West Hill Drainage Study

Southwest Lake Washington Basin

King County
Department of Natural Resources

January, 1999

- Basin Boundary
- Sub-basin Boundary
- GR2-1 Subcatchment Number
- Lake and River
- Stream Channel
- Ditch and Surface Flow Direction
- City Boundary and Area
- Surface Gradient

- 10 inch Diameter and Smaller
- 12 inch to 15 inch Diameter
- 18 inch to 21 inch Diameter
- 24 inch Diameter
- 30 inch Diameter
- 36 inch Diameter
- 48 inch Diameter
- 60 inch to 96 inch Diameter

- 40 Flooding Problem and Index Number
- Erosion Problem
- Flooding and Erosion Problem
- 95-0680 KCLDS Flooding Complaint
- KCLDS Erosion Complaint
- KCLDS Flooding and Erosion Complaint
- KCRSD Maintenance Problem Area

Acronyms:
KCLDS King County Local Drainage Services Unit
KCRSD King County Roads Services Division

Map Sources:
Topography generalized from 2-foot contour King County GIS coverage, 9/97; Roads from King County GIS parcel coverage, 6/97; Streams from KC GIS streams coverage, 4/97; Constructed Drainage from King County Roads Division NPDES Survey, 8/96; Problem locations from mail-in survey, spring 1997; Complaint locations from Local Drainage Services records; Road names from Thomas Bros Atlas, 1997.

Credits, West Hill Drainage Study
Tim Kelly, Senior Engineer
Cynthia Newton, Engineer
Study Produced by the Project Management and Design Unit

Topography
Drainage Divides
Constructed Drainage
Natural Drainage
Drainage Problem Sites
Roads
Cities

King County
Department of Natural Resources

❖ WEST HILL DRAINAGE STUDY ❖

Table of Contents

TECHNICAL DOCUMENT AND RESEARCH CENTER
KING COUNTY DEPARTMENT OF
NATURAL RESOURCES AND PARKS

EXECUTIVE SUMMARY

The West Hill Drainage Study was funded by the King County Department of Natural Resources (KCDNR) to identify drainage systems and drainage problems in the West Hill area. The study was recommended because of the large number of drainage complaints received in this area and because of the limited information on drainage basin hydrology, drainage system capacity, and potential downstream impacts.

The funding for the West Hill Drainage Study was further justified by two concurrent requirements: One, the 1987 amendments to the Clean Water Act required a drainage inventory for all of unincorporated King County; this document fulfills these requirements for the West Hill area. Two, the Growth Management Act recommends annexation or incorporation of the West Hill area. The transfer of this area from King County to a local jurisdiction will require the transfer of all drainage information; this document will fulfill this requirement.

The goals of the study are to:

1. Compile existing drainage information for decisions relevant to land use planning and development and for drainage infrastructure Capital Improvement Program (CIP) project recommendations.
2. Compile existing drainage information for decisions relevant to water quality planning as required by the National Pollution Discharge Elimination System permit.
3. Allow for a single reference for drainage information, both for current use by King County, private developers, and for the eventual transfer to the newly annexed or incorporated cities.

The study area consists of the unincorporated areas of King County that are currently surrounded by Seattle to the north, Renton to the south and east, and Tukwila to the south and west. Sections of this area are often referred to as West Hill, Skyway, Bryn Mawr, Earlington, Lakeridge, Campbell Hill, and Panorama View.

The content of the study is divided into three sections. These include an inventory of the West Hill drainage system, hydrologic and hydraulic analysis of the drainage basins, and land use and CIP project recommendations.

Section 1, Existing Water Resource Inventory, is divided into five subsections:

- Subsections 1 and 2 are field inventories of the existing drainage system (including pipe systems, catch basins, natural drainage channels, and ditches) and field inventory of existing habitat (including natural drainage channels, wetlands, and open space).

- Subsection 3 discusses related drainage and CIP project information. This subsection gives a brief history of government agency drainage infrastructure programs and how to access this drainage CIP project information. It also gives a brief description of the development process as it relates to private drainage systems and discusses how to access private drainage plans.
- Subsection 4 discusses the various processes for recording and tracking drainage complaints.
- Subsection 5 discusses relevant mapping and studies. This includes an overview of other available resources relevant to drainage in the West Hill area and how to access this information.

Section 2, Hydrologic and Hydraulic Analysis, models the study area using the King County Runoff Time Series (KCRTS) hydrologic program, then analyzes the existing conveyance system to determine capacity.

Section 3, Proposed Actions, utilizes the information from Sections 1 and 2 to generate a list of capital projects and land use recommendations.

The Appendix to this document can be accessed by connecting to the KCDNR website at www.metrokc.gov. The Appendix includes electronically transferable files, including all public domain Geographic Information System (GIS) maps, all KCRTS files, all hydrologic support files, and a copy of this document.

ACKNOWLEDGMENTS

This document is the result of a cooperative effort among the KCDNR's Wastewater Treatment and Water and Land Resources (WLR) Divisions, the West Hill community, other jurisdictions in the West Hill area, and the King County Department of Transportation's (KCDOT's) Road Services Division. The Citizens Advisory Committee members provided valuable input on historical and current conditions, as well as assisting with local meetings, the draft plan review, and input on community needs and local flooding problems.

We would like to acknowledge the excellent work completed by the KCDOT's Road Maintenance Division GIS mapping group. The Road Maintenance Division has its own Global Positioning System (GPS) community-based station that provides GPS data to public and private users. It has been active in GIS/GPS mapping since 1993 and is recognized as a pioneer in this field.

Road Maintenance Division 3 has both assisted with completing the report and concurrently constructed drainage fixes in the area. Division 3's knowledge of local flooding issues has been invaluable in the preparation of this report.

The WLR Division has loaned out GIS support for this project. The WLR Division's task has been to compile the nearly infinite amount of data from other sources and to prepare accurate, legible documents.

Section 1
Existing Water Resource Inventory

SECTION 1 — EXISTING WATER RESOURCE INVENTORY

The Existing Water Resource Inventory Section of this study is a compilation of all relevant water resource information available for the West Hill area. This section describes the available information and discusses how to access this information. Both the Addendum and this document will be published on the King County Department of Natural Resources (KCDNR) web page at www.metrokc.gov.

1.1 Drainage Systems Inventory

This section documents the list of available maps relevant to the West Hill area.

West Hill Drainage Inventory Map

The single most significant work product prepared as part of this study is the Drainage Inventory Map. The Drainage Inventory Map was surveyed and mapped by the King County Department of Transportation's (KCDOT's) Road Maintenance Division and the KCDNR. The survey work was started on October 23, 1996 and completed May 1, 1997. The information inventoried for this study includes roads drainage infrastructure (including pipe systems, culverts, catch basins, drainage ditches, and natural drainage channels). The KCDOT work was completed for drainage systems within or adjacent to King County right-of-way. The KCDOT work was augmented by a KCDNR Geographic Information System (GIS) survey, which included some of the off right-of-way drainage systems. These included natural drainage channels, private pipe, and ditch systems. Both of these systems were field-reviewed by King County Wastewater Treatment Division personnel.

The drainage inventory mapping was required as part of the National Pollutant Discharge Elimination System (NPDES) permit. In 1987, amendments to the Clean Water Act created the requirement for municipal stormwater permits under the NPDES program, which was designed to reduce pollution in and improve the water quality of waters of the United States. These permits require the preparation of stormwater management programs that describe the measures the permittees are taking to protect water quality as it is affected by stormwater runoff. This includes mapping of drainage systems throughout unincorporated King County.

The drainage information was mapped using the MCV-GPS data logger with Trimble PRO-XL 12-channel software/firmware. The horizontal and vertical error for the equipment used was submeter for the horizontal and 1.5 to 2 meters for the vertical.

The data-logging procedure consisted of collecting Global Positioning System (GPS) readings for both the drainage features and the road centerline. Each of the GPS location points also included attribute information; this is text information such as flow direction, pipe size and type, and catch basin size. The drainage, road centerline, and attribute information is then downloaded on a daily basis to a computer file. The data-logging portion of the drainage study took approximately three months.

The data processing and final map production was completed with ARCAD software, using a proprietary program that produces line work and feature symbols (including road centerlines, pipes, catch basins, and drainage channels). The mapping procedure was completed on July 23, 1997, taking three months to complete.

The West Hill Drainage Study Inventory Map is a fold-out map located in a page sleeve found in Section 1, Referenced Figures. The GIS work described above is augmented with other geographic information, including political borders, contour lines, and a roads overlay.

Ortho/Contour Information

Walker and Associates completed two mapping projects in the West Hill area. One project was a 1993 project with the Seattle Water Department. This included aerial photography to complete a 100-scale, 2-foot contour interval digital map and imagery of the entire West Hill study area.

Walker and Associates also completed a 1995 project with the City of Renton that covers portions of the West Hill area toward Renton. The work includes 1,200-scale aerial mapping with 1-meter accuracy contour intervals. The project also included digital, black and white, orthophotographic files at 1,200 scale.

King County Land Use and Zoning Maps

The King County Land Use Map is based on the King County Comprehensive Plan (KCCP) and the community plans for unincorporated areas of the County. The land use map designates general uses of the land through such categories as residential, commercial, industrial, and resources. The King County Zoning Map implements the land use designations. The GIS zoning layer was created as a product of the Development Regulations Team in 1993 and 1994. Nancy Laswell, Legislative Analyst with the King County Council, and Greg Kipp, Department of Development and Environmental Services (DDES) Deputy Director, headed this multi-agency team. The team included GIS Section Supervisor George Horning as the project manager of the GIS land use database for unincorporated parcels, which included West Hill. The Land Use Map was completed in 1994. The West Hill area zoning portion of this map is shown in Section 1, Referenced Figures.

The zoning information is augmented with an overlay, including King County Roads right-of-way and parcel boundary information. These were digitized from King County Assessor's maps. The zoning information was digitized from current DDES zoning maps.

The hydrology section of this report modeled flows for both existing conditions and future build-out conditions. The future build-out conditions assumed that the West Hill area will be built out to the full extent zoning will allow, and that both impervious surface and peak storm flows will increase proportionately. Any modifications to the 1994 zoning designations used in the report will require adoption of a new King County Council ordinance through

the annual KCCP amendment process. Changes to the zoning designations are maintained by DDES's GIS Section.

Aerial Photography

Walker and Associates completed more than 20 aerial mapping projects in the West Hill area. These range in date from 1936 to 1997 and in scale from 1"=800' to 1"=4,500'. This information can be purchased from Walker and Associates by contacting Craig Berry at (206) 244-2300.

The Washington State Department of Transportation's (WSDOT's) Aerial Photogrammetry Section has completed a number of mapping projects along the Martin Luther King Jr. Way (State Route 900) corridor. The prints and maps are available at the WSDOT District 1 Office, Plans and Right-of-Way Research Center. The information can be accessed by calling Jim Johnson, Transportation Technician of the Research Center, at (206) 440-4000.

Natural Drainage System Information

Extensive development in the West Hill area has significantly affected natural drainage systems (including streams, springs, and wetlands). Information on the history of natural drainage systems could be accessed from early land development surveys (including plats, subdivisions, and commercial developments), from early aerial photographs, and from King County DNR stream and wetland inventories. Field notes from these inventories have been included in the Appendix. Existing open channels were included in the GIS drainage inventory subsection of this report. Due to the difficulty in accessing many of these drainage systems on private property, the GIS mapping process normally included only survey shots at locations with access, such as streams adjacent to roads.

Soils Information

At this time, the West Hill area has not been mapped for soils information.

Geology

The 1997 King County geology data was compiled by Derek Booth and Jill Sacket from existing United States Geological Survey (USGS) geology maps and King County basin plan mapping. West Hill/Skyway geology is based on the USGS 7.5-foot Des Moines (Booth *et al.* in review, 24,000 scale) and Renton (Mullineaux *et al.*, 1965, 24,000 scale) quadrangles and a USGS Seattle quad (Waldron *et al.*, 1962, approximately 31,000 scale). The West Hill Surficial Geology Map can be found in Section 1, Referenced Figures.

Sanitary Sewer Infrastructure

Development in a basin is closely associated with the available sanitary sewer infrastructure. Prior to developing properties to urban densities (as shown on the King County Land Use and Zoning Maps), the drainage basin will require sewer service. The West Hill area is serviced by three sewer districts: the City of Seattle Drainage and Wastewater Utility, the

Bryn Mawr-Lakeridge Water and Sewer District, and the Skyway Sewer and Water District. Not all areas in a sewer district have sewer infrastructures in place. These areas are mapped on the Sewer Service Area Map found in Section 1, Referenced Figures.

Other maps available (but not in this study) include: USGS Quadrangle Maps; Thomas Brothers Street Guide and Directory Map; King County Assessor's Office Parcel Identification Maps; King County DDES GIS Section City Directory Maps and Database; Washington State DNR Water Features (Hydrography) Maps; and USGS Public Land Survey Data. Mapping information is also available by accessing the referenced studies shown in Subsection 1.5 (Other Information) of this study.

1.2 Sensitive Areas Inventory

In general, the West Hill area is highly urbanized with little remaining forested land. Degraded water quality in the creeks, little or no habitat diversity, and little or no large woody debris correlate with residential and commercial land use. Much of the historic habitat has been lost or damaged by urbanization. Habitat loss results from barriers to fish migration (for example, blocked or undersized culverts), poor water quality from stormwater runoff transporting pollutants into streams, and streambank erosion and landsliding in steep-walled ravines. Sedimentation in the tributary streams is induced by increased peak flows and erosion of steep ravines. Sediments carried downstream settle out in Lake Washington or the Duwamish River, with adverse impacts on water quality and fish habitat in these water bodies.

Following is a description of the streams and wetlands in the West Hill area. These ecologically sensitive areas are mapped and labeled in Section 1, Referenced Figures.

Streams

Lake Washington Basin

The major tributary in the Lake Washington Basin portion of the West Hill area is Taylor Creek (Tributary 0464D), a small stream that flows 1.35 miles through unincorporated King County and the City of Seattle's Lakeridge Park in Dead Horse Canyon before discharging into southwest Lake Washington. Taylor Creek is a King County-designated Class 1 stream from Lake Washington to the culverts at Rainier Avenue, and is "unclassified" upstream of Rainier Avenue (King County Sensitive Areas Map Folio, 1995). The remainder of the 615-acre Taylor Creek watershed is largely characterized by high-density urban residential and commercial development. As a result, flows in the creek are generally "flashy," causing erosion of unprotected streambanks and excessive sediment deposition downstream. Sedimentation causes localized flooding and has the potential to smother salmon spawning grounds.

The lower reach of Taylor Creek has been channelized and redirected through a series of culverts. Streambanks have been cleared of native vegetation. It is common to see lawns extending to the streambanks and rock retaining walls on the banks. Several vertical drops more than 1-foot high have developed in the stream, creating barriers to fish passage. For example, there is a 4- to 5-foot drop below a steep culvert where Taylor Creek crosses under Holyoke Way at the lower boundary of Lakeridge Park.

The King Conservation District conducted a stream survey of Taylor Creek from Holyoke Way upstream. The slopes adjacent to the stream are steep, some as much as 90 percent. Recent streambank and ravine slumps and slides are causing a high sediment load in the channel substrate; over 35 percent of the channel substrate is now comprised of fine silt. Pools are very scarce in the creek (the pool/riffle ratio is 1 to 9) and of moderate quality. Deposition of sediment in the creek has reduced the pool volume and the associated fish rearing and refuge habitat. Spawning gravel is marginal in quality, that is, heterogeneous in size and usually without adjacent cover. The shallow depth of the water further restricts available spawning areas. The riparian zone is mainly deciduous, with a few scattered understory conifers such as western red cedar and hemlock. There is not much large woody debris in the stream due to the small diameter of the adjacent trees. This limits the quality of salmonid habitat as well.

Aside from Taylor Creek, other streams in the Lake Washington Basin Portion of the West Hill area are:

- Tributary 0464E, which is the headwaters of Taylor Creek.
- Tributaries 0464B and 0464C, which join together and flow into Lake Washington.
- Tributary 0464F, which is a separate tributary to Lake Washington and is partially free-flowing and partially piped.
- Tributary 0464A and 0464G, which are located in the south end of the basin and are not free-flowing (channelized or piped underground).

Duwamish River Basin

There are two unnamed tributaries with unknown salmonid use: Tributary 0003I near Langston Road and 59th Avenue South, and Tributary 0003J near Langston Road and South 121st Street. Little diversity of in-stream habitat, rare occurrence of large woody debris, and residential land use characterize these tributaries.

Wetlands

There are two wetlands located in the Lake Washington Basin portion of the West Hill area. The major wetland is in Subcatchment 4 on Tributary 0464E at river mile 0.25. This wetland provides flow attenuation and water quality enhancement functions for Tributaries 0464E and

0464D. Another wetland is located south of South 115th Street at Tributary 0464D. The wetlands and tributaries are mapped and labeled in Section 1, Referenced Figures.

