Warrenton

Stormwater Management Plan

Final

Submitted to:
City of Warrenton
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Warrenton, OR 97146

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Preface and Acknowledgements

Development of the Warrenton Stormwater Management Plan was a team effort between the City of Warrenton and consultant services. The individuals listed below contributed their time, expertise, and support to make the project a success.

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Section 1— Executive Summary

1.1 Overview

The City of Warrenton, Oregon contracted with HLB-Otak, Inc. in 2007 for Phase 2 of their Stormwater Master Plan to study their stormwater management system and develop a stormwater management plan with Capital Improvement projects for the City to implement in anticipation of continued growth.

The City previously undertook Phase 1 of the effort, working with CH2M Hill and HLB, Inc. to perform a large data collection effort that included an inventory of the tide gates and topographic survey data on many of the stormwater conveyances in Warrenton.

The City of Warrenton is not currently obligated to manage stormwater per any specific regulatory requirements. The City simply has a growing concern that increased development activity would overload the existing system of ditches that have not been routinely dredged, the tide gates that are leaky or missing, and the pump station that is nearing the end of its useful life. The City recognizes that a comprehensive look is necessary to determine how they should manage the system before investing stormwater revenue in any particular project.

The scope of work for Phase 2 included Meetings, Public Involvement, Characterization of the City's Watersheds, development of a stormwater management strategy, and preparation of a Stormwater Master Plan that includes recommendations for existing facility maintenance and a Capital Improvement Plan. The stormwater management strategy was primarily focused on conveyance and flooding issues. Minimal time was spent discussing stormwater water quality and the relationship between stormwater management and the City's abundant natural resources. The City's development code was reviewed and samples of stormwater ordinances from other jurisdictions were compiled and included for reference in the stormwater management plan document.

Several meetings were held with City staff to inform the consultant team about their current stormwater system, management practices, and existing problem areas and to discuss progress on the project. The City invited several members of the Warrenton Community to participate in two Stakeholder Committee Meetings. The first stakeholder meeting was held on April 5, 2007 to review the data collection and watershed characterization efforts. The second stakeholder meeting was held on September 5, 2007 to review and discuss the list of recommended Capital Improvement projects. The project was presented before a Joint City/Planning Commission workshop on October 16, 2007. A draft of the plan was completed and the project shared with the general public at an open house at City Hall on October 30, 2007. Comments were received and recorded in the Final version of the Stormwater Management Plan.

1.2 Recommendations

Several recommendations resulted from this project that can be implemented in the near-term and over the long-term to maintain livability in the Warrenton Community when it comes to stormwater management. This summary tries to capture all of the recommendations with greater detail provided later in various sections of the document.

Education: Increased public awareness is considered the most important part of any municipal stormwater management program. Simple outreach ideas include:

- Awareness surveys
- Storm drain stenciling
- Posting this plan on your website
- Articles for publication
- Walking and bicycle tours
- Educational signs and plaques

Flood Hazards: Much of the City is located within multiple hazard zones. Continue to coordinate with state and federal emergency management agencies on emergency preparedness and public education. Work with FEMA to sort out issues surrounding recently proposed revisions to the Flood Insurance Rate Maps. Try to locate copies of the data used to produce the previous flood insurance study and maintain a filing location for such data.

Existing Levees: The levee system with culverts and tide gates are a major piece of infrastructure that protects the City from flood waters. Continue with regular maintenance activities and develop a plan for repair/replacement of culverts and tide gates that are deteriorating.

Maintenance of Existing Ditches: The drainage system in Warrenton (behind the levees) relies primarily on ditches that have not all been routinely cleaned due to permitting hurdles and property access issues. The City should have easements for any ditches that they agree to own and maintain. Programmatic permits can be obtained to allow maintenance dredging that restores the ditches to their previous condition.

Development Code: Adopt new ordinances that require development and re-development projects to provide stormwater management facilities designed to remove pollutants from the runoff before leaving the site. A downstream analysis should be required by the developer to document downstream conditions and demonstrate the downstream system has conveyance capacity for additional flows, or that stormwater detention is necessary to restrict the rate of flow released from a site.

