged into the storm system with varying intentions from accidental or ignorant to deliberate. These discharge points include indoor drains improperly connected to the storm sewer system; and pressure washing and steam cleaning wash water, improper disposal of automotive fluids, building materials and paint, spills, and other illegal discharges into storm drains, ditches, and Thornton Creek.

Sewage. Fecal coliform bacteria are found in sewage, as well as excrement from other warm bodied animals. Infiltration of seepage from municipal sanitary sewers to the storm drain system could be a source of bacterial contaminants to stormwater discharges. However, infiltration from the sewer into the storm drain systems is of low concern in Seattle. Seattle's sewer system dates back to the 1890s and is constructed quite deep. The sewer pipes convey sewage to the West Point Sewage Treatment Plant. The storm drains were constructed after the mid-1970s and are relatively shallow, so seepage up from the sewers into the storm drains is unlikely. New sewer and storm drain connections to city lines require a permit and inspection. There is little opportunity for cross connection and very few are found in Seattle.

There are a few septic systems in the Thornton Creek watershed. Four septic systems are located in Seattle and an unknown number are located in Shoreline. Although septic systems built after the 1970s are mapped, older systems may not be mapped. Without proper maintenance, septic systems can fail and leach pollutants into groundwater and eventually the creek.

There are no combined sewer overflow (CSO) outfalls to Thornton Creek. CSO outfalls are situated in areas where stormwater and sewage are conveyed in the same set of pipes. In the Thornton Creek watershed, stormwater primarily flows overland through ditches or through separated storm sewers, although some roof drains are connected to the sanitary sewer.

On rare occasions, the sanitary sewers can overflow. This may occur due to a blockage in the sewer line. City or County crews respond immediately to unplug the blocked sewer line and clean up any sewage. It is also possible for sewer lines to fill beyond capacity and cause multiple overflows. This occurred during the 1997 holiday storm. A snowstorm followed by warming temperatures and rain caused excessive runoff from roof drains to enter the sanitary sewer caused it to overflow in multiple locations.

9.2 Comprehensive Government Non-point Pollution Programs

Under the Federal Water Pollution Control Act, Ecology administers the State’s National Pollution Discharge Elimination System (NPDES) permits. Under NPDES there are programs to deal with point sources (sewage treatment plants), urban runoff (from cities/counties with populations over 100,000), construction runoff (for sites greater than five acres), and industrial runoff (from select industries such as auto recyclers). Businesses and government agencies that meet certain conditions are required to submit applications for NPDES permits.

Ecology’s Comprehensive Non-point Pollution Programs

This is a summary from Section 6.3. The Washington State Department of Ecology (Ecology) is designated as the State’s water pollution control agency for all purposes of the Federal Clean Water Act. Ecology has been granted jurisdiction to control and prevent the pollution of streams, lakes, rivers, and other surface and underground waters within the State. Ecology has developed a plan that designates the beneficial uses of all water bodies in Washington. Ecology has established instream water quality standards for freshwater streams that are consistent with the beneficial uses (WAC 173.201).

Under the Washington Pollution Control Act, Ecology administers the State’s NPDES permits. Under the NPDES there are programs to deal with point sources (sewage treatment plants), urban runoff, construction runoff, and industrial runoff. Businesses and government agencies that meet certain conditions are required to submit applications for NPDES permits. Ecology has approved stormwater permits for Seattle, Tacoma, King County, Pierce County, Snohomish County, Clark County, and Washington State Department of Transportation.

Seattle's Stormwater Management Program

In 1995, Seattle obtained from Ecology a combined State Waste Discharge and NPDES permit authorizing discharges of stormwater from its separate storm sewer system. This permit required that the City develop a comprehensive Stormwater Management Program (SWMP), which was submitted to and approved by Ecology in 1997. Seattle must submit an annual report to Ecology, and reapply for a permit every five years. The goals of Seattle's SWMP are to: minimize risks associated with flooding, minimize erosion and sedimentation, and minimize environmental degradation.

The contents of the SWMP are summarized below.

- A prioritized list of Seattle water bodies. Thornton Creek ranked high, along with other urban creeks.
- A summary of citywide problems, which included high volumes of stormwater, excess peak flows, and water quality and groundwater concerns.
- A list of specific problems for each water body. The following problems were considered high priorities in Thornton Creek: excess bacterial contamination in the water column, excess sedimentation in the streambed, degraded aquatic and riparian habitat, limited benthic community, shortfalls in public education, shortfalls in enforcement of regulations, and floatable and shoreline debris. The SWMP concluded that the following items were lower priority problems in Thornton Creek: excess nutrients in the water column, low dissolved oxygen in the water column, and heavy metals. The SWMP did not consider contaminated sediment or groundwater to be problems of concern. However, subsequent studies have shown that sediments are contaminated (see Section 5.4) and temperature and dissolved oxygen levels may not support salmonid requirements (see Section 5.2).
- A summary of citywide programs including: development regulations, water quality related CIP projects, road maintenance, drainage maintenance, education, and source control programs. These programs are also described in this document and address regulatory issues (Chapter 6), water quality (this chapter), public involvement (Chapter 11), drainage operation and maintenance (Chapter 8), drainage CIPs (Chapter 8), and toxic control (this chapter).
- A list of identified unmet needs such as evaluation of erosion control Best Management Practices (BMPs), ongoing business inspection program, private detention system inspections, creek restoration program, inspector training, and review of enforcement procedures.
- A fiscal analysis. Expedited to implement the above tasks.

Seattle's Development Requirements and BMP Manuals. For new development, the City of Seattle requires use of stormwater management BMPs, including pollution control techniques that reduce pollution at the source rather than at the end of the pipe. Seattle currently has two BMP manuals giving approved methods for meeting specific stormwater requirements: Construction Best Management Practices Manual (1994), which describes methods to control erosion and sedimentation; and a Source Control Manual for urban land use practices (1989).

As a condition of the City's NPDES municipal stormwater permit, Seattle is currently revising the Stormwater, Grading and Drainage Control Code to increase stormwater requirements for new development. To support these changes in the Municipal Code, Seattle is developing a total of four BMP manuals, which are expected to be adopted by joint Directors' Rules by July 2000. These manuals will include:

- Flow Control—reducing the peak runoff rate during high storms through infiltration or detention.
- Treatment—removing pollutants from stormwater through devices such as oil and water separators.
- Construction—reducing erosion and sedimentation during construction.
- Source Control—preventing stormwater from being contaminated by pollutants through housekeeping practices, storage, material handling, spill response, landscaping, and pollution reduction structures.

Washington Department of Transportation (WSDOT)

WSDOT projects and operations are affected by provisions of the NPDES. For example, WSDOT is mandated to construct stormwater quantity and quality BMPs in conjunction with projects that add more than 5,000 square feet of impervious surface.

Erosion and Sediment Control Permits. Using the WSDOT Highway Runoff Manual as guidance, a Temporary Erosion and Sediment Control Plan (TESC) is prepared for all WSDOT construction projects that involve any amount of earthwork. Earthwork includes excavation, clearing, grubbing, trenching, or any activity that exposes bare soil to precipitation and/or wind. When more than 5,000 square feet of impervious surface are being added, the TESC is incorporated into the Stormwater Site Plan. When less than 5,000 square feet of impervious surface is being added, the TESC is prepared as a stand-alone. Construction projects that disturb five or more acres of land require WSDOT and other developers to file a NPDES Notice of Intent for coverage under the NPDES Baseline General Permit for Construction Activities.

Local and State Regulations. In addition to the NPDES permit requirements, WSDOT construction projects come under the jurisdiction of numerous State and local government regulations, which may require stormwater BMPs or extraordinary levels of erosion and sediment controls. These include local grading permits, Right-of-Way Management Sensitive Area Ordinance, Shoreline Management Substantial Development Permit, Ecology Water Quality Certification, Ecology Temporary Modification of Water Quality Standards, Department of Fish and Wildlife Hydraulic Project Approvals, and Endangered Species Act requirements.

9.3 Citizen-oriented Non-point Pollution Prevention Programs

Many programs and campaigns aim to reduce non-point pollution in the greater Seattle area. The programs focus on changing citizens' everyday behaviors and improving City maintenance practices. Seattle and Shoreline offer citywide programs and activities designed for different people based on age and/or geographical location. Programs dealing with lawn and gardens, household hazardous waste, automobiles, and other activities are described below.

Lawn and Garden Programs

Natural Lawn Care. Seattle and suburban cities promote resource-efficient and less toxic methods of maintaining healthy turf. The messages include ways to use less water, pesticides, and other chemicals. This program has relied on direct mailing, radio ads, bill inserts, and demonstration sites to get the message out.

Green Gardening Program. Sponsored by Seattle, King County, and Washington State University (WSU), Green Gardening educates the public about practices to reduce chemical use, toxic runoff, and water use. By teaching Green Gardening principles to professional groundskeepers, Master Gardeners, horticulture students, and garden shop employees who can share this information with the public, this program has a broad and lasting citywide reach. Following are examples of projects conducted in 1998:

- Developed curriculum and trained staff at nine local garden centers and horticulture students at three colleges about less-toxic pest control methods, to help them educate their own customers.
- Made Green Gardening presentations to 34 groups in King County.
- Taught a Green Gardening curriculum as part of the regional WSU Extension Master Gardener program and presented it to 135 Master Gardeners.
- Presented a one-day training for professional groundskeepers on successful integrated pest management (IPM) strategies, which attracted public agencies and private landscaping companies.
- Designed, produced, and distributed fact sheets and brochures for residential and professional use.

Seattle Tilth. The non-profit Seattle Tilth Association contributes to decreasing non-point pollution through its composting and organic gardening programs. Tilth teaches and encourages Seattle citizens to compost yard and kitchen wastes, reduce or cease use of pesticides and fertilizers, and discover the benefits of organic gardening. Using these methods, people can greatly reduce their household contributions to non-point pollution by keeping pesticides, fertilizers, and organic debris out of stormwater and creeks. See Section 7.1 for more information.

Household Hazardous Waste

Household Hazardous Waste Drop-Off. Local government provides watershed residents appropriate ways to dispose of household hazardous wastes. In Seattle, residents make appointments to deliver household hazardous wastes by calling (206) 296-4692. The Seattle North Haz Shed is located on N 130th St and Ashworth Ave N. Seattle's two Household Hazardous Waste (HHW) collection facilities are among the longest operating in the nation. In 1998, these facilities served more than 13,000 households and collected 435 tons of materials for proper disposal. Collecting these materials keeps them out of the storm drains and serves to educate the public about the impacts on water quality. Educational displays and brochures are available at the collection sites, and facility staff interact with citizens on-site and at public events. Local governments do not charge a fee at the collection sites, because they want to encourage people to bring in their hazardous wastes rather than pollute the environment. The program is paid for through garbage and sewer bills.

Green Cleaning and Green Cleaning Kits. Through special promotions and programs, Seattle distributes “Green Cleaning Kits” containing lower toxicity cleaning products, such as baking soda and vinegar, and simple recipes for common household cleaning jobs. The kits are distributed selectively through the Household Hazardous Waste Department to enhance promotions geared towards reducing toxic and hazardous substances in the home. Tips for green cleaning are included in citywide mailings, such as Seattle's Curb Waste Times.

Master Home Environmentalists. The Washington Toxics Coalition offers "healthy homes" analysis to interested area residents. The program focuses on reducing use of household hazardous materials. Contact the Washington Toxics Coalition at (206) 632-1545.

Automotive Maintenance

Green Car Wash Program. Shoreline and Seattle help fund-raising groups to host car washes that don't send soapy water to the nearest stream. Shoreline and Seattle will provide groups with a kit to block a storm drain inlet and pump the soapy water to an appropriate location, usually the sewer. There is no charge to borrow the car wash kits. Contact Seattle Public Utilities (SPU) at (206) 684-7587.

Other Citizen-oriented Programs

Water Quality Investigations. Both Shoreline and Seattle rely on citizens to spot and report potential surface water problems. The City's field investigators respond to water quality-related complaints from citizens (through a special, dedicated telephone line), and from other departments and agencies. Citizens who spot surface water quality violations, illegal dumping or graffiti problems can report them directly to SPU by calling (206) 684-7587 and to Shoreline by calling (206) 546-1700.

City investigators attempt to determine the responsible party and facilitate corrective action on the part of the polluter. The City coordinates with Ecology on potential water quality violations. City investigators provide information on disposal options, erosion control, and BMPs, and frequently send follow-up letters containing additional information to the responsible party. If practical, the responsible party is required to clean up the materials. When needed, other city departments will assist in cleanup such as street sweeping and catch basin pump out.

Adopt-a-Street (SPU). Adopt-a-Street is a partnership between the City of Seattle and its residents. Groups or individuals agree to adopt a mile or more of City streets, keeping them clean and reducing non-point pollution. The City provides organizational help, cleanup supplies, free hauling, and street signs that announce the Adopt-a-Street sponsors. The Adopt-A-Street program is one of a handful of community programs that make up the Environmental Partnerships team. Contact Adopt-a-Street, (206) 684-7647.

Septic System Management. Failing septic systems can be a significant source of non-point pollution. Septic system owners are responsible for maintaining their systems. To prevent failure and maximize the useful life of a septic system, the King County Health Department recommends:

- Inspect the septic tank once every year and pump as necessary.
- Avoid flushing harmful material into the septic tank, such as grease, paper, cigarettes, coffee grounds, sanitary napkins, solvents, oils, paint, caustic chemicals, or pesticides.
- Avoid the use of any type of chemical or biological septic tank additive.
- Use water wisely. Minimize operating the system above its "daily designed flow." Use low flow fixtures on faucets, showerheads, and toilets.
- Limit garbage disposal use. Frequent garbage disposal use significantly increases the build-up of solids in septic systems, leading to failure.
- Don't construct patios, carports, or decks or use landscaping plastic over the drainfield or septic tank. The system must be accessible and requires air to function properly.

- Keep all vehicles off the septic tank and drainfield areas. Vehicular traffic damages drainfields, crushing pipes, collapsing systems, and compacting soils.
- Direct water from roof drains and surface drainage away from the drainfield and septic tank. Additional water overloads the drainfield, leading to system failure.
- Keep a detailed record of all maintenance activities.

Neighbor Referrals. Two community groups, the Thornton Creek Alliance and the Thornton Creek Project, receive many calls from citizens concerned about the creek. These organizations offer advice and refer callers to the appropriate response agency.

Pet Waste Scoop Law and Leash Law (City of Seattle). The City of Seattle passed a "Scoop Law" in 1982 to reduce the thousands of pounds of animal feces deposited in public areas each year and decrease the spread of bacteria carried in the feces. The Scoop Law states that it is unlawful for a pet owner to:

- Allow the accumulation of cat or dog feces in any open area of his/her property wherein dogs/cats are kept and fail to remove or dispose of feces at least once every 24 hours.
- Fail to remove the fecal matter deposited by his/her animal on public property before the owner leaves the immediate area.

Seattle has a leash law to further regulate pets for the safety and health of its citizens. The law states that it is unlawful for any owner of a domestic animal, except cats and pigeons, to allow it to run at large, but that pets may be removed from the premises of the owner if restrained by a leash that is eight feet or shorter, and if in physical control of a person.

Storm Drain Stenciling. In the Storm Drain Stenciling Program, Seattle and Shoreline provide supplies to community groups to stencil a message above storm drains that reads: "Dump No Waste, Drains to Stream." Storm Drain Stenciling is administered through the Adopt-a-Street Program, Salmon in the Classroom, and various community groups. Salmon in the Classroom students have begun stenciling in several foreign languages in addition to English.

9.4 Business Non-point Pollution Prevention Programs

Business programs are intended to improve water quality by reducing pollutants at their source. Source control efforts include construction site inspection, business inspections, and inspection for and response to illicit discharges. This section describes recognition/support programs and inspection/enforcement programs.

Recognition/Support Programs

EnviroStars. EnviroStars is a business-oriented component of the Local Hazardous Waste Management Program, a cooperative effort between King County and the City of Seattle. After enrolling in the EnviroStars program, participating businesses are given a two-to-five star rating based on their demonstrated commitment to reducing hazardous waste. The higher the star rating, the more proactive the business has been and the more recognition they receive. Consumers who want to shop at environmentally responsible businesses can look for the EnviroStars decal in store windows and reception areas. Businesses with three stars or more are featured in success stories sent to local media, highlighted in radio and print advertisements, and nominated for environmental awards. Contact the Local Hazardous Waste Management Program, King County, (206) 263-3051.

IMEX. The Industrial Materials Exchange (IMEX) is a free service designed to match businesses that produce wastes, industrial by-products, or surplus materials with businesses that need them. IMEX helps businesses to find markets for their industrial by-products, surplus materials, and wastes. Through IMEX, waste generators can be matched with waste users. The goal of IMEX is to conserve energy, resources, and landfill space by helping businesses and organizations find alternatives to the disposal of valuable materials or wastes. Contact the Local Hazardous Waste Management Program, King County, (206) 296-4899, imex@metrokc.gov.

WIN. The Waste Information Network (WIN) helps small businesses meet their environmental responsibilities while meeting their bottom line. The focus of WIN revolves around local hazardous waste and pollution prevention issues faced by small business. WIN includes over 700 members from local businesses, public agencies, trade associations, environmental groups and others involved in resolving waste management concerns. Members come from throughout Puget Sound and attend quarterly meetings, receive Network News, and hold the annual WIN Environmental Achievement Awards. WIN is a component of the Local Hazardous Waste Management Program, King County. For information contact the Business Waste Line, (206) 296-3976.

