1.0 Executive Summary

1.1 Overview

Like many areas in western Washington, Snohomish County has experienced rapid change due to urban development in once rural areas. The drainage facilities in these recently urbanized areas are often a patchwork of pipes, roadside ditches and channels rather than a coordinated system as found in a mature utility. These conditions have highlighted the need for new information regarding urban drainage systems and related stormwater problems in the county's unincorporated Urban Growth Areas (UGAs). It has also focused attention on the need to develop solutions to address drainage issues, both now and in the future, as expected growth continues. The goal of the Drainage Needs Report (DNR) project has been to gain a better understanding of the drainage systems, streams, and wetlands in the unincorporated UGAs and to plan for future infrastructure needs in ways that will reduce road and property flooding, protect and enhance aquatic habitat, and reduce stormwater pollution.

A Recognized Need:
Detailed stormwater planning is an important element of the County's efforts to solve drainage problems, manage the stormwater infrastructure, protect natural resources, guide new development, and plan for future development.

This ambitious project involved the assessment of drainage needs in nearly all of the County's unincorporated UGAs in only two years. The results provide a wealth of information and new tools that the County, local cities, developers, and citizens alike can use to make decisions on drainage related issues. These tools are designed to answer questions not only today but also in the future, as conditions change.

The Drainage Needs Report project parallels the County's successful Transportation Needs Report (TNR), which has proved to be a valuable tool for prioritizing projects and focusing the County's limited resources on road improvements that provide the highest value. The County recognized the need for a similar detailed level of information regarding the urban stormwater system and likewise the need to identify needed drainage improvements and funding priorities.

New Tools to Better Manage Drainage

The DNR project provides a set of practical tools that will help the County, developers, and property owners solve and avoid flooding and related surface water problems now and in the future. The main products of the DNR report include:

- The inventory of 58 square miles of existing drainage systems, mapped for the first time (including inventories conducted prior to the DNR, the total equals 73 sq. mi.)

- The identification of 1,036 existing and future surface water problems
- A list of 378 priority projects with conceptual designs
- The development of hydrologic and hydraulic models for a number of the major conveyance systems
- 11 Drainage Needs Reports for individual study areas.

The DNR project was focused on identifying projects that primarily reduce flooding by constructing a combination of conveyance and detention facilities that accommodate higher volumes of stormwater without overloading downstream drainage systems.

By inventorying and mapping complete drainage systems for the first time, locating present and future drainage problems, and identifying possible corrections, the County has the tools to take a comprehensive approach to managing urban drainage areas and solving the top priorities within them. The individual study area reports provide an understanding of conditions, problems, and reasonable solutions that can benefit a number of applications:

- Prioritize projects for the ACP (Annual Construction Program) and 6-year CIP (Capital Improvement Program)
- Help new development identify drainage improvements needed to meet Title 24 (the Snohomish County Drainage Code)
- Assist major regional and local government projects
- Develop HCPs (Habitat Conservation Plans) to expedite County road and drainage projects in the South County or elsewhere
- Coordinate drainage maintenance
- Support County land use planning
- Target emergency response to spills
- Support County compliance with state and federal regulations, such as NPDES
- Provide public information
- Provide new tools to evaluate drainage code updates or other development standards.

1.2 A Comprehensive Approach

Looking at All the Urban Areas

The DNR project area includes all of the unincorporated UGAs in the county except for the Lake Stevens UGA, where the County recently completed similar drainage evaluations. This overall DNR project area was divided into 11 individual study areas, as shown in Figure 1-1. In general, more detailed analyses were conducted for the larger UGAs that have experienced more development and have had a history of problems. A

primary direction was to prioritize the evaluation efforts in the areas where most of the growth is occurring and to tailor the reports and analyses to the complexity of the areas and the likely drainage impacts.

A Focused Approach: A primary direction was to concentrate the evaluation efforts in the areas where most of the growth is occurring and to tailor the reports and analyses to the complexity of each area and its likely drainage impacts.

The study team included Snohomish County staff and two multidisciplinary consultant teams that studied and analyzed the 11 DNR study areas concurrently and prepared 11 separate Drainage Needs Reports, this DNR Summary Report, an Aquatic Habitat Summary report, and supporting documentation of the inventory and drainage system analyses and documentation methods.