Design Standards: Adopt design standards based upon existing guidance documents. Collaborate with other communities to develop a stormwater design manual that is applicable to coastal conditions and consistent with the needs of coastal communities.

Capital Improvement Plan: The Capital Improvement Plan includes recommendations for twelve projects, some of which will generate additional projects. The following list of twelve projects is estimated to cost as much as $6 million to implement. Cost estimates assume projects are bid to private contractors. However, some aspects of the projects could be performed by City crews and result in significant cost reductions.

1. Repair/Refurbish West Hammond Marina Tide gate
2. Repair/Refurbish East Hammond Marina Tide gate
3. Tide Gate Repair & Replacement Plan
4. Evaluate and upgrade existing pump station adjacent to SE 3rd/4th St.
5. Refurbish existing pump station adjacent to NE 1st St.
6. Upsize storm system in west portion of Hammond Marina subbasin.
7. Relieve stormwater drainage issue in the East Hammond/Enterprise Ditch Area.
8. Obtain programmatic permit to allow O&M routine maintenance of City ditches.
9. Create and Implement Monitoring Plan for City of Warrenton
10. Upgrade downtown conveyance system and create definitive connection between north and south downtown pump stations
11. Sanitary Sewer Inflow/Infiltration Study
12. Stormwater Rate Study

Each CIP project was discussed with City staff and assigned a relative priority. Based upon the priorities and feedback from the public at the open house, the projects listed in Table 1.1 are considered LEVEL 1 priority and recommended as the first to be implemented.

Table 1.1: Recommended LEVEL 1 Capital Improvement Projects
CIP 3 Tide Gate Repair & Replacement Plan The City relies upon the levee system along the Columbia River for protection from tidal fluctuations and flooding. A failure in the levee system could be costly in term of damage to property and repair of the levee failure. The Corps of Engineers is undertaking inventory and risk assessment of levees in the Portland District. However, the full scope and timeline for risk assessment of the Warrenton levees is unclear. The tide gates and culverts are the most likely location for a failure due to the ability for water to penetrate into the levee though an eroded head wall or a corroded pipe. It is in the City's interest to complete an evaluation of the condition of the tide gates and associated culverts. The cost and priority for repair or replacement can be determined as a part of the study.
CIP 4 – 3rd/4th Street Pump Station Downtown Warrenton relies upon this pump station to remove stormwater from the downtown area during high tides. This pump station should be upgraded first. In addition, the existing motor can be re-installed on the NE 1st Street pump station until funding becomes available to replace the NE 1st Street pump station.
CIP 8 - Ditch Maintenance Permit Much of the City conveyance system is comprised of open channel conveyances, many of which are regulated by the Corps of Engineers. This CIP would simplify the process involved in performing ditch maintenance by obtaining the regulatory compliance necessary to maintain the City owned ditches.
CIP 12 - Stormwater Rate Study The City needs to identify sufficient funding sources to implement the recommended Capital Improvement Plan, continue on-going maintenance, and maintain/repair the levee system.

Section 2—General Information and History

The Study Area incorporates the entire Urban Growth Boundary (UGB) of the City of Warrenton. The UGB is bordered by the Pacific Ocean and Fort Stevens State Park in the west, the Columbia River in the north, and the Lewis and Clark River in the east. There is no significant geographic feature along the southern boundary of the Study Area, instead the border follows a series of east-west roads, shifting south in the middle and then shifting back north along the Clatsop County Airport. Figure 1 is a base map of the study area.

There are two main waterways that run through the Warrenton UGB, the Skipanon River and Alder Creek. The majority of the study area drains to these two water bodies. In addition there are a number of smaller creeks and sloughs which flow into the Skipanon River, Alder Creek or the Columbia River. The Study Area is mostly flat and at low elevation. The area was dominated by tidally influenced wetlands prior to settlement. A series of levees, tide gates and fill projects reclaimed portions of the City for urbanization. The undeveloped portions of the City are primarily palustrine wetlands. The topography, natural history, and urbanization of the study area have produced complex drainage patterns. Storm runoff and river water can either fill or drain various subbasins depending on tidal conditions and storm intensity. Basins interact with each other differently based on current soil moisture and flood conditions. Most of the stormwater conveyance system within the City has little or no slope, resulting in ponding and localized flooding.