Inspection Programs

Seattle Business Inspections. Seattle's Business Inspection program is intended to reduce potential sources of water pollution by encouraging the use of good housekeeping and other BMPs. This program focuses on the areas that drain to the Duwamish, Elliott Bay, Lake Washington Ship Canal, and Thornton Creek.

The City focuses on the businesses most likely to impact water quality if BMPs are not followed. High priority businesses include sand and gravel yards, foundries, car wash establishments, auto repair shops, and veterinary clinics (for pet waste control). City personnel use Standard Industrial Classification (SIC) codes to identify businesses that have a high potential to pollute stormwater.

In an initial assessment, City personnel drive by the businesses to determine which ones actually perform high risk activities. City personnel subsequently visit these businesses and conduct an on-site inspection to identify potential stormwater pollutant sources. Historically, very few businesses refuse the inspection. All businesses receive a follow-up letter. Inspectors work with the business owners, recommending BMPs and developing effective solutions to any problems encountered. Sometimes the solution is as simple as sweeping more frequently to keep materials out of stormwater runoff. If polluted runoff from a business is routed to a separated sewer system, the business is informed that it is in violation of City code and may be subject to a fine.

Inspections in Thornton Creek Watershed. The City inspectors are currently working in the Thornton Creek watershed. Staff identified over 700 of the 2,300 businesses in the watershed that have a high potential to pollute stormwater. They completed 740 preliminary business inspections, and sent 130 letters to the businesses selected for on-site inspections during the preliminary inspections. In 1999-2000, 140 on-site inspections are scheduled.

In May 1997, the water quality team conducted a "car wash sweep" in the Lake City area to address numerous complaints about soap suds in Thornton Creek. Lake City has many new and used car lots, automotive repair facilities, car washes, and fleet operators. City staff contacted more than 42 facilities regarding car wash practices.

Construction/Erosion. At construction sites, building inspectors inspect and enforce the erosion and sedimentation control requirements, and evaluate the effectiveness of BMPs. In Seattle, three inspectors are assigned specifically to projects occurring in environmentally critical areas (ECAs). If a project is located in a critical area, the contractor is required to attend a preconstruction conference with the inspector to discuss the project's plans for erosion and sedimentation control and for BMPs. The Stormwater, Grading, and Drainage Code is enforceable by civil penalties for violations and by liens to recover costs if the City performs necessary work

9.5 Government Maintenance Non-point Pollution Prevention Programs

Seattle, Shoreline, King County, and WSDOT have instituted a number of maintenance programs to reduce the amount of pollution that enters streams and waterways. Several are described below in this section.

Drainage Maintenance

Catch Basin/Sand Box Maintenance. Seattle, Shoreline, and WSDOT have programs to routinely maintain these drainage system components. In Seattle, catch basins are inspected annually and cleaned as needed. In a given year, approximately one-third of the catch basins are cleaned. See Section 8.3, for more details.

Private Detention System Inspections. Seattle and Shoreline routinely inspect private detention systems to ensure they are maintained. Although these systems primarily are designed to detain stormwater, they also capture litter and sediments. (See Chapter 8.)

Detention Ponds and Maintenance. In addition to flood control, detention ponds provide some water quality improvements. Detention ponds store water and allow sediments and their associated pollutants to settle out of the water column. Vegetation in the ponds may absorb pollution as well. Debris often collects in ponds and is removed. Routine maintenance activities remove litter and accumulated sediments. (See Chapter 8.)

Street Maintenance

Street Sweeping. In Seattle, the Seattle Transportation Department (SeaTran) conducts the street sweeping program. Major public streets and roads are swept on a regular schedule; industrial and commercial areas are swept on a rotating basis; and bike paths are cleaned monthly. Two sweeper trucks operate in the north half of Seattle. Generally the trucks clean arterial roads, although they will respond to cleanup requests on residential streets. In addition to scheduled sweeping, additional efforts are made after a very large snowstorm (to remove sand) and special events such as parades.

Spill Response. Local government staff respond to spills on the roadway. Staff will contain and clean up spilled material and appropriately dispose of the material.

Grounds Maintenance

City of Seattle Pesticide Reduction Strategy. The City of Seattle adopted a new pesticide strategy in October 1999 to be implemented by the Office of Environmental Management. This program seeks to eliminate the City's use of the most hazardous herbicides and insecticides by June 2000; and reduce overall pesticide use by 30% by December 2002. For further information contact the Office of Environmental Management Department, (206) 386-4595, or the City of Seattle Public Access Network at www.ci.seattle.wa.us/oem. The program has developed this strategy:

- Research and pilot-test alternative IPM strategies.
- Evaluate broader application of current IPM techniques.
- Develop alternative maintenance standard test sites to get public input.

- Develop IPM strategies for achieving 30% reduction from present levels.

Grounds Management Task Force (Seattle). Seattle has established a Grounds Management Task Force (GMTF), including representatives from SPU, Parks, SeaTran, Office of Environmental Management (OEM), Seattle Center, and City Light to accomplish the following:

- Provide a forum for City departments to share information on BMPs.
- Assist City departments to balance environmental stewardship, aesthetic goals, and maintenance issues.
- Promote management and maintenance practices that enhance natural ecosystems.
- Improve and implement inter-departmental approaches to shared environmental issues such as compost management and training.
- Promote integration of Landscape and Grounds Management Guidelines into planning, construction, and maintenance of City landscapes and grounds.
- Assist the OEM in implementing the following Environmental Management Program (EMP) Landscape and Grounds Management Policy elements:
- Maximize water use efficiency.
- Practice integrated pest management.
- Reduce and reuse landscape waste.
- Select and use fertilizers that minimize negative impacts.
- Design landscaped areas to suit site conditions.
- Restore, create, and protect environmentally valuable areas.

King County Golf Course BMPs. In 1993 the King County Environmental Division completed a manual for suggested maintenance practices at golf courses in King County. Best Management Practices for Golf Courses: Development and Operation details ecologically and environmentally sensitive methods for established and new golf courses, based on the best available science of the day. The manual will be updated regularly to reflect and incorporate new information.

Primary issues addressed within the manual include:

- Land use planning
- Wildlife habitat
- Water consumption and conservation
- Hydrology and water quantity control
- Geology and groundwater
- Turf grass maintenance and operation
- Water quality and management chemical selection

Other

Septic System Maintenance. The Seattle-King County Health Department oversees the maintenance of an estimated 100,000 septic systems in King County. Seattle has developed a special program for the 200 septic systems located in the City limits, four of which are in the Thornton Creek watershed. Seattle systems are documented on the Geographic Information System (GIS) and inspected annually. Owners of failing systems are required to make corrections. There are an unidentified number of septic systems in Shoreline. Although the County inspects and records new septic systems, records for older systems are difficult to locate. The Shoreline septic systems receive the routine services provided for the entire county. The Health Department provides countywide information about septic maintenance, but does not conduct an inspection program.

WSDOT Erosion and Sediment Control Permits. Using the WSDOT Highway Runoff Manual (HRM) as guidance, a Temporary Erosion and Sediment Control Plan is prepared for all WSDOT construction projects that involve any amount of earthwork. Earthwork includes excavation, clearing, grubbing, trenching, or any activity that exposes bare soil to precipitation and/or wind. Construction projects that disturb five or more acres of land require WSDOT to file a NPDES Notice of Intent for coverage under the NPDES Baseline General Permit for Construction Activities.

Metro North Bus Base, Shoreline (King County). Metro North Base bus facility in Shoreline, completed in 1990, was designed to meet and exceed current standards for stormwater and non-point pollution control as outlined by King County. Several key technologies are employed at the facility to control non-point pollution. Parking lots and impervious surfaces are graded away from the creek. All repairs and cleanings are performed indoors in double-wall, electronically monitored and controlled facilities. Oils, antifreeze, lubricants, and other vehicle and engine fluids are pumped directly into underground tanks that are later removed in trucks and taken to treatment facilities. A spill cart equipped with the latest spill control technologies is nearby at all times for emergencies to ensure that contaminants do not reach stormwater systems or the creek. The facility is monitored and reviewed on a regular schedule for State and County permit compliance by Ecology.

9.6 Research and Monitoring

Chapter 5 includes an assessment of the available Thornton Creek water quality data. Water quality sampling that takes place in the watershed includes:

- Monthly grab samples of water from the mouth of Thornton Creek (King County).
- Annual benthic samples from various sites within the creek (SPU).
- Annual sediment sample from the mouth of Thornton Creek (King County).
- Sediment samples analyzed for pesticides, PCBs metals (USGS).
- Water quality and benthic samples analyzed by local schools.

Seattle has focused its research efforts on evaluating structural BMPs to treat stormwater runoff. The intent is to determine which products work best under various scenarios (high volume, low flow, intermittent dry periods). The BMPs include oil and water separators, swirl technologies (using centrifugal forces to settle out solids and float debris), swales, wetlands, and others. The BMP sites are located throughout the city and include BMP devices at:

- North Seattle Community College – oil and water separator, wetland.
- Meadowbrook Pond – detention pond, aeration.
- I-5 at Northgate Mall (WSDOT project with SPU support).
- 1st Ave S Bridge.

- Westlake Ave (proposed).
- I-5 near Lake Union (proposed project by WSDOT with SPU support).
- I-5 near Ronald Bog (proposed project by WSDOT and Shoreline) – swale.

The results of these and other studies will help SPU, Shoreline, and WSDOT select and install effective devices in the watershed to treat urban runoff.

9.7 Non-point Pollution Program Assessment

Government agencies and non-profit groups have many strong programs designed to reduced non-point pollution and improve water quality. Because non-point sources are so numerous, multiple strategies are needed to address them. Regulations, enforcement, government operations, and business operations are part of the solution. Reducing non-point pollution is especially challenging because it requires individuals to change their behavior. It is the opinion of the Watershed Management Committee that there is not enough funding, nor staff, for non-point pollution reduction and control because they believe regulatory agencies and citizens don't value it.. The Committee has identified the following areas for continued attention.

Regulation

- Continue to improve stormwater management programs in accordance with Ecology requirements.
- Determine if faulty sewer connections may be contributing to high fecal coliform levels.

Citizen Programs

- Educate citizens about non-point pollution and their role in preventing it.
- Develop a watershed-specific program, rather than relying on regional programs to address non-point pollution in the Thornton Creek watershed.
- Continue to promote alternative modes of transportation, including public transit, walking, and biking.

Business Programs

- Conduct the proposed business inspection program.
- Develop a program to address pollutant discharge from mobile businesses.

Government Maintenance

- Reduce use of pesticides and improve grounds maintenance practices in parks, schools, golf courses, and other public property.
- Improve street sweeping methods to increase removal of dirt, sand, leaves, oil, and litter.
- Treat stormwater runoff from streets within the watershed.
- Improve maintenance of detention ponds.
- Continue to incorporate water quality improvements into CIP projects such as detention ponds and wetlands.

Research

- Strengthen the research program to study other locations on the creek.
- Identify the sources of elevated fecal coliform levels, and develop a program to prevent pollutants from entering surface water.
- Identify the sources of elevated temperature and low dissolved oxygen, and develop a program to improve conditions for fish.

CHAPTER 10: WILDLIFE AND HABITAT PROGRAMS

This chapter describes numerous programs and activities offered in the watershed that address wildlife and habitat. These programs are sponsored by community groups, non-government organizations, and government agencies. The following types of programs are described: maps and inventories, coordination, open space and land acquisition, trees and native plants, community restoration sites, and habitat-related capital improvement projects. The final section is an evaluation of the effectiveness of these programs.

10.1 Maps, Inventories, and Studies

Numerous maps and assessments of wildlife and habitat in the Thornton Creek watershed have been prepared. Information is often collected on a citywide or countywide scale and consequently may lack specific information about this watershed. The following summarizes existing watershed maps, habitat inventories, creeks, and wildlife.

Maps

Numerous maps contain information about the Thornton Creek watershed. The following maps have been useful in the development of this report:

- Thornton Creek Project Atlas (1997).
- Thornton Creek Riparian Corridor Maps (SPU, 1999 - companion document to this report).

Geographic Information System (GIS) maps showing roads, buildings, streams, storm drains, parks, steep slopes, community services, wetlands, and many other attributes. The Seattle GIS maps also include ortho photos. The public can access GIS data through Arcview at local libraries, through neighborhood groups, and at some watershed schools.

Habitat Assessments

The following assessments consider habitat throughout the watershed.

Urban Wildlife and Habitat Management Plan. In 1994, Seattle Parks and Recreation completed the Recreation Urban Wildlife and Habitat Management Plan (Seattle Parks, 1994), which describes the environment in City parks. The purpose of this Urban Wildlife and Habitat Management Plan is to provide the framework and guidelines for integrating natural and human systems in Seattle's parks and open spaces. The overall goal is to benefit both the people and the native wildlife that use these lands. This plan is intended to be an ongoing and dynamic part of Seattle Parks' resource management efforts.

The Urban Wildlife and Habitat Management Plan details the current status of wildlife and habitat conditions in Seattle parks, followed by a list of management goals for these areas. A comprehensive inventory of habitat types follows, including both aquatic and terrestrial resources. Wildlife species were evaluated as they relate to each habitat type. The document concludes with a series of goals and objectives for future management of urban wildlife in Seattle Parks, including detailed plans to enhance environmental education and volunteerism, increase wildlife populations, improve interagency cooperation, increase communication among departments, and bolster wildlife protection and enhancement programs. The management plan has yet to be fully implemented as written in 1994.

Thornton Creek Forest Restoration Plan (Seattle Parks, 1994). The Seattle Parks Department developed a forest restoration plan for five open space parks in the Thornton Creek watershed: Thornton Creek Park #1, 2, and 6; Ravenna/Blindheim; and Sand Point Open Space. These parks are designated as open space areas and won't be developed for ball fields or playgrounds. Staff investigated the conditions within the parks, documented existing conditions, and mapped out restoration activities for each site.

In general, the existing forest canopy contains mature Big leaf maples and declining alders. In a natural forest, deciduous trees are succeeded by conifers. This isn't happening due to a lack of conifers to provide seeds and competition from invasive plants such as blackberry and ivy. The work described in this plan is slowly being completed, primarily through the Adopt-a-Park program, which uses the plan as a source of project ideas.

Plant Habitat Physical Structure in Thornton Creek Parks (A. B. Adams, 1995). In this survey of open space and park areas in the Thornton Creek watershed, the physical structure of plant communities was evaluated by examining vegetation layers, tree trunk diameters, stem density, and large woody debris. Digitized maps for Thornton Creek Parks #1 and 6 are shown in Figures 10.1 and 10.2. Information for other areas is available from Adams, a watershed resident, and principal of Ecosystems Database, a non-profit organization working to develop GIS databases for application to locally based ecological research.

Thornton Creek Park #6 Studies (A. B. Adams). In addition to the plant habitat survey, Adams has conducted a number of studies in Thornton Creek Park #6. These include a soil survey, a blackberry removal study, a survival assessment for volunteer planting efforts, and bank stabilization projects.

The soil survey found significant areas of fill along the borders of southwest Park #6. The fill was likely deposited from nearby construction.

At the west end of the park, near Northgate Mall, volunteers conducted an experimental blackberry removal program. Volunteers used several techniques to control blackberries and found that cutting back the canes and dabbing with an herbicide suitable for riparian areas was slightly more effective than the labor-intensive method of digging out the roots and rhizomes. Adams documented the success of the three blackberry removal strategies and the success of replanting efforts. The plantings did best along the riparian corridor, and did poorly in areas containing fill material. The streambank stabilization projects are described in Section 10.5.