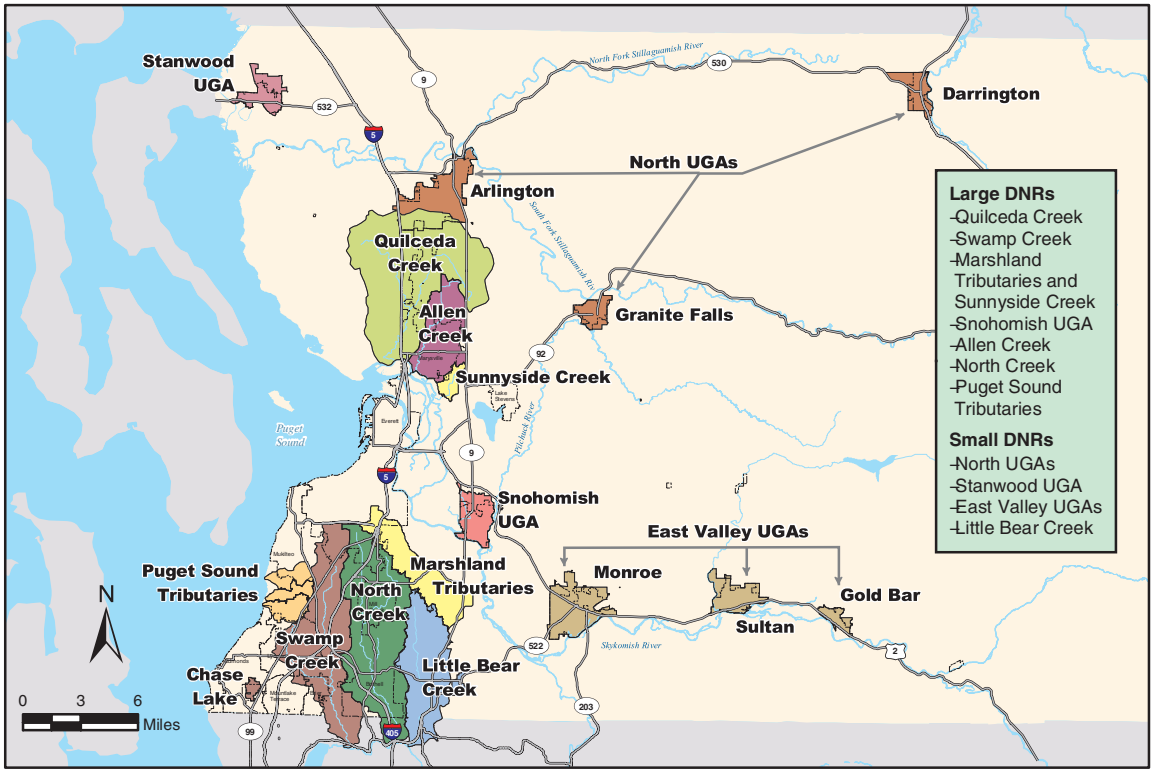


Figure 1-1. The 11 DNR study areas

An Integrated Approach to Evaluating Problems

A variety of federal, state and local laws require storm drain systems to discharge water that is clean and does not damage the natural waters to which it drains. Increasing urbanization can result in increase drainage, which can erode streambanks and damage stream beds. More recently, the listing of Puget Sound chinook and bull trout as a threatened species under the Endangered Species Act has made drainage solutions more complex to evaluate and often more difficult to implement. For example, new regulations require coordination and cooperation of various engineering and scientific disciplines and regulatory agencies. To install a larger drain pipe to alleviate a flooding

problem involves analysis of changes in the stormwater flow (both upstream and downstream) and evaluation of the potential impacts to fish habitat and fish migration. Often, compliance with the conditions of required permits from the regulatory agencies dictates the scope, schedule, and cost of the work. As a result, while this project largely focuses on drainage and flooding issues, it must also consider other issues that are inextricably intertwined, such as aquatic habitat, water quality, and erosion.