There are two wetlands located in the Green/Duwamish Basin portion of the West Hill area (United States Fish and Wildlife Service National Wetlands Inventory, 1987). The larger wetland is a palustrine (freshwater, with water depth that is less than 20 meters), seasonally flooded wetland with emergent vegetation. This means that the plants in the wetland grow rooted in shallow water and stand vertically with their bark emerging from the water. The smaller wetland is a palustrine, open-water, permanently flooded wetland.

1.3 Drainage Capital Improvement Program (CIP) Project Inventory

King County Department of Transportation — Drainage CIP Projects

The KCDOT is responsible for most of the drainage infrastructure in the West Hill area. This includes all drainage structures in maintained King County right-of-way. The drainage projects completed by the KCDOT are split into two distinct work units, drainage CIP projects and maintenance projects. The following outlines the KCDOT structure as it relates to drainage projects:

1. CIP projects exceed $25,000 for construction and are a new drainage system, or a substantial improvement of an existing system. These projects fall into two categories:
   a) Small Works projects are drainage projects with construction costs greater than $25,000 and less than $100,000.
   b) Large CIP projects are projects with construction costs greater than $100,000; they can also include smaller drainage projects associated with new road construction.
2. Maintenance projects include routine maintenance and small drainage improvement projects, defined below:
   a) Maintenance projects are projects that typically will not alter the existing drainage system. These projects have no upper dollar limit that dictates program responsibility or contracting procedures.
   b) Drainage Improvement projects upgrade right-of-way drainage at costs less than $25,000.

KCDOT Maintenance is divided into a Special Operations group and a Division group. The Division group is responsible for routine maintenance within the four maintenance districts. The Special Operations group typically completes small projects as capital improvements, as stated.

The CIP projects completed by the KCDOT prior to July 1997 are included in the drainage inventory portion of this study. To locate backup files from the KCDOT or to access

information for projects constructed after July 1997, contact the KCDOT at the King County Administration Building, 500 Fourth Avenue, Seattle, Washington 98104, or call (206) 296-8100. Information from the King County Road Maintenance Division is cataloged by project location and the year constructed. This information can be queried from Thomas Brothers Maps with the project number flagged on the map. The projects are flagged on the Thomas Brothers Map yearly and begin with the 1978 Thomas Brothers series. The project number can then be used to reference the project file.

King County Department of Natural Resources — Drainage CIP Projects

The KCDNR is responsible for a wide variety of drainage CIP projects, including regional stormwater detention, stormwater conveyance, hillside stabilization, and habitat restoration. Because of the KCDNR's diversity, the project selection process is often determined by the program of origin, such as the Basin Planning Program (now the Watershed Program), the Local Drainage Services Unit (now the Drainage Services Section) Large Capital Improvement Program, the Small Habitat Restoration Program, the Drainage and Habitat Improvement Program, or the Neighborhood Drainage Assistance Program (NDAP). Many of these programs target resource and habitat projects, which exclude most of the urbanized drainage systems found in the West Hill area.

The KCDNR NDAP and the Drainage Services Section Large CIP projects address urban flooding issues. The NDAP is funded to assist in private drainage problems that are caused by upstream development and the associated increase in flows. The projects are prioritized throughout unincorporated King County by evaluating a flood damage impact score and are weighed against the project cost. The program is limited to projects that have construction costs less than $25,000. In 1998, King County approved $280,000 to construct additional drainage projects similar to these NDAP projects. The funding is targeted for the West Hill area; the projects are scheduled for construction in 1998 and 1999.

Drainage Services projects are identified by special studies conducted by the Drainage Services Section. The recommended CIPs are prioritized and funded as individual projects. Design and construction management is completed by the King County Wastewater Treatment Division's Surface Water Engineering and Environmental Services group.

Drainage infrastructure completed prior to July 1997 is included in Subsection 1.1 (Drainage Systems Inventory) of this study. The drainage work completed by the KCDNR is shown on the West Hill Drainage Inventory Map, discussed in Subsection 1.1. Additional information on recent drainage projects constructed by the KCDNR can be located by calling the King County Water and Land Resources Division at (206) 296-6519. The Department tracks the CIP projects on a GIS database. The information from the database includes the project description, cost, and project number. More detailed information can be obtained by contacting the King County Wastewater Treatment Division's Surface Water Engineering and Environmental Services group at (206) 296-6519. The project number can be used to obtain

project construction plans and specifications, which are archived within the same division of King County.

Washington State Department of Transportation — Roads Drainage Information

The WSDOT is responsible for drainage along State Route 900, also known as Martin Luther King Jr. Way. Drainage information along State Route 900 and other state highways can be accessed by contacting Jim Johnson, Transportation Technician with the WSDOT's Northwest Regional Office, Right-of-Way Research Center, at (206) 440-4000. This office is responsible for archiving right-of-way maps, contract plans, and as-built drawings (on microfiche).

WSDOT drainage information for the Martin Luther King Jr. corridor in West Hill was researched as part of this study. The information from these as-built drawings was added to the Drainage Study Inventory Map discussed in Subsection 1.1.

Private Drainage System Information

Drainage information associated with land development (including plats, subdivisions, and commercial development) can be located by contacting the KCDOT Map Counter at (206) 296-6548. The Map Counter archives private drainage information and construction plans for plats, short plats, and all road construction projects. Commercial development construction plans permitted after 1976 can be found in the King County Water and Land Resources Division's Drainage Services Section. Commercial development includes high-density, multi-family development, and will typically include some type of retention/ detention facility. The Drainage Services Section's phone number is (206) 296-1900. Project files are inventoried by development name and address. The DDES Records Center should also have copies of all development plans for projects that require a permit. The Records Center's phone number is (206) 296-6696, or you could call Ruby Herron, Supervisor, at (206) 296-6719.

Private drainage infrastructure completed prior to July 1997 and constructed in King County right-of-way is included in the West Hill Drainage Inventory Map, discussed in Subsection 1.1. Most of the private drainage infrastructure completed before this date has been included in the West Hill Drainage Inventory Map, as discussed in Subsection 1.1.

Other CIP Projects

Emergency projects are typically flooding or landslide events that are funded in part by the Federal Emergency Management Agency, Federal Highway Administration, or other state or federal emergency funds. There are also drainage projects completed by other King County divisions, or by other agencies or private groups that could not be accessed from either the KCDNR or KCDOT. These include stream restoration projects completed by private citizens or the Washington Department of Fish and Wildlife, drainage along the Burlington Northern Railroad right-of-way, or drainage work completed by King County Parks. Also,

pathway projects generated by Traffic or Traffic and Planning typically involve drainage work either by maintenance or private contractors.

1.4 Drainage Complaint Inventory

Over the past ten years, King County has received more than 200 drainage complaints from citizens in the West Hill area. Poorly draining soils, unstable hill slopes, filled ditches, older roads, and development without planned drainage systems all contribute to this history of drainage problems.

In preparing this document, there were three resources available to us to gather information regarding drainage and erosion problems. Those resources include the King County Road Services Division, the King County Drainage Services Section, and King County Surface Water Engineering and Environmental Services group. Each of these resources identified drainage and erosion problems in the area.

King County Road Services Division

The King County Road Services Division often receives calls from the community concerning flooding across streets, sidewalks, or driveways. The Road Services Division generally knows what the drainage problems are and where they are located, especially those problems that have become a maintenance routine year after year. The study team arranged field meetings with Road Services Division personnel to learn about the problems they were often encountering. Locations of the maintenance problem areas are shown on the West Hill Drainage Study Inventory Map found in Section 1, Referenced Figures.

Drainage Complaints on File with the County

Another resource of information was from the Drainage Services Section. The section has a computerized listing of drainage complaints that have been filed with the KCDNR. Each complaint was investigated by Drainage Services personnel, and a few of these complaints are included in this report. The location of these complaints is shown on the West Hill Drainage Study Inventory Map. A copy of this map can be found in Section 1, Referenced Figures.

West Hill Drainage Questionnaire

A third resource identifying problematic drainage areas was compiled by the King County Surface Water Engineering and Environmental Services group as part of this study. The study team formulated a questionnaire and sent it (via bulk mail) to all the residents in the West Hill area. Approximately 4,000 questionnaires were sent out; 415 residents responded to them, 105 did not have any complaints or concerns, and 310 did have a drainage or erosion issue. The questionnaire was designed with the intent that community input would be useful for us to determine which drainage problems affected the most people and if a specific area had more complaints than others. If one area was saturated with complaints, this would be a good indicator that there may be a need for further investigation (perhaps a drainage system needs to be installed or the existing one is undersized, etc.).

Another reason for sending the questionnaire was to bring to our attention other major (non-private) problems that either the Road Services Division or the Drainage Services Section was not aware of. The locations of the problem areas, based on the questionnaires, are shown on the West Hill Drainage Study Inventory Map. Additionally, a sample copy of the questionnaire and a summary table of all the questionnaire responses can be found in the Appendix.

1.5 Other Information

The following reports include relevant land use and/or drainage information:

Reconnaissance Report No. 28 — Lake Washington Basin, Dated 1987

King County Natural Resources and Parks Division and Surface Water Management Division, Reconnaissance Report No. 28 — Lake Washington Basin, dated 1987. In 1985, the King County Council approved funding of the Planning Division to conduct a reconnaissance of 29 major drainage basins in King County. These investigations used available data and new field observations to examine geology, hydrology, and habitat conditions in order to determine existing and potential surface water problems.

The reconnaissance report provides an evaluation of drainage conditions as an aid to policy makers in developing more detailed regulatory measures and specific capital improvement plans. The report is viewed as a descriptive environmental narrative of the basin. The reconnaissance report can be located through the King County Water and Land Resources Division.

West Hill Community Plan and Area Zoning Document

The West Hill Community Plan and Area Zoning document, dated January 6, 1994, was completed by King County DDES. Developed by the Planning Division, the plan was adopted effective January 6, 1994. The final edited version was completed by King County DDES in 1995. This community plan is a six- to ten-year long-range policy and zoning document. This document responds to a broad range of communitywide issues, including community services, quality of infill development, provision of affordable housing, and beautification of the Skyway Business District. In addition, the land use map, policies, guidelines, and recommended projects contained in this document implement the KCCP and the 1990 Washington State Growth Management Act.

The KCCP is a long-range plan containing the 20-year version for King County. The plan contains 13 planning goals, as outlined in the 1990 Growth Management Act, giving direction to the urban, rural, and resource areas of unincorporated King County. Community plans are area-specific policies for land use, the environment, services and facilities, and capital improvements. Community plans must be consistent with the KCCP. Functional plans are issue-specific plans that may cover the entire County. The KCCP, community plans, and

functional plans are implemented through zoning, decisions on individual land-development proposals, annexations, and public spending decisions for facilities and services.

King County Wastewater Treatment Division — Skyway Inflow and Infiltration Study

The King County Wastewater Treatment Division is working concurrently on the Skyway Inflow and Infiltration (I&I) Study. The Renton Treatment Plant has high levels of stormwater entering the system through inflow and infiltration. One of the areas the inflow and infiltration is coming from is the Bryn Mawr Sewer District. The additional flows will require upgrades to both the Bryn Mawr trunk line and the Bryn Mawr siphon. The I&I study was developed to determine how much flow was due to inflow and infiltration, and to determine which alternatives would be the most cost-effective. The alternatives are to either upgrade the system or to reduce the amount of inflow and infiltration. The results of the study are not yet definitive; however, they indicate that much of the inflow and infiltration is coming from side sewers that join the houses to the main line. Though in the preliminary stages, a decision has been made to undertake a small sewer rehabilitation project within the Bryn Mawr area and to create better connections. The rehabilitation project entails slip-lining the side sewers to determine how well this will reduce the inflow and infiltration. Should this method prove cost-effective in reducing the inflow and infiltration, then similar projects will be initiated.

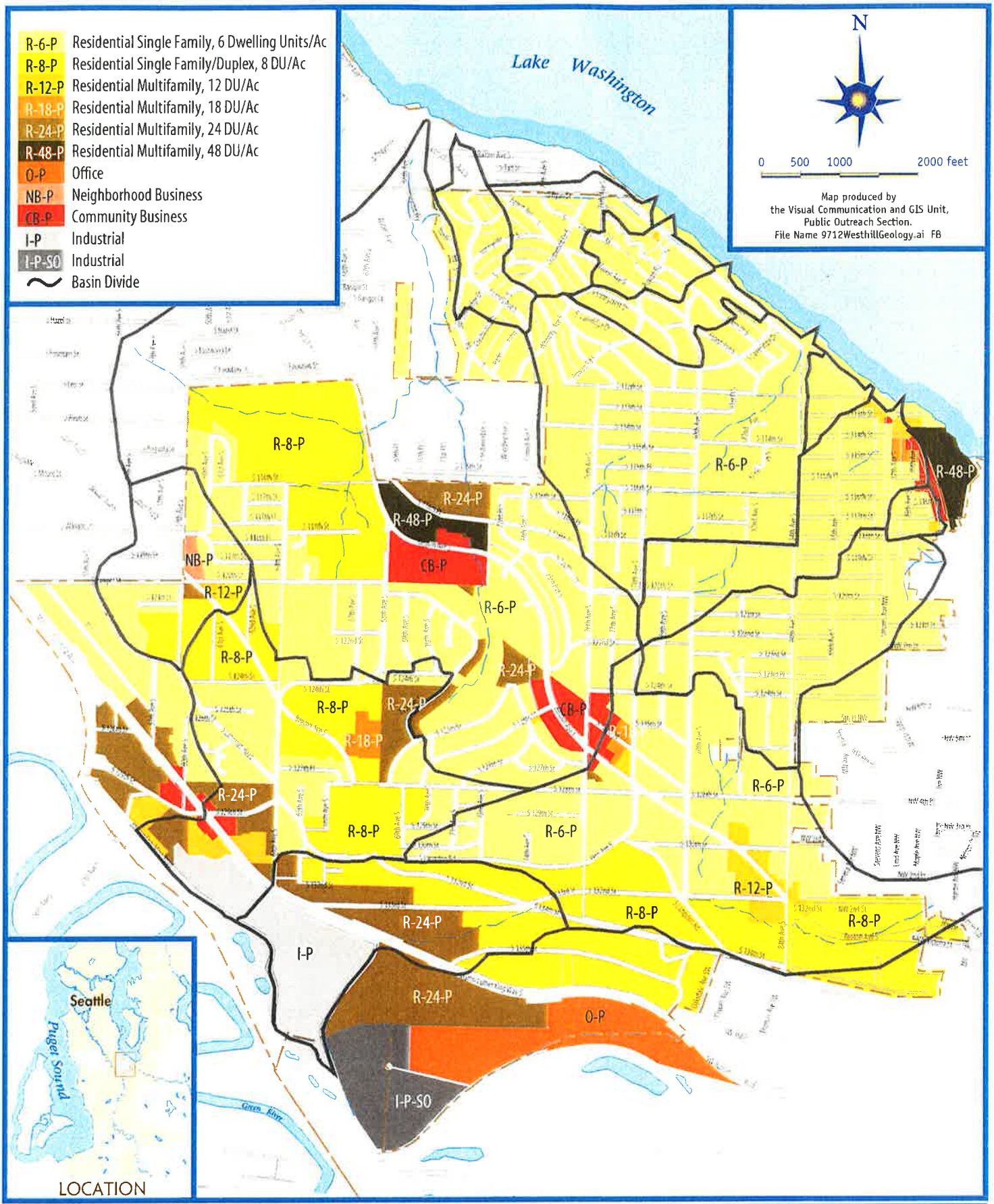
This document will be forwarded to the King County Wastewater Treatment Division's I&I study group. The I&I study group will use this document to locate problem drainage areas; these areas include undersized stormwater pipe systems and properties with drainage complaints. In the event that the I&I study locates a significant inflow point source, the I&I study group will be able to analyze the impact of diverting the inflow to a nearby stormwater drainage system.

West Hill Community Profile

In 1997, the King County Office of Budget and Strategic Planning (renamed the Office of Regional Policy and Planning) completed the West Hill Community Profile. The Community Profile updates the 1994 West Hill Community Plan, providing demographic, facilities and services, and tax and fee revenue information. The Profile is intended to provide baseline information for the governance options study that will be conducted in 1999. The governance project will analyze the options of annexation and incorporation.