Figure 10.1. Habitat Survey of Thornton Creek Park #1 (1995)

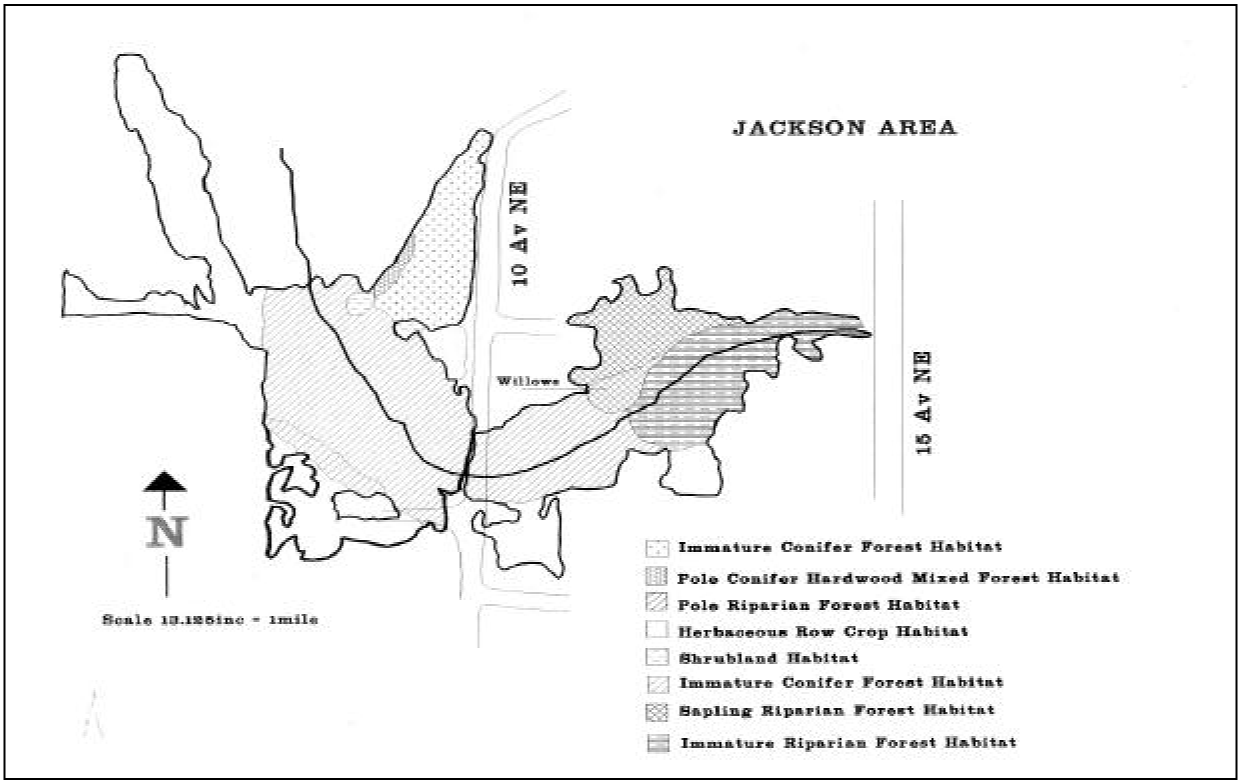
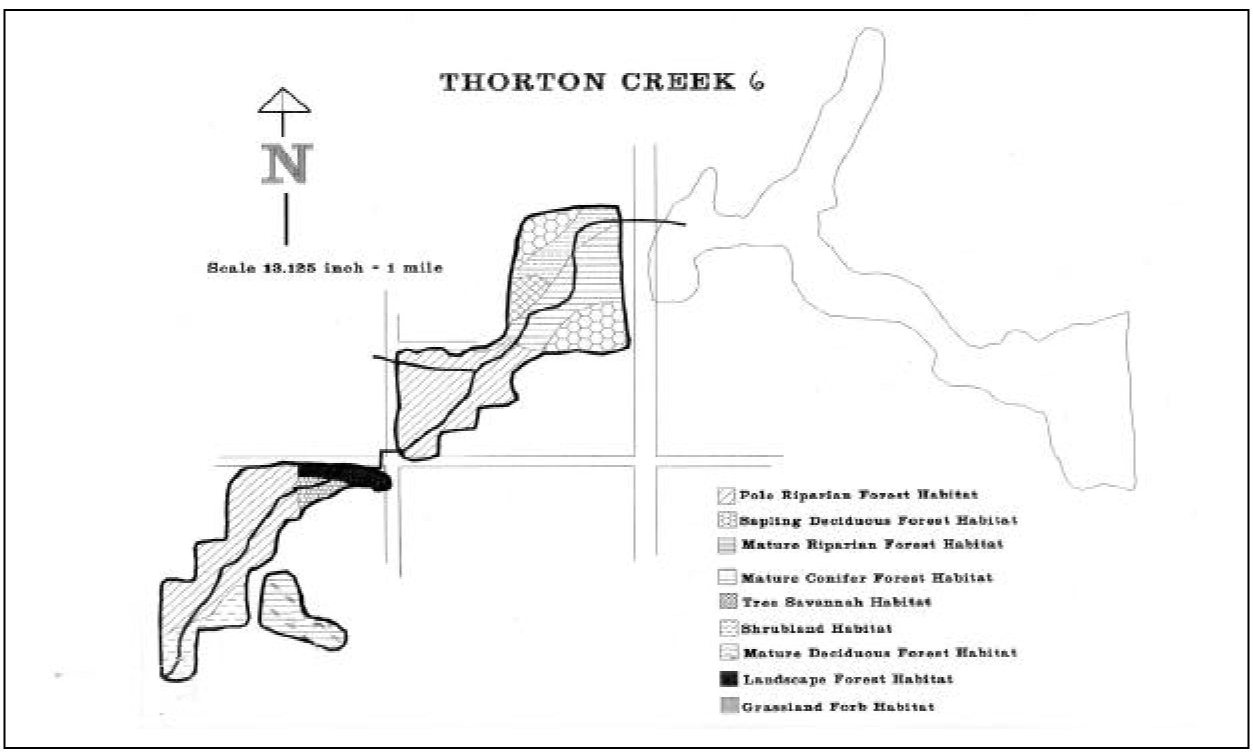


Figure 10.2. Habitat Survey of Thornton Creek Park #6 (1995)



Seattle Urban Nature Project (1999). A non-profit organization, Seattle Urban Nature Project (SUNP), is surveying existing wildlife habitats and associated wildlife in Seattle's parks and green spaces to create an independent, continuously updated and refined database to be used for science, conservation, and education. SUNP completed the initial survey in 1999.

SUNP is mapping all terrestrial and freshwater habitats in publicly accessible or visible green spaces in the City of Seattle larger than half an acre, although special features (particularly wetlands) are mapped at a finer scale. Over 50 terrestrial and aquatic habitat types have been defined, based on percentage of impervious surface, including several forest types and size classes, non-forested habitats, landscaped habitats, and development categories. Structural vegetation types use cover classes for all dominant and incidentally observed species, and make special note of invasive species and special structural habitat elements such as snags and downed logs. The structural vegetation types are based on the Seattle Parks Department Urban Wildlife and Habitat Management Plan (Gregg Miller, 1994). Wildlife data includes only incidental sightings.

In the future, SUNP plans to expand the program. General goals include: making the written and spatial databases publicly accessible using a website or other means; gathering more detailed data in a representative sample of habitat polygons; and filling in data gaps.

Stream and Aquatic Habitat Assessments

The following inventories and assessments cover specific stream and aquatic habitat conditions in the Thornton Creek watershed.

Creek Restoration Grant (1995-1996). Seattle Public Utilities (SPU) has recently completed this study as part of a creek restoration grant funded by Washington State Department of Ecology's Centennial Clean Water Fund. The overall goal of this program is to improve water quality through minimizing the impact of urbanization on Seattle's creeks. The restoration program has three phases:

- ♦ Creek identification and documentation
- ♦ Physical and habitat assessments
- ♦ Creek restoration plan development and implementation

In 1995 and 1996, SPU staff conducted a physical and habitat assessment in Thornton Creek (see Section 4.5). As a result of this assessment, numerous problems were identified along public property and considered for Capital Improvement Plan (CIP) projects.

Thornton Creek Restoration Projects Conceptual Design Report (1998). Based on the 1995-1996 Thornton Creek stream assessment, SPU staff identified 29 sites on public property that posed potential problems to the creek. The Watershed Company and Thomas/Wright Inc. were hired to aid SPU in developing criteria for prioritizing and evaluating the 29 sites, and developing preliminary designs. Site reconnaissance took place in June 1998. For each site, a field checklist was completed. Sites were prioritized according to factors including access, potential for instream habitat improvement, hydraulics, upstream and downstream impacts, fish use, cost, and community involvement. The list of potential sites, field checklist, evaluation sheet and priority ranking are shown in Appendix J. The results of this work are available in Thornton Creek Restoration Projects, Conceptual Design Report (Watershed Company, 1998). These projects were forwarded to SPU for Capital Improvement Projects. (See Section 10.6. for further discussion of these habitat CIPs.) In general, the proposed projects are designed to:

- ♦ Improve fish passage

- Protect sewer crossings
- Reduce erosion (on public property)
- Control sediment
- Improve habitat

Evaluation of Salmonid Habitat Conditions and Opportunities along the Main Branch (1998). Alan Johnson and Gary Minton were hired by SPU to evaluate habitat conditions along the Main Branch of Thornton Creek (Minton, Johnson, 1998). They inventoried stream conditions, examined and electroshocked the stream to determine fish presence, mapped good existing habitat areas, and identified potential improvement areas. The researchers found a shortage of pools and theorized that excessive storm flows and a lack of refuge during storms are limiting factors. They also identified several potential fish barriers along the Main Branch. These recommendations were forwarded to SPU's CIP planners.

Hydraulic and Hydrological Analysis of Thornton Creek. SPU has hired Entranco, Inc. to evaluate the hydraulic and hydrological conditions within Thornton Creek. The final report is expected in early 2001. The findings will be used to refine proposed drainage and habitat-related CIPs.

Wildlife Surveys

Salmon and Fish Surveys. The primary sources of information about fish in and near the watershed, previously described in Section 4.4, are:

- Salmon Watchers, an annual volunteer program to identify spawning salmon and the stream reaches used in the Lake Washington area.
- Washington Trout survey of fish and fish habitat (1999) in Seattle streams.
- Fish and Wildlife surveys in 1981, 1984, and 1990 (Washington Department of Fish and Wildlife).
- Lake Washington Sockeye Salmon Studies (1990s) examining reasons for diminishing Sockeye runs in the lake.

Benthic Macro-invertebrates. Benthic macro-invertebrates are the small creatures that live at the bottom of lakes and streams. They are used as indicator species to evaluate the health of creek systems. Staff from City of Seattle and King County, and students from the Thornton Creek Project collect samples annually. (See Chapter 5 for the results.)

Birds. The Seattle chapter of the Audubon Society is a valuable resource for learning about the birds of the watershed. Audubon is involved in study and enjoyment of all bird species. Christmas 1999 marked the 100th year of the Audubon Society Christmas Bird Count, which is the longest-running bird inventory in existence, and provides the best longitudinal data available on birds. In addition to data collection, Seattle Audubon Society offers field trips and classes on observation, identification, and appreciation of native bird species.

There are several other bird watching activities in the watershed. Students at many schools, from grade school through college, gather information on birds in the watershed. North Seattle Community College, Evergreen School, and the Thornton Creek Project monitor birds in the watershed several times a year in four primary habitats, recording numbers and species types, and observing behavior. This data is later compiled and studied by TCP and NSCC students and instructors to further understand wildlife and habitat issues in the watershed.

Amphibians. The Thornton Creek Project researches and records data on amphibians in Thornton Creek. The King County Amphibian Monitoring Program trains volunteers to identify amphibian egg masses. Finding egg masses is much easier than searching for adult amphibians and/or identifying their calls. The King County program protocol recommends making at least two visits to a wetland to accurately determine which species are present. One visit should occur between March 1 and March 29, and the second visit between April 4 and April 26, preferably two weeks apart; a third visit in May is also recommended.

Studies

Lake Washington Studies. Lake Washington Sockeye runs, which historically have been the largest in the country outside of Alaska, have generally been too low to support fishing since the mid-1980s and are expected to remain low through the rest of this century. Scientists don't know why the overall run has dropped so dramatically, but Sockeye seem to have had greater survival problems in the lake than in ocean or river waters.

In 1993, a team of scientists from the University of Washington, State and local governments, and the Muckleshoot Indian Tribe sponsored a series of scientific studies to help increase Sockeye survival rates in the lake. The studies, as originally proposed, were designed to examine three main issues:

- Are young Sockeye dying because of food shortages in the lake?
- Are lake predators eating large numbers of young Sockeye?
- Why do survival rates for Sockeye from the Sammamish system seem to be significantly better in some years than those for Sockeye from the Cedar River?

The research has been expanded to include studies of injury and mortality of juvenile Sockeye at the Ballard Locks as they migrate to Puget Sound. As a result of this study, several capital and operational improvements at the Locks are underway (see Section 10.6). These would benefit all species of anadromous salmonids from all areas of the Lake Washington watershed, including Thornton Creek.

Additional studies are proposed for the Ship Canal in the year 2000. Representatives from the Army Corps of Engineers, the State, the Muckleshoot Tribe, King County, and Seattle are working together to improve communication and collaboration between agencies.

Mapping Lake Washington and Ship Canal. King County contracted with J.C. Headwaters of the University of Toronto to map temporal and spatial variances of physical and biological features in Lake Washington and the Ship Canal in September 1999. Advanced technological methods were used to help meet Chinook salmon needs under the Endangered Species Act. Features mapped include bottom topography, water quality, plankton and fish. Methods included use of hydroacoustics, the Global Positioning System (GPS), and water quality sensors.

10.2 Coordination of Habitat Projects

Many habitat restoration projects involve volunteers. Volunteer restoration efforts are usually organized by Seattle's Adopt-a-Park Program, the Thornton Creek Alliance, the Thornton Creek Project and SPU's Urban Creek Legacy program. Hundreds of volunteers work in Thornton Creek parks every year. Many projects receive funding from local and State grants. (See Appendix K for a list of grant sources.)

CIP projects often have their own public involvement process and involve coordination with other government agencies. Various agencies including SPU, Shoreline, and the Army Corps of

Engineers coordinate habitat projects with each other, landowners, permitting authorities, and the community. Proposed projects are presented to local community groups for discussion and to identify concerns.

10.3 Open Space and Land Acquisition

Several programs exist to acquire and protect open spaces. These include bond measures, tax incentives, and conservation easements.

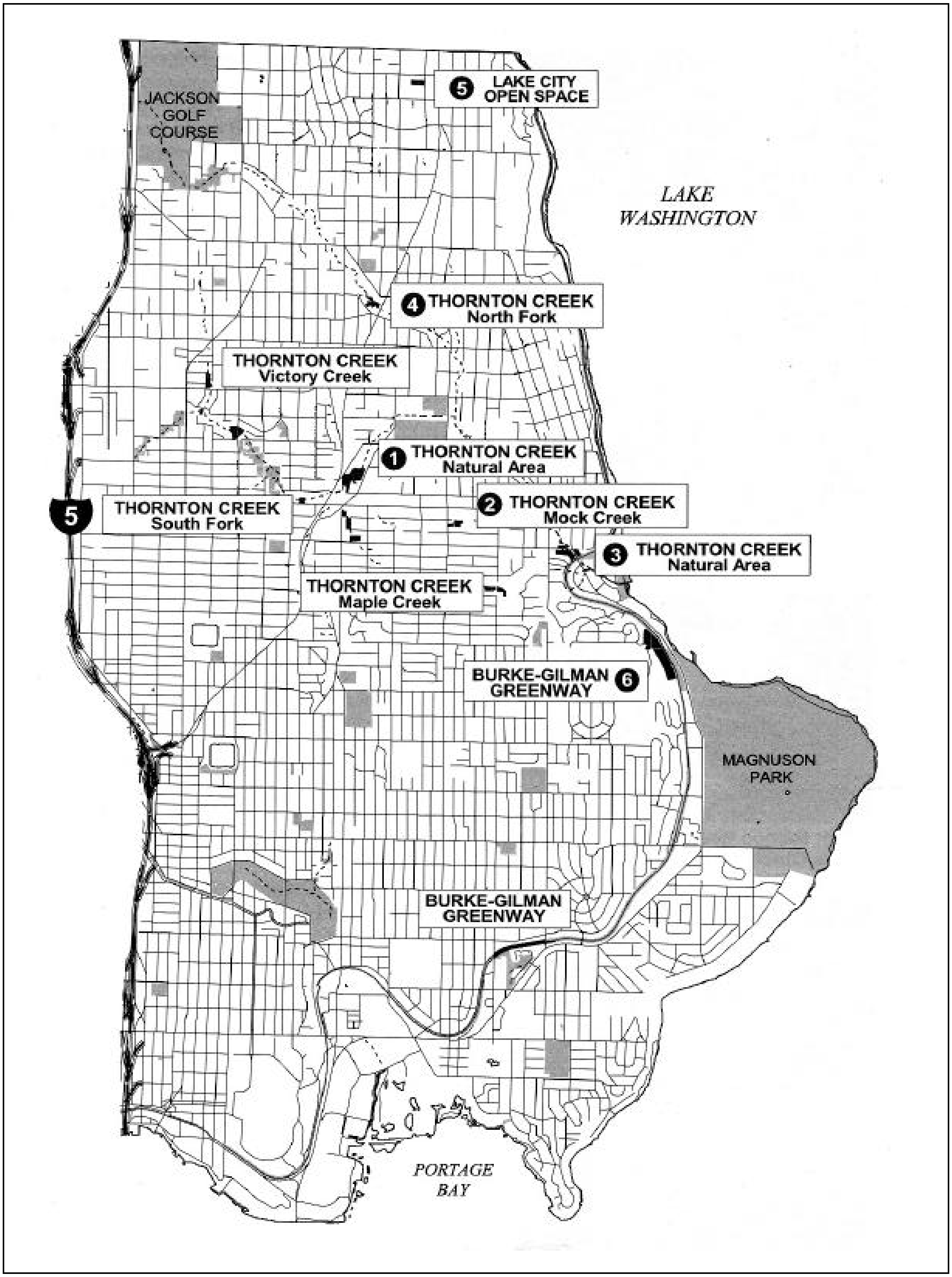
Open Space Acquisition Program (Seattle Parks Department)

In 1989, King County voters approved a $120 million King County Open Space and Trails Bond. Approximately one third of this amount was earmarked for Seattle. The County's Open Space Program leveraged the bond funding to gain State grants, interest revenue, and new funding sources.

Between 1990 and 1997, the City of Seattle has spent or committed nearly $90 million of these bond funds to acquire open space land through purchases, donations, conservation easements, and government transfers. Along Thornton Creek, 19 acres have been preserved through the program, including 4.2 acres through donations. Sites are highlighted in Figure 10.3. Additional sites are located along the South Fork and Maple Creek tributaries. Several of the recent acquisitions are described below.

- South Fork (trail, creek, map, restoration): This 3.8-acre site was owned by the Fischer-Blindheim family for 100 years, and was once the La Villa Dairy. Volunteers have removed blackberries and planted conifers and other native plants.
- Willow Creek (creek, restoration): Citizens enhanced fish passage in this natural area along Willow Creek and were rewarded when Cutthroat trout spawned in the area. To a person walking along the street end, the South Fork of Thornton Creek is visible as it crosses under Lake City Way.
- Mock Creek Ravine (creek, restoration): This small site was purchased through the Opportunity Fund and significant replanting has been done.
- Sand Point Way NE and NE 95th (creek, restoration, map): The Program has preserved 2.4 acres on the three corners of this intersection. On the northwest corner, the developer had removed vegetation before the site was acquired by the City. Volunteers have worked with Seattle's Urban Forester to replant the area.
- North Fork, also known as Homewood (creek, restoration, map): The creek flows through this scenic one-acre site before it crosses under Lake City Way.
- Lake City Open Space (restoration and park development planned): Citizens initiated the successful effort to save this site in a densely developed neighborhood, and are working with Seattle Parks and Recreation on park design. Plans include a flood control and habitat pond in conjunction with Little Brook, a Thornton Creek tributary.