Recognizing this reality, the DNR project team adopted a comprehensive approach to address these related issues. For the larger study areas, the analyses included flooding, habitat, water quality, and in some cases, erosion. The only exceptions were in the smaller study areas where the focus was primarily on flooding issues. The team's approach relied on an integration of high-accuracy inventory data, geographic information system (GIS) technology, stream and wetland habitat surveys, and detailed hydrologic and hydraulic modeling for many of the major conveyance systems.

Hydrologic and hydraulic computer models were used to quantify existing and future surface water conditions and identify any additional flooding problems. The hydrologic models determined the amount of stormwater runoff that will be generated by various storm events within a drainage basin, based upon current development conditions and future buildout according to the Future Land Use Map adopted in the 1995 Comprehensive Plan. The hydraulic models used that flow information to determine how the runoff travels though the system of stream channels and drain pipes, and to identify where flooding problems will occur. Today's detention standards under the County's existing drainage code (Title 24) was assumed in determining flow from new development and in proposing new flood control solutions. Selecting problem solutions for each DNR involved analyzing various options including increasing conveyance capacity, adding detention storage, and adding high-flow bypass systems. The alternative problem solutions were also modeled to evaluate their effectiveness to solve flooding problems and address permitting issues so that the projects could be implemented and were cost effective.

1.3 General Results and Conclusions

Inventorying/Mapping the Public Drainage System

The DNR project developed an inventory of the existing drainage systems in all the individual study areas, which is now contained in the County's GIS. Combined with the 15-square miles of inventory data collected prior to the DNR project, the total inventory now includes nearly 600 miles of enclosed pipes, 400 miles of open channels, 70,000 catch basin and pipe features, and 140,000 ditch and stream cross section points that crisscross a 73-square-mile area. While this information was used to support the hydrologic and hydraulic modeling analyses, it also created an accurate and complete record of the existing drainage systems.

Hundreds of Flooding Problems Identified

The 11 Drainage Needs Reports document 591 flooding problems for the priority areas studied for this project. These flooding problems were identified by constructing detailed

computer models, reviewing recent drainage complaints recorded by the County, talking with local residents, and interviewing County staff. The majority of the problems are associated with undersized culverts and drainage pipes, many of which are located on private property.

Based on the analyses, the following general conclusions stand out:

- Flooding problems tend to be concentrated in the older drainage systems that were designed prior to the current County standards.
- Fewer flooding problems occur in areas where more modern drainage systems are in place.
- As development occurs, the remaining undeveloped areas will need significant drainage system improvements.
- County drainage system improvements complying with current Title 24 standards seem to be working well.
- In the smaller UGAs where unincorporated land is small and often fragmented, the DNR studies have isolated specific problems, but it is important to recognize that many of these problems cross boundaries between unincorporated and incorporated land and between adjacent study areas.
- In general, stormwater flows are predicted to increase in most areas where future development would occur. Although current Title 24 standards require new development to control the surface water leaving a site, stormwater flows are predicted to increase within the basins as a result of the additional impervious areas.
- For those drainage pipes that are undersized and hold back a large volume of stormwater during rainfall events, replacing these pipes with larger ones will send more water downstream and could create new downstream problems. In such cases, stormwater detention is generally recommended to offset the increase in flows that would occur by replacing these drainage pipes.
- Providing regional detention ponds is preferred over increasing conveyance capacities, and detention pond options were the least-cost option when they did not require removing residential structures or impacting sensitive areas.
- Some opportunities were found to retrofit existing detention ponds to provide water quality treatment or to increase the detention volume in the pond (though often the increased volume was only marginal).
- Follow-up work with property owners for their correction of flooding problems on private property will benefit basin drainage conditions and conveyance capabilities.

Habitat Impacted by Development

Based on the stream inventories and analyses, the following general conclusions regarding habitat conditions are noteworthy:

- As expected, habitat conditions along the existing streams, particularly in the more developed UGAs, were generally poor as a result of impacts from urbanization in these basins.

- Many of the identified habitat problems are due to culverts that were not designed to allow fish passage.
- Many streams have inadequate riparian vegetation along their banks, resulting in excessive erosion.
- Additional pools and improved shade along stream corridors would improve habitat.
- Many habitat problems will be alleviated by correcting flooding problems.