REFERENCED FIGURES

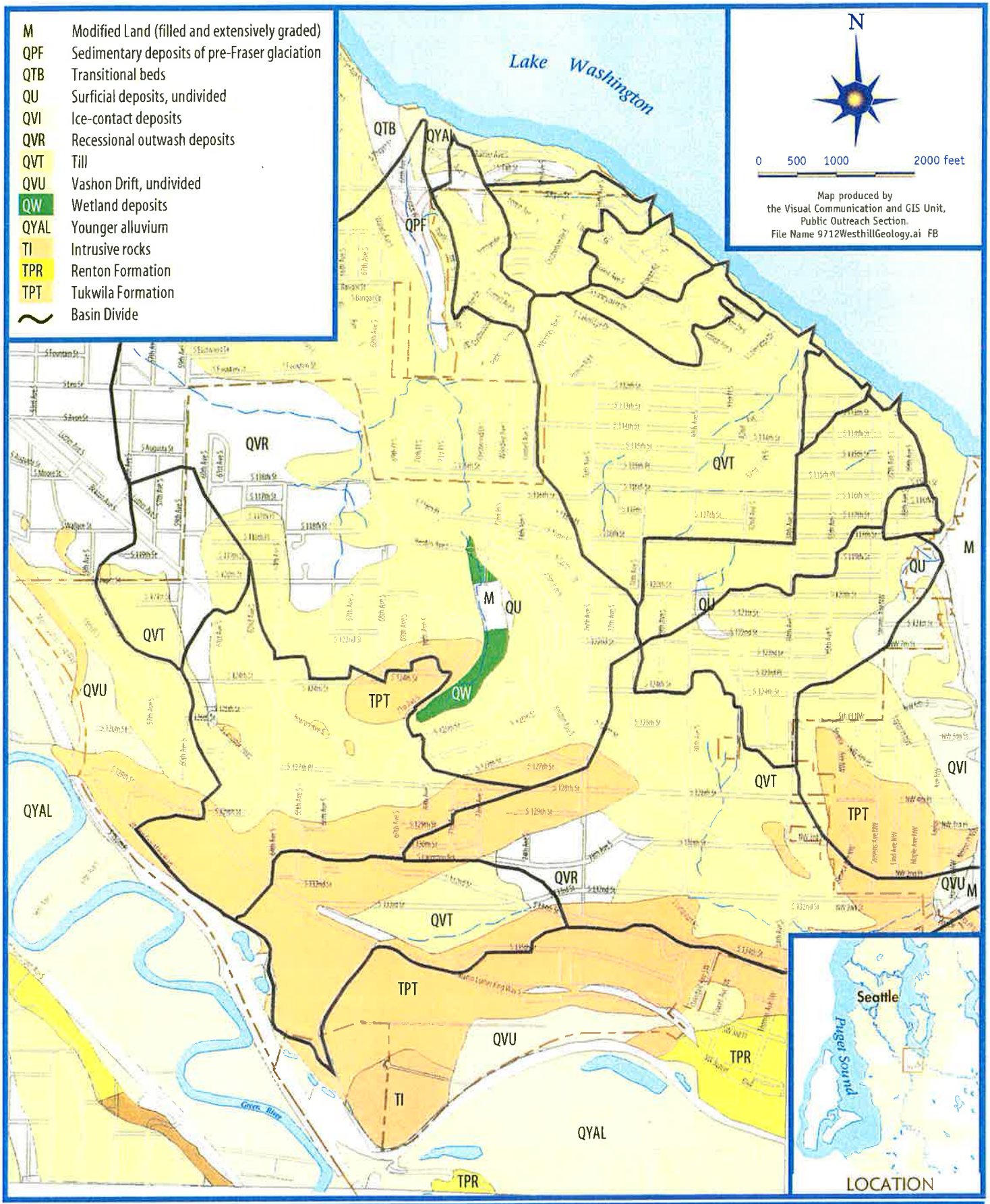
1. West Hill Drainage Study Inventory Map (located in front cover sleeve)
2. West Hill Area Zoning Map
3. West Hill Surficial Geology Map
4. West Hill Sewer Service Area Map
5. West Hill Water Features Map



WEST HILL

AREA ZONING

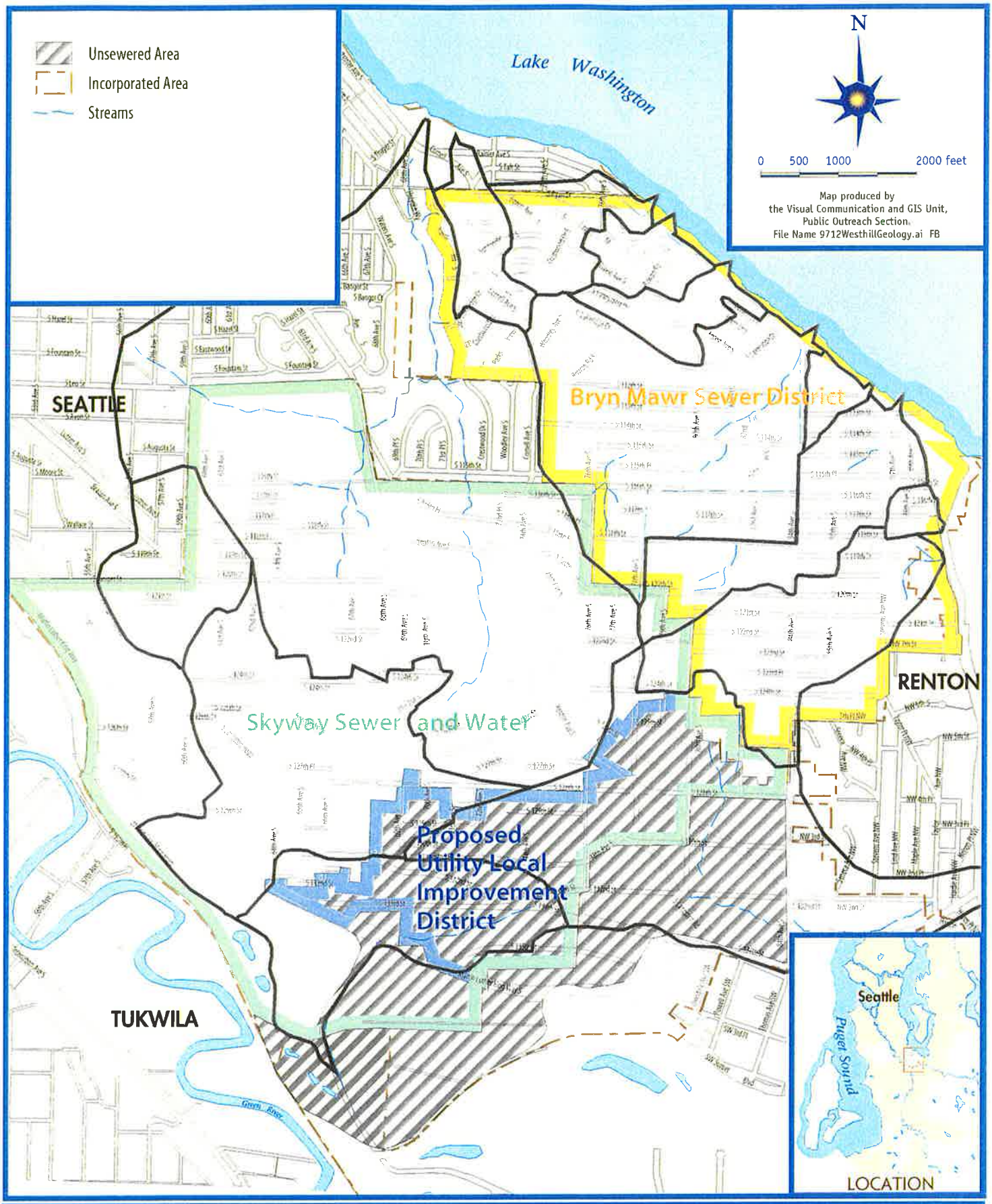
WEST HILL DRAINAGE STUDY



WEST HILL

SURFICIAL GEOLOGY

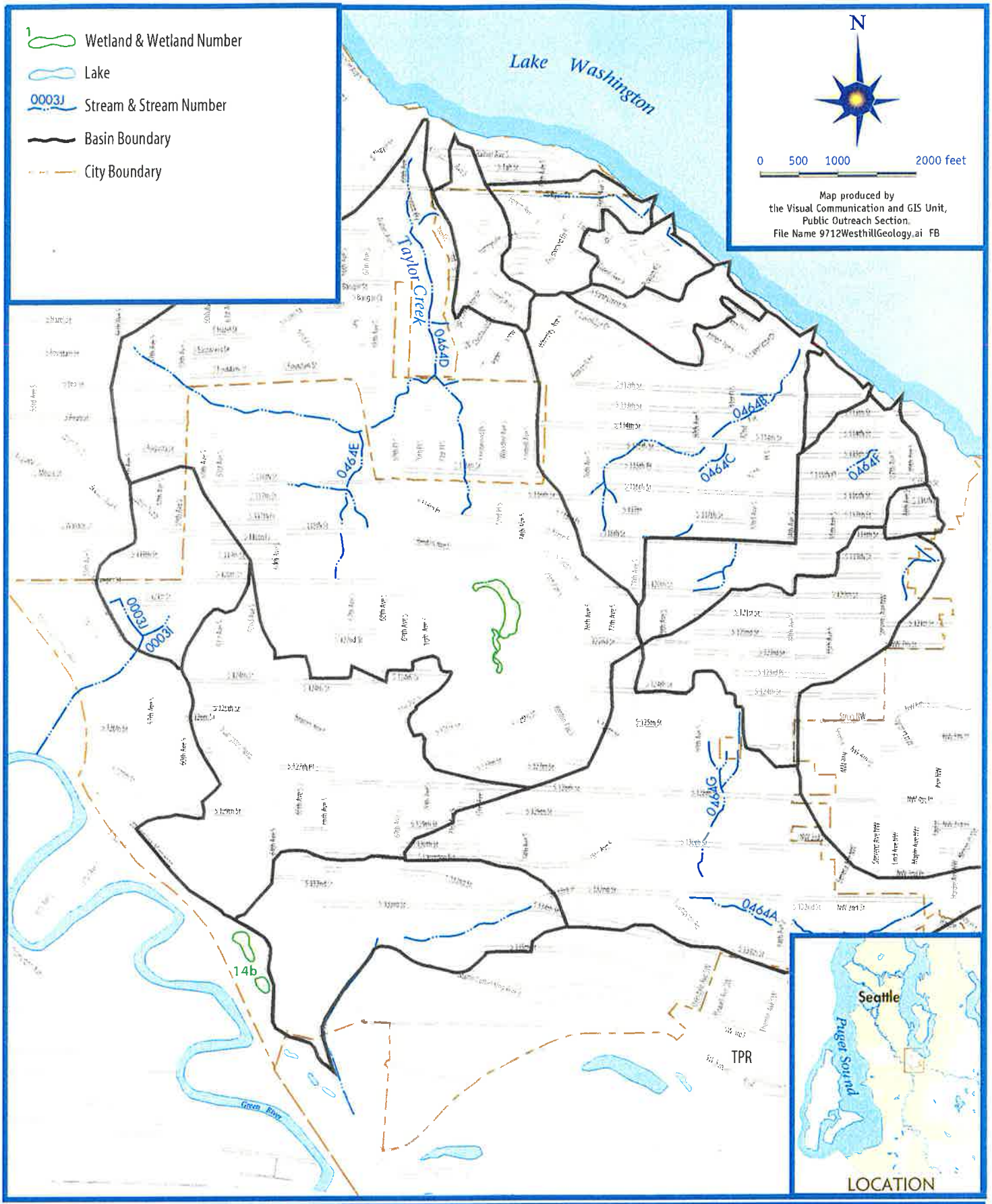
WEST HILL DRAINAGE STUDY



WEST HILL

SEWER SERVICE AREA

WEST HILL DRAINAGE STUDY

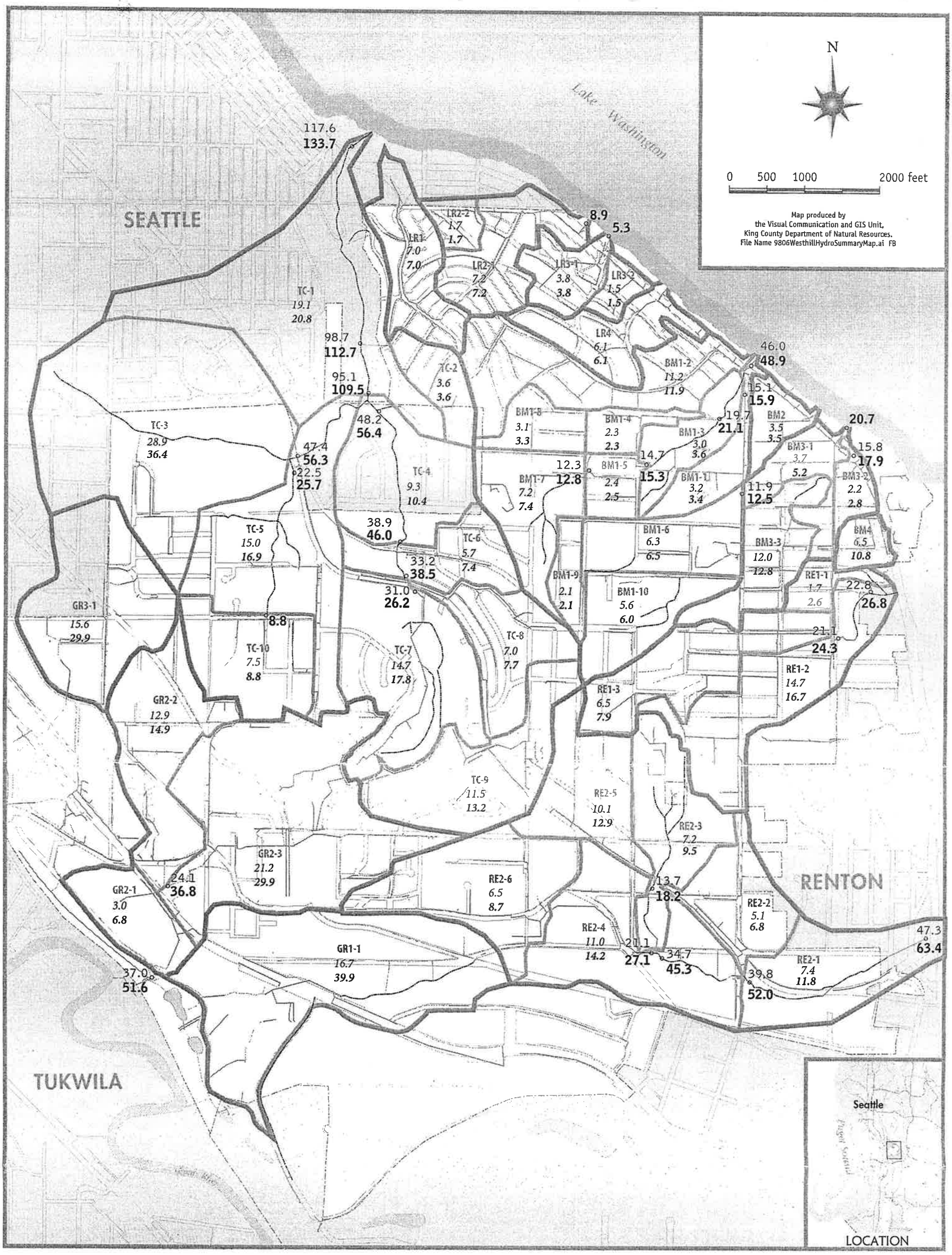


WEST HILL

WATER FEATURES

WEST HILL DRAINAGE STUDY

Section 2
Hydrologic and Hydraulic Analysis



LEGEND

- Basin Boundary
- Sub-basin Boundary
- City Boundary and Area
- Stream
- Pipe
- Lake and River
- GR2-1 Sub-basin Number
- 6.8 / 6.8 Existing Flow by Subcatchment / Future Flow by Subcatchment
- 6.8 / 6.8 Existing Accumulated Flow to Point / Future Accumulated Flow to Point

Acronyms:
KCLDS King County Local Drainage Services Unit
KCRSD King County Roads Services Division

Map Sources:
Roads from King County GIS parcel coverage, 6/97; Streams from KC GIS streams coverage, 4/97; Constructed Drainage from King County Roads Division NPDES Survey, 8/96; Capital Improvement Projects from the Project Management and Design Unit, Wastewater Treatment Division; Road names from Thomas Bros Atlas, 1997.

Credits, West Hill Drainage Study
Tim Kelly, Senior Engineer
Cynthia Newton, Engineer
Study Produced by the Project Management and Design Unit

WEST HILL
HYDROLOGIC SUMMARY MAP - 25 YEAR FLOW
WEST HILL DRAINAGE STUDY

King County
Department of Natural Resources

SECTION 2 — HYDROLOGIC AND HYDRAULIC ANALYSIS

2.1 Hydrologic Study

2.1.A Overview:

The hydrologic study for the West Hill area was completed using the King County Runoff Time Series (KCRTS) hydrologic software package. The analysis was completed using both existing (1997) land use conditions and future build-out conditions. The existing 1997 land use conditions were based on 1996 aerial photographs and field observations completed during the 1997 drainage inventory.

Future build-out condition land use data is based on the saturated development as dictated by the basin zoning maps. The zoning information is based on the 1994 West Hill Land Use Maps; access to this information is discussed in Subsection 1.1, King County Land Use Maps. Additional information can be found in the West Hill Community Plan and Area Zoning document, and is discussed in Subsection 1.5, Other Information. Future build-out conditions do not assume onsite detention and do assume subcatchment connectivity will be the same as current conditions. The term "connectivity" refers to how drainage systems connect. This includes how subcatchments are added together and how long the flow time is in each subcatchment.