Figure 10.3. Open Space Acquisition Sites



- Burke-Gilman Greenway: This 7.7 acre site along the Burke-Gilman Trail near Sand Point is the largest property purchased in northeast Seattle. The community advocated for its preservation due to the impact the proposed 40 large new houses would have had on wildlife habitat and the serenity of this portion of the trail.

Additional sites in northeast Seattle, including the Pinehurst P-Patch and properties in Inverness Ravine, are being voluntarily preserved by their owners for a minimum of ten years by enrolling in King County's Current Use Taxation program.

Seattle will continue to receive approximately $1 million from King County each year in Conservation Futures real estate taxes and will use these funds to maintain a reduced acquisition program.

Conservation Easements

Across the nation, millions of acres have been preserved using conservation easements to prevent future development on private property. This method is often used to protect land from development while permitting continued use as homes, working farms, forests, and ranches. Easements may be used to prohibit future development on specific parcels. The easement may apply to a portion or all of a property. In the Thornton Creek watershed, several homeowners near a small tributary have created a conservation easement in their neighborhood.

A conservation easement is a legal agreement between a landowner, and a qualified conservation organization or government agency (i.e., King County) that permanently limits a property's use in order to protect its conservation value. The Land Conservancy of Seattle and King County is a non-profit organization working with local property owners to preserve the special character of their property. Conservation easements offer the following benefits:

- Property remains in the ownership of the landowner, who may continue to live on it, sell it, or pass it on to heirs.
- Estate taxes, income taxes, and property taxes can be significantly lower.
- Easements can be written to meet the particular needs of the landowner.
- They are permanent, remaining in force when the land changes hands. A land trust or government agency ensures the restrictions are followed.

The City of Seattle, through Seattle Public Utilities, is exploring the possibility of a conservation easement program. Questions should be directed to Dotty DeCoster of SPU, (206) 684-8745.

Open Space Tax Incentives

As an incentive to preserve open space, King County offers the Public Benefit Rating System (PBRS), a voluntary program that lowers land taxes for qualifying property.   Landowners whose property includes one or more open space resources are eligible to apply. The actual value is determined using a point system. Examples of open space resources include stream buffers, wetlands, certain wildlife habitats, and open space adjacent to parks. Taxable value may be reduced from 50 to 90 percent. The program, usually applied to rural and semi-rural properties, is not well tailored to preserve open space in urban areas due to minimum size requirements. The open space tax program is administered through the King County Department of Natural Resources, Water and Land Resources Division. Contact Ted Sullivan, PBRS coordinator, (206) 205-5170.

10.4 Tree and Native Plant Programs

There are numerous programs in the watershed to increase the number of trees and native plants and to reduce noxious weeds.

Tree Programs

Trees are a valuable resource in the city for many reasons. Among their many virtues, trees provide habitat and food for wildlife, beautify neighborhoods and parks, stabilize hillsides and soils, store water and nutrients, enrich soils, clean the air, provide shade on sunny days, and shield winds on stormy days. A number of programs in the watershed promote tree planting.

TREEmendous Seattle. TREEmendous Seattle is a public/private partnership whose mission is to unite and coordinate the efforts of volunteers, communities, businesses, not-for-profit organizations, and government agencies to plant, preserve, and maintain a healthy urban forest in Greater Seattle. In one project, the City is working with TREEmendous Seattle and citizens to inventory and restore sites where aging stands of native forest are being threatened by aggressive non-native plants. TREEmendous Seattle is also involved in the Millennium tree-planting project. Phone: 206-985-6867. URL: http://www.seattletrees.org/.

Millennium Celebration Tree Planting. As part of Seattle's Millennium Celebration, the Seattle Millennium Woods Legacy Project is committed to planting 20,000 trees by Earth Day, April 21, 2000. Many of these will be planted in the Thornton Creek watershed. Funded by the Seattle Millennium Woods Legacy Tree Fund, trees are being planted on private property, street rights-of-way, City parks, and other publicly owned property, thanks to the public/private structure of the Seattle Millennium Campaign. The City offered complimentary trees for community tree planting projects, and $25 coupons for individual trees for citizens and groups participating in the project. Contact Robert Baines, (206) 684-4113, Ext. 2.

Urban Forest Restoration Program. The Seattle Parks and Recreation Department manages trees in parks, greenbelts, boulevards, and other publicly-owned open spaces. The Urban Forest Restoration Program, supervised by the Park Horticulturist and the Senior Urban Forester, was begun in 1994 to plan for the long-term health and integrity of trees in developed parks, natural areas, and other public open spaces. Contacts: Rick Barker, Senior Urban Forester, (206) 684-4113; or Paul West, (206) 684-4122.

Urban Forestry and Tree Steward Programs. Seattle's Transportation Department is a strong advocate for effective management of urban forest resources on City streets. The Department's educational and regulatory programs combine to ensure proper planting, pruning, and removal practices. These efforts have helped Seattle to receive national recognition by the National Arbor Day Foundation as a Tree City USA for 11 years, and a Tree Growth City four years in a row.

The Urban Forestry program receives community assistance through Tree Stewards, initiated in 1994 to train and support volunteers who want to do more for City trees and green spaces. Participants donate time back to the community by organizing tree-planting activities. The program is coordinated through Seattle Transportation in partnership with Seattle Parks, Seattle City Light, and TREEmendous Seattle. The Tree Steward program seeks to raise community awareness of Seattle's urban forest and to grow a network of tree care volunteers, with a steward on every block. Phone: 206-684-7649. URL: http://www.ci.seattle.wa.us/td/arborist.asp.

National Arbor Day Foundation. The Arbor Day Foundation's mission is to help promote tree care and conservation and to educate people on tree issues. Arbor Day programs affecting the Seattle area include the Trees for America Program, based on the Foundation's belief that everyone has a responsibility for environmental stewardship. Each year the Foundation distributes millions of trees, fosters tree-care education, and helps reforest thousands of fire-ravaged acres in national forests. A newly created program, Partnership for Trees, aims to help groups work with the Foundation to promote tree planting and provide effective educational programs about trees. URL: http://www.arborday.org/.

National Tree Trust. The National Tree Trust (NTT) was established as part of the American the Beautiful Act of 1990. Congress endowed the NTT, a non-profit organization, with a one-time-only grant. The NTT mobilizes volunteer groups, promotes public awareness, provides grants, and unites civic and corporate institutions in support of local tree planting and education projects throughout the United States. NTT's mission is to act as a catalyst for local and volunteer groups in growing, planting, and maintaining trees in rural communities, in urban areas, and along the nation's highways. The Thornton Creek Alliance has received trees from the Trust for watershed projects. URL: http://www.nationaltreetrust.org.

Heritage Tree Program. The Heritage Tree Program seeks to protect mature, historic, unique, beautiful, difficult to replace, or otherwise special trees from removal or destruction in communities across the nation. The Heritage Tree program is a great opportunity for people to celebrate their favorite trees by nominating trees or groves to be Heritage Trees. Currently there are nine Heritage Trees in Seattle. Trees are selected to be Heritage Trees based on criteria such as age, size, type, historical association, or horticultural value. The tree must be in good health, and aerial space and open ground area for the root system must be certified as sufficient by a qualified arborist. Other Puget Sound cities and citizens are dedicating their own Heritage Trees on their own initiative, as increasing sprawl and growth foster a renewed interest in preserving mature trees. Currently, there is no formal recognition of, or protection for, special trees in Seattle. Phone (SEATrans) 206-684-5008. URL: http://www.ci.seattle.wa.us/td/planamne.asp

Native Plant Programs

Salmon Berry. Photo © Will Austin.

Plants native to Pacific Northwest ecosystems are uniquely adapted to environmental conditions in Puget Sound and are integral to watershed health. Native plants have evolved to thrive in this marine climate, are adapted to regional hydrological cycles and soils, and provide habitat for native wildlife. Several programs in the watershed promote native plant use. Additional information on native plant programs can be found in Section 10.5. The native plant programs listed below offer information-based and/or action-oriented activities.

Washington Native Plant Society. The Washington Native Plant Society holds lectures, regular meetings, plant sales, and landscaping workshops emphasizing planting, care, and use of native plants. The Society is actively involved in education and conservation within the watershed, and works with schools and a variety of other organizations to increase public awareness of the importance of native plants and their environment.

The Society works with Washington State University Cooperative Extension in King County to implement education, restoration, cultivation, and other projects throughout the Puget Sound region. When possible, the society grows, donates, or locates plants for projects in the watershed.

Naturescaping and Natural Lawn Care. Naturescaping is a landscape style that incorporates native plants and wildlife-friendly vegetation. The natural lawn care program encourages lower use of pesticides and garden chemicals. Seattle and King County offer workshops on both concepts. (See Section 9.3.)

WSU Cooperative Extension Community Horticulture Program. The mission of the WSU Cooperative Extension Community Horticulture Program is to provide access to research-based information and encourage use of this information by individuals, communities, and horticulture professionals to promote human well-being, protect and enhance the environment, and foster community stewardship. The program is built upon the successful Master Gardener program. URL: http://gardening.wsu.edu/text/mission.htm.

Master Gardeners. The main activity of Master Gardeners has been to answer gardening questions at WSU Cooperative Extension offices or community gardening clinics. However, many Master Gardeners teach gardening classes, others write horticultural articles, and some operate websites. Master Gardeners also address important social and environmental issues, for example, by educating the public about the threat fertilizers and pesticides can pose to water quality if used improperly. Some have led efforts to re-vegetate eroded streambanks with native plants. They help reduce solid waste by teaching people to compost. Master Gardeners also teach children's gardening classes that emphasize environmental stewardship and human nutrition. URL: http://gardening.wsu.edu/.

King Conservation District Native Plant Salvage. Since 1992, King County's Native Plant Salvage Program has organized volunteers, in cooperation with developers, to dig up native plants from sites slated for development. The "rescued" plants are used to restore streambanks, wetlands, and buffers near capital improvement and roads projects. The program has "recycled" valuable locally adapted plant materials from construction sites, become a reliable source of low-cost plant materials, and educated the public in native plant propagation and environmental restoration techniques. Phone: 296-1923. URL: http://dnr.metrokc.gov/wlr/PI/salopps.htm

Seattle Department of Parks and Recreation Adopt-a-Park. In Adopt-a-Park projects, invasive plants are always replaced with Northwest natives. Adopt-a-Park volunteers and coordinators are responsible for a significant portion of the native plantings in both large and small parks in Thornton Creek. Volunteers typically remove invasive plants, such as Himalayan blackberry and Scotch broom, plant native trees and shrubs, and care for them by mulching nearby. This program is coordinated with Thornton Creek Alliance and Thornton Creek Project. (206) 233-3979. URL: http://www.ci.seattle.wa.us/parks/Volunteers/index.htm.

Skunk Cabbage

Horticulture Programs. High school horticulture programs at Nathan Hale, Shorewood, and Shorecrest include propagation of native plants. The horticulture program at Nathan Hale High

School, adjacent to the Meadowbrook detention pond, has been especially active in propagating natives for transplant at various restoration sites and plantings in the watershed. The students involved in this popular program receive high school credit, while improving their community.

Noxious Weed and Invasive Plant Programs

Noxious weeds and invasive plants are non-native plants that have been introduced accidentally or as ornamentals in gardens. Some are poisonous to humans and livestock and most grow rapidly and are extremely difficult to control. They can reduce crop yields, displace desirable plant species, destroy beneficial native habitat, damage recreational opportunities, clog waterways, and diminish land values (King County Noxious Weed Control Board, 1999). Eventually, the dominance of non-natives can cause ecosystem changes, plant and animal extinction, and a precipitous drop in organism diversity. This is a serious problem being addressed throughout the Northwest by agencies and groups such as those described below.

King County Noxious Weed Control Program. This program focuses on education, prevention, technical assistance, and control of noxious weeds through voluntary compliance. Preventing the spread of weeds is more effective and less costly than eradication. Between April and September, when weeds are growing the most rapidly, the program employs field staff members with scientific backgrounds to survey public and privately owned lands in King County for noxious weeds and to work with landowners to control them. Phone: (206) 296-0290. URL: http://dnr.metrokc.gov/wlr/LANDS/weedid.htm

Community Restoration Efforts. Many volunteer restoration projects include removal of invasive weeds.

10.5 Community Restoration Projects

In recent years, many community-based restoration projects have occurred along the creek. Volunteers do the work with some financial support from local businesses and grants from Seattle, Shoreline, and King County.

Funding for Community Projects

Projects in the Thornton Creek Watershed have been funded by Seattle's Stewardship Through Environmental Partnership (STEP) funds, Seattle's Neighborhood Matching Funds, Shoreline's neighborhood grants, and King County's Waterworks and Water Quality grants. These programs offer technical advice, materials, equipment, and cash. Some of the small grants, under $1,000, have simple applications and are awarded throughout the year. The larger grants have more rigorous application procedures and due dates. (See Appendix K for a description of grants and other assistance programs.)

Seattle uses two funds to support community based restoration projects. The Neighborhood Matching Fund provides money and technical assistance to neighborhood-based groups to implement neighborhood projects. The semi-annual program awards up to $99,000. For "small and simple" projects, community groups can apply for up to $5,000 and Quick Step allows quick approval for grants under $1,000. The STEP program supports projects for streambank restoration, bank stabilization, wetland restoration, informational brochures, restoring native plants, creating urban gardens, and rehabilitating vacant lots.

Restoration Projects

Community restoration projects have involved planting conifers and other native species along the riparian corridor, restoring wetlands, creating frog ponds, and maintaining trails. Some of these projects are described below and the locations are shown in Figure 10.4.

Ronald Bog Restoration. Students and staff from Shorewood High School have taken action, based on their ongoing study of this area, to address problems and improve the area's health. They have worked with local citizens, businesses, and agency staff to create biofiltering vegetation strips to prevent street runoff oil from polluting the pond and to establish an arboretum in the area northeast of the pond. (Shown as project 1 in Figure 10.4.)

Twin Ponds Restoration and Monitoring. Volunteers, students, and staff from nearby Evergreen School and the Parkwood Neighborhood Association are working to solve creek health problems identified in their ongoing monitoring of this area. Students are restoring creekside vegetation upstream of the creek's inlet to the pond. Many conifers and native plants have been established around the ponds. Volunteer efforts have also included creating and installing interpretive signs. (Shown as project 2 in Figure 10.4.)

Twin Ponds Park

Paramount Park Restoration. Neighbors living next to Paramount Park in Shoreline have worked together to bring back Pacific Chorus frogs to their neighborhood. In 1996, volunteers began clearing blackberries, planting native plants, and creating a frog pond. In 1998 this group received King County Water Quality Grants for a major restoration of a portion of the park's wetlands. According to Paramount Park Neighborhood Group members, this project has had a profound positive change on the habitat, wetland function, Littles Creek, the park, and the neighborhood character. Over the past four years, students from nearby elementary schools have raised tadpoles and released them into the frog pond. Paramount Park and Ridgecrest Neighborhood Groups and the Thornton Creek Alliance have worked on this project. (Shown as project 3 in Figure 10.4.)

Thornton Creek Park #1. On the former site of Little's sawmill, students from Lakeside School have worked with government staff to remove invasive non-native plants and restore a healthier creekside by planting native trees. Regular monitoring by Lakeside School students documents that this mile-wide forest area has a positive influence on creek health, particularly for helping to cool water temperatures.