Water Quality and Erosion Need Improvement

Water quality and erosion analyses were generally more limited than the flooding analyses and habitat assessments. However, based on the analyses conducted, the following general conclusions are warranted:

- Overall, the water quality in many areas was found to be poor according to Washington State water quality standards.
- Natural rates of erosion and sedimentation have been accelerated in many locations as a result of increased stormwater from upstream development.
- Many of the water quality problems are typical of urbanizing areas with new construction, additional impervious areas, and changes in hydrology.
- Many of the water quality problems could be reduced through preventive measures such as street cleaning and best management practices for construction and farming.
- Correcting flooding problems will, in many cases, also improve water quality.

Beneficial Uses of New Information

The individual study area reports provide new information for the County that otherwise would not have been available for many years. The inventory and modeling, in particular, provide a reference to the existing conditions and a capability to evaluate impacts resulting from further development within the basins, as well as how those impacts can best be mitigated.

The hydrologic models predict basin flows for current conditions and at complete buildout of the current comprehensive land use plan. The hydraulic models represent system capacities for current and future flows. The hydraulic models also identify conveyance improvements, and these models can be modified later to account for changes to the drainage system.

Although it was not necessary to model all areas within the basins, especially those with no known problems, there is now background information and modeling that facilitate designs within new areas. The modeling further provides the opportunity to compare drainage impacts of different land use patterns and various growth scenarios.

Table 1-1 lists each DNR product and shows that it can be used for a number of beneficial purposes.

Table 1-1. Beneficial Uses of the DNR Products

DNR Product	Beneficial Uses
1. Inventory of Existing Drainage Systems	• The County will have a better record of its drainage systems for maintenance purposes. • Developers conducting a downstream analysis will be able to use this information in their analyses. • The emergency response to contain spills will be able to more quickly trace downstream drainage paths. • Local residents will be able to better understand the drainage systems in their local neighborhood.
2. Identified Surface Water Problems	• Developers conducting a downstream analysis will be able to use this information in their analyses. • The County will also be able to use this information in its Title 24 review of the downstream analyses.
3. List of Recommended Projects	• Top priority projects can be selected and implemented to solve historical and/or predicted problems due to buildout of current land use plans. • Projects could be proposed as mitigation opportunities for large regional projects. • Projects could be used in the design of County roadway projects to help minimize impacts. • Identified habitat projects could be used for the Habitat Conservation Plan (HCP). • Projects and identified problems could be used in Title 24 review of proposed developments. • Private property owners may wish to implement projects to fix problems on their property.
4. Preliminary Project Designs	• Whoever implements a given project will have a better starting point for completing final designs and obtaining needed permits.
5. Hydrologic & Hydraulic Models	• Developers conducting a downstream analysis will be able to use these models in their analyses. • The County will be able to evaluate effects of proposed changes in regulatory standards, such as an update to the drainage code. • County engineers can identify drainage solutions for road projects. • The County and developers will have a better starting point for completing final designs and obtaining needed permits.
6. Individual Drainage Needs Reports	• The County will be able to document how problems and projects were identified and whether additional analyses will be needed in the future. • Local residents will be able to better understand the main surface water problems and issues in their neighborhood.

Individual Study Areas

In addition to the general conclusions for the entire project, general conclusions were also reached regarding some of the individual study areas. Table 1-2 summarizes some of the main results or conclusions for each study area.