Most of the current land use for the Bryn Mawr and Lake Ridge basins closely approximates future build-out conditions. These basins are modeled for existing conditions only, with the assumption that future conditions will not change significantly.

The KCRTS program was developed as a hydrologic modeling tool for western King County. The program utilizes a set of files containing unit-area continuous runoff records. The runoff files have been presimulated for a range of land-cover conditions and soil types for different regions of King County, using the United States Environmental Protection Agency's HSPF10 model. The KCRTS program allows the user to simulate the project hydrology through the scaling, summing, lagging, and level-pool routing of the runoff files.

2.1.B Hydrologic Modeling Process:

The hydrologic modeling process was divided into four tasks: (1) define basin and subcatchment boundaries; (2) define basin hydrologic parameters; (3) define subcatchment hydraulic connectivity; (4) run the KCRTS model.

1. The first task, to delineate basins and subcatchments, was completed using field reconnaissance notes, topographic maps, and the West Hill Drainage Inventory Map. The West Hill study area is composed of 14 distinct basins. The basin designations used in this report are:

RE1 and RE2 — Two separate basins that drain toward Renton.
GR1, GR2, and GR3 — Three separate basins that drain toward the Green River.
BM1, BM2, BM3, and BM4 — Four separate basins that drain from the Bryn Mawr area.
TC — Taylor Creek (Dead Horse Canyon) Drainage Basin.
LR1, LR2, LR3, and LR4 — Four separate basins that drain from the Lakeridge area.

The basins were then divided into subcatchments. An example of dividing the basins into subcatchments is shown by representation of the third Bryn Mawr Basin (BM3). This basin was subdivided into three subcatchments: BM3-1, BM3-2, and BM3-3. The subcatchments are numbered starting from the lowest elevation in the basin and increase as you move up the basin. Using the BM3 example, the BM3-1 subcatchment would be the subcatchment adjacent to Lake Washington.

The basin and subcatchment boundaries are shown on the West Hill Drainage Study Inventory Map located in Section 1, Referenced Figures. The basin and subcatchment boundaries can also be found on the West Hill Hydrologic Inventory Map shown in the Hydrologic Summary figure in Section 2, Referenced Figures.

2. The second task was to define the subcatchment hydrologic parameters for KCRTS input. The hydrologic parameters for the basins were derived for both the future build-out and existing land use conditions. These included land use information such as impervious surface (roads, parking areas, roof tops), forested areas, parks, lawns, wetlands, and open space. Soil types also influence the hydrologic parameters of the pervious areas; these are modeled as either outwash soils or till soils. The hydrologic parameters change with development, so two scenarios were modeled. They include:

   - Define hydrologic parameters for future build-out conditions: Future build-out conditions were completed by overlaying the proposed zoning map for the area over existing topography and drainage connectivity, then assuming the infrastructure of the basin allows for saturated development to match the zoning designation. The hydrologic parameters were based on tables developed by King County and published in the *King County Surface Water Design Manual.*
   - Define hydrologic parameters for existing conditions: Existing conditions for the basin were used by overlaying the 1996 aerial photographs over the existing topography and drainage connectivity. Field information, collected in July 1997 as part of the drainage inventory work, was used to augment the 1996 aerial photographs.

     The subcatchment hydrologic land use parameters table summarizes the required input used for the KCRTS program. This table is called the "West Hill Basins Hydrologic Land Use Data" table, which can be found in Section 2, Referenced Figures.

3. The third task was to define subcatchment connectivity for input into the KCRTS model. The subcatchment connectivity defines how each of the subcatchments transfers stormwater from subcatchment to subcatchment. The subcatchment connectivity is influenced almost exclusively by the topography of the basin. The drainage infrastructure is typically constructed using the natural topography, allowing positive stormwater drainage through the subcatchments.

   The "Hydrologic C Connectivity" table summarizes the required input used for the KCRTS program. This table can be found in Section 2, Referenced Figures.

   The Hydrologic C Connectivity table also summarizes stormwater travel time. This value is the summation of the time it takes rainfall to collect as sheet flow (stormwater prior to forming a channel), then the time it takes to flow in either an open channel or a pipe system (or both). The travel time is influenced by the length of the channel or pipe, the slope of the channel or pipe, and the roughness of the channel or pipe.

4. The last task was to run KCRTS using the data discussed above, then output the hydrologic information.

2.1.C Analysis Summary:

All of the basins in the West Hill area have been analyzed according to the process described in Subsection 2.1.B. The KCRTS model generates runoff for the 1.1-, 1.3-, 2-, 3-, 5-, 10-, 25-, 50-, and 100-year storm events for both the existing 1997 land use conditions and future build-out conditions. A table showing a summary of the peak flow output generated by KCRTS is found in Section 2, Referenced Figures.

A summary map of the KCRTS model generated flows is also shown on the West Hill Hydrologic Summary Map located in Section 2, Referenced Figures. This fold-out map shows only the 25-year peak storm flows and graphically labels these flow rates at subcatchment confluence points.

2.2 Hydraulic Study

2.2.A Overview:

The theoretical analysis of culvert capacity can be extremely complex because of the wide range of possible flow controls, including outlet submergence, pipe geometry, and inlet geometry. A detailed analysis usually involves three separate studies: detailed backwater calculations to determine culvert capacity using outlet submergence; a barrel control study (Manning's equation) to determine pipe geometry control; and a calculation of culvert capacity using inlet control equations. The culvert capacity is typically controlled by the more restrictive of the three analyses.

The hydraulic study for the West Hill area was completed using the Federal Highway Administration (FHWA) publication, *Hydraulic Design of Highway Culverts*, HDS No. 5 (Report No. FHWA-IP-85-15), September 1985. This publication defines the equations used to calculate capacity for culverts that are controlled by the culvert inlet geometry. Both the barrel control study and the backwater study were not used, for the following reasons:

1. The West Hill Geographic Information System (GIS) mapping does not show vertical control necessary for barrel and backwater control calculations.
2. The steep slopes within the West Hill area do not lend themselves to flatter pipe systems, which are more often either backwater or barrel controlled.
3. This hydraulic study calculated the capacity of the culvert, assuming an allowable buildup of stormwater on the upstream end (headwall) of the culvert. Using the culvert inlet control assumption, for almost all cases this can closely approximate the culvert's capacity.

The hydraulic variables required to calculate pipe capacity using culvert inlet control include the culvert diameter and the allowable hydraulic head at the headwall; both variables are made available from the Drainage Inventory (GIS) work. A third variable, the culvert headwall shape, is also required, but has little effect on the capacity calculation and can generally be considered a simple square-edge culvert with a headwall. This assumption was made for all pipe capacity calculations.

2.2.B Hydraulic Modeling Process:

Due to the complexity and numerous pipe systems within the West Hill area, the hydraulic analysis was completed using the following process:

1. Calculate a table of the culvert conveyance capacities (based on inlet control) for all culvert diameters located in the study area. The table is based on a simple square-edge culvert with a headwall. The allowable hydraulic head was discretized into three representative headwater elevations: low, calculated at 1 foot of head; medium, calculated at 3 feet of head; and high, calculated at 6 feet of head. This information is presented in the "Culvert Conveyance" table, located in Section 2, Referenced Figures.
2. Calculate the 25-year flow values at the selected culvert. This value would be determined by examining the location of the culvert and its relationship to the hydrologic output generated from Subsection 2.1 of this study. This flow value would require some interpolation when analyzing culverts located between subcatchment confluence points.
3. Analyze the culvert capacity by determining if it exceeds the allowable 25-year flows. If the culvert capacity is less than the peak 25-year flow, then this culvert is determined to be "critical," and is coded as such on the West Hill Proposed CIP Map. This map

will illustrate which pipes are currently undersized or would be undersized in the build-out condition. Refer to the West Hill Proposed CIP Map in Section 3, Referenced Figures.

Hydraulic Modeling Process — Example:

To clarify the procedure, a 30-inch culvert with 3 feet of allowable hydraulic head crosses Renton Avenue South. This pipe would have the capacity of 52.2 cubic feet per second (cfs), as shown in the "Culvert Conveyance" table located in Section 2, Referenced Figures. The culvert is in the Taylor Creek Basin, downstream of subcatchment TC-5. The flow nearest this point would be found in Section 2, Hydrologic and Hydraulic Analysis (2.1.B.3.), as TC-S6, which has a 25-year flow of 22.5 cfs. There would also be additional flow from TC-3 of 28.5 cfs. The total 25-year flow at the 30-inch culvert would be computed as the sum of the two values, or 50.9 cfs. Since 50.9 cfs is less than 52.2 cfs, the 30-inch pipe is not at capacity, and this particular 30-inch pipe would not be further analyzed in this study. However, this same pipe, when analyzed in the developed conditions, has a flow of 61.4 cfs, which exceeds the allowable 52.2 cfs. In this case, this pipe would be at capacity during a 25-year storm event, and this pipe would be considered "critical" and would be shown on the Proposed CIP Map, shown in Section 3, Referenced Figures.

The pipes throughout the West Hill area were reviewed, using the hydrologic modeling process. Those pipes that were shown to be undersized are added to the Future Capital Improvement Projects and Actions subsection of Section 3, Proposed Actions. The pipe upgrades requiring more immediate attention are listed as individual projects, which are listed in Subsection 3.3. Other pipe systems and culverts that are undersized or will require upsizing are discussed in the Pipe Upgrades item, toward the end of Subsection 3.3.

The following is a discussion regarding the simplifying assumptions used in the hydraulic analysis of this study:

Both barrel and backwater control are dependent on the slope of the culvert, and would be the primary hydraulic control for culverts with slopes less than 0.5 percent and for flat pipe (0.5 to 1.5 percent) systems that are submerged at the outlet end of the pipe. Otherwise, the inlet control assumption will be acceptable. Culverts that are normally submerged at the outlet end, or are at less than 0.5 percent grade, should be analyzed using a more detailed hydraulic study.

Most culverts with an allowable buildup of hydraulic head at the culvert entrance, even with a flat pipe/submerged outlet condition, can be analyzed for capacity using the inlet control assumption.

The hydraulic study does not reflect damaged headwalls, problematic trash racks, catch basin grate inlet problems, or any effects due to debris or maintenance problems.

The available hydraulic head is the maximum water elevation above the crown of the culvert inlet. This elevation can be obtained by observing the elevation difference shown on the 1-foot contour maps. To expedite the hydraulic analysis, the available hydraulic head was discretized as either 1 foot, 3 feet, or 6 feet high, and was always calculated as the more conservative value. One scenario where this assumption would overestimate pipe capacity would be for perched pipe systems. Perched pipe systems are typically where the pipe crown is perched above the incoming ditch.

The hydraulic study also assumed that the capacity of a ditch/pipe system would be limited by the pipe only.

The culvert capacity was based on GIS survey information, which measured culvert diameters at catch basins and culvert daylight points. It has been observed that some of the early construction techniques used in the West Hill area used a wide assortment of pipe types and sizes. Usually these restrict flows, which overestimates the culvert capacity.

The hydraulic analysis used KCRTS-generated, build-out condition flows. Any changes to planned, built-out zoning could significantly change these flows and alter the critical pipe list.

2.2.C Analysis Summary:

All of the West Hill storm drainage pipe systems within King County right-of-way, and some of the off-road right-of-way systems, have been analyzed according to the process above. Subsection 3.3, Future Capital Improvement Projects and Actions, discusses the "critical" pipe systems. A color-coded map illustrating those pipes that are critical either in existing conditions or build-out conditions is shown on the West Hill Drainage Study Proposed CIP Map, located in Section 3, Referenced Figures.

REFERENCED FIGURES

1. West Hill Hydrologic Summary Map
2. West Hill Basin Hydrologic Land Use Data Table
3. West Hill Basin Hydrologic Connectivity Table
4. West Hill Peak Flow Values Table
5. Culvert Conveyance Table

WEST HILL BASINS - HYDROLOGIC LANDUSE DATA

KCRTS Input - With Current Land Use Conditions								KCRTS Input - With Built-Out Land Use Conditions							
Area (ac)	ubBas	Zoning	Eff Imp.	Forest	Pasture	Grass	Imp.	Area (ac)	ubBas	Zoning	Eff Imp.	Forest	Pasture	Grass	Imp.
BM1								**BM1**							
1.9	1	R12	100%			0.6	1.3								
1.5	1	SA	50%	0.8	0.5	0.2	0.1	2.1	1	R12	100%			0.6	1.5
10.5	1	R6	92%			5.5	5.0	1.3	1	SA	50%	0.7	0.4	0.2	0.1
3.5	1	R4	75%			2.4	1.1	14.0	1	R6	95%			7.1	6.9
17.4			**3.2**	**0.8**	**0.5**	**8.7**	**7.5**	**17.4**				**0.7**	**0.4**	**7.9**	**8.5**
0.6	2	R12	100%			0.2	0.4								
41.2	2	R6	92%			21.5	19.7	0.6	2	R12	100%			0.2	0.4
17.6	2	R4	75%			12.1	5.6	58.8	2	R6	95%			29.8	29.0
59.4			**59.4**			**33.7**	**25.7**	**59.4**						**29.9**	**29.5**
2.8	3	R6	92%			1.5	1.3	2.2	3	R6	95%			1.1	1.1
11.7	3	SA	50%	5.9	3.5	1.8	0.6	7.4	3	SA	50%	3.7	2.2	1.1	0.4
8.3	3	R6	92%			4.3	4.0	13.2	3	R6	95%			6.7	6.5
22.8			**22.8**	**5.9**	**3.5**	**7.5**	**5.9**	**22.8**				**3.7**	**2.2**	**8.9**	**8.0**
4.5	4	R4	75%			3.1	1.4								
6.8	4	R6	92%			3.5	3.3								
11.3			**11.3**			**6.6**	**4.7**	**11.3**	**4**	**R6**	**1.0**			**5.7**	**5.6**
2.5	5	R4	75%			1.7	0.8								
10.0	5	R6	92%			5.2	4.8								
12.5			**12.5**			**6.9**	**5.6**	**12.5**	**5**	**R6**	**1.0**			**6.3**	**6.2**
29.1	6	R6	92%			15.2	13.9	30.1	6	R6	95%			15.3	14.9
6.4	6	SA	50%	3.2	1.9	1.0	0.3	5.7	6	SA	50%	2.8	1.7	0.9	0.3
1.1	6	SA	50%	0.6	0.3	0.2	0.1	0.8	6	SA	50%	0.4	0.2	0.1	0.0
36.6			**36.6**	**3.7**	**2.2**	**16.3**	**14.3**	**36.6**				**3.2**	**1.9**	**16.2**	**15.2**
11.4	7	R4	75%			7.8	3.6								
26.6	7	R6	92%			13.9	12.7								
38.0			**38.0**			**21.7**	**16.3**	**38.0**	**7.0**	**R6**	**0.9**			**20.2**	**17.8**
4.9	8	R4	75%			3.4	1.5								
11.4	8	R6	92%			6.0	5.5								
16.3			**16.3**			**9.3**	**7.0**	**16.3**	**8**	**R6**	**1.0**			**8.3**	**8.1**
3.3	9	R4	75%			2.3	1.0								
7.7	9	R6	92%			4.0	3.7								
11.0			**11.0**			**6.3**	**4.7**	**11.0**	**9**	**R6**	**0.9**			**5.9**	**5.1**
26.1	10	R6	92%			13.6	12.5	29.1	10	R6	92%			15.2	13.9
4.2	10	SA	50%	2.1	1.3	0.6	0.2	2.1	10	SA	50%	1.1	0.6	0.3	0.1
2.7	10	SA	50%	1.4	0.8	0.4	0.1	1.8	10	SA	50%	0.9	0.5	0.3	0.1
33.0			**33.0**	**3.5**	**2.1**	**14.6**	**12.8**	**33.0**			**33.0**	**2.0**	**1.2**	**15.8**	**14.1**
BM3								**BM3**							
5.9	1	R4	75%			4.1	1.9								
13.8	1	R6	92%			7.2	6.6								
19.8			**19.8**			**11.3**	**8.5**	**19.8**	**1.0**	**R12**	**1.0**			**5.7**	**14.0**
0.5	2	R18	100%			0.0	0.4								
2.7	2	R18	100%			0.2	2.5	0.5	2	R18	100%			0.0	0.4
1.9	2	R4	75%			1.3	0.6	2.7	2	R18	100%			0.2	2.5
4.5	2	R6	92%			2.3	2.2	6.4	2	R12	100%			1.9	4.6
9.6			**9.6**			**3.9**	**5.7**	**9.6**						**2.1**	**7.5**
32.2	3	R6	90%			17.1	15.1								
8.5	3	R4	75%			5.8	2.7	33.3	3	R6	90%			17.7	15.6
15.8	3	R12	100%			4.6	11.2	24.3	3	R12	100%			7.1	17.3
8.4	3	SA	50%	4.2	2.5	1.3	0.4	7.2	3	SA	50%	3.6	2.2	1.1	0.4
64.9			**64.9**	**4.2**	**2.5**	**28.8**	**29.4**	**64.9**				**3.6**	**2.2**	**25.9**	**33.2**
RE1								**RE1**							
2.1	1	SA	50%	1.1	0.6	0.3	0.1								
0.2	1	R48	100%			0.0	0.2								
2.5	1	R4	75%			1.7	0.8	0.4	1	R48	100%			0.0	0.4
4.5	1	R12	100%			1.3	3.2	9.2	1	R12	100%			2.7	6.5
9.3			**9.3**	**1.1**	**0.6**	**3.3**	**4.3**	**9.6**						**2.7**	**6.9**
4.5	2	R48	100%			0.2	4.3								
11.2	2	R4	75%			7.7	3.5	4.4	2	R48	100%			0.2	4.2
21.2	2	R12	100%			6.1	15.1	37.2	2	R12	100%			10.8	26.4
32.4	2	R6	92%			16.9	15.5	27.7	2	R6	95%			14.0	13.7
69.3			**69.3**			**30.9**	**38.4**	**69.3**						**25.0**	**44.3**
5.0	3	R12	100%			1.4	3.5								
8.4	3	R4	75%			5.8	2.7	5.0	3	R12	100%			1.4	3.5
15.6	3	R6	92%			8.2	7.5	33.6	3	R6	90%			17.9	15.7
0.7	3	SA	50%	0.4	0.2	0.1	0.0	0.7	3	SA	50%	0.4	0.2	0.1	0.0
11.5	3	SA	50%	5.8	3.5	1.7	0.6	2.1	3	SA	50%	1.0	0.6	0.3	0.1
41.3			**41.3**	**6.1**	**3.7**	**17.2**	**14.3**	**41.3**				**1.4**	**0.8**	**19.7**	**19.4**