Diking of the Skipanon River began in 1878 and the City was established in 1899. The levee and tide gate system was initially constructed in the late 1800's and early 1900's. The current system configuration dates to improvements engineered by the US Army Corps in the late 1930's. The 8th Street Dam was built across the Skipanon River in the early 1960's to alleviate flooding upstream of this location during high tide conditions. Improvements to the structure were made in 1997 to improve fish passage and water quality. Two pump stations were built near downtown Warrenton in the early 1970's to facilitate drainage of the City during high tailwater conditions in the Skipanon and Columbia. Figure 3 is a flood hazard map overlaid on the Study Area showing the FEMA 100-year Floodplain.

2.1 Basin Boundaries, Location and Areas

The Study Area was divided into four major basins based on drainage to Alder Creek, Skipanon River, Lewis and Clark River and directly to the Columbia River. Only a small portion of the City drains to the Lewis and Clark, the remainder is divided among the other three basins.

Each basin was divided into subbasins based on topography and locations of levees, roads and existing conveyance features such as pipes and ditches. Information from conversations with City employees and an April 2007 site visit was also factored into the determination of basin boundaries. A total of 38 subbasins were delineated, 30 of which are completely within the Study Area and 8 that are partially within the Study Area but still contribute stormwater runoff. The total contributing area, excluding subbasins that empty to the Columbia or Skipanon River without first passing through a tide gate is approximately 5727 acres. Figure 4 shows the major basin and subbasin boundaries for the Study Area.

The topography of the Study Area, especially within the developed area is fairly flat. As such, the subbasins interact with each other in both directions, not just upstream to downstream. Stormwater flows in and out of the subbasins depending on the tidal conditions and storm magnitude. These interactions create complex drainage patterns which are heavily influenced by factors such as antecedent soil moisture conditions and groundwater. In some cases a defined control, such as a culvert, exists and limits subbasin interactions. In other cases the subbasin interaction covers a broad area. Each subbasin eventually drains to a particular tide gate in the City levee system, with a chain of subbasins contributing to some outfalls and only a single subbasin contributing to others.

2.2 Climate

The City of Warrenton experiences a coastal temperate climate strongly influenced by the Pacific Ocean and related weather patterns (Taylor and Hatton 1999). Climate in the Pacific Northwest usually includes an extended winter rainy season followed by a long, dry summer season. In nearby Astoria, air temperatures range between a mean daily minimum of 35° F in January and a mean daily maximum of 70° F in August (OSU-Extension 2000).

The Study Area receives approximately 76 inches of precipitation annually. (Skipanon River Watershed Assessment, 2000) The Astoria Airport reports an annual average of 67.13 inches. This precipitation falls primarily during the rainy winter months. Precipitation is predominantly rain with rare snowfall occurrences that are short in duration. The Skipanon is unique in the Pacific Northwest in that the headwaters rarely see snowfall. As a result, high peak flows due to rain-on-snow events are rare. In February 1996, when much of the Willamette Valley experienced near 100-year flooding, the City's flooding was much less because a portion of the flooding in the Willamette Valley was melt water from a heavy snow pack. On the other end of the spectrum, cloudless days are fairly rare in the study area. Typically Astoria has 242 cloudy days a year, per a 1975 report from the Department of Commerce. Figure 2.1 shows the monthly averages for temperature in precipitation in nearby Astoria.