Table 1-2. General Conclusions on the 11 DNR Study Areas

DNR	General Conclusions about the Basin
Quilceda Creek (DNR No. 1)	Most of the flooding problems in this basin can be attributed to the numerous small and undersized culverts on tributaries and ditches. The flat geography and the high groundwater table compound flooding problems.
Swamp Creek (DNR No. 2)	Many of the flooding problems have occurred due to the incremental development of the area, where existing drainage systems and streams are unable to handle the increased stormwater. Most of the flooding is due to undersized pipes and channels. Relatively few flooding problems occur along the main stem of Swamp Creek, due in large part to the significant riparian wetlands that ameliorate potential flooding problems and provide water quality and habitat benefits.
North UGAs (Arlington, Darrington, Granite Falls) DNR No. 3)	The study confirmed that historical drainage problems (if any were on file) had been closed and no existing drainage problems were identified.
Marshland Tributaries and Sunnyside Creek (DNR No. 4)	Many of the drainage systems in the developed plateau area of the Marshland tributaries are older piped systems that lack sufficient conveyance capacity. Erosion and habitat problems are significant in the Marshland subbasin. The Sunnyside Creek study area had no identified flooding problems along the main stem of the creek.
Snohomish UGA (DNR No. 5)	Relatively few flooding problems were identified in this basin; habitat and water quality problems were more numerous. Upsizing culverts would solve a number of the flooding and habitat problems.
East Valley UGAs (Monroe, Sultan, Gold Bar) (DNR No. 6)	Relatively few flooding problems were identified in these primarily rural areas; most of them were located in the Monroe UGA study area.
Stanwood UGA (DNR No. 7)	Less than ten flooding problems were identified in this primarily rural area. Problems typically included clogged culverts and pipes with insufficient conveyance capacities.
Allen Creek (DNR No. 8)	Flooding problems were identified in the older residential developments and along the northern main stem of the creek, although the number of problems was fewer than expected. Habitat along the main stem is poor. The greatest opportunity to improve the system's habitat, solve some significant drainage problems, and improve water quality would result from a relocation of the northern main stem. The computer analysis showed that recently constructed stormwater facilities designed to meet current standards in the study area are generally working as planned.
Little Bear Creek (DNR No. 9)	Flooding problems in this urbanizing area are the result of undersized pipes and channels in the developed areas of the basin and/or blocked pipes that are clogged with sediment and vegetation.
North Creek (DNR No. 10)	Most of the flooding occurs at roadway culverts and in neighborhoods in the upland areas along the tributaries, where drainage systems are undersized. There were relatively few widespread flooding problems along the main stem, except in the Bothell area.
Puget Sound Tributaries (DNR No. 11)	A number of flooding problems were found in the developed areas as a result of undersized culverts. This study area also has a history of erosion-related problems because of natural processes in the steep ravines; however, development has exacerbated these problems.

1.4 Recommended Solutions

Appropriate and reasonable solutions were developed for many of the significant problems that were identified. As previously mentioned, the project focused on capital project solutions, though non-capital project solutions such as maintenance and best management practices were also recommended where appropriate.

French Creek before and after a culvert replacement

Computer models were created to evaluate the drainage systems, identify future flooding problems, and select appropriate improvements. Hydrologic models were used to determine the amount of stormwater runoff that would occur during a series of storms for both current land use and full buildout of the adopted land use plan. Hydraulic models were used to determine flows through the conveyance system, to identify flooding problems and to evaluate solutions based upon current Title 24 drainage design standards.

Potential projects were modeled for two basic alternatives: (1) solutions relying primarily upon increasing the capacity of the conveyance system, and (2) solutions relying primarily upon a combination of conveyance improvements and maximizing the water storage available in the basin. In this manner the most cost-effective solutions were identified.

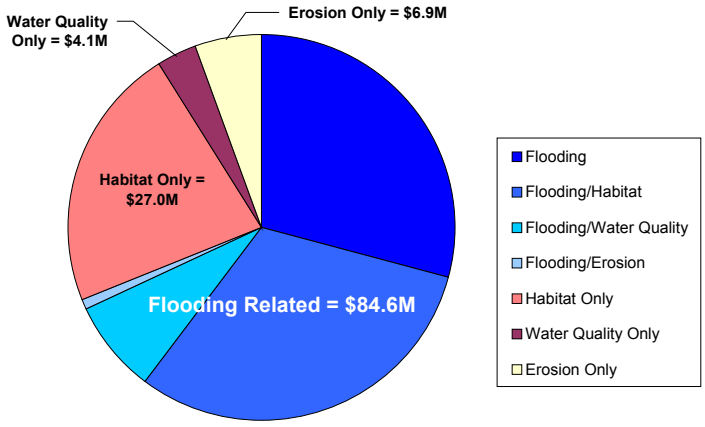
Recommended Projects

Combining all of the recommended projects for the 11 study areas, the reports identify 378 projects with an estimated cost of roughly $123 million. These projects correct flooding problems, enhance habitat, and reduce stormwater pollution. Because current County code does not require that any of the recommended projects be implemented, the County will need to determine which projects will be funded using available or additional revenue and the priority or order of construction. Section 1.5 below discusses a possible process to define implementation priorities and funding opportunities.