WEST HILL BASINS - HYDROLOGIC LANDUSE DATA

KCRTS Input - With Current Land Use Conditions								KCRTS Input - With Built-Out Land Use Conditions							
Area (ac)	ubBas	Zoning	Eff Imp.	Forest	Pasture	Grass	Imp.	Area (ac)	ubBas	Zoning	Eff Imp.	Forest	Pasture	Grass	Imp.
RE2															
4.2	1	R6	92%			2.2	2.0								
0.3	1	R12	100%			0.1	0.2								
0.1	1	R12	100%			0.0	0.1	4.2	1	R6	90%			2.2	2.0
0.4	1	R12	100%			0.1	0.3	0.3	1	R12	100%			0.1	0.2
1.3	1	R12	100%			0.4	0.9	0.1	1	R12	100%			0.0	0.1
11.5	1	SA	50%	5.7	3.4	1.7	0.6	0.4	1	R12	100%			0.1	0.3
12.1	1	R2	60%	0.6	2.4	7.3	1.8	1.3	1	R12	100%			0.4	0.9
22.5	1	R4	75%			15.4	7.1	46.1	1	R8	100%			18.4	27.6
52.4			**52.4**	**6.3**	**5.9**	**27.2**	**13.0**	**52.4**						**21.3**	**31.1**
5.2	2	SA	50%	2.6	1.5	0.8	0.3								
6.0	2	R2	60%	0.3	1.2	3.6	0.9								
11.1	2	R4	75%			7.6	3.5	22.3	2	R6	95%			11.3	11.0
8.4	2	R6	92%			4.4	4.0	8.4	2	R8	100%			3.4	5.0
2.0	2	R12	100%			0.6	1.4	2.0	2	R12	100%			0.6	1.4
32.7			**32.7**	**2.9**	**2.7**	**17.0**	**10.1**	**32.7**						**15.2**	**17.5**
1.8	3	R8	100%			0.7	1.1								
5.3	3	R12	100%			1.5	3.7								
1.7	3	R8	100%			0.7	1.0	1.8	3	R8	100%			0.7	1.1
3.9	3	SA	50%	1.9	1.2	0.6	0.2	9.1	3	R12	100%			2.6	6.5
13.1	3	R2	60%	0.7	2.6	7.9	2.0	1.7	3	R8	100%			0.7	1.0
19.7	3	R4	75%			13.5	6.2	32.8	3	R6	95%			16.6	16.2
45.4			**45.4**	**2.6**	**3.8**	**24.8**	**14.2**	**45.4**						**20.6**	**24.8**
29.1	4	R2	60%	1.5	5.8	17.5	4.4								
43.7	4	R4	75%			29.9	13.8								
72.8			**72.8**	**1.5**	**5.8**	**47.4**	**18.1**	**72.8**	**4**	**R6**	**0.9**			**38.7**	**34.1**
15.2	5	R2	60%	0.8	3.0	9.1	2.3	37.9	5	R6	90%			20.2	17.7
22.7	5	R4	75%			15.6	7.2	0.6	5	CB	100%			0.0	0.5
0.6	5	CB	100%			0.0	0.5	1.2	5	R18	100%			0.1	1.1
1.2	5	R18	100%			0.1	1.1	1.0	5	CB	100%			0.1	1.0
3.0	5	SA	50%	1.5	0.9	0.5	0.2	2.0	5	R12	100%			0.6	1.4
0.2	5	R24	100%			0.0	0.2	0.2	5	R24	100%			0.0	0.2
42.9			**42.9**	**2.3**	**3.9**	**25.3**	**11.4**	**42.9**						**20.9**	**22.0**
25.8	6	R2	60%	1.3	5.2	15.5	3.9								
38.6	6	R4	75%			26.5	12.2	64.4	6	R6	90%			34.3	30.1
1.6	6	R6	92%			0.8	0.8	1.6	6	R8	100%			0.6	1.0
66.0			**66.0**	**1.3**	**5.2**	**42.8**	**16.8**	**66.0**						**34.9**	**31.1**
RE3								**RE3**							
3.9	1	SA	50%	2.0	1.2	0.6	0.2								
26.2	1	R2	60%	1.3	5.2	15.7	3.9								
17.5	1	R4	75%			12.0	5.5								
47.6			**47.6**	**3.3**	**6.4**	**28.3**	**9.6**	**47.6**	**1**	**R8**	**1.0**			**19.0**	**28.5**
GR1								**GR1**							
22.2	1	R2	60%	1.1	4.4	13.3	3.3	44.5	1	R8	100%			17.8	26.7
37.0	1	R4	75%			25.3	11.6	17.9	1	R24	100%			0.9	17.0
10.2	1	CB	100%			0.5	9.7	13.8	1	R24	100%			0.7	13.1
14.8	1	R1	60%	2.2	4.4	6.8	1.3	3.1	1	R8	100%			1.2	1.8
47.4	1	SA	50%	23.7	14.2	7.1	2.4	52.3	1	I	100%			2.6	49.7
131.6			**131.6**	**27.0**	**23.1**	**53.1**	**28.4**	**131.6**						**23.2**	**108.3**
GR2								**GR2**							
								1.2	1	CB	100%			0.1	1.2
4.2	1	CB	100%			0.2	4.0	4.0	1	R12	100%			1.2	2.9
12.3	1	SA	50%	6.1	3.7	1.8	0.6	5.7	1	R24	100%			0.3	5.4
4.3	1	R8	100%			1.7	2.6	9.8	1	I	100%			0.5	9.3
20.7			**20.7**	**6.1**	**3.7**	**3.8**	**7.2**	**20.7**						**2.0**	**18.7**
30.8	2	R6	92%			16.0	14.7								
3.7	2	CB	100%			0.2	3.5	21.3	2	R8	100%			8.5	12.8
3.1	2	SA	50%	1.5	0.9	0.5	0.2	31.4	2	R6	95%			15.9	15.5
18.5	2	R8	100%			7.4	11.1	8.0	2	R24	100%			0.4	7.6
9.2	2	R4	75%			6.3	2.9	3.5	2	CB	100%			0.2	3.3
65.2			**65.2**	**1.5**	**0.9**	**30.4**	**32.4**	**64.2**						**25.0**	**39.2**
								19.6	3	R6	95%			9.9	9.7
								11.6	3	R24	100%			0.6	11.0
								5.3	3	R18	100%			0.4	4.8
40.5	3	R6	92%			21.1	19.4	23.0	3	R8	100%			9.2	13.8
9.4	3	R18	100%			0.8	8.7	28.6	3	R8	100%			11.5	17.2
18.4	3	SA	50%	9.2	5.5	2.8	0.9	34.6	3	R6	95%			17.5	17.1
20.2	3	R2	60%	1.0	4.0	12.1	3.0	3.1	3	R24	100%			0.2	2.9

WEST HILL BASINS - HYDROLOGIC LANDUSE DATA

KCRTS Input - With Current Land Use Conditions								KCRTS Input - With Built-Out Land Use Conditions							
Area (ac)	ubBas	Zoning	Eff Imp.	Forest	Pasture	Grass	Imp.	Area (ac)	ubBas	Zoning	Eff Imp.	Forest	Pasture	Grass	Imp.
40.5	3	R4	75%			27.7	12.7	3.3	3	R12	100%			1.0	2.3
129.0			**129.0**	**10.2**	**9.6**	**64.5**	**44.7**	**129.0**						**50.2**	**78.9**
TC								**TC**							
52.5	1	R8	100%			21.0	31.5	66.3	1	R8	100%			26.5	39.8
51.1	1	SA	50%	25.5	15.3	7.7	2.6	37.3	1	SA	50%	18.6	11.2	5.6	1.9
20.4	1	R6	95%			10.3	10.1	20.4	1	R6	95%			10.3	10.1
123.9			**123.9**	**25.5**	**15.3**	**39.0**	**44.1**	**123.9**				**18.6**	**11.2**	**42.4**	**51.7**
18.0	**2**	**R6**	**1.0**			**9.1**	**8.9**	**18.0**	**2**	**R6**	**1.0**			**9.1**	**8.9**
98.8	3	R8	100%			39.5	59.3								
42.2	3	SA	50%	21.1	12.7	6.3	2.1	141.0	3	R8	100%			56.4	84.6
22.1	3	R6	95%			11.2	10.9	22.1	3	R6	95%			11.2	10.9
163.1			**163.1**	**21.1**	**12.7**	**57.0**	**72.3**	**163.1**						**67.6**	**95.5**
9.5	4	R24	100%			0.5	9.0								
8.8	4	R4	75%			6.0	2.8	9.5	4	R24	100%			0.5	9.0
20.6	4	R6	95%			10.4	10.2	36.2	4	R6	95%			18.3	17.9
14.8	4	SA	50%	7.4	4.4	2.2	0.7	7.9	4	SA	50%	4.0	2.4	1.2	0.4
53.7			**53.7**	**7.4**	**4.4**	**19.1**	**22.7**	**53.7**				**4.0**	**2.4**	**20.0**	**27.3**
56.3	5	R6	95%			28.5	27.8	70.6	5	R6	95%			35.7	34.9
4.3	5	R48	100%			0.2	4.1	4.3	5	R48	100%			0.2	4.1
21.1	5	SA	50%	10.6	6.3	3.2	1.1	6.8	5	SA	50%	3.4	2.0	1.0	0.3
4.1	5	CB	100%			0.2	3.9	4.1	5	CB	100%			0.2	3.9
85.8			**85.8**	**10.6**	**6.3**	**32.1**	**36.8**	**85.8**				**3.4**	**2.0**	**37.2**	**43.2**
12.7	6	R6	95%			6.4	6.3								
10.1	6	R2	60%	0.5	2.0	6.1	1.5								
2.5	6	R4	75%			1.7	0.8	20.7	6	R6	95%			10.5	10.2
1.7	6	CB	100%			0.1	1.6	1.7	6	CB	100%			0.1	1.6
3.7	6	R48	100%			0.2	3.5	8.3	6	R48	100%			0.4	7.9
30.7			**30.7**	**0.5**	**2.0**	**14.5**	**13.7**	**30.7**						**11.0**	**19.7**
29.5	7	R6	95%			15.0	14.6								
5.9	7	R2	60%	0.3	1.2	3.5	0.9								
23.6	7	R4	75%			16.2	7.4	49.9	7	R6	95%			25.3	24.7
8.2	7	CB	100%			0.4	7.8	12.8	7	CB	100%			0.6	12.1
6.4	7	R24	100%			0.3	6.1	11.0	7	R24	100%			0.5	10.4
73.7			**73.7**	**0.3**	**1.2**	**35.4**	**36.8**	**73.7**						**26.4**	**47.2**
14.9	8	R6	95%			7.5	7.4								
22.3	8	R4	75%			15.3	7.0	37.2	8	R6	95%			18.8	18.4
1.0	8	CB	100%			0.0	0.9	1.0	8	CB	100%			0.0	0.9
38.2			**38.2**			**22.9**	**15.3**	**38.2**						**18.9**	**19.3**
25.3	9	R6	95%			12.8	12.5								
9.7	9	R2	60%	0.5	1.9	5.8	1.4								
14.5	9	R4	75%			9.9	4.6	47.8	9	R6	95%			24.2	23.6
6.6	9	CB	100%			0.3	6.3	8.8	9	CB	100%			0.4	8.4
4.2	9	R12	100%			1.2	3.0	3.7	9	R12	100%			1.1	2.6
60.2			**60.2**	**0.5**	**1.9**	**30.1**	**27.7**	**60.3**						**25.7**	**34.6**
1.7	10	R8	100%			0.7	1.0								
8.4	10	R2	60%	0.4	1.7	5.1	1.3								
21.1	10	R4	75%			14.4	6.6	1.7	10	R8	100%			0.7	1.0
12.6	10	R6	95%			6.4	6.2	42.1	10	R6	95%			21.3	20.8
43.8			**43.8**	**0.4**	**1.7**	**26.6**	**15.2**	**43.8**						**22.0**	**21.8**
LR1	Existing & Built-Out							**BM2**	Existing & Built-Out						
35.2	**1**	**R6**	**1.0**			**17.8**	**17.4**	**13.2**	**1**	**R12**	**1.0**			**3.8**	**9.3**
LR3	Existing & Built-Out							**LR2**	Existing & Built-Out						
0.4	1	R12	100%			0.1	0.3	0.5	1	R12	100%			0.1	0.3
18.4	1	R6	95%			9.3	9.1	35.6	1	R6	95%			18.0	17.6
18.8						**9.4**	**9.4**	**36.0**						**18.1**	**17.9**
7.6	**2**	**R6**	**1.0**			**3.8**	**3.7**	**8.5**	**2**	**R6**	**1.0**			**4.3**	**4.2**
GR3	Existing & Built-Out							**LR4**	Existing & Built-Out						
57.2	1	R6	95%			28.9	28.2	0.6	1	R12	100%			0.2	0.4
2.6	1	NB	100%			0.7	1.8	29.8	1	R6	95%			15.1	14.7
1.5	1	R12	100%			0.4	1.0	**30.4**						**15.2**	**15.1**
0.9	1	R24	100%			0.0	0.9								

West Hill Drainage Study

Basin Hydrologic Connectivity

********Sub-Basin********						********Pipe********		******Channel******		*********Sheet Flow**********			
Basin	From	To	Sum	Sub Basin	Slope	Distance	Travel Time	Distance	Travel Time	Slope	Type	Travel Time	Sum Travel Time
					%	feet	minutes	feet	minutes	slope		minutes	minutes
LR2	2	1	S1	2	3.2%	990	3.0	110	1.0	0.11	Urban	6.1	**10.1**
				1	4.2%	2340	6.1	260	2.1	0.11	Urban	6.1	**14.3**
LR3	2	1	S1	2	4.0%	900	2.4	100	0.8	0.13	Urban	5.7	**9.0**
				1	6.2%	1170	2.5	130	0.9	0.11	Urban	6.1	**9.5**
BM1	10	6	S1	10	6.0%	1050	2.3	1050	7.2	0.1	Pasture	16.1	**25.6**
	9	7	S2	9	3.3%	840	2.5	360	3.3	0.1	Pasture	16.1	**21.9**
	8	S2	S3	8	2.5%	1400	4.8	600	6.3	0.1	Pasture	16.1	**27.2**
	S3	5	S4	7	4.0%	300	0.8	1200	10.0	0.11	Pasture	15.5	**26.3**
	4	3	S5	6	3.9%	2520	6.9	1080	9.1	0.13	Pasture	14.5	**30.5**
	S5	S4	S6	5	2.5%	720	2.4	80	0.8	0.1	Urban	6.4	**9.6**
	2	S6	S7	4	2.6%	1710	5.7	190	2.0	0.1	Urban	6.4	**14.0**
	1	S1	S8	3	3.5%	200	0.6	1800	16.0	0.08	Urban	6.9	**23.6**
	S7	S8	S9	2	2.8%	4140	13.2	460	4.6	0.1	Urban	6.4	**24.2**
				1	2.8%	1800	5.8	200	2.0	0.08	Urban	6.9	**14.8**
BM3	3	1	S1	3	2.1%	1820	6.7	780	8.9	0.12	Pasture	15.0	**30.6**
	2	S1	S2	2	3.2%	1530	4.6	170	1.6	0.06	Urban	7.8	**13.9**
				1	3.1%	1620	5.0	180	1.7	0.06	Urban	7.8	**14.5**
RE1	3	2	S1	3	5.6%	1820	4.1	780	5.5	0.2	Pasture	12.2	**21.9**
	1	S1	S2	2	4.0%	3080	8.3	1320	11.0	0.18	Pasture	12.7	**32.1**
				1	2.9%	1120	3.6	280	2.8	0.08	Urban	6.9	**13.3**
RE2	5	3	S1	6	3.3%	1920	5.7	480	4.4	0.14	Pasture	14.1	**24.1**
	6	4	S2	5	2.3%	2080	7.4	520	5.7	0.08	Urban	6.9	**20.0**
	S1	S2	S3	4	3.9%	1620	4.4	180	1.5	0.08	Urban	6.9	**12.9**
	2	S3	S4	3	2.3%	880	3.1	3520	38.9	0.06	Pasture	19.8	**61.8**
	1	S4	S5	2	3.0%	3780	11.8	1620	15.7	0.06	Urban	7.8	**35.3**
				1	2.8%	870	2.8	2030	20.4	0.08	Pasture	17.6	**40.8**
GR2	3	1	S1	3	2.1%	3840	14.3	960	11.1	0.08	Pasture	17.6	**43.0**
	2	S1	S2	2	1.9%	2580	10.2	1720	21.0	0.06	Pasture	19.8	**51.0**
				1	3.6%	1260	3.6	140	1.2	0.1	Pasture	16.1	**20.9**
TC	9	7	S1	10	2.5%	800	2.7	200	2.1	0.06	Urban	7.8	**12.6**
	8	S1	S2	9	1.9%	2160	8.5	540	6.6	0.08	Urban	6.9	**22.1**
	6	S2	S3	8	2.1%	1920	7.2	480	5.5	0.06	Urban	7.8	**20.5**
	4	S3	S4	7	0.4%	1120	10.1	1680	46.9	0.06	Urban	7.8	**64.7**
	10	5	S5	6	2.3%	1040	3.7	260	2.9	0.06	Urban	7.8	**14.3**
	3	S5	S6	5	2.3%	840	3.0	1960	21.4	0.08	Pasture	17.6	**42.0**
	S4	S6	S7	4	2.3%	220	0.8	1980	21.9	0.1	Urban	6.4	**29.0**
	2	S7	S8	3	0.7%	760	5.0	3040	62.5	0.06	Urban	7.8	**75.3**
	1	S8	S9	2	2.9%	1020	3.2	680	6.6	0.06	Urban	7.8	**17.6**
				1	2.4%	170	0.6	3230	35.1	0.08	Urban	6.9	**42.6**