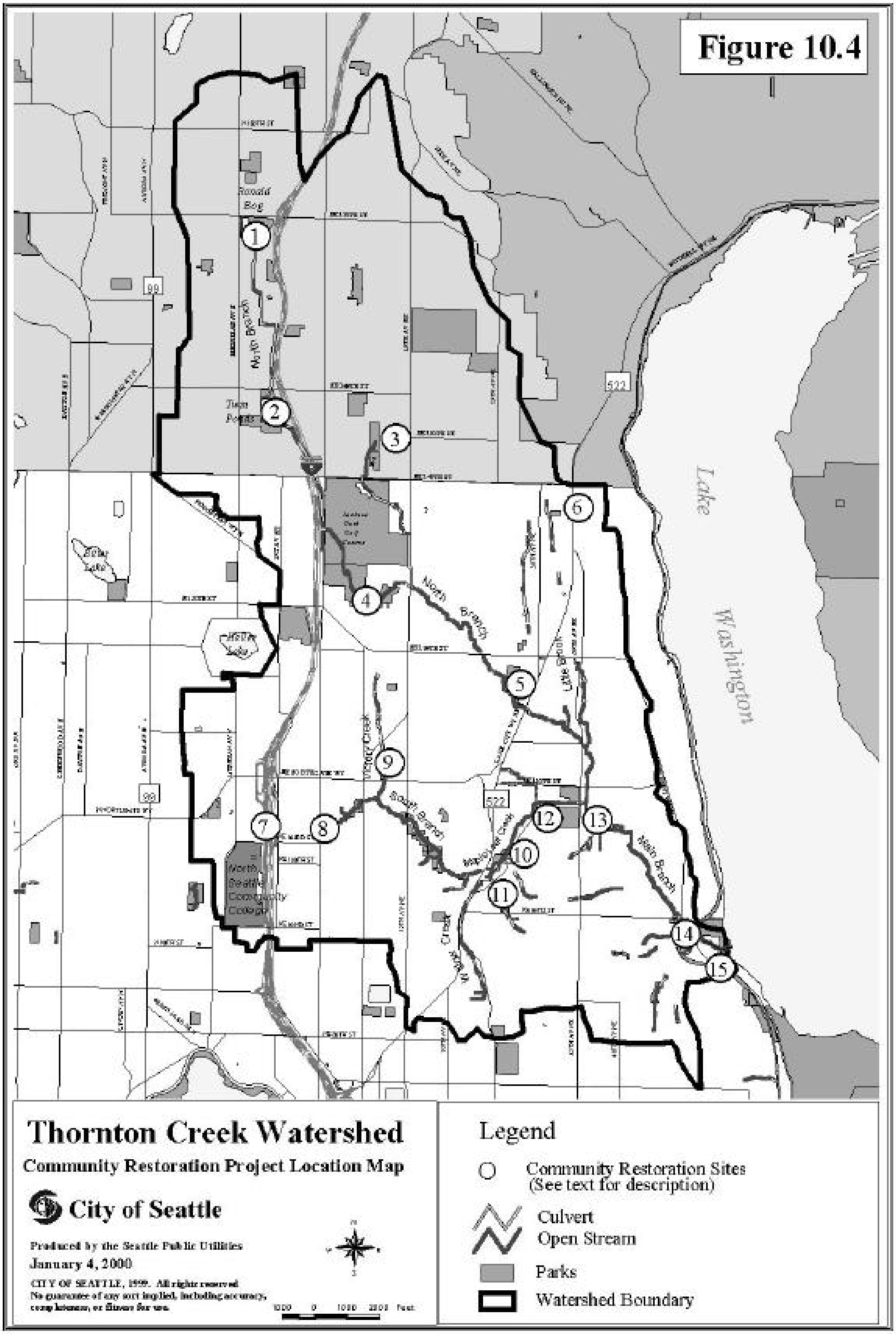


Figure 10.4
Ronald Bog
Twin Ponds
North Branch
Little Brook
Willow Creek
South Branch
Maple Leaf Creek
Main Branch
Lake Washington
North Seattle Community College
Thornton Creek Watershed
Community Restoration Project Location Map
City of Seattle
Produced by the Seattle Public Utilities
January 4, 2000
CITY OF SEATTLE, 1999. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Community Restoration Sites (See text for description)
Culvert
Open Stream
Parks
Watershed Boundary

Thornton Creek Alliance members and nearby neighbors have planted native vegetation in this park, maintained trails, removed invasive species, and helped stabilize an eroding hillside. (Shown as project 4 in Figure 10.4.)

Homewood. Located along the North Branch just upstream of Lake City Way, this open space parcel is overrun by Japanese knotweed (*P. cuspidatum*). The Thornton Creek Alliance organizes volunteers to remove this invasive plant and restore native plants. The park contains some flat land at the bottom of the ravine that could be used to create backwater channels or wetlands. (Shown as project 5 in Figure 10.4.)

"The Last Open Space." Community activists acquired this site, located on the banks of upper Little Brook, as part of Seattle's Open Space initiative. On the east end of the property, the community has built a playground, grassy passive recreation areas, and a trail. The community is working with SPU and Seattle Parks to create a stream channel, flood plain, and riparian vegetation in the west end. (Shown as project 6 in Figure 10.4.)

Community College Wetlands. Staff and students at North Seattle Community College and Thornton Creek Alliance volunteers have worked together with local citizens, City staff, and others to design and build the first phase of a restored wetland on the north end of the college campus. Volunteers planted native vegetation and laid irrigation pipe. (Shown as project 7 in Figure 10.4.)

Thornton Creek Park #6. The Thornton Creek Alliance has organized numerous work parties in Thornton Creek Park #6. A few years ago, volunteers created frog habitat by excavating two ponds in an area of the park that is typically marshy almost year-round. The ponds receive groundwater and runoff from a nearby hillside to maintain a 10-inch depth. When the pond gets too high, the overflow spills over a rock weir into a channel that leads to the creek. The ponds are designed to dry up in summer. Native frogs are better adapted to drier summer conditions than predatory, non-native bullfrogs.

In 1997, a Scout troop planted reeds, rushes, ferns, skunk cabbage, various types of native shrubs, and a few native trees. The emergent plants provide support for the frogs' egg masses. Some of the shrubs provide the cover around the edge of the pond that the frogs need as they develop. Small brush piles will be placed to provide hiding places the young frogs need when they first leave the pond.

As described earlier in this chapter, volunteers conducted an experimental blackberry removal program. As a result, many blackberries were removed, and conifers and other native plants have replaced them. (Shown as project 8 in Figure 10.4.)

In 1997 as part of a stream restoration training session, three sites in southwest Park #6 were given bioengineering bank treatments. These efforts strove to reestablish a more natural vegetative buffer and reduce on-site erosion. At the downstream site, the undercut bank was preserved, while live fascines and cuttings of willow, red osier dogwood, and Douglas spirea were installed to establish a soil stabilizing root mass. At the second site, a trail was relocated away from the streambank, and the bank was replanted with native plants, armored with a root wad, and further stabilized with more cuttings and brush layering. At the upstream site, the steep sandy banks were secured and restored with coir cloth, a geo-textile fabric made of natural fibers, in conjunction with pole cutting and brush layering.

Victory Creek Park. A new park and restored creek reach were established along the lower stretch of Victory Creek when a nearby grocery store was remodeled. This is an example of watershed businesses working together with citizens and local government to restore the creek. (Shown as project 9 in Figure 10.4.)

Ravenna Avenue Natural Area. In an effort launched by the sale of this land by the Blindheim family to the City in 1993, citizens and local government have worked together to help restore the riparian forest to a more natural condition. The Thornton Creek Alliance organizes work parties here. (Shown as project 10 in Figure 10.4.) SPU has sponsored other restoration efforts at this site.

Willow Creek Restoration Project. The Willow Creek Restoration Project is restoring Willow Creek, a tributary to Thornton Creek's South Fork, as a place of beauty and pride in the community, and a resource for people and other living things. Volunteers do this through habitat improvement efforts and community involvement. The Willow Creek Restoration Project received a grant to improve fish passage near the mouth of the creek. Volunteers from all over the world (coordinated through the King County World Conservation Corps) removed mountains of concrete, dug a new channel, and placed over three tons of clean rock and gravel into the creek. The number and size of fish found upstream of the project have increased. Nearby residents have planted trees and other native plants. (Shown as project 11 in Figure 10.4.)

Meadowbrook Wetland and Creeklet. A marshy area adjacent to a ballfield was restored to a series of ponds and a small creek by community residents, the Thornton Creek Alliance, and the Seattle Parks Department. The restored creek has been taken out of pipes and brought to the surface. The small creek now flows out of the wetland, through ponds, past the community center and ballfield before joining the South Branch of Thornton Creek. Volunteers have added rocks and logs to increase instream habitat diversity. They have also planted the hillside, wetland, and creek banks with native trees, shrubs, and emergent plants. This small creek system provides rearing habitat for juvenile salmon and other wildlife. Frogs and small fish are often seen in the ponds. (Shown as project 12 in Figure 10.4.)

Improvements around Meadowbrook Detention Pond. Volunteers have assisted with planting and caring for thousands of native plants around the detention pond. Volunteers also help keep up the appearance of the park by picking up litter. (Shown as project 13 in Figure 10.4.)

Sand Point Open Space. The open space area near NE 95th St and Sand Point Way NE has received many native plants and efforts to control invasive weeds, thanks to local neighbors. (Shown as project 14 in Figure 10.4.)

Matthews Beach Creek. After a small creek was diverted from the south end of Matthews Beach Park to connect with Thornton Creek, volunteers helped to plant and care for hundreds of native plants around the new pools and creek channel. (Shown as project 15 in Figure 10.4.)

10.6 Habitat Related Capital Improvement Projects (CIPS)

This section describes CIPs that primarily address habitat issues. Other CIP projects were previously described in Section 8.4 and shown in Figure 10.5.

Corps of Engineers and Seattle Parks Projects

Matthews Beach Creek. In 1998, the Corps of Engineers (COE) and Seattle Parks diverted a nearby small stream, located along the south edge of Matthews Beach Park, from its discharge point in Lake Washington to Thornton Creek. The new stream meanders through a clay-lined channel topped with gravel to provide spawning habitat for salmon. The COE installed root wads and logs to create small pools and riffles away from the main flow for juvenile salmon. The community helped plant native vegetation in the project area. The purpose of the project was to provide an off-channel rearing area for juvenile salmon. (Shown as D in Figure 10.5.)

Improvements to Ballard's Chittenden Locks. In 1999, several improvements were made to the Chittenden Locks to improve fish passage. Although the Locks are not located in the watershed, improvements to the Locks improve fishery resources for the entire Lake Washington and Cedar River area, which includes the Thornton Creek watershed. The four main components of the project were:

- Installation of strobe lights at the entrance of the filling culverts to prevent entrainment of smolts.
- Installation of new variable speed motors to allow for slower filling of the large lock.
- Installation of four smolt slides to aid in juvenile passage.
- Scraping razor-sharp barnacles off the walls of the filling culverts to reduce injury and mortality to smolts.

SPU Habitat-related Projects

SPU seeks to incorporate habitat improvements into its flood control and conveyance projects. These projects are described below. In 1999, SPU began a program to monitor the effectiveness of CIP projects in improving habitat conditions.

Instream Improvements next to Meadowbrook Detention Pond. As part of the Meadowbrook Pond construction, SPU made improvements to the adjacent stream channel to increase habitat and reduce erosion. Several tree logs, wood weirs, large boulders, and bunkers were installed along the Main Branch. (Shown as C in Figure 10.5.)

North Seattle Community College Wetlands. As part of a flow reduction strategy, SPU constructed a wetland at the north end of the college campus. With help from college staff and volunteers, numerous native plants, shrubs, and trees were located around the wetland. (Shown as E in Figure 10.5.)

Detention Ponds. To the extent possible, SPU incorporates habitat elements into detention ponds, by planting native trees, shrubs, and ground cover around the detention pond.

Jackson Park Detention Pond. As part of the proposal to build detention ponds in Jackson Park Golf Course, a section of Thornton Creek may be relocated. Currently this section of the creek runs along a straight concrete lined channel. Grass grows to the edge of the channel. If the final plans call for relocation of the stream, additional stream characteristics (such as meanders, gravel bottom, riparian plants, woody debris) will be added to the relocated stream. (Shown as A in Figure 10.5.)

SPU's Thornton Creek Restoration Projects

Based on earlier work, numerous potential habitat CIP projects have been identified (see Section 10.1). SPU will conduct a multi-year program of small restoration projects along the various branches of Thornton Creek. The projects are part of the CIP program. They will be constructed within the street right-of-way or on City-owned property such as park open space land. The projects are designed to remove fish barriers, control erosion and sedimentation, repair landslide areas, and protect sewer crossings.

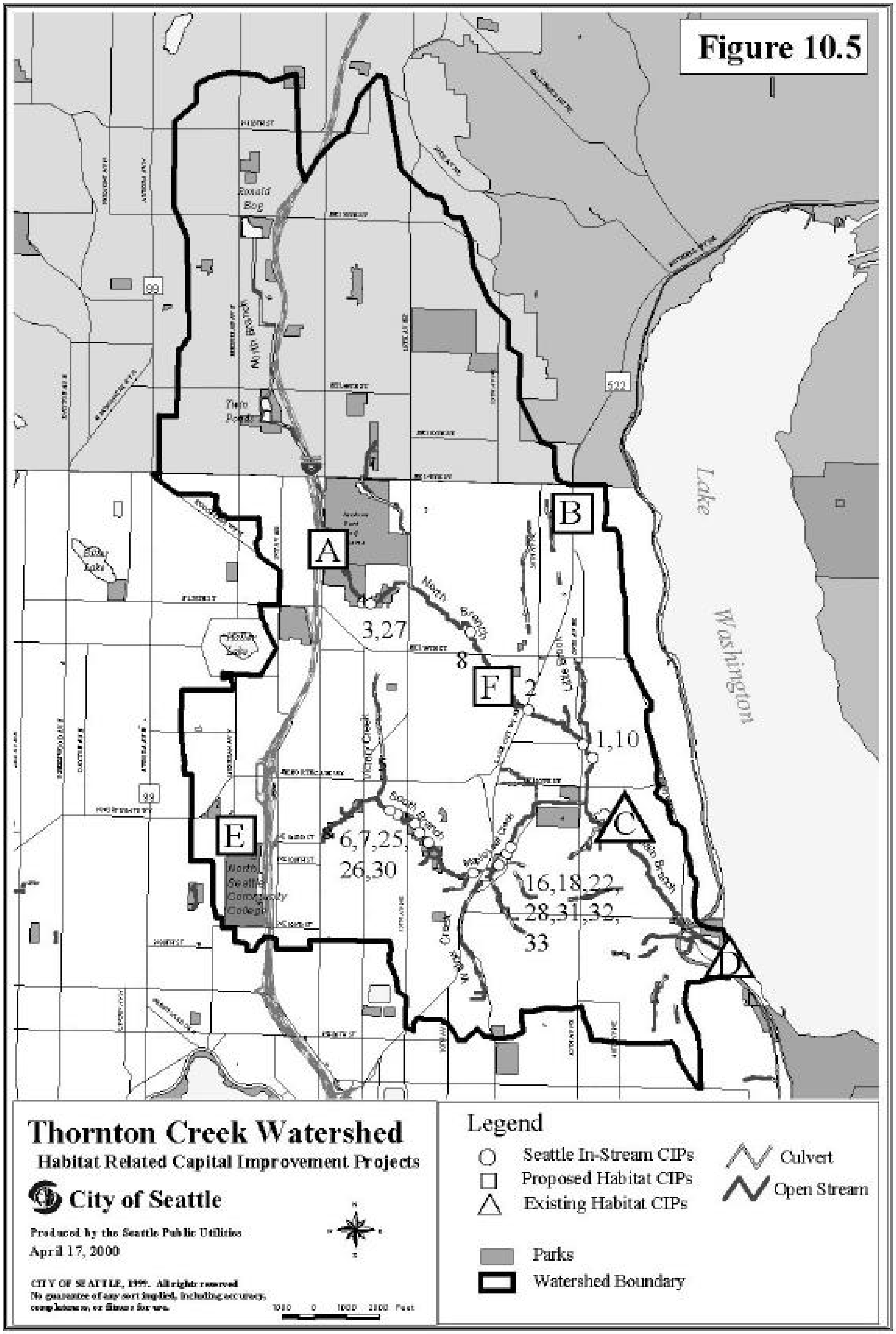


Figure 10.5
Thornton Creek Watershed
Habitat Related Capital Improvement Projects
City of Seattle
Produced by the Seattle Public Utilities
April 17, 2000
CITY OF SEATTLE, 1999. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
Legend
Seattle In-Stream CIPs
Proposed Habitat CIPs
Existing Habitat CIPs
Parks
Watershed Boundary
Culvert
Open Stream
Lake Washington
A
B
C
D
E
F
3,27
8
2
1,10
6,7,25,
26,30
16,18,22,
28,31,32,
33
North Branch
South Branch
Little Brook
Kramer Creek
Maple Leaf Creek
Willow Creek
Ronald Bog
Twin Ponds
Haller Lake
Bitter Lake
North Seattle Community College
99
522
1000 0 1000 2000 Feet

Proposed SPU 1999 Habitat Projects. In 1999, five projects identified and developed by the Watershed Company were constructed (projects 1, 3, 16, 28, and 33 in Table 10.1). An additional 19 were slated for construction; however, permitting delays prevented construction in 1999. Others were built in Summer 2000. All of these projects are shown in Figure 10.5 and listed in Table 10.1.

Summer 2000. Projects numbered 2, 6, 7, 8, 22, and 32 in Table 10.1 are scheduled for construction in Summer 2000. Designs for two additional habitat-related projects have been developed:

- Diverting a section of Little Brook into the "Last Open Space" park at NE 143rd St, creating a small floodplain, and adding native riparian plants. Project shown as B in Figure 10.5.
- Improving instream habitat diversity in the Homewood Open Space along the North Branch near Lake City Way. Project shown as F in Figure 10.5.

Future Projects. Future habitat projects have not been determined. The Thornton Creek Watershed Action Plan will be used to guide selection of future projects, as will Entranco's Hydraulic and Hydrologic Assessment of Thornton Creek. It is anticipated that Johnson's recommended improvements to the Main Branch (Johnson, 1998) will be implemented in the near future. (See Section 4.5 for a description of Johnson's work.) Johnson proposed the following projects:

- Add overhanging vegetation in the area west of Matthews Beach Park.
- Add large rock, logs and overhanging cover near pools in the Sand Point & NE 95th St Open Space.
- Raise the weir to flood the outlet of the culvert under the Burke-Gilman Trail.
- Install several boulders and/or wood complexes to provide instream habitat.
- Create meanders.
- Replace Japanese knotweed with native vegetation along private property between the Sand Point Open Space and Meadowbrook Pond.
- Add boulders and/or wood clusters to increase instream habitat diversity at the 44th Ave NE street end.
- Create a side pool or backwater eddy to provide fish refuge.

Shoreline Habitat Projects

At this time, Shoreline has not identified specific habitat projects in its CIP program. However, many of the drainage improvements described in Section 8.4 will incorporate habitat elements when possible. Shoreline will use the Thornton Creek Watershed Action Plan to guide selection of future habitat projects.