Table 1-3 summarizes the total number of recommended projects for each study area while Table 1-4 summarizes the total costs of the projects. As indicated in these tables, the recommended projects were divided into different categories according to the main types of problems that they would address. Four of these categories are for projects that primarily address only one type of problem: flooding, habitat, water quality, and erosion. The other categories represent projects that address more than one type of problem,

including flooding and habitat, flooding and water quality, or flooding and erosion. A typical project that addresses both flooding and habitat problems is a culvert replacement that addresses both a flooding and a fish passage problem. An example of a project that addresses both flooding and water quality problems is the retrofit of an existing detention pond to provide water quality features and to expand the existing detention volume. A typical example of a project that addresses both flooding and erosion issues would be a regional detention pond that reduces downstream flows to help solve both types of problems.

Figure 1-2. Costs of Recommended Projects, by Project Category



As indicated in Figure 1-2, the recommended projects in this study addressing one or more flooding problems represent 69 percent of the cost of all projects.

Table 1-3. Total Number of Recommended Projects, by DNR

DNR	Study Area	Type of Project							
		Flooding	Flooding & Habitat	Flooding & Water Quality	Flooding & Erosion	Habitat	Water Quality	Erosion	Total
1	Quilceda Creek	33	22	0	0	31	4	1	**91**
2	Swamp Creek	35	10	5	0	14	5	0	**69**
3	North UGAs	0	0	0	0	0	0	0	**0**
4	Marshland Tributaries & Sunnyside Creek	12	4	3	0	10	3	11	**43**
5	Snohomish UGA	1	0	0	0	9	5	0	**15**
6	East Valley UGAs	7	0	0	0	12	0	3	**22**
7	Little Bear Creek	4	0	0	0	1	0	1	**6**
8	Allen Creek	7	8	0	0	10	2	2	**29**
9	Stanwood UGA	9	1	0	1	0	0	0	**11**
10	North Creek	34	9	1	0	13	7	0	**64**
11	Puget Sound Tributaries	11	1	0	2	7	1	6	**28**
Total		**153**	**55**	**9**	**3**	**107**	**27**	**24**	**378**

Table 1-4. Total Costs for Recommended Projects, by DNR
(in $thousands)

DNR	Study Area	Type of Project							
		Flooding	Flooding & Habitat	Flooding & Water Quality	Flooding & Erosion	Habitat	Water Quality	Erosion	Total
1	Quilceda Creek	$4,974	$20,103	$0	$0	$7,668	$514	$145	**$33,404**
2	Swamp Creek	13,023	2,245	6,289	0	6,001	744	0	**28,302**
3	North UGAs	0	0	0	0	0	0	0	**0**
4	Marshland Tributaries & Sunnyside Creek	2,893	1,439	1,787	0	1,211	884	5,430	**13,644**
5	Snohomish UGA	236	0	0	0	1,863	386	0	**2,485**
6	East Valley UGAs	796	0	0	0	1,753	0	119	**2,669**[a]
7	Little Bear Creek	115	0	0	0	51	0	47	**213**
8	Allen Creek	2,559	6,017	0	0	2,471	340	412	**11,799**
9	Stanwood UGA	828	100	0	107	0	0	0	**1,035**
10	North Creek	8,821	7,768	1,699	0	4,387	1,104	0	**23,779**
11	Puget Sound Tributaries	1,443	433	0	877	1,656	143	712	**5,264**
	Total	**$35,688**	**$38,105**	**$9,775**	**$984**	**$27,062**	**$4,115**	**$6,865**	**$122,594**

a. Total of rounded numbers does not match rounded total of numbers. See Appendix B for estimated project costs.