Notes:

1. Travel Time is based on L/KS^0.5 where L is the flow length, K is a flow roughness coefficient and S is the Slope of the channel or pipe.
2. KCRTS allows for the addition of only 2 subcatchment hydrographs at a time, so the connectivity of a confluence of 3 subcatchments is modeled as the addition of four independent hydrographs, for example add subcatchment 1 and 2 and name it S1, then add S1 to subcatchment 3.
3. Travel Time for Sheet Flow is based on 0.42(nL)^0.8/[P^0.5xS^0.4. For basins with developed headwaters (R4 and denser), L=100 and n=0.15; For basins with pasture or light brush L=200 and n=0.24. S=slope in headwater area. P is the 2yr, 24hr rainfall depth (=2.1 in.)

West Hill Basins - Peak Flow Values(KCRTS)

For the 100, 25, and 2 Year Storm

Return								
Basin - Bryn Mawr One (bm1)								
Period	BuiltOut	Exist.	BuiltOut	Exist.	BuiltOut	Exist.	BuiltOut	Exist.
	bm1-1		bm1-6		bm1-s1		bm1-s6	
100	5.8	5.5	11.1	10.7	21.3	20.4	36.1	34.0
25	3.4	3.2	6.5	6.3	12.5	11.9	21.1	19.7
2	2.8	2.5	5.0	4.7	9.6	9.0	16.6	14.8
	bm1-2		bm1-7		bm1-s2		bm1-s7	
100	20.3	19.3	12.7	12.3	16.3	15.8	56.4	53.3
25	11.9	11.2	7.4	7.2	9.6	9.2	33.0	31.0
2	9.6	8.6	5.9	5.5	7.5	7.0	26.2	23.4
	bm1-3		bm1-8		bm1-s3		bm1-s8	
100	6.19	5.22	5.58	5.27	21.87	21.05	27.12	25.8
25	3.6	3.0	3.3	3.1	12.8	12.3	15.9	15.1
2	2.7	2.0	2.6	2.3	10.2	9.4	12.4	11.4
	bm1-4		bm1-9		bm1-s4		bm1-s9	
100	3.9	3.6	3.7	3.6	26.1	25.2	83.5	79.1
25	2.3	2.1	2.1	2.1	15.3	14.7	48.9	46.0
2	1.8	1.6	1.7	1.6	12.2	11.2	38.6	34.9
	bm1-5		bm1-10		bm1-s5			
100	4.3	4.1	10.3	9.6	10.0	8.8		
25	2.5	2.4	6.0	5.6	5.9	5.1		
2	2.0	1.9	4.7	4.2	4.5	3.6		
Basin bm2			**Basin - Bryn Mawr Three (bm3)**					
	bm2-1		bm3-1		bm3-2		bm3-3	
100	5.2	5.2	7.8	6.4	4.0	3.5	21.7	20.6
25	3.5	3.5	5.2	3.7	2.8	2.2	12.8	12.0
2	2.6	2.6	3.9	2.9	2.0	1.7	10.6	9.6
Basin bm3 (cont.)					**Basin bm4**			
	bm3-s1		bm3-s2		bm4-1			
100	29.5	27.0	33.4	30.5	17.5	11.5		
25	17.9	15.8	20.7	17.9	10.8	6.5		
2	14.5	12.4	16.5	14.2	8.6	3.7		
Basin - Taylor Creek (tc)								
	tc-1		tc-6		tc-s1		tc-s6	
100	35.6	32.8	11.6	9.8	49.6	44.7	98.3	83.5
25	20.8	19.1	7.4	5.7	31.0	26.2	56.3	47.4
2	16.1	14.3	5.8	4.5	24.5	21.0	48.3	38.4
	tc-2		tc-7		tc-s2		tc-s7	
100	6.1	6.1	27.9	25.0	62.8	56.8	189.4	165.8
25	3.6	3.6	17.8	14.7	38.5	33.2	109.5	95.1
2	2.9	2.9	13.8	11.9	30.8	26.2	92.5	76.4
	tc-3		tc-8		tc-s3		tc-s8	
100	59.4	49.3	13.1	12.1	74.4	66.6	195.3	171.7
25	36.4	28.9	7.7	7.0	46.0	38.9	112.7	98.7
2	29.2	23.2	6.3	5.2	36.5	30.7	95.4	79.3
	tc-4		tc-9		tc-s4		tc-s9	
100	17.7	15.8	21.8	19.7	92.1	82.4	230.7	204.5
25	10.4	9.3	13.2	11.5	56.4	48.2	133.7	117.6
2	8.7	7.3	10.7	9.1	45.2	38.0	112.7	93.6
	tc-5		tc-10		tc-s5			
100	28.8	25.7	15.0	13.0	43.7	38.7		
25	16.9	15.0	8.8	7.5	25.7	22.5		
2	13.9	11.9	7.1	5.3	21.0	17.2		

West Hill Basins - Peak Flow Values(KCRTS) Continued

For the 100, 25, and 2 Year Storm

Return	Basin gr1		Basin - Green River Two (gr2)					
Period	BuiltOut	Exist.	BuiltOut	Exist.	BuiltOut	Exist.	BuiltOut	Exist.
	gr1-1		gr2-1		gr2-2		gr2-3	
100	56.1	29.4	9.3	5.1	23.8	22.0	47.9	36.6
25	39.9	16.7	6.8	3.0	14.9	12.9	29.9	21.2
2	28.3	10.1	4.7	2.3	11.7	10.5	23.6	15.2

	Basin - gr2 (cont.)				Basin gr1	
	gr2-s1		gr2-s2		gr3-1	
100	57.1	41.7	80.9	63.7	26.4	26.4
25	36.8	24.1	51.6	37.0	15.6	15.6
2	28.3	17.5	40.1	27.9	12.9	12.9

Basin - Renton One (re1)

	re1-1		re1-2		re1-3		re1-s1	
100	3.8	2.9	26.2	24.7	13.5	11.3	39.7	35.9
25	2.6	1.7	16.7	14.7	7.9	6.5	24.3	21.1
2	1.9	1.4	13.0	12.1	6.3	4.8	19.5	17.0
	re1-s2							
100	43.6	38.8						
25	26.8	22.8						
2	21.4	18.4						

Basin - Renton Two (re2)

	re2-1		re2-2		re2-3		re2-4	
100	19.2	13.1	11.5	8.9	16.1	12.6	24.3	19.4
25	11.8	7.4	6.8	5.1	9.5	7.2	14.2	11.0
2	9.4	4.7	5.6	3.5	7.9	5.0	11.2	6.8
	re2-5		re2-6		re2-s1		re2-s2	
100	14.8	11.4	22.1	17.7	30.8	24.0	46.3	37.1
25	8.7	6.5	12.9	10.1	18.2	13.7	27.1	21.1
2	7.1	4.2	10.2	6.3	15.1	9.1	21.4	13.1
	re2-s3		re2-s4		re2-s5			
100	77.2	61.0	88.6	70.0	107.8	83.0		
25	45.3	34.7	52.0	39.8	63.4	47.3		
2	36.5	22.1	42.1	25.6	51.9	30.3		

	Basin lr1		Basin - Lake Ridge Two (lr2)					
	lr1-1		lr2-1		lr2-2		lr2-s1	
100	12.0	12.0	12.3	12.3	2.9	2.9	15.2	15.2
25	7.0	7.0	7.2	7.2	1.7	1.7	8.9	8.9
2	5.7	5.7	5.8	5.8	1.4	1.4	7.2	7.2

	Basin - Lake Ridge Three (lr3)						Basin lr4	
	lr3-1		lr3-2		lr3-s1		lr4-1	
100	6.4	6.4	2.6	2.6	9.0	9.0	10.3	10.3
25	3.8	3.8	1.5	1.5	5.3	5.3	6.1	6.1
2	3.1	3.1	1.2	1.2	4.3	4.3	4.9	4.9

Culvert Conveyance Capacity Table			
Maximum CFS based on Inlet Control Eqauations			
Pipe	Maximum CFS		
Size	Depth of Head Water (feet)		
(inch)	1	3	6
12	5.5	7.1	7.3
18	10.9	16.9	20.2
24	23.5	33.0	43.0
30	38.1	52.2	68.1
36	57.0	76.8	99.4
48	108.5	141.0	180.0
60	181.0	230.0	288.0

Section 3
Proposed Actions

SECTION 3 — PROPOSED ACTIONS

3.1 Concurrent Actions

Additional Study Needs

The West Hill Drainage Study was targeted for areas of unincorporated King County. There is considerable overlap with both the Cities of Renton and Seattle, and to a lesser extent with the City of Tukwila. The overlap consists of:

1. Areas where the drainage basins and drainage infrastructure are located across City and County borders.
2. The Drainage Complaint Inventory, which includes all residents in Zip Code area 98178; this includes all of West Hill and part of Seattle, Tukwila, and Renton.
3. Locations where drainage outfalls from unincorporated King County then flows to a city.

Two examples of this are: (1) drainage from the Taylor Creek Basin that is split between King County and the City of Seattle, which then flows into a ravine within Seattle jurisdiction; and (2) the outfall from Basins RE1 and RE2, which outfall toward the City of Renton. The basin area outside of unincorporated King County is currently neither inventoried in this study nor modeled for drainage conveyance properties.

Concurrent Capital Improvement Program Projects

King County drainage programs are concurrently constructing Capital Improvement Program (CIP) projects and completing drainage improvements as this study progresses, and will continue after completion of this study. These updates that are concurrently being completed include:

1. King County's allocation of $280,000 for design and construction of Skyway drainage projects. The fund was established to remedy a portion of the large number of drainage complaints located in this area.
2. Neighborhood Drainage Assistance Program (NDAP) projects, including projects constructed as "quick-fix" projects and larger NDAP CIP projects.
3. Road Services Division drainage projects, including drainage projects completed in conjunction with roads overlay work.
4. The City of Seattle and the King Conservation District are currently implementing habitat restoration projects in the portion of Taylor Creek that flows within the City. The headwaters of Taylor Creek originate in the City of Seattle. Streambank and ravine erosion is contributing sediment to the lower reaches of Taylor Creek, and is also increasing flooding.

5. The King County Wastewater Treatment Division is currently completing the Skyway Inflow and Infiltration study. A summary of this study is written up in Subsection 1.5 (Other Information) of this document. There has been coordination between the two studies to identify stormwater inflow sources into the sanitary system. In the event of locating these inflow sources, this document will assist in analyzing the impact of diverting the inflow to a nearby stormwater drainage system.

An update showing concurrent drainage work has been included as the "Concurrent CIP" table found in Section 3, Referenced Figures. This table can also be accessed through the www.metrokc.gov website. It is our intention to update this file as new projects are completed.

3.2 Land Use Planning and Development Recommendations

Both land use planning and land development in the West Hill area, as it relates to water resources, should consider the following facts:

- The West Hill drainage basins that discharge directly to Lake Washington and the Green River have no impact on either the Lake Washington water surface level or the Green River flood stage. The West Hill drainage basins will also have no effect on the hydraulics of these receiving waters under future built-out conditions.
- Much of the West Hill area is either fully developed or is well on its way. Many of these small, fully developed basins consist of heavily piped and landscaped systems that transfer drainage with poor water quality.
- The topographic and geologic formations found in the West Hill area create springs, seeps, and unstable soil conditions. Many of the remaining undeveloped lots are located near these areas.
- The current lack of sanitary sewer infrastructure is the principal reason why there are still underdeveloped lots in the West Hill area. The underdeveloped basins that do not have sanitary sewers are shown on the Sanitary Sewer Map found in Section 1, Referenced Figures; these include Basins GR1, GR2, and RE2. These basins, coincidentally, are the areas with the greatest potential for future increase in stormwater peak flows and, conversely, with the greatest potential for future drainage problems.
- The City of Renton has expressed a concern about the erosion and debris problem with flows from Basin RE2. This problem will be further increased as this basin is developed. The flows are anticipated to increase by 34 percent.

Given these observations, this study recommends that the following development standards be incorporated in land development drainage review and CIP projects:

1. Drainage complaints, including those inventoried and mapped as part of this study, adjacent to and downstream of a proposed development, should be reviewed for impacts to the existing drainage complaint(s), and appropriate mitigation should be required.
2. All permit submittals with potential drainage impacts to the West Hill area should be routed to King County Road Maintenance Division 3 for its review. This should include Preliminary Plat submittals, SEPA review, Commercial Use permits, Utility Right-of-Way Use permits, and Clearing and Grading permits. Division 3 should have budgeted resources to follow through with the review and coordination process required to oversee any potential drainage fixes or mitigation.
3. For drainage systems that have adequate capacity, there is no advantage to requiring detention. The cost to a developer includes construction of a retention/detention (R/D) facility and the cost of losing valuable building lots. These funds would better serve the public by upgrading existing drainage systems, fixing local drainage problems, or constructing additional water quality projects. A more detailed study of detention revenue offset, as a funding source, would be required to determine whether funds could be made available for any large drainage CIP projects.
4. West Hill currently has significant water quality impacts to both Lake Washington and the Green River. Development standards should target water quality issues.
5. Preliminary site assessments for new development should require information regarding seeps, springs, steep slopes, and slide potential, as well as information on local and downstream drainage complaints (as stated in item 1, above). This information should assist the engineer and plan reviewer in minimizing potential drainage or slide hazards associated with the site.
6. Require either regional stormwater detention, or require detention standards for Basin RE2. Construct a debris removal structure near the outlet of RE2-1.

With that in mind, proposed development in these basins should be reviewed for:

- Existing and proposed conveyance capacity of the downstream system.
- Downstream impacts to both adjacent and downstream drainage complaints.
- Local springs and seeps and potential impacts to local groundwater.
- Slides and hillside instability.
- Channel aggradation or degradation.
- Water quality impacts. Both Lake Washington and the Green River are significant environmental resources. Development in these basins should consider water quality issues as they relate to the receiving waters.
- Maintenance requirements.

In compliance with the 1990 *King County Surface Water Design Manual* (SWDM), stormwater runoff from all new development in the West Hill area that has more than 5,000 square feet of new impervious surface and is subject to vehicle use shall be treated prior to discharge from the project site by onsite biofiltration measures. Redevelopment projects within the West Hill area should also apply the biofiltration requirements in the SWDM.

3.3 Future Capital Improvement Projects and Actions

The following projects should be considered for future CIP action. The projects are numbered to allow for cross-referencing the project description with the project location. The project location is mapped on the West Hill Drainage Study Proposed CIP Map, found in Section 3, Referenced Figures.

Project 1 — 59th Avenue South (between South 112th and South 118th Streets)

The lack of a drainage system on this avenue is causing erosion, shoulder damage, and recurrent maintenance. The site also has the potential for flooding existing structures. The project estimate is $40,000 for design and construction.