Table 10.1. Proposed 1999 Instream CIP Projects

ID # and Branch	Location	Description
Improve Fish Passage		
1. North (built in 1999)	NE 117th St & 35th Ave NE	Improve fish passage by modifying upstream end of culvert and downstream check dam series.
2. North	Lake City Way near NE 117th St	Improve fish passage by modifying existing check dam series and adding a rock weir. Revegetate hillside near culvert and check dams.
3. North (built in 1999)	10th Ave NE near NE 130th St (near Thornton Creek Park #1)	Rehabilitate upstream end of 10th Ave NE culvert. Add large woody debris to stream channel. Replace trash rack. Revegetate riparian corridor.
6. South	Culvert under 17th Ave NE near NE 104th St	Improve fish passage by adding a rock weir downstream of culvert. Stabilize streambank by removing ~100' gabion wall and replacing it with ~150' rock and rootwad revetment. Revegetate north bank.
7. South (postponed due to access issues)	Twin culverts under NE 105th St near 15th Ave NE	Improve fish passage by removing twin 42" culverts and replacing them with a 4' x 12' arch. Add several rock weirs up and down-stream. Replant areas disturbed by construction.
32. South	Culvert under Lake City Way near NE 100th St	Improve fish passage by modifying culvert and existing "waterfall." Add a series of rock weirs downstream and install baffles and wooden weir in the culvert.
Protect Sewer Crossings and Reduce Erosion		
22. South	NE 103rd St & Ravenna Ave NE	Protect exposed sewer by adding upstream rock weir, reinforcing failing bank, and adding rock to cover exposed pipe. Replant disturbed areas.
25. South	Near NE 105th St & 17th Ave NE	Protect exposed sewer line by adding rocks. Plant steep hillside.
26. South	NE 105th St & 12th Ave NE	Protect exposed sewer line by adding rocks behind existing concrete weirs. Use gravel, cobble boulder mixture. Plant both sides of stream.
Control Erosion and Sediment		
8. North	NE 127th St & 23rd Ave NE	Reduce erosion by armoring outside curve with logs, root wads, and rock. Plant inside curve. Add rock under storm drain outfall.
10. North	Near NE 113th St & 35th	Reduce erosion by armoring creek bank with logs, root wads, and

ID # and Branch	Location	Description
	Ave NE	rock. Widen streambed. Remove some existing concrete walls. Remove failed concrete wall. Plant along outside curves and along right-of-way.
16. South (built in 1999)	NE 100th St & Ravenna Ave NE (confluence of Willow and South Branch)	Control bank erosion by re-grading slopes to 2:1. Reinforce confluence by adding logs, root wads, and rock. Plant uphill of confluence.

Table 10.1 continued on next page

Table 10.1. Proposed 1999 Instream CIP Projects (continued)

ID # and Branch	Location	Description
18. South	Upstream of culvert at Lake City Way	Control bank erosion with root wad revetment along curves.
30. South	NE 104th St & 17th Ave NE in Park #2	Repair scoured creek bed by adding rock weirs and large wood "debris jams." Revegetate north slope and access route.
31. South	10200 Ravenna Ave NE	Reduce streambank erosion, scour, and downcutting by adding wood debris jams and rock weirs. Use logs, root wads, and rocks to reinforce eroded banks. Replant both banks and access routes.
33. Willow (built in 1999)	NE 96th St & 27th Ave NE	Reduce erosion by repairing landslide. Regrade and stabilize slope. Reinforce toe with boulders, logs, and root wads.
Improve Instream Habitat		
27. North	Downstream of 10th Ave NE in Park #1	Improve instream conditions by reshaping existing rock weirs, and adding logs and root wads to create pools. Plant slopes.
28. Willow Creek (built in 1999)	Between NE 98th St and NE 100th St	Add deflector logs and other large woody debris to stream channel. Replant site with native plants.

10.7 Assessment of Existing Habitat Programs

This section presents an assessment of the strengths, weaknesses, and gaps of programs described in this chapter.

Maps and Inventories

There are many good maps. The GIS data and Arcview are accessible to many citizens through the public library, community colleges, and neighborhood planning efforts. The Seattle Habitat maps are likely to be a valuable addition. GIS and Arcview-generated maps are the most useful and accurate tools available for documenting and understanding the watershed. They have been used extensively to create this report and the Action Plan. Although they have proven invaluable, much more information must be added to the Thornton Creek watershed database for these maps to be accurate. The Watershed Management Committee has identified the following shortcomings in existing maps and inventories:

- Wetlands are not delineated nor well mapped.
- The fish survey data is sparse and has only recently started to be seriously documented and evaluated. Data should be made widely available when studies are complete.
- Sections of the creek with good riparian corridor are not identified nor mapped.
- SPU's creek walk and habitat assessment in 1995-1996 did not extend to tributaries of Thornton Creek.
- Fish passage barriers are not well identified.
- The Habitat Assessment of Lower Thornton Creek (Johnson, 1998) identified several restoration projects. These projects have not yet been constructed.
- A comprehensive assessment of instream conditions for fish (i.e., temperature, dissolved oxygen, high flows, and summer low flows) doesn't exist.
- Groundwater movement isn't well understood.

Open Space and Acquisition Programs

The King County tax incentive program is popular in rural areas. However, the minimum size requirement means few urban lots qualify. Several residents are voluntarily participating in conservation easements. SPU is exploring creative ways to expand this program into urban neighborhoods.

The Watershed Management Committee has identified the following areas for improvement:

- The tax incentive programs and conservation easements should be better advertised and tailored to urban settings.
- Additional funds are needed for purchasing open space.
- Land donation programs are needed in urban areas.

Trees and Native Plant Programs

The Millennium Celebration, Adopt-a-Park, and numerous volunteers have greatly contributed to the number of trees in the watershed. Many of the plants and trees planted near Thornton Creek are the result of volunteer programs arranged through Adopt-a-Park, Thornton Creek Alliance, TREEmendous Seattle, and other advocacy or neighborhood groups. SPU and Parks are also responsible for replanting many sites during restoration projects and open space improvement programs. Great potential exists for inspiring citizens to choose native plants, cherish and care for existing trees, plant millennium trees, and reclaim overgrown areas to be replanted with native species.

The Watershed Management Committee has identified the following areas for improvement:

- Encouraging protection and retention of large trees during land development.
- Continuing support for existing tree planting programs.
- Increasing citizen awareness of noxious weeds and invasive plants (such as blackberry and ivy) and ways to eradicate them.

- Increasing citizen awareness of the benefits of native plants and how to incorporate them into yard landscapes.
- Promoting local, reliable sources for native plants.

Community Restoration Projects

Volunteers in this watershed have generously donated time and materials to restore publicly owned parks and open spaces. Thanks to the work of the Thornton Creek Alliance (TCA), the Thornton Creek Project (TCP), Adopt-a-Park, and numerous neighborhood organizations that realize the potential of this urban treasure, Thornton Creek has enjoyed tremendous improvements. Organizations such as TCA and TCP continue to organize volunteer work. Among these groups there is a feeling that the work has just begun. To further their list of projects and goals for the watershed, additional organization and resources will be necessary.

The Watershed Management Committee has identified the following areas for improvement:

- Continuing to provide technical and financial assistance to organizations such as Adopt-a-Park, TCA, and TCP, which manage volunteers and restoration projects.
- Identifying ways to address habitat problems (identified in Section 4.7) that are not addressed by currently proposed community restoration efforts or City CIP projects.
- Ensuring that community restoration projects (and City projects) are following agreed-upon restoration principles.
- Improving documentation for community restoration projects (and City projects) and evaluation of each restoration effort.
- Increasing emphasis on managing private property for maximum habitat value.

Habitat-related Capital Improvement Projects

SPU has dedicated ongoing funding to improvements along Thornton Creek. This is a notable change from historic practices of spending little money for instream improvements in this creek. SPU has also recently developed a monitoring protocol to assess the success of habitat projects throughout the City. Shoreline's drainage CIP program calls for inclusion of habitat elements in drainage improvement projects. (See Section 8.4.)

The Watershed Management Committee has identified the following areas for improvement:

- Currently proposed CIP projects (or community restoration efforts) do not address many of the problems identified in Section 4.7.
- Removing remaining barriers to fish passage.
- Ensuring that habitat CIP (and community) projects follow guiding principles for instream restoration.
- Improving documentation and evaluation of each restoration effort, and improving data sharing for pre- and post-construction monitoring.
- Improving instream diversity along Thornton Creek (i.e., adding large woody debris, overhanging vegetation, boulders, and cobbles).
- Controlling current, excessive high flows in the stream before embarking on premature instream habitat projects.
- Ensuring that wetland restoration occurs.

- Including community partnering and stewardship in CIP projects.
- Incorporating strong habitat elements into drainage and water quality CIP projects.
- Providing incentives to private property owners to reduce runoff rates.

Summary Assessment of Habitat Programs

Issues of concern to the Watershed Management Committee include:

- High storm flows severely degrade instream habitat conditions.
- Extensive development in this urban area has drastically reduced the amount and diversity of habitats such as forests, wetlands, and grasslands.
- Linkages between habitats have been broken.
- Sharing information about habitat conditions, projects, and evaluations doesn’t occur often enough.
- There is a shortage of programs to help streamside property owners address erosion, bank stabilization, and streamside management.
- Incentives are lacking for developers to protect natural features such as mature trees, native plants, wetlands, streams, and riparian corridors.
- Degraded wetlands are not often restored.

CHAPTER 11: EDUCATION AND STEWARDSHIP PROGRAMS

Many of the programs presented in the non-point pollution and habitat chapters have educational elements that have already been described. The purpose of this chapter is to describe general outreach programs not already mentioned, school programs, and education-related capital improvement projects. The previously described outreach and stewardship programs are briefly listed. This chapter concludes with an assessment of education and stewardship programs.

11.1 Watershed and Creek Awareness Programs

The programs listed under this heading are designed so residents and people who work in or travel through the watershed will be aware that they are in the Thornton Creek watershed. These programs also alert participants to some of the attributes of the watershed. In addition to these programs, articles in local papers often address Thornton Creek issues.

Watershed Awareness Programs Specific to Thornton Creek

Watershed Signs. Approximately one dozen signs around the watershed alert people to the Thornton Creek watershed and urge them to care for it. Several interpretive signs are located in watershed parks. These signs highlight native wildlife and habitat. Many of the signs were developed by the Thornton Creek Alliance (TCA) and the Thornton Creek Project (TCP) with assistance from local government.

Newsletters. The TCA distributes a monthly newsletter, Thornton Creek Currents, to its members. The TCP also sends a newsletter to its members. Seattle Public Utilities has distributed several newsletters in conjunction with the development of the Action Plan.

Website. Internet users can visit www.thorntoncreek.org to access the TCP and TCA websites, useful links, and the on-line TCP Community Library (see below). These sites offer a wealth of information on creek and watershed programs, activities, and events.

On-line Thornton Creek Community Library. The TCP developed an on-line Community Library in 1998 to improve distribution and sharing of information about the Thornton Creek watershed. Currently it contains maps, data on creek health, reports, projects, and links to other sites. Plans are underway to expand the amount of material stored at this site to create a useful research tool for the community.

Workshops, Watershed Tours, and Lectures. Every year numerous workshops are held in the watershed. In the past, workshops have covered native plants, birds, history, wildlife, flooding, landslides, and watersheds. Several organized tours of the watershed are hosted every year. The TCP, TCA, SPU, and King County have hosted these in the past.

Work Parties. Volunteer work parties arranged by organizations such as Adopt-a-Park and the TCA are effective ways of creating new creek stewards. After citizens attend a work party for the first time and experience the good company and sense of accomplishment that watershed stewardship provides, many are hooked on the experience and become involved in more creek and watershed activities. Work parties are a tested and reliable form of watershed outreach.

Local and Regional Watershed Programs

Other organizations and agencies in the region help teach residents about watersheds. Notable programs include the Seattle Aquarium's Sound-to-Mountain exhibit
Program, Seattle's Cedar River Watershed Program, the Salmon Information Center and

Creekside Living Workshops (SPU). During November 1999, Seattle Public Utilities conducted a set of public workshops for private property owners and residents who live adjacent to Seattle's urban creeks. One workshop was held for each major urban creek system in the City. The purpose of the workshops was to provide information for property owners and residents living next to urban creeks for evaluating their property, identifying solutions, and learning how to successfully make improvements for the benefit of water quality, fisheries, and drainage. Local experts gave presentations on erosion control and streambank stabilization, water quality and drainage concerns, and landscaping. The workshops were intended to be the first of a series of workshops and educational programs for local residents on improving riparian conditions of Seattle's urban creeks.

Sound-to-Mountains Exhibit. In an effort to showcase the importance and vitality of Puget Sound watersheds, the Seattle Aquarium designed the Sound-to-Mountains exhibit and Watershed Activity Center. The exhibit was designed to allow residents a hands-on experience with common watershed features. Centerpieces of the exhibit include an otter pond (home to three resident river otters), a 15-foot waterfall, and a 125-foot salmon stream, which nurtures native plants, salamanders, frogs, giant insects, salmon, and trout. The Activity Center invites visitors to locate their home watershed in the "zip code computer" to illustrate that everyone lives in a watershed, and offers maps, games, and a water wheel to engage participants. The children's play area contains a 40-foot interactive freshwater marsh mural, an old-growth log for children to climb on and into, a cattail forest, a "quaking bog," tadpole tanks, and animal costumes to wear.

Boeing Creek Stewardship Program. Shoreline currently receives funding through a Puget Sound Water Quality Action Team Public Involvement and Education (PIE) contract, and is creating a watershed steward and education program. Although this program is focused on nearby Boeing Creek, it will offer watershed education classes to all Shoreline citizens. The program will also create watershed/salmon cycle education packets for local K-5 schools.

Lake Washington/Cedar River Workshops. For the past several years, King County has offered an autumn series of workshops about watersheds. Topics have included salmon, the water cycle, trees, native vegetation, and other related subjects. The lectures are held at various sites around the county. Each lecture is accompanied by a field trip to such places as the Cedar River and Issaquah Creek.

Cedar River Watershed Public Education Programs. The 90,545-acre Cedar River Watershed, in the Cascade Mountains, provides two-thirds of the region's drinking water. In 1917, the watershed was formally closed to the public. SPU's Cedar River Watershed public education program, which teaches about the watershed and opens it to students and tours on a limited basis, received a National Environmental Education Achievement Award.

- **School Field Program.** Each year 7,000 children in grades three to six visit the watershed for a day. Prior to the field trip, teachers receive packets to help them prepare their students. During the day, students experience the nature and condition of the source of their drinking water, with the help of two educational specialists, who use a variety of hands-on activities, games, and props. They learn about the challenges of managing a large land area for many uses. Understanding the fragility and limits of the water supply encourages conservation at home and school.
- **Public Tours.** In summer months, water use soars from 90 million to over 200 million gallons per day. The primary purpose of summer public tours is to help people understand water supply conditions and to connect people at the end of a hose with the source of their water. Education specialists discuss land and water management issues, from forestry to instream flows for fish.
- **Group Tours.** Organized groups from the greater Seattle area schedule weekday watershed tours tailored to meet their needs and interests. Participating groups have included garden clubs, environmental groups, history classes, and governmental agency staffs. Increasingly, water managers and utility officials from around the world request the tours.

Salmon Information Center. The Salmon Information Center was established to track the progress of the Tri-County Endangered Species Act response, comprised of King, Pierce, and Snohomish Counties. The Center provides a credible, neutral, comprehensive source of information to empower the public (citizens, businesses, and other stakeholders) to become engaged in salmon recovery. The Salmon Information Center strives to provide up-to-date information that represents the rich diversity of perspectives found in regional discussions about salmon recovery. Contact the Center at 1-877-SALMON-9 or www.salmoninfo.org.

Salmon Friendly Gardens (SPU). Our landscaping practices are an important part of the changes around Puget Sound that threaten salmon with extinction. The ways we garden can make a real difference in whether our salmon neighbors have a healthy place to come home to. Salmon Friendly Gardens Are Beautiful, Healthy and Easy To Maintain. Salmon Friendly Gardens work with natural processes to grow healthy plants with minimal irrigation, fertilizer and pesticides. In addition to keeping the water clean and protecting habitat, Salmon Friendly Gardens can save you time and money. Take a look at your garden and see what you can do to welcome salmon home. Phone: (206) 386-1981.
URL:http://www.ci.seattle.wa.us/util/RESCONS/plantNaturally/salmonfriendly.htm

Urban Creeks Legacy. In a renewed effort to care for Seattle's vital urban creeks system, Seattle Public Utilities built the Urban Creeks Legacy Program as a component of Seattle's Millennium Project. The need for the program stemmed from SPU's responsibility to enhance degraded creek systems, recognize the need for community and business education, resolve critical water quality and quantity problems, and coordinate restoration efforts of multiple agencies, groups, and individuals throughout Seattle. The Urban Creeks Legacy Program is actively involved in promoting and enhancing watershed health and restoration. Visit the Urban Creeks Legacy website to access information on Seattle's watersheds and related organizations. URL: http://www.ci.seattle.wa.us/util/urbancreeks/.

11.2 School Programs

A number of schools in and near the watershed have incorporated Thornton Creek and watersheds into their curriculum. The Thornton Creek Project and Seattle Public Utilities have provided assistance. (See Thornton Creek Project activities in Section 7.1.)

The list of participating schools in this section has been provided by the SPU Salmon in the Classroom program and the Thornton Creek Project. TCP staff note that their records on general watershed orientation activities and the Salmon in the Classroom program may be incomplete. All Thornton Creek schools participate in the annual Storm-Drain Stenciling program in June.