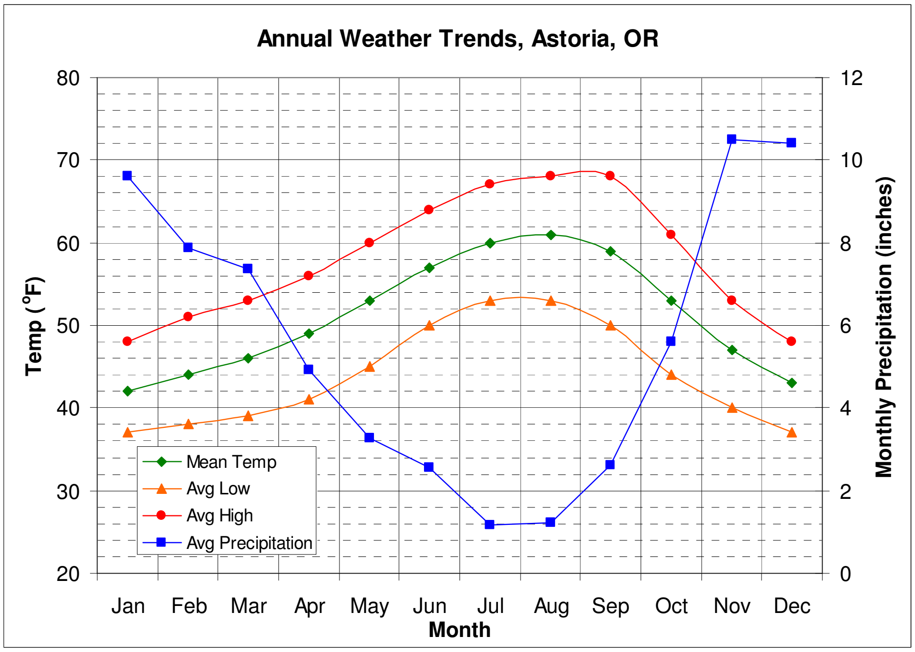


Figure 2.1: Temperature and Precipitation Trends for Astoria Oregon

2.3 Land Use and Surface Cover – Current and Future

Human activities in a watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and aquatic habitats. These types of changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge. Land cover within the Study Area is dominated by urban areas, palustrine wetlands, non-commercial forests, and grasslands. Dunes and groundwater-fed lakes are also prominent features in the western portion of the UGB.

Development is generally concentrated in Warrenton's UGB. The UGB encompasses an area of approximately 13.45 sq. mi, which encompasses 48 percent of the Skipanon River and Alder Creek watersheds. Almost 29 percent of the land within this urban growth boundary is occupied by locally significant wetlands per the City's Goal 5 inventory. Actual wetland boundaries have to formally be delineated to determine actual presence of wetlands. Future development concentrated in the lower elevations of the watershed has the potential to impact wetlands within the urban growth boundary which may lead to the loss of important wetland functions. First, development can result in the placement of fill in wetland areas. Wetlands are regulated so that filling of wetlands must be mitigated by either wetland construction or restoration (some exceptions may occur after evaluation by the Division of State Lands). Second, these same land use activities often result in the channelization and diking of the rivers for flood protection. Loss of these wetland areas may lead to changes in the hydrology of the watershed by decreasing flood water storage and groundwater recharge.

Tables 2.1 and 2.2 show the current and projected future land use breakdown for the City. These percentiles are based on information provided in a draft study by Cogan Owens Cogan, dated 5/03/07. The current land use was evaluated using zoning data and a survey of vacant versus developed lands. The future land use was evaluated using zoning data and a buildable lands inventory created by Cogan Owens Cogan. Any remaining acreage not accounted for in the tables below was considered to be undeveloped. Figures 5 and 6 show a City overview of current and future land use, respectively.

Table 2.1: Current Land Use

Land Use Category	Total Area (acres)	Percentage of Total Study Area
Low Density Residential	732.5	8.5
Medium Density Residential	281.6	3.3
Rural	431.1	5.0
Industrial/Commercial	1512.4	17.6
Undeveloped	5651.4	65.6

Table 2.2: Future Land Use

Land Use Category	Total Area (acres)	Percentage of Total Study Area
Low Density Residential	1209.1	14.0
Medium Density Residential	459.9	5.3
Rural	431.1	5.0
Industrial/Commercial	1816.8	21.1
Undeveloped	4692.1	54.5

2.4 Landform, Topography and Slopes

Topography in the Skipanon River watershed is characterized by flat lowlands bordered by rolling hills and sand dunes. Elevations within the study area range from sea level at the confluence with the Columbia River Estuary to 110 ft in the sandy highlands on the western side of the UGB. Slopes in the Study Area are fairly flat, with an average slope of only 0.65 percent. There are low hills in the western and south-eastern portion of the site with steeper slopes. Figure 7 is a topographic map of the study area, including contours and hill shade.