Project 2 — 11029 – 84th Avenue South

Roadway drainage is severely eroding shoulder and private property (Arends residence) along this heavily used road. The flow needs to be tightlined to the bottom of the ravine, or place boulders to stabilize the channel and shoulder. The project estimate is $50,000 for design and construction.

Project 3 — 8735 South 117th Street

There is serious erosion of property (Spears residence) due to a damaged drainage system. The existing system needs to be re-routed, replaced, or slip-lined. The project estimate is $20,000 for design and construction.

Project 4 — South 129th Street and Martin Luther King Jr. Way

Three drainage courses converge and flood private properties and structures. The project will require upgrading the piped drainage system and increasing the capacity of existing ditches near the confluence. The project will cost approximately $130,000 for design and construction.

Project 5 — Renton Avenue Drainage Improvement (between South 130th and Southwest Victoria Streets, on north side)

Renton Avenue near South 132nd Street lacks adequate drainage collection. The road also has hillside seepage that collects on the road, all of which cause unsafe driving conditions and degradation of the road. Adding catch basins with storm grates and diverting groundwater seepage to nearby drainage collectors can solve the drainage-collection problem. The project estimate is $40,000 for design and construction.

Project 6 — 12241 – 56th Place South (Lloyd Residence)

Surface water ponds along the frontage of four homes. There is no outlet to which the water can drain. A storm drainage system needs to be installed to collect the water and outlet it to a nearby channel or ditch that has positive drainage, or tie the system into an existing system that has capacity. The project will cost approximately $50,000 to correct.

Project 7 — 11603 South 116th Street (McCalsky Residence)

The existing drainage system often reaches capacity and flow overtops the catch basin and floods nearby properties. The existing system needs to be cleaned and/or upgraded. The project will cost approximately $25,000 for design and construction.

Project 8 — Skyway Park Outlet Pipe

The drainage from Skyway Park includes flows from subcatchments TC-9 and TC-7. The existing 25-year flow rate at this location is 26.2 cubic feet per second (cfs). The existing drainage system consists of two open channels converging at the northerly end of Skyway Park; this drainage system flows into a 12-inch concrete pipe. The Skyway Park Outlet Pipe project would be an upgrade to this existing 12-inch drainage system.

Project 9 — South 123rd Place near 84th Avenue

Uncollected road runoff flows onto adjacent properties, therefore causing flooding problems. Springs located in the area and on the road cause road maintenance problems. The springs cause both safety concerns when this steep road freezes and increased degradation of the road.

Project 10 — Beacon Coal Mine Road Project

Moderate storm events cause Beacon Coal Mine Road to flood, which leads to road closures, public safety concerns, road degradation, and repair costs. Both culvert capacity problems at Beacon Coal Mine Road and backwater conditions from the Burlington Northern Railroad embankment cause flooding along the low areas of this road. Water from the wetland (southwesterly of the road) does not have a positive drainage outlet. This contributes to the flooding problems.

The pipe capacity problem is caused by flows outletting from Basin GR1. This basin generates flow that outlets from a steep-sloped, undersized 18-inch pipe, then into a road ditch adjacent to Beacon Coal Mine Road. The existing ditch has limited capacity due to shallow grade and channel-width restrictions. The road ditch then drains to two 18-inch culverts that cross under the road and drain into the wetland. One of the 18-inch culverts is a corrugated metal pipe that is crushed on both sides.

The second road-flooding mechanism is the backwater condition caused by limited conveyance under the Burlington Northern Railroad embankment. These culverts currently backwater into the wetland adjacent to Beacon Coal Mine Road. The backwater is generated from flow volumes from Basins GR1 and GR2. Both of these basins anticipate significant development and flow increases, which will greatly increase the problem at this location.

The effect of the railroad embankment and culvert system on road flooding was not analyzed as part of this report because of the complexity of the analysis. The solution to the problem will also require a balance between upgrading the culverts under the Burlington Northern Railroad and fully utilizing the existing wetland for water quality benefits. Currently, the railroad embankment assists in retaining runoff in the wetland, which greatly assists in improving water quality prior to discharging into the Green River.

The flooding problem at this location will intensify due to anticipated development in this basin. Development in this basin, and the associated flow increases, will soon follow the recently proposed sewer Utility Local Improvement District in this basin. The increased flows will create a condition that will routinely flood the low area of the road.

Short-term solutions to the flooding problem include:

1. Ditch maintenance along the east side of Beacon Coal Mine Road and maintenance of the pipe outfall on the west side of the road.
2. Repair of the crushed inlet and outlet of the existing 18-inch corrugated metal pipe to allow full utilization of this culvert.
3. Addition of another 18-inch culvert under Beacon Coal Mine Road.

Raising Beacon Coal Mine Road or adding culverts under the Burlington Northern Railroad embankment could permanently solve the flooding problem. The problem could also be addressed by constructing a large R/D facility above the problem area.

Project 11 — Beacon Coal Mine Sediment Pond

The outlet to Basin GR2 currently drains from a 36-inch reinforced concrete pipe (RCP). (See also Project 14, Pipeline Slipline at Martin Luther King Jr. Way to Beacon Coal Mine Road.) The 36-inch pipe then outlets to a small sediment pond, which drains to a 36-inch concrete culvert under Beacon Coal Mine Road. The existing sediment pond should be enlarged closer to the road. The outlet channel from the sediment pond should be graded to allow for a water quality swale. Maintenance of the pond could be transferred to the County and placed on an as-needed or yearly maintenance schedule.

Project 12 — Beacon Coal Mine Cleanup/Water Quality Project

One of the water pollution sources, and aesthetic nuisances, is the waste dumping that has occurred along Beacon Coal Mine Road. The water quality issues are associated with dumped refrigerators, car batteries, motor oil, and other contaminants. The cleanup project could be completed with volunteers, but equipment and equipment operators would be needed to move car bodies and to haul waste material from the site.

Project 13 — Pipeline Slipline at Martin Luther King Jr. Way to Beacon Coal Mine Road

All flows from Basin GR2 merge above Martin Luther King Jr. Way and are collected in a 36-inch RCP that drops 200 feet vertically and 500 feet horizontally to the Green River floodplain. The RCP is currently functioning without problems, but reinforced concrete pipe will separate when placed at steep slopes and under unstable soil conditions. The separated pipe will erode the pipe bedding, which will eventually lead to pipe failure. Failure of this pipe would be extremely costly and could be avoided by slip-lining the 500 feet of steep-slope RCP with continuously welded, high-density polyethylene pipe.

Project 14 — Water Quality Swale near Monster Road and Martin Luther King Jr. Way

Onsite runoff from Lily Industries often contains contaminants. Many of these contaminants are pigments used in the paint production industry that could be removed by diverting the onsite runoff to a water quality swale. The water quality swale would benefit the runoff from Basin GR1, which now outlets to the Green River.

Project 15 — Renton Avenue Channel Stabilization

Flows from Basin RE2 merge at a pipe culvert under Renton Avenue near the Renton City limits. The existing 2-year storm event has a flow rate of close to 30 cfs, which has caused erosion problems at the pipe outfall. The basin build-out flow rate for the 2-year storm will be close to 50 cfs. This additional flow will further downcut the ravine and eventually undermine Renton Avenue. The stabilization project would include an energy dissipater at the pipe outfall and some bank protection downstream of the structure.

Project 16 — Taylor Creek Restoration, Phases 1, 2, and 3

Two regional R/D facilities in the Taylor Creek Basin could be constructed near the confluence point of the north and south tributaries. The location of both facilities would utilize an existing road embankment for impoundment. Use of the embankment would greatly reduce the project cost by minimizing excavation and haul items. The project would provide the following benefits:

1. Water quality benefits and related habitat benefits for the mainstem of Taylor Creek.
2. Flow control, which would have the following benefits:
   - Reduce ravine downcutting and associated property damage.
   - Reduce flooding along 68th Avenue South and flooding north of Rainier Avenue South.
   - Reduce peak flow in Taylor Creek, allowing for use of the mainstem as a fisheries resource.
   - Increase mainstem base flow due to additional groundwater seepage from the imboundment area, which would assist in fisheries restoration.

Constructing a fish passage and habitat improvement project from the mouth of Taylor Creek to 68th Avenue South would enhance the habitat benefits associated with construction of R/D projects. This project would require coordination with the City of Seattle, King County, and many property owners, but the project would be a net benefit to everyone. The end results would be to re-establish much-needed natural resources in the West Hill area, and to reduce the potential for property damage due to slope failure and flooding.

Project 16-1 — Taylor Creek Restoration, Phase 1

This phase of the project would be located adjacent to and south of South 115th Street. The project would include design, a geotechnical analysis of the South 115th Street roadway embankment, right- of-way procurement, and construction of an R/D facility. By constructing a flow control structure adjacent to the embankment, the area currently could impound approximately 5 acre-feet of stormwater. The site could be excavated to impound 10 acre-feet.

Project 16-2 — Taylor Creek Restoration, Phase 2

This phase of the project would be located adjacent to and southerly of Renton Avenue. The project would include design, a geotechnical analysis of the Renton Avenue roadway embankment, right-of-way procurement, and construction of an R/D facility. The area currently could impound approximately 50 acre-feet of stormwater without the need for additional excavation.

Project 16-3 — Taylor Creek Restoration, Phase 3

The final phase of the Taylor Creek Restoration project would include fish passage and habitat restoration across the 800 feet of channel at the outlet end of Taylor Creek. Currently, this area includes either pipe with fish blocks or structural landscaping with little riparian vegetation. Completing Phases 1 and 2 of the project would be helpful in solving recurrent flooding problems in this area, which would be useful in negotiating right-of-way for habitat improvements on private property. The decreased flood flows resulting from the Phase 1 and 2 portions of the project would allow for fish passage structures to be retrofitted to existing culverts. The fish passage retrofits will sometimes decrease the capacity of a culvert.

Project 17 — 59th Avenue South at South 120th Street Drainage Project

The existing drainage system on the northeast corner of South 120th Street and Beacon Avenue consists of four catch basins connected by 12-inch pipe. This system has no outfall. The project would extend the drainage system along 59th Avenue South, where it will tie into an existing system.

Project 18 — South 129th Street (between Martin Luther King Jr. Way and 64th Avenue South

Water seeps over the sidewalk along the north side of South 129th Street. This creates hazardous conditions and requires maintenance year-round. Adding French drains behind the

sidewalk and tying these into the main storm drainage system should correct the problem. The project will cost approximately $25,000 to correct.

Project 19 — Renton Avenue Channel Projects, Phases 1 and 2

One of the West Hill basins with the greatest potential for increased development is Basin RE2. A large section of this basin is not using a piped sewer system, but is currently in the sewer utility improvement process. The anticipated flow increases from this basin flow into the City of Renton. The City of Renton is concerned with increased flows from Basin RE2. The City is also concerned with the debris problems that could plug the inlet at the end of the ravine, which flows to the City's drainage system.

The Phase 1 project would be to construct a debris rack and maintenance access road at a location upstream of the inlet to the City's piped drainage system. The debris rack should be designed such that the problematic large debris is targeted for removal. Maintenance access should be made accessible to the City of Renton in the event County maintenance personal are unavailable during an emergency situation.

The Phase 2 project would target the increased flows anticipated for this basin. The options would be to construct a regional R/D facility on the mainstem of channel. The location of the R/D facility should be upstream of 84th Avenue South, and downstream of the drainage outfall across South 132nd Street.

An alternative to the Phase 2 project would be to require detention standards in Basin RE2 at or more restrictive than those required by the King County SWDM. The regional facility would be the preferred alternative. Construction costs for the regional facility could be acquired by offsetting the costs of onsite detention for new development in the basin.

Project 20 — Ravine Hillside Stabilization at Stream Number 0464B

This project would stabilize the hillside at the steepest sections of the ravine that outfall from Basin BM1. Increased development in this basin has caused downcutting and the potential for landslide events.

Local Flooding Problems

The most widespread drainage problem in West Hill is local flooding due to poorly constructed, poorly maintained, or nonexistent drainage collection. Upon completion of the hydrology for the West Hill area and after review of the drainage complaints, it shows that most of the problems could not be grouped together as a common project, or combined together to be solved as a single capital improvement project. Many of the problems were caused by new development, typically residential construction, which did not properly tie-in all the onsite storm runoff to an adequate drainage system.

The cost to correct all of these drainage problems would be beyond the funding limits of King County. Most of these projects would require work on private property, which can be cost-

prohibitive (due to right-of-way considerations) for a government agency to undertake. In the best interest of the public, King County should consider funding the following projects:

- Projects that would provide property owners with the availability to drain into an adequate public drainage system.
- Projects that would direct flows off of public right-of-way toward an adequate drainage system.
- Projects that would upgrade a private permitted conveyance system, which, due to upstream development, no longer has capacity.

Construction estimates for completing drainage projects that would address these types of projects were submitted independently by the King County Department of Natural Resources (KCDNR) and the King County Department of Transportation (KCDOT); both estimates were close to $1 million.

Due to limitations in resources needed to map all problem locations and because of extensive drainage problems in the area, the process for identifying these local drainage problems includes:

- Information from the Road Services Division.
- Drainage complaints on file with the County.
- Information from the West Hill questionnaire.
- Information collected during the drainage field survey.

The first three items listed are discussed in Subsection 1.4 (Drainage Complaint Inventory).

The solutions to most of these problems include:

- Enhancement/retrofitting of existing drainage collection.
- Construction of local berms for flow diversion.
- Construction of French drains to divert and collect seepage.
- Construction of asphalt berms to divert and collect flow.
- Construction of ditches.
- Construction of curbs and gutter systems.

Proposed actions to correct these problems include:

1. *Additional funding for the Neighborhood Drainage Assistance Program.* A total amount of $280,000 has been added to this program; all of this additional money will be used

to correct West Hill drainage problems. Information on the program is discussed in Subsection 1.3 (Drainage CIP Project Inventory). Information regarding ongoing work is discussed in Subsection 3.1 (Concurrent Actions).

2. *New Development Projects.* All new development in the West Hill area will affect drainage. To minimize these impacts and in some cases to correct a local flooding problem, any new development would be required to assess drainage impacts and either mitigate or correct relevant drainage problems. A more detailed discussion of new development projects is included in Subsection 3.2 (Land Use Planning and Development Recommendations).

3. *Road Services Division Small Capital Improvement Projects Program and Roads Overlay Program.* Both of these programs are ongoing and are mentioned in Subsection 3.1 (Concurrent Actions). The Roads Overlay Program normally corrects drainage problems as part of the pre-leveling work completed prior to roads overlay. The pre-leveling work will often correct drainage by resetting a catch basin elevation, recon-touring areas near drainage inlets, or constructing small drainage berms in problem areas. This study recommends budgeting resources within the Roads Overlay Program for the purpose of review and coordination required to oversee any potential drainage fixes identified in this report. This document, along with the Drainage Complaint Appendix, will be forwarded to the Overlay Program Manager to assist in locating the problem areas.

4. *Proposed Ditches, Curbs, and Gutters.* Most of the roads constructed in West Hill do not have curb and gutter systems, and in some cases they do not have road ditches to collect runoff. Most of these roads that had road runoff problems as a result of non-existent curb collection systems were solved by adding asphalt-concrete road curbs. A recommendation for this study is to add some type of road collection system, including a ditch, asphalt-concrete curb, or conventional curb and gutter as needed. The West Hill Drainage Study Proposed CIP Map (found in Section 3, Referenced Figures) highlights some of these collection systems. This map is based on KCDOT input, field observations, and complaint information. The information highlighted on the Proposed CIP Map is not a complete listing of all the roads with runoff collection problems.

Pipe Upgrades

Section 2 of this report details the process used to model the basin hydrology, then calculates the existing hydraulic capacity of the existing system. Section 2 analyzes the pipe capacity for both the existing basin conditions as well as the fully built-out conditions that are anticipated for West Hill. One outcome of that process was to target drainage systems that will require upsizing. The pipe systems that need to be upsized are labeled on the West Hill Drainage Study Proposed CIP Map. Some of the pipe-upsizing projects requiring more immediate attention are singled out and included among the numbered projects listed at the beginning of this subsection of the report.

Potential Storm/Sewer Inflow and Infiltration Projects

The process of field-verifying the GIS data identified a number of drainage systems that were not built to County Standards. These drainage systems, which are listed on the Proposed CIP Map, contain outfall pipes that have no observable connection to a nearby drainage system, and are close to a sewer system. The substandard drainage systems should be inspected to determine whether they connect to the sewer system, then modified as needed.

3.4 Other Programs

Habitat Partners Program

King County has a volunteer program called Habitat Partners, which involves volunteers in long-term maintenance and monitoring of native plant revegetation and habitat restoration sites. Each person or group participating in the program adopts a section of newly planted streambank for one year, caring for the plants and monitoring the success of the plantings. Please contact Greg Rabourn, Community Stewardship Specialist, at (206) 296-1923 regarding information about this program.