Seattle Public Utilities School Programs

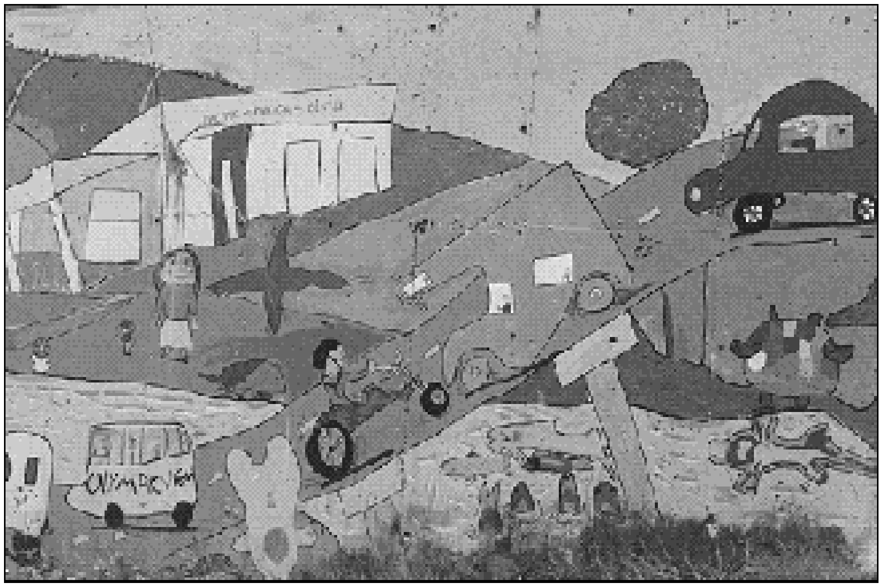
Thornton Creek Project Student Researchers

School age children are an important audience for SPU's message about protecting water quality. Educational programs targeted to this audience not only encourage respect for water resources and responsible behavior by the next generation but can also influence students' parents. SPU's schools program is building upon existing environmental education offered within the schools. A variety of educational opportunities have been and are continuing to be developed that can be selected by teachers to enhance their individual programs. The schools program emphasizes activities that can be incorporated into existing curriculum. The programs include:

- **Salmon in the Classroom.** Seattle sponsors Salmon in the Classroom programs in 115 Seattle schools. This program helps teach school children about the salmon life cycle, watershed stewardship, and natural habitat. Since 1990, students in 23 Thornton Creek watershed schools have been raising Coho and Chinook fry in the classroom. Half of the schools receive fertilized eggs, while the other half fertilize their own eggs. Students raise the fry and release the fingerlings in early spring, introducing approximately 2,100 fry into Thornton Creek each year. Throughout the city, 7,000 to 10,000 fry are released each year. Over the last seven years, 5,000 Chinook and 9,000 Coho have been released in Thornton Creek alone. Phone: 2060684-7624. URL: http://www.ci.seattle.wa.us/util/ept/salmon/default.htm
- **Water You Doing?** is a 35-minute educational video about watersheds produced by SPU through Ecology's Centennial Clean Water Fund. This video has recently been converted to an interactive CD. The video and CD have been distributed widely to schools and libraries.

- **Washington Environmental Education Committee.** SPU is a member of the Environmental Education Committee convened by the State Superintendent for Public Instruction.

Seattle Public Schools



Children's Mural at Olympic View Elementary School

Alternative School #1 actively monitors the creek, conducts creek orientation classes and is involved in a pilot project using the Geographic Information System (GIS) and Thornton Creek.

Alternative School #2 created a video, Thornton Creek: In Your Care last year. The school includes a study of the watershed as part of the curriculum.

American Indian Heritage High School (nearby) participates in the Salmon in the Classroom program and the TCP Confluence (see Section 7.1).

Eckstein Middle School participates in the Salmon in the Classroom program and attends the TCP Confluence.

Nathan Hale High School has been monitoring the creek for several years. The school's horticulture program plans to include native plants along with ornamental plants. Watershed study has been part of the ninth grade urban ecosystem study.

Northgate Elementary School participates in the Salmon in the Classroom program.

Olympic Hills Elementary School actively monitors the creek and has participated in the Salmon in the Classroom program. Students were involved in the Rudy Project, a book cooperatively written by students about a mouse traveling along Thornton Creek.

Olympic View Elementary School has monitored the creek, and has participated in restoration projects, the Salmon in the Classroom program, and the TCP Confluence. The curriculum has included a general overview of the watershed.

John Rogers Elementary School actively monitors the creek, conducts creek orientation, and its own creek website. Students are also involved in the Rudy Project. The school is working with SPU to redevelop the playfield to include a wetland and participates in the Salmon in the Classroom program.

Sacajawea Elementary School participates in the Salmon in the Classroom program and will likely incorporate more creek issues into the curriculum this year.

Summit School (K-12) actively monitors the creek and has participated in restoration projects and the Salmon in the Classroom program. Students were involved in the Rudy Project.

Wedgewood Elementary School participated in the TCP Confluence last year.

Shoreline Public Schools

Kellogg Middle School has conducted creek monitoring and presented a watershed overview to students. The school takes a coordinated studies approach.

Meridian Park Elementary School has an alternative school program called "Room 9" that has been involved with Thornton Creek in the past.

Parkwood Elementary School has shown a strong interest in Thornton Creek and staff participated in a basic orientation.

Shorecrest High School has an active horticulture program that raises native plants. The school has been involved with monitoring and restoration efforts at Paramount Park and Littles Creek. Students are participating in a pilot project using GIS and Thornton Creek. One of the teachers is planning development of an uplands forest learning center on 17 acres of forested land south of the school.

Shorewood High School (nearby on Boeing Creek) has monitored Ronald Bog pond for several years. The monitoring and analysis has led to restoration projects.

Private Schools

Evergreen School actively monitors the creek, conducts creek orientation classes, and is involved in a pilot project using GIS and Thornton Creek. The school also monitors birds and started a program called "Wild Places." The school has "adopted" Twin Ponds and has worked on restoration projects. They are also involved in the Rudy Project.

King's School (all ages, nearby on Boeing Creek) has done monitoring, and students helped with Meadowbrook wetlands restoration last year.

Lakeside High School is very active with creek issues. Science classes are strongly involved in creek monitoring and have plans to monitor birds and amphibians as well. Some English classes write poetry inspired by the creek and watershed. In the past, the watershed has been integrated into US history and foreign language classes. The school has developed a website and the Thornton Creek Atlas. It is a pilot school for the GIS project.

Lakeside Middle School also monitors the creek. Students are involved in the Rudy Project. The watershed is part of the sixth grade curriculum. The school is also involved in a pilot study using GIS and Thornton Creek.

Ryther Child Care participates in the Salmon in the Classroom program.

Seattle Waldorf School recently received funding through a grant from SPU for a pond/habitat restoration project on school grounds.

Shoreline Christian School (formerly Watson Green) plans to monitor the creek.

University Prep Academy has held several creek cleanup projects. The school monitors the creek and offers a watershed adventure physical education class, which includes a general watershed orientation.

Colleges and Universities

North Seattle Community College. The college is a source of student and staff volunteers for many Thornton Creek programs and provides office space for the Thornton Creek Project.

Several NSCC instructors incorporate Thornton Creek research into their curriculum and participate in TCP programs. A wetland restoration project is developing at the north end of campus, and students use the existing surge pond, and will use the new wetland, as outdoor classrooms for ecology and biology field research. In the past, the college has offered wetland orientation courses and Web Walks for interested community members.

University of Washington. Individual students have done and continue to do research on Thornton Creek. Students also participate with Thornton Creek Project activities to meet service learning requirements. Professors Karr, Horner, and associates frequently use Thornton Creek as an example of an urban creek when studying the effects of development on a regional scale. UW students continue to collect macro-invertebrates from Thornton Creek as part of an ongoing study.

11.3 Educational Capital Improvement Projects

SPU is currently designing a "hands on" environmental learning center, to be located north of the Meadowbrook Pond near NE 110th St and 36th Ave NE. The learning center will help Seattle citizens understand how everyday actions affect the health of our creeks and waterways. It will be a place where citizens, both adults and children, can experience and practice sustainable living. Its theme is "Living in the Flow." The public will be extensively involved in designing the facility and associated programs. Displays might examine:

- Water quality
- Conservation and recycling
- Native plants and natural lawns,
- Backyard stewardship
- Composting
- Sustainable building

In addition to the environmental learning center, many drainage CIP projects include educational components. These often take the form of interpretive signs or volunteer monitoring.

11.4 Previously Identified Education and Stewardship Programs

In earlier chapters, a number of educational pollution prevention and habitat improvement programs were described. Programs with educational components are listed below. The reader is referred to Chapters 8 and 10 for more detailed information.

Non-point pollution prevention programs described in Sections 9.3 and 9.4 are:

- Lawn and garden
- Household hazardous waste
- Automotive maintenance
- Water quality complaints
- Adopt-a-Street
- Septic system care
- Pet waste

- Storm drain stenciling
- Business recognition
- Business inspection
- Construction and erosion

Habitat improvement programs described in Chapter 10 are:

- Adopt-a-Park (10.2)
- Conservation easements (10.3)
- Adopt-a-Park (10.2)
- Tree planting (10.4)
- Native Plants (10.4)
- Master Gardeners (10.4)
- Noxious weeds (10.4)
- Community Restoration sites (Section 10.5)

11.5 Internet Resources

Many websites are potentially useful for people working on watershed issues. Specific Thornton Creek information is at www.thorntoncreek.org. Other websites include those listed below.

Government Sites

City of Shoreline	http://cityofshoreline.com/
City of Seattle	http://www.seattle.gov/util
King County	http://www.metrokc.gov/
Puget Sound Water Quality Action Team	http://www.wa.gov/puget_sound/
WA Department of Fish and Wildlife	http://www.wa.gov/wdfw/
Washington State Department of Ecology	http://www.wa.gov/ecology/
US Environmental Protection Agency	http://www.epa.gov/

Stream, Salmon, and Watershed Sites

Adopt-a-Stream	http://www.streamkeeper.org/
Center for Urban Horticulture	http://depts.washington.edu/urbhort/
Longfellow Creek Community	http://www.longfellowcreek.org
Master Gardeners (sponsored by WSU)	http://gardening.wsu.edu/text/nwnative.htm
Muckleshoot Indian Tribe	http://www.muckleshoot.nsn.us/
Northwest Indian Fisheries Commission	http://www.nwifc.wa.gov/
People for Puget Sound	http://www.pugetsound.org/
Salmon Information Center (Tri County)	http://www.salmoninfo.org

Seattle Audubon Society	http://www.seattleaudubon.org/
TREEmendous Seattle	http://www.seattletrees.org/
University of Washington	http://www.washington.edu/
Washington Native Plant Society	http://www.wnps.org/

11.6 Assessment of Educational Programs

Most of the existing outreach efforts about Thornton Creek have been hosted by the Thornton Creek Alliance and Thornton Creek Project with grants from local government. A recent phone survey of residents in the watershed found that half the people contacted couldn't name Thornton Creek or its tributaries when asked to identify a creek near their home (See chapter 2, section 2.3). Many watershed residents don't know the creek exists and consequently have little motivation to protect this resource.

The Watershed Management Committee has identified these areas for improvement:

- Notifying residents and workers that they live and work near Thornton Creek.
- Increasing messages welcoming people to the watershed.
- Expanding outreach efforts beyond English speakers.
- Integrating creek awareness into activities of non-environmental groups, such as sport associations, business associations, and religious groups.
- Improving local residents' awareness and appreciation of the natural riches in the watershed.
- Continuing to organize work parties, workshops, tours, and forums.
- Increasing efforts to bring local residents to the creek and watershed parks.
- Documenting watershed history.
- Improving information packaging, such as slide shows and photo albums.
- Expanding the on-line library of Thornton Creek information.
- Enriching the experience of watershed students who visit Thornton Creek.
- Evaluating and modifying the Salmon in the Classroom program in light of hatchery concerns.
- Making monitoring data available to the public.
- Providing support to organizations that recruit and organize volunteers, such as Adopt-a-Park and the Thornton Creek Project.
- Educating watershed residents about how their individual actions impact the watershed.
- Continuing and expanding efforts to foster stewardship in the watershed.

PART 4

Summary and Next Steps

Willow Creek. Photo © Will Austin.

CHAPTER 12: CONCLUSION

This final chapter examines how the creek benefits the watershed and summarizes the main challenges facing watershed health. In previous chapters, the Watershed Management Committee has reported its findings on four major problems in the watershed: degradation of water quality resulting from non-point pollution; excessive stream flows caused by stormwater runoff; habitat degradation caused by development, stormwater, and pollution; and public education and stewardship efforts that haven't reached their full potential. Interwoven in these chapters were problems associated with regulations and enforcement, coordination, and monitoring. This chapter concludes the report by setting forth the mission and goals developed by the Committee to guide creation of the Thornton Creek Watershed Action Plan and reiterating the steps needed to complete the Action Plan.

12.1 Benefits and Beneficial Uses

Thornton Creek provides a wealth of benefits to all the people, plants, and wildlife living in and around the creek and the rest of the watershed. Possible beneficial uses listed in Washington State regulations for Class AA streams (WAC 173-201A) are listed below.

- Fish and shellfish habitat (includes salmonid and other fish migration and spawning, rearing, and harvesting of fish and shellfish).
- Wildlife habitat.
- Recreation.
- Water supply (Thornton Creek used only for irrigation).
- Stock watering (not applicable due to the urban nature of this watershed).
- Commerce and navigation (not applicable due to the small size of Thornton Creek)

The Committee felt this list did not clearly describe the numerous current and potential benefits that Thornton Creek and its watershed provide. The Committee created its own list (Table 12.1), adding benefits related to natural resources, community, quality of life, education, and refuge. Many of these uses have been impaired or threatened by non-point pollution and other effects of urbanization.

Table 12.1. Potential Benefits Provided by Thornton Creek and Its Watershed

Water and Air Resources ♦ Year-round supply of clean water. ♦ Natural drainage system for the watershed. ♦ Wetlands that provide flood control and water quality improvement. ♦ Groundwater recharge. ♦ Maintaining air quality through cooling of air, release of oxygen, and absorption of carbon dioxide.
Fish and Wildlife Habitat ♦ Diverse habitat for plants, birds, fish, amphibians, and mammals that is scarce in an urban environment. ♦ Food, shelter, nesting, spawning, and rearing areas necessary for resident and migrant species. ♦ Corridor linking the Lake Washington and Puget Sound ecosystems. ♦ Environmental maintenance such as insect control by birds.
Community ♦ Focus for building community ties between humans and the larger community of life. ♦ Focus for pride, identity, and ongoing cooperation among community members, businesses, government, and schools. ♦ Means for improving the economic vitality of the watershed, since the landscape attracts people to businesses and public amenities.
Education ♦ “Outdoor classroom” for students and the general public to discover (or rediscover) nature. ♦ Place to try out new creek and habitat restoration techniques. ♦ Focus for community based learning in schools and other educational settings. ♦ Way to appreciate the watershed’s unique cultural and ecological heritage. ♦ Accurate indicator of the health of the watershed.
Refuge and Recreation ♦ Sanctuary for connecting with nature, for inspiration and tranquility, for retreat, and for spiritual renewal. ♦ Place for hiking, fishing, bird watching, exploration, and play. ♦ Refuge for species pushed toward local extinction and recovering native plant colonies.
Water Supply (Irrigation) ♦ Irrigation of Jackson Park Golf Course (only water supply use).

Source: WMC 1998

12.2 Problem Summary

The Thornton Creek watershed has changed over the last 150 years. What once was primarily forest is now covered with homes, roads, stores, businesses, parks, and parking lots. Approximately one-half of the watershed is covered with impervious surfaces like roads, roofs, and parking lots. Stream studies in the Puget Sound area often include Thornton Creek, because it is one of the most developed watersheds in the region. Seventy thousand people live in this watershed, tens of thousands work in it, and thousands more commute through it. The Puget Sound area is experiencing rapid growth, and the Thornton Creek watershed is certain to receive some of it.

Restoration plans for urban watersheds, such as Thornton Creek, receive some public criticism. Some people, including local residents and public officials, feel urban streams are so degraded that a great deal of money would need to be spent to achieve only small improvements. The argument is that resources are better used to protect streams in undeveloped areas that still have high quality habitat. However, this view does not acknowledge the role streams play in the quality of life in urban areas and it undermines the political and financial support city dwellers can offer for regional stream protection.

The following paragraphs summarize the problems and challenges the Committee has observed in the Thornton Creek watershed.

Stormwater

Problems / Challenges

Stormwater plays a crucial role in determining the health of this watershed, especially water quality and habitat. Half of the watershed is paved or covered with buildings. This high level of impervious surface causes stormwater to rapidly run into streams, without much opportunity to be caught in vegetation or soak slowly into the ground. Stormwater carries pollutants to the stream and excessive flows contribute to sediment and turbidity problems. High flows damage habitat by eroding streambanks and wearing down natural channels. During heavy storms, flooding occurs on properties along the creek. In an attempt to minimize the amount of land being flooded, people install flood control structures. These alter natural drainage patterns and often further aggravate the problem.

Much of the property in the Thornton Creek watershed was developed before the cities began requiring stormwater detention. Land developed and built upon without sufficient stormwater controls increases flood occurrences, because the additional impervious surface prevents vegetation and soil from absorbing water. Because impervious surfaces cause the stormwater to reach nearby creeks all at once, the streams carry higher flow levels for shorter periods of time. High flows in the rainy season erode streambanks and scour the creek bed, which raises sediment levels; increase downstream flooding; and flush salmon eggs and juveniles out of the stream. In summer, flows are reduced because rainwater is not stored in soil for gradual release to the stream. (See Chapters 3 and 9 for details.)