The Skipanon River watershed and the Study Area feature predominantly Broadleaf (20 percent) and small conifer (17 percent) stands. Less than 1 percent of the watershed is occupied by large conifer stands. The Skipanon River watershed is a unique Oregon coastal basin dominated by low-elevation plains and a high density of wetlands and lakes. Only 52 percent of the entire Skipanon watershed is forested, and less than 20 percent of the watershed is currently managed for timber harvest. These numbers are less inside the study area.

2.5 Surface Water Features and Drainage System

The Skipanon River, Alder Creek and other streams in the watershed are derived mostly from groundwater. Changes in the groundwater hydrology will most likely have greater effects on surface water features than changes in land use in the upper elevations of the watershed which represents proportionally less area.

Except during the winter months, fresh water flow in the Skipanon River is low, averaging approximately 50 cubic feet per second (cfs). Columbia River water and ocean water are the main water masses observed below the 8th Street dam. The Skipanon River is also fed by the outflow from Cullaby Lake. There is no continuous discharge data available for the Skipanon River or for Alder Creek.

The land between the Skipanon River and the airport is characterized by four large sloughs, named Skipanon, Hollbrook, Vera and Adams. A slough is a shallow, secondary channel off of the main waterway. They typically have stagnant or slow moving water and are flushed regularly by the tide. If healthy, sloughs can be quality habitat for a variety of aquatic species. Warrenton's sloughs drain a large portion of the land east of the Skipanon River. Flow into and out of these sloughs is regulated by a tide gate through the levee system. Skipanon Slough empties into the Skipanon River, and the Hollbrook, Vera and Adams Sloughs drain to the Columbia River. The tide gate at the entrances to each of these water bodies has been categorized as a potential fish barrier. The Columbia River Estuary Study Taskforce (CREST) has recently been conducting tests on a new, "fish friendly" tide gate on Adams Slough. The City has expressed concerns, however, that these fish passage tide gates will create flooding issues in the developed area surrounding the sloughs. Water surface elevations could be monitored to substantiate or disprove these concerns.

Drainage facilities consist primarily of roadside ditches with culverts for street crossings. Storm sewer pipe systems are also used in and around the Hammond and Downtown areas. The slope of most of these conveyances are basically flat, leading to sedimentation issues in many of the ditches and pipes in the city, which further reduces capacity. The levee system along the Columbia, Skipanon and Lewis and Clark Rivers prevents high tides from inundating the City. A series of culverts with tide gates connect the City's drainage system to the natural waterways. During high tide, the majority of these tide gates close and do not allow stormwater to drain out of the City. The trapped stormwater is routed to two pumping stations on the west bank of the Skipanon River just north and south of the downtown area. These two stations pump stormwater over the levee system and into the Skipanon River, continuing to drain the City until the tide lowers enough to allow stormwater through the tide gates. Currently only the southern pump station is operational. A 1999 survey of the tide gates by the Skipanon River Council showed that 6 of the 23 tide gates were in need of repair. Many of the current tide gates are old iron doors that no longer work properly or are missing entirely. City maintenance personnel stated these disabled tide gates may allow Columbia River water into the City during high tide, potentially reducing available flood storage. This is especially true of the two tide gates in the Hammond Marina.

The majority of the undeveloped portions of the City are classified as wetlands. The levees and tide gates restrict interaction between the wetland areas and the natural waterways, which may disconnect the stream channels from their floodplains. Disconnecting the floodplain from the stream can lead to stream simplification and down-cutting due to increased water velocities, resulting in erosion and deteriorated habitat conditions. Additionally, disconnection from the floodplain can lead to changes in the biotic structure of the stream by limiting nutrient and organic material exchanges between the stream and floodplain. Except for the sand ridges of the Clatsop Plains, the land area of Warrenton was originally all wetlands. Diking in the Skipanon River began as early as 1860 at the mouth and east side of the river. Between 1917 and 1939, extensive diking occurred in the Skipanon River, with dredge spoil disposal along the mouth. By 1950 dikes ringed the lowlands of the Skipanon.