Business Programs

Businesses can help save salmon and protect our water resources by taking simple steps to keep pollutants such as antifreeze, dirt, oils, and grease out of storm drains that lead to local lakes and streams. In an effort to encourage businesses to protect our local waterways and the fish that live in them, the KCDNR is offering Watershed Action Grants of up to $5,000 to any organization that will help educate businesses on water quality issues.

Project ideas include educational materials such as brochures, videos, or other informational material on stormwater pollution prevention practices and how businesses can follow them; business and employee involvement through organizing and hosting workshops, traveling displays, events, and other activities that involve and educate businesses or employees about stormwater pollution prevention; and community partnerships that encourage businesses to get involved in environmental stewardship events in their community. Grant applications are due December 15 of each year and awarded on a competitive basis. Call (206) 296-8494 for an application packet and a grants gallery booklet.

King County Water Works Grants provide additional funding opportunities for salmon recovery projects. Projects must protect or improve water quality, foster community stewardship, develop long-term partnerships, leverage resources, and ensure ongoing results. Grants from $5,000 to $50,000 are considered on a competitive basis twice a year. There are no deadlines for grants below $5,000. Call (206) 296-6519 to request an application packet.

Businesses can also access the following County services: The EnviroStars Program in King County's Water and Land Resources (WLR) Division provides technical assistance and recognition to businesses that implement BMPs related to hazardous waste prevention. The WLR Division's Drainage Services Section field engineers conduct water quality site audits by

appointment. For technical assistance on stormwater issues and water quality, contact (206) 296-1900. The Green Works Program in King County's Solid Waste Division encourages recycling and provides informational resources on the purchasing of recycled materials. Call the Master Recycler Composter Program at (206) 296-4353 for free training on waste prevention, recycling, home composting, and household hazardous wastes and in turn share your knowledge with King County residents and businesses.

Storm Drain Stenciling Program

Storm drain stenciling is an easy, effective way for residents of the West Hill area to have hands-on involvement in protecting water quality in Taylor Creek and Lake Washington. Stencil kits are available free of charge from the Washington State Department of Ecology and contain the message "Dump no waste, drains to stream" or "Dump no waste, drains to lake." Please contact Doug Nine, Communication Specialist, at (206) 296-8228 regarding information about this program.

Education Initiatives

Erosion and nonpoint pollution within the West Hill area result from everyday human activities. Nonpoint pollutants originating on each parcel of land can collectively become a serious threat to water quality in the West Hill area. Improper use of fertilizers, pesticides, and other common household chemicals, and many "housekeeping" activities, are among the ways that people generate significant amounts of nonpoint pollution. Backyard practices can contribute to or control the erosion of one's land and the sedimentation of Swamp Creek.

King County can sponsor workshops in the community on topics such as backyard erosion control, water quality improvements for the homeowner, and water quality regulations. Best management practices (BMPs) to be covered in the workshops and implemented by homeowners include proper lawn fertilization and yard maintenance, native vegetation planting, household hazardous waste and yard waste disposal, proper car-washing practices, animal-keeping practices, the use of low phosphate household and garden products, septic system maintenance, and recycling/composting.

Displaying educational posters and brochures in local public libraries and businesses has the potential to educate many people who would see these materials while carrying out their daily activities. King County can coordinate with the public schools in the West Hill area to involve school children in designing posters and brochures with messages about water quality protection, fish habitat protection, and erosion control. There could be a poster contest followed by a display of the winning posters in the Skyway Public Library and local businesses.

For further information about education initiatives, please contact Fran Solomon, Senior Ecologist, at (206) 296-1924.

Open Space Buyout Program

Through the County's existing Public Benefit Rating System Program, KCDNR staff will facilitate citizen access to information and coordinate the involvement of interested property owners. This program provides tax relief to property owners with sensitive areas on their property, who agree to maintain those areas in their natural state in return for reductions in their property tax.

In addition, property owners can sell all or a portion of natural areas, as permanent open space, to King County. These parcels include stream buffer areas and wetlands. Please contact Lise Ward, Acquisition Agent, at (206) 296-7814 regarding information about this program.

REFERENCED FIGURES

1. West Hill Drainage Study Proposed CIP Map (located in back cover sleeve)
2. West Hill Concurrent CIP Table

WEST HILL CONCURRENT CIP TABLE

Introduction

The concurrent CIP table lists all projects that have been completed during the preparation of this study. The following list also includes pending projects that are funded and scheduled for construction in the near future. This list also includes information on "other" work in progress in the West Hill area, which would include updates on other concurrent studies mentioned in the West Hill Drainage Study or any new information that is relevant to this drainage study.

Spears Drainage Project — The Spears property, located at 8735 South 117th Place, was severely impacted by a failing private steel drain pipe installed across the steep front yard many years ago. Impacts included damage to the access stairs from the street above, damage to the home's basement and wooden deck foundation, and garden and yard erosion. In order to minimize disturbance to the steep slope, the old steeply sloped pipe was TV-inspected and then slip-lined with a smaller pipe inside the old leaky pipe. Mrs. Spears is delighted with the results of the project, which substantially reduced the drainage impacts on her property. The work was completed as part of the King County Water and Land Resources (WLR) Division Neighborhood Drainage Assistance Program in July of 1997. The problem is listed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 3.

Saunders Drainage Project — This project routed flows safely down an alley and through two properties to the street below, eliminating flooding of several yards and one finished basement located near 10831 Auburn Avenue South (between Crestwood Drive South and Woodley Avenue South). Several local residents called in to express their thanks for a job well done. The work was completed as part of the King County WLR Division Neighborhood Drainage Assistance Program in December 1997.

Taylor Creek Restoration Projects, Phases 2 and 3 — The Taylor Creek Restoration Projects consist of three phases, including the construction of two regional retention/detention facilities in the Taylor Creek Basin and a third phase, which includes stream restoration and fish passage work in the main channel. The project is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 16.

The Taylor Creek projects have been initiated due to two potential development projects associated with the creek. One project is currently being designed by the City of Seattle, and is almost identical to the Taylor Creek Phase 3 project discussed in Subsection 3.3 of the report. The City of Seattle project would include construction of a fish passage and habitat improvement project beginning at the mouth of Taylor Creek and extending past 68th Avenue South. This project would also include additional stream improvements along the mainstem of Taylor Creek. The preliminary findings from the City's design report indicate that the habitat improvements will require flow control in the upper basin. The findings in that report were similar to the recommendations in this report.

The second project would be the Taylor Creek Phase 2 project; this project would be located adjacent to and southerly of Renton Avenue. The project is currently in the design phase and has a preliminary cost share package in place. In order to complete the regional detention facility, the project will require:

- Use of the road embankment to impound storm water. This will require a geotechnical analysis of the road embankment by the King County Department of Transportation.
- Coordination with the developer, which will include onsite drainage modifications and cost offsetting for the regional detention pond.
- Coordination with the City of Seattle, which will include implementation of the City of Seattle's downstream restoration work (the Phase 3 work). This work will be mitigation for the Phase 2 project.
- Survey of the site.
- Impact mitigation for the utilities at the project site.
- Procurement of easements from private property owners for the area to be impounded.
- Endangered Species Act (ESA) permit review and processing.
- Permit acquisition from the King County Department of Development and Environmental Services (DDES) for construction of the project.

At this time, King County has discussed each of the listed issues with the affected parties. Other than one property owner, there has been a positive response from everyone associated with this project. The City of Seattle and King County are currently attempting to obtain easements for the project. If the project is constructed, the end result will be to re-establish much-needed natural resources in the West Hill area, and to reduce the potential for property damage due to slope failure and flooding in lower Taylor Creek.

Rosenthal Drainage Project (7517 South Lakeridge Drive) — Drainage from uphill properties impacted three residential properties, including ponding in the alley access and parking areas, wet yards, and one wet basement. This project regraded 120 feet of an alley to route storm water to a new catch basin that was piped via a 6-inch drain pipe northwest of the drainage system on Crestwood Drive South. The project substantially reduced the drainage impacts, and King County staff received a letter of appreciation from the project residents. The work was completed as part of the King County WLR Division Neighborhood Drainage Assistance Program in February 1998.

Beacon Coal Mine Drainage Project — Beacon Coal Mine Road is a recurrent flooding problem caused by an inadequate drainage system. A discussion of the Beacon Coal Mine problem is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 10. King County Roads Maintenance has enlarged the ditch along Beacon Coal Mine Road and cleaned the inlet and outlet to the two 18-inch culverts that cross the road. Also, at

the request of the King County WLR Division, the Burlington Northern-Santa Fe Railroad cleaned out the drainage ditches and culverts on its property. The roadway has not flooded since the work was completed in 1997.

Renton Avenue Drainage Project — King County Roads Maintenance completed an upgrade to the drainage collection system on the northeast side of Renton Avenue near Southeast 133rd Street. The work was completed in November of 1998 as part of the Road Overlay Program. The extent of the problem is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 5.

Allentown Acres Drainage Improvement (56th Place South near 57th Avenue South) — Surface water collects in a closed depression along the frontage of four homes near 12241-56th Place South (Lloyd Residence). A storm drainage system will be placed within King County right-of-way that will transport the flow to a nearby drainage ditch. Construction of this project should take place in 1999 and will be completed as part of the West Hill Neighborhood Drainage Assistance Program. The extent of the problem is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 6.

59th Avenue South Drainage Project (between 112th Street and 118th Street) — The area has safety concerns, road degradation, and maintenance costs due to the lack of a road drainage system. An asphalt gutter has been recently constructed along the east side of the street to direct flows away from the front of the properties. This work was completed by King County Roads Maintenance. The extent of the problem is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 1.

South 129th Street Drainage Project (between Martin Luther King Jr. Way and 64th) — Water seeps over a sidewalk, causing safety concerns, maintenance expenses, and road degradation. The project will collect the seepage in a 4-inch drain and rout the flows to a nearby drainage system. Construction of this project was completed in December 1998 as part of the West Hill Neighborhood Drainage Assistance Program. The extent of the problem is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 18.

South 123rd Place Drainage Improvement (near 84th Avenue) — Uncollected road runoff flows onto adjacent properties, causing flooding problems. Springs located in the area and on the roadway cause safety concerns and road maintenance problems. The project will route the seepage and roadway runoff to a recently constructed drainage system. This project was constructed in January 1999 and completed as part of the West Hill Neighborhood Drainage Assistance Program. The problem is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 9.

11603 South 116th Street (McCalskey Residence) — The existing drainage system often reaches capacity and then flows overtop the catch basin and flood nearby properties. The problem is

discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 7. This project was constructed in 1997.

59th Avenue South at South 120th Street — The existing drainage system consists of 12-inch pipe with no outfall. The project is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 17. The drainage problem has been forwarded to King County DDES, which has an open permit for the drainage on this site. The developer will be required to fix this problem prior to King County's acceptance of the drainage system.

East Riverton Gardens Drainage Improvement Project (at Martin Luther King Jr. Way and South 129th Street) — Two existing open drainage channels combine with local runoff and drain to an 18-inch concrete pipe. The 18-inch pipe and two open channels are undersized to carry the existing storm flows at this location. The project is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 4. The project was constructed in December 1998 as part of the West Hill Neighborhood Drainage Assistance Program.

Skyway Park Drainage Improvement Project (74th Avenue South and South 116th Street) — Runoff from Lakeridge Elementary School and local roadway runoff combine to flood three homes at this location. The project is currently in the design phase. The flooding solution will require a new drainage system to be constructed in this area. A temporary fix for the problem would include the construction of a road curb, placed at the location where the flooding occurs. The project is scheduled for construction in 1999 as part of the West Hill Neighborhood Drainage Assistance Program.

Combined Sewer Overflow (CSO) Projects — During the field reconnaissance work associated with the West Hill Drainage Study, a number of storm drains were listed as potential CSOs. These CSOs are typically small storm drains that are connected to the sewer system. The Surface Water Engineering and Environmental Services group is currently working with the King County Wastewater Treatment Division to verify these potential CSOs. In some cases, new storm drainage systems may be required to re-route storm water that is currently connected to the sewer system.

Renton Avenue Emergency Repair Project — The King County Road Services Division completed repair work of a slide that damaged the Renton Avenue roadway and embankment. The slide occurred at the outfall of the 30-inch culvert under Renton Avenue that drains Basin RE2. The area had been down-cutting before the failure and targeted as a CIP project. The original project is discussed in Subsection 3.3, Future Capital Improvement Projects and Actions, Project 15.

64th Avenue South Drainage Improvement Project — Dense blackberry growth with other debris in the channel backflows onto private property then floods the Skyway Mobile Home Park. The project is located upstream of the East Riverton Drainage Project near South 129th

Street and Martin Luther King Jr. Way (discussed on the previous page). The project is scheduled for 1999 construction and is currently awaiting ESA biological review.

Upgraded GIS Drainage Information — The last paragraph of the Executive Summary mentions the availability of support files to be located on the King County Department of Natural Resources (DNR) website. Currently, the West Hill Drainage Inventory Map can be accessed on the Internet at: ftp://splash.metrokc.gov/wlr/pubout/graphics/maps. This map is the latest update to the West Hill Drainage Inventory Map found on the inside front cover sleeve. The electronic file is in Adobe Acrobat format; there is information on the King County DNR website if you need to download the Adobe software to view this file.

City of Seattle Concurrent Capital Improvement Projects in Taylor Creek

Seattle Public Utilities - Culverts Replacement Project — Taylor Creek flows through two culverts at the hairpin turn under Holyoke Way South and 68th Avenue South. The upper culvert is a 36-inch diameter concrete pipe with a length of 75 feet and ecology blocks that form a headwall at its entrance. The lower culvert is a 42-inch diameter corrugated metal pipe with a length of 73 feet and ecology blocks that also form a headwall at its entrance. Both culverts are failing on their upstream sides and are barriers to fish migration.

The primary objective of the Culverts Replacement Project is to eliminate barriers to fish migration. The project will evaluate and modify or replace the culverts to convey stream flows under the roadway with entrance and outlet designed to prevent erosion and allow fish migration. Project design is underway; construction is scheduled to begin in the summer of 1999.

King Conservation District - Restoration Projects — The City of Seattle Parks and Recreation Department received a Puget Sound Urban Resources Partnership Grant to fund a two-phase Taylor Creek restoration effort. The King Conservation District administered the grant and provided project design, coordination, and onsite construction supervision for the two phases. Work crews from the Seattle Conservation Corps and the King County World Conservation Corps completed Phase 1 of the project in summer 1996. This work involved the removal of three barriers to anadromous and resident fish passage and the development of additional flood storage space downstream of Rainier Avenue South. The success of the project was evident in the fall of 1996, when there was a sockeye salmon run (the first in 25 years) in the lower reach of Taylor Creek.

In summer 1997, work crews from the King Conservation District and the Seattle Conservation Corps completed Phase 2 of the Taylor Creek Restoration Project. Phase 2 focused on streambank erosion control and flood mitigation near Lakeridge Park in Dead Horse Canyon to provide bank stabilization and reduce downstream sediment deposition. Bioengineering techniques, including rock, coir (coconut fiber) wraps, and native vegetation, were used to stabilize two sections of eroding streambanks and to provide shade, shelter, and

forage areas for fish and wildlife. Portions of the stream channel were widened and banks were pulled back to a shallow slope in order to better accommodate flood flows.

Community Project — In April 1998, volunteers from the citizen group Friends of Dead Horse Canyon planted trees in Lakeridge Park in order to restore the forest canopy. In cooperation with the City of Seattle's Parks and Recreation Department, the group conducted a streamside planting project in October 1998 and hillside planting projects in November and December 1998. The newly planted trees will benefit fish habitat in the creek by shading the creek, thereby moderating summer water temperatures, by providing habitat for insects on which fish feed, and by contributing large woody debris to the creek.

School children have also been involved in stewardship projects for Taylor Creek. Children from the Emerson School in Seattle released coho salmon fingerlings into the creek this past winter and will monitor the return of the coho to spawn in the creek in three to five years.

WEST HILL DRAINAGE STUDY

Proposed Capital Improvement Projects Map

Capital Improvement Projects
Constructed Drainage
Natural Drainage
Drainage Divides
Roads
Cities

Legend

- Basin Boundary
- Sub-basin Boundary
- GR2-1 Subcatchment Number
- City Boundary and Area
- Stream
- Ditch and Surface Flow Direction
- Pipe
- Lake and River
- Surface Gradient

Proposed Capital Improvement Projects

- Pipe Upgrade
- Curb and Gutter or Road Ditch
- Potential CSO Storm/Sewer Connection
- 40 Recommended CIP (see West Hill Drainage Study Report, Section 3)

Acronyms:
KCLDS King County Local Drainage Services Unit
KCRSD King County Roads Services Division

Map Sources:
Roads from King County GIS parcel coverage, 6/97; Streams from KC GIS streams coverage, 4/97; Constructed Drainage from King County Roads Division NPDES Survey, 8/96; Capital Improvement Projects from the Project Management and Design Unit, Wastewater Treatment Division; Road names from Thomas Bros Atlas, 1997.

Credits, West Hill Drainage Study
Tim Kelly, Senior Engineer
Cynthia Newton, Engineer
Study Produced by the Project Management and Design Unit

King County
Department of Natural Resources