Current Solutions

Seattle and Shoreline address stormwater problems in three basic ways: improving conveyance, increasing storage, and reducing runoff volumes.

Improving Conveyance. In many neighborhoods, stormwater runs across lawns, along the side of roads, and into ditches and pipes. Stormwater movement can be improved by maintaining ditches and identifying and removing bottlenecks, such as undersized culverts. A major improvement was installing a bypass pipeline to convey high storm flows from the creek at the confluence of the North and South Branches directly to Lake Washington. Street sweeping and placement of public trash cans have reduced the amount of litter that can wash into the creek.

Increasing Storage. Regional detention ponds, such as Meadowbrook Pond, store stormwater from a large upstream drainage area and release the water back into the stream at a slower rate. Ideally, such public flood control projects balance fish protection; however, some components are compatible while others conflict. Local building codes require on-site detention for new construction and remodels. Current regulations may be sufficient to mitigate the impacts of new development, but do not address the high level of development that has already occurred.

Reducing Runoff Volume. This can happen by reducing impervious surfaces and increasing infiltration. Seattle and Shoreline permit infiltration of property runoff, but it's challenging given the soils in the watershed which are prone to slides when saturated, setback requirements, and avoidance of steep slopes.

A hydraulic and hydrological study of Thornton Creek is currently underway. Sophisticated computer models are being developed to predict flood prone areas and identify sections of the stream with flow velocities causing rapid erosion. This study will evaluate the potential for various flood control strategies to improve habitat and instream conditions. Seattle and Shoreline will use the results to guide future capital improvement projects, with the involvement of local citizens.

Non-point Pollution

Problems / Challenges

In one way, the non-point pollution problem is analogous to a heavy snowfall. The weight of any individual snowflake is inconsequential, yet snow piled deep enough can cause a roof to cave in. Likewise, any individual source of non-point pollution, like a drop of oil or a cigarette butt, may be inconsequential. But, when multiplied by the thousands, natural resources are damaged. Sources of non-point source pollution, found all over the watershed, include automobiles, lawn and gardens, construction, pets, and home maintenance activities.

A 13-year record of water quality data has been taken from the mouth of Thornton Creek. Water quality data from other locations in the system are sparse. During dry weather, the water is usually clear and odorless. The data shows that fecal coliform bacteria concentrations routinely exceed State water quality standards. Over 98% of samples exceed State criteria, usually significantly. Thornton Creek is on the Washington State 303(d) list because of recurring fecal coliform exceedances. Studies have also shown that temperature and dissolved oxygen levels occasionally exceed State standards. Appropriate temperature and dissolved oxygen levels are necessary for fish survival. Pesticides have been found in the water, especially during spring storms. Both the quantity of pesticides and application methods contribute to problems in the stream. Home application of yard and garden chemicals is highest in the spring, and stormwater can wash these chemicals into the stream.

During storms, water quality rapidly deteriorates. This is not surprising, as stormwater runoff "washes" the ten square miles and carries pollutants to the stream. Pipes and ditches deliver runoff to Thornton Creek generally without treatment. The levels of sediments, turbidity, nutrients, bacteria, organic compounds, metals, oils, and grease rise. In urban watersheds such as Thornton Creek, pollutant levels are exacerbated because high levels of impervious surfaces result in greater runoff and offer few opportunities to filter out contaminants.

Even in dry weather, pollutants find their way into the creek. For instance, car washing sends soap down a drain, mop water tossed out the back door flows into an inlet and then into a creek, paint from a brush rinsed out with a hose in the driveway finds its way to the stream, a truck with a broken fuel line can leak diesel into the storm system.

Regional studies of stream sediments in the Puget Sound area have found Thornton Creek sediments to contain elevated levels of heavy metals, pesticides, PCBs, and hydrocarbons harmful to aquatic life. Although some of these compounds have been banned for decades, they may still persist in the environment.

Over the last 13 years, the number of people and cars in the watershed has grown. Interestingly, the 13-year water quality record doesn't reveal that water quality is improving or deteriorating. This may be explained by the natural variability of pollutant levels in stormwater and by the high level of development that already existed at the start of this period. The trend also suggests that some non-point pollution reduction may have take place that has countered the impacts of growing population. (See Chapters 5 and 9 for details.)

Current Solutions

Local government can play a large role in reducing non-point pollution. Through laws, maintenance practices, outreach programs, and example, government can help to protect this watershed. Seattle's 1997 comprehensive Stormwater Management Manual identifies the multiple strategies the City uses to protect local waterways.

Federal, State, and local laws forbid the intentional or unintentional polluting of Thornton Creek and other streams and lakes. When aggressively enforced, local laws such as Seattle's Stormwater, Grading and Drainage Ordinance can be effective in this watershed. Through promotion of Best Management Practices (BMPs), local governments encourage businesses to adopt good housekeeping, storage, and material handling practices to prevent pollutant discharges to stormwater. Businesses should be encouraged, and in some cases required, to incorporate BMPs in both new and existing facilities.

An effective program to reduce non-point pollution will require multiple strategies. Arguably the most effective, and difficult to achieve, is the voluntary change of individual behavior. As the tens of thousands of people in the watershed choose to "live lightly" and reduce the level of pollution produced by their cars, yards, homes, and businesses, water quality in Thornton Creek will improve. Non-profit organizations and government offer programs on topics such as gardening naturally without reliance on chemicals and pesticides, mass transit and bicycling, oil recycling, and reduced use of toxic household chemicals.

Waiting for individual behavior changes takes time. Meanwhile, local governments have many other programs designed to reduce non-point pollution. Local governments can improve maintenance activities such as street sweeping, outdoor storage of materials, employee training, and reduced use of pesticides and fertilizers. Local stormwater utilities provide regional treatment devices, such as swales, filters, and oil/water separators, to treat road runoff. Many drainage-related capital improvement projects incorporate water quality treatment while controlling flooding.

Habitat

Habitat is one of the most critical elements in protecting water quality and beneficial uses of water. Good habitat provides cover, shelter, and food for fish and wildlife. It also filters stormwater runoff and absorbs rainwater, allowing it to enter stream systems more slowly.

Existing Conditions

Remnants of rich natural resources still remain in the watershed, to the delight of local residents. Towering conifers and shady fern-covered ravines, the occasional sight of a Great blue heron, Bald eagle, River otter, or Coyote, and returning salmon spawning in the creek all contribute to the appeal of the Thornton Creek watershed for area residents. Local parks are a refuge for wildlife and a retreat for people. The creek connects many of the parks and serves as a wildlife “highway.” Cutthroat and Rainbow trout and Sculpins are commonly found in the creek. Juvenile Coho and Chinook salmon are here along with a few returning adults.

Problems / Challenges

In this urban setting, much of the historical habitat is gone. Only 4% of the land remains in parks. Wetlands are physically and functionally gone. Native plants are out-competed by exotic species such as Himalayan blackberry and English ivy. Local residents do not receive assistance in eliminating invasive species. Many watershed parks contain mature deciduous forests. However, these alders and maples are reaching the end of their life span; they are not being replenished by young conifers, as in a natural succession process, due to the shortage of conifer seeds and competition from invasive plants.

Like most urban streams, Thornton Creek does not offer prime habitat for fish. Significant problems affecting fish survival include high storm flows, channelized banks, sedimentation, lack of food, poor water quality, high temperatures, low dissolved oxygen levels, barriers to passage, inadequate instream wood and rock structures, and lack of refuge, spawning and rearing areas. (See Chapters 4 and 10 for details.)

Current Solutions

Habitat is protected in many ways – through laws, policies, and programs. The Growth Management Act (GMA) seeks to manage growth in most Washington counties through the adoption of local comprehensive land use plans and development regulations. Local comprehensive plans are required to protect natural resources including wetlands and water bodies. Under the GMA, comprehensive plans also protect regional resources by directing growth toward urban areas such as Seattle. For the two prime growth areas in the watershed, the Seattle Comprehensive Plan designated the Northgate area as an urban village and Lake City as an urban hub. In coming years, an increase in high density housing and commercial development are expected in both areas.

Local building laws, such as the Environmentally Critical Areas Ordinance, seek to protect stream corridors and wetlands by providing buffers and restricting development. Environmental protection is balanced by private property rights, and variances are often issued.

Since only 4% of the watershed is parkland, efforts to improve habitat must focus on private property. Programs such as backyard sanctuaries, native plant landscaping, and tree planting are sponsored by non-profit organizations and local governments. Local parks, Audubon Society chapters, and other non-profit groups are key partners in habitat restoration.

Local stormwater utilities include habitat enhancement elements in their flood control projects. However, most of Thornton Creek flows through private property. Programs designed to educate and inform streamside residents are beginning to occur.

One of the richest resources in the watershed are the many active and concerned residents who are working to restore the creek. Hundreds of volunteers donate time to clean up trash and debris, remove invasive plants, and replace them with trees and native plants.

Awareness/Education

Problems / Challenges

A recent phone survey of residents in the watershed found that half the people contacted couldn't name Thornton Creek or its tributaries when asked to identify a creek near their home (see chapter 2, section 2.3). The success of the Action Plan depends on residents being more aware of the watershed and committed to protecting and restoring the creek and watershed. The next goal of outreach efforts will focus on residents who are less aware of watershed issues.

The ultimate goal of awareness and education is to create stewards. However, people have to know and appreciate a thing before they want to take care of it. So the first challenge is to make watershed residents aware of the creek, the benefits it offers, and the impacts people have on the creek. The more difficult challenge is to get people to change their behaviors. (See Chapters 7 and 11 for details.)

Current Solutions

Local residents learn about the watershed in a number of ways, including articles in local papers, community meetings, workshops and lectures, newsletters, and welcome-to-the-watershed signs. More than 30 schools are located in the watershed, and many have programs that bring students to the creek; these include Salmon in the Classroom, storm drain stenciling, and creek and wildlife monitoring. Writing, art, and history classes sometimes use the creek as a learning focus.

Two non-profit groups, the Thornton Creek Alliance and the Thornton Creek Project, are effective partners in developing the Watershed Action Plan. These organizations are dedicated to informing and involving the adults and children of this community. Several local government groups also support stewardship. Seattle's Adopt-a-Park program organizes many efforts to plant native trees and shrubs and control invasive plants. Seattle's Urban Creeks Legacy Program involves residents in caring for creeks.

Regulations/Enforcement

Problems / Challenges

At all levels of government, many laws and policies have been developed to protect natural resources. Key Federal laws are the Clean Water Act and the Endangered Species Act. Local regulations include:

- Building and permit review (including SEPA)
- Land use development codes
- Stormwater, Grading and Drainage Ordinance
- Environmentally Critical Areas Ordinance

These regulations apply to new development and remodels. However, many buildings pre-date regulations for stormwater detention and treatment and structural BMPs designed to minimize environmental impacts associated with building construction.

The Committee is concerned that existing regulations do not adequately protect stream resources from development. Environmental protection must be balanced with private property rights, and the appropriate balance is hard to achieve. The Committee is also concerned that local cities do not carry out their own policies and regulations in regards to creek and wetland protection.

Enforcement of water quality and land use regulations is expensive, difficult, a low priority for the judicial system, and not seen as politically popular. In general, the Committee found enforcement programs to be underfunded and understaffed. Some agencies are more effective than others, but for the most part, the Committee concluded that almost all agencies need to improve enforcement programs. Enforcement needs to occur during all daylight hours to cover evening and weekend work by businesses and homeowners. Ideally staff should be able to respond quickly enough to stop the work and prevent damage, not just step in after damage is complete. Staff should also receive adequate training in environmental protection. (See Chapter 6 for details.)

Current Solutions

Laws are continually developed and refined. Habitat protection, stormwater treatment and detention requirements, and development standards have evolved. For example, in the last two years, Seattle has increased the number of staff available to respond to development concerns and inspect private detention systems. Seattle is developing an enforcement protocol to penalize water quality violators. The City of Seattle is presently covered by its first NPDES permit, which is in effect through April 2001. During Spring of 2001 Seattle will prepare its second National Pollution Discharge Elimination System (NPDES) five-year permit application, which will be more comprehensive than the first one. Seattle is currently rewriting its BMP manuals to better address detention, infiltration, treatment, structural, and operational BMPs. When Shoreline became an incorporated city, it adopted many King County codes. Since then, Shoreline has been revising a number of codes to offer more environmental protection.

Coordination

Many agencies and organizations work within the watershed. The Committee would like to see more internal organization within cities, between Seattle and Shoreline, and between cities and King County. An interlocal agreement between Seattle and Shoreline to manage the Watershed Action Plan is needed. The Committee believes that a Watershed Oversight Council representing a broad group of stakeholders should be convened to manage the Action Plan, communicate with decision makers and the community, and address future issues as they arise.

Monitoring

Problems/Challenges

A lot of data about this watershed has been collected by local and State agencies, volunteers, and students. Information on stormwater and dry-weather water quality has been collected, and sediment samples have been analyzed. Over a dozen flow meters continuously measure water depth and flow throughout the system. Biological assessments include fish surveys, stream habitat typing, and benthic invertebrate samples. (See Chapters 4, 5,10, and 11 for details.)

Challenges include:

- Sharing information
- Essential data analysis
- Using data as a basis for decision making
- Ensuring high quality data
- A coordinated approach involving all participants

Current Solutions

The Thornton Creek Project is developing an online library containing information about the Thornton Creek watershed. Seattle has recently expanded its monitoring program to include monitoring of instream CIP projects and fish resources, and assessing habitat near the stream.

12.3 Information Desirable but Not Available

The Committee has identified the following data needs:

- A full hydraulic and hydrological assessment of flows in Thornton Creek (work in progress, report anticipated in Spring 2000).
- Wildlife survey by sub-basin.
- Extent of inflow and infiltration of stormwater into sewer system (King County is currently studying this).
- List of vacant parcels.
- Detailed instream and riparian corridor habitat assessments .
- Detailed assessment of fish barriers (work in progress, report anticipated in January 2001).
- Summary of Washington Trout findings (draft in progress, final report due in January 2001).
- Amphibian monitoring data.

12.4 Mission and Goals

The Watershed Management Committee has developed a mission statement, goals, and objectives to guide development of the Thornton Creek Watershed Action Plan.

Mission

Protect and restore the Thornton Creek ecosystem for the welfare of fish, wildlife, and people; improve the quality of life in the watershed; and prevent further degradation as human population and development increase.

Goals and Objectives

Goal #1: Reduce stormwater-related flooding and damage to stream and wetland habitat, and increase infiltration.

- Improve the process of evaluating, selecting, and designing capital investments in the Thornton Creek watershed.
- Increase detention throughout the watershed on both private and public properties.
- Increase groundwater recharge (infiltration) by reducing the amount of impervious surfaces.
- Improve citizen and commercial management of stormwater and runoff.
- Improve maintenance of the public stormwater conveyance system

Goal #2: Improve water quality by reducing non-point pollution in Thornton Creek and its watershed.

- Eliminate violations of State water quality standards (exceedances of fecal coliform, dissolved oxygen, and temperature standards).
- Reduce pollutant discharge from residences, businesses, roads, and publicly owned properties.
- Remove pollution from stormwater and/or the creek.

Goal #3: Protect and improve instream, riparian, and upland habitat for the survival of remaining native species.

- Protect and improve the riparian corridor.
- Enlist residents and developers in preservation and restoration activities.
- Protect and replace native trees and other plants and remove noxious weeds.
- Increase fish and aquatic species survival.
- Increase survival of native animal species and wildlife.
- Increase open space through public acquisition and conservation easements.

Goal #4: Increase public awareness and develop stewardship of the watershed.

- Increase basic awareness and appreciation of Thornton Creek and its watershed and understanding of how a watershed works.
- Integrate watershed education into school programs at all levels. Maintain and improve existing programs.
- Provide learning opportunities for the general public.
- Strengthen people’s connections with nature.
- Offer stewardship opportunities.
- Provide incentives for residents, businesses, and developers to incorporate “watershed friendly” practices into everyday activities.

Objectives supporting two or more goals.

- Strengthen land use and development regulations.
- Improve enforcement of existing regulations.
- Improve monitoring efforts.
- Improve reporting.
- Establish a Watershed Oversight Council to oversee implementation of Watershed Action Plan recommendations.
- Improve local agency cooperation for implementation.
- Improve agency internal management and training.

12.5 Next Steps

Using the background information and problem analysis in the Characterization Report, the Committee will develop a Watershed Action Plan outlining specific steps needed to control sources of non-point pollution, manage stormwater, improve habitat and biological diversity, and foster stewardship.

The Committee will evaluate actions that use a number of strategies, including:

- Regulation
- Incentives
- Outreach and education
- Enforcement
- Policies
- Stewardship
- Capital improvement projects
- Maintenance programs
- Mapping
- Monitoring and evaluation
- Adaptive management
- Coordination
- Volunteer programs

A draft Thornton Creek Watershed Action Plan will be available for public comment and agency review in 2000 or early 2001. The draft Watershed Action Plan will be reviewed by the public, all affected local agencies, affected Tribes, and State and/or Federal agencies. In addition, the Committee will sponsor a public meeting on the Plan.

The final Action Plan will describe specific actions, budgets, and schedules. Most importantly, it will include letters of concurrence, or commitment, from sponsoring agencies and organizations. When completed, the plan will be submitted for adoption by the Seattle and Shoreline City Councils and approved by the Department of Ecology (Ecology). Largely, the Cities of Seattle and Shoreline are expected to implement the plan; however, other government agencies, volunteers, non-profit organizations, businesses, and individual landowners may complete other actions.

The Action Plan agreement between Ecology and SPU has set aside a minimum of $100,000 to implement three projects addressing instream improvements, water quantity control, and non-point water quality improvements that are scheduled to be completed within one year of the final Action Plan.

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