Non-Project Recommendations

In addition to the recommended list of projects, some non-project recommendations were also made in certain situations where these types of solutions would be more appropriate or more cost-effective. Examples of some of these types of recommendations include:

- Continue to regularly maintain existing drainage systems, particularly on roadways with heavy traffic and therefore higher pollutant levels.
- Conduct routine sweeping of public parking lots and high-use roadways to reduce pollutants in these areas.
- Promote best management practices to improve water quality.
- Coordinate with local cities and agencies to implement recommended projects.
- Conduct supplemental studies as drainage problems develop in new areas, or as there are changes in land use plans or design standards.

1.5 Next Steps Toward Implementation

Using the list of recommended projects, the next phase of this project will involve selecting and implementing the highest priority projects. An implementation strategy needs to be defined that is based upon a policy framework representing reasonable County funding capabilities and supportive of further development within the Urban Growth Areas.

Identifying Priorities:
The next steps toward project implementation begin with reviewing current financial capabilities and identifying County Council priorities for a stormwater capital improvement program.

A $123 million capital program is certainly beyond current funding capabilities; however, modest revenue increases and other agency support could make significant progress in implementing DNR projects during a 20-year capital improvement program. The next steps toward project implementation begin with identifying County Council priorities for stormwater projects, reviewing funding capabilities, and creating an effective Annual Construction Program and 6-year Capital Improvement Program. Some of the main steps in this process are anticipated to include:

- **Select Highest Priority Projects for Implementation:** The County will need to develop an approved method to prioritize projects for implementation that reflects County Council policy direction. The individual DNR reports provide some guidance regarding how technical issues, such as flooding frequency, could be used to help prioritize projects. Other issues, such as geographical balance, funding equity, sequencing project construction, and permitting, should also be considered in this selection process, consistent with Council policy concerns. Department staff would then use the Council-approved methodology to rank projects quickly.
- **Determine Available Funding:** The County will need to determine how much funding will be available to implement the highest priority recommended projects. A full range of financial resources should be considered, such as REET (real estate excise tax), construction support from other capital programs (such as roads), interlocal agreements with adjacent cities, mitigation from major government construction projects (such as Brightwater), and SWM fees.
- **Adopt a Drainage Construction Program:** Based on the priority list and funding outlook identified above, the County would immediately align its Annual Construction Programs for 2003 and 2004. The County would then develop a 6-year Capital Improvement Program, and later create a 20-year drainage Capital Facilities Plan as a supporting analysis for the County's Comprehensive Plan Update (which plans through 2025).

Work should also continue that will maintain the value of the DNRs and keep them up-to-date:

- **Update Drainage Inventory:** As new drainage systems are constructed for new development or as existing systems are upgraded, this information will need to be incorporated into the current inventory and maps in order to keep it up-to-date. For the larger projects the updated information could be provided by project engineers incorporating "as-constructed" information and other drainage feature information into an electronic file and provided to the County for GIS processing. An alternative method that may be more efficient, especially for moderate to small projects, is for Surface Water Management Division GPS/GIS staff to collect and process the information as a reimbursable activity.
- **Keep Drainage Information Current:** Likewise, the hydrologic and hydraulic models should be updated periodically to reflect changes within the basins. As the County, developers, and other agencies use and expand upon these models for specific purposes, the County can track these changes in order to make the most recent models available. The models will also be an important tool for addressing drainage issues in areas were new drainage problems develop, when a new 20-year land use

Comprehensive Plan is adopted, or when there are changes in regulatory standards such as private detention requirements in the County's drainage code (Title 24). These updated models will enable the County to update its drainage construction priorities to reflect these changed circumstances. The Surface Water Management Division has the knowledge and staff to update and run these models.

Providing for the Future

The County now understands and can address the surface water systems in the Urban Growth Areas. The Drainage Needs Reports are living documents that can continue to provide information and tools for Snohomish County's drainage needs as the County continues to meet the demands that growth brings and deals with current problems and future needs. These reports provide a list of 378 projects that provide a collection of preferred solutions to solve flooding problems and opportunities to improve habitat, water quality and erosion conditions. These projects will be used to define capital investments and evaluate investment options to protect people, property and the environment.