There are approximately 48 stream/road crossings in the Skipanon River watershed. The Oregon Department of Fish and Wildlife (ODFW) conducted a survey of culverts on state and county roads in the 1990's. Of the six culverts surveyed by ODFW, only two did not meet standards, suggesting that they block access to upstream habitat areas. Neither of these two culverts occurred on the mainstream Skipanon River. There are, however three possible fish passage barriers on the Skipanon River. These are the dams at the 8th Street road crossing, the Plyter Dam, and the Cullaby Lake Dam. These possible barriers are all fitted with fish passage facilities but still may represent partial fish passage barriers. Tide gates not fitted with fish passage facilities act as fish passage barriers. Only the 8th Street Dam is within the study area. It has been retrofitted with fish passage facilities.

2.6 Groundwater

Direct precipitation is the primary source of water entering the Clatsop plains aquifer, although some natural inflow may occur as underflow from the foothills of the Coast Range or in small ephemeral foothill streams that percolate into the ground at the base of the hills. Water leaves the aquifer by discharge to the ocean, either directly as subsurface flow or indirectly as discharge to surface streams, primarily the Skipanon River and Neacoxie Creek (Frank, 1970). Most of the precipitation percolates into the ground. It is estimated that the Clatsop Plains dune sand aquifer contains about 900,000 acre-feet of water. Water in some areas of the aquifer has a short residence time, emerging as discharge to surface waters in hours, days or weeks, while water in other portions may be retained for decades (Frank, 1970).

A distinct feature of the western edge of the study area is the dunes and the lakes within this dune area. Between these dunes are several long, narrow lakes: Coffenbury Lake, Sunset Lake, Smith Lake, West Lake, Crabapple Lake, Wild Ace Lake, Slusher Lake and Clear Lake. Most of the lakes in the Clatsop plains have no streams entering or leaving them and are formed entirely by surfacing groundwater, with water levels fluctuating with seasonal changes in the water table. Cullaby Lake is the major exception in that it is partially fed by a foothill stream, Cullaby Creek. Water levels in the lakes are directly related to water levels in nearby groundwater wells.

The City of Warrenton Public Works Department has several monitoring wells in the downtown area. Terry Ager, a Water Quality Technician for the City stated that the water level in these wells typically stayed within two to three feet of the surface during the rainy winter months and lower during the dryer summer months.

2.7 Wetlands

Wetlands are a prominent landscape feature in the Study Area. They represent a little more than 20 percent of the total Skipanon River watershed area. The predominant wetland type is palustrine. Palustrine wetlands are defined as all non-tidal wetlands dominated by trees, shrubs, and persistent emergents and all wetlands that occur in tidal areas with a salinity below 0.5 parts per thousand (Mitsch and Gosselink 1993, Cowardin et al. 1979). Although wetlands may or may not contribute large woody debris (LWD) to the stream channel depending on the wetland type, they do provide several important fish habitat features, such as back channels and cover. Unfortunately, many of these wetlands are now diked and disconnected from the stream, limiting access to this habitat. Wetland features in the Skipanon River watershed may have historically been a more important feature than LWD, as none of the riparian areas in the Skipanon River watershed demonstrate an adequate potential to contribute LWD to the stream channel. Stream shading in the Skipanon River watershed is generally low to moderate. Sub-watersheds have large proportions of wetlands in the riparian areas, ranging from 20 to 42 percent. Wetlands can provide shade from vegetation. Most undeveloped areas within the UGB have been classified as wetland, either Locally Significant Wetlands (LSW) or non-LSW.

2.8 Water Quality & Sediment sources

In general, water quality is typically managed to protect the most sensitive beneficial use. In Warrenton, managerial responsibility varies depending on the location. The City of Warrenton, the Port of Astoria, Clatsop County, the State of Oregon and federal agencies all manage different parts of the watershed and its array of wetlands, sloughs and stream channels. In the case of the Skipanon River watershed, the most sensitive beneficial use is likely salmonid fish spawning. It is assumed that if the water quality is sufficient to support the most sensitive use, then all other less sensitive uses will also be supported. For the Study Area, temperature and dissolved oxygen are considered to be the areas of greatest concern in regards to water quality. (Skipanon River Watershed Assessment, 2000) The levee tide gate structures along the Skipanon and Columbia Rivers significantly reduce the "flushing effect" of the tidal fluctuations. As a result, waterways behind the levees become stagnant and subject to contamination. Water bodies can become dissolved oxygen deficient or anoxic under certain conditions. Lack of shoreline shade in the majority of the Study Area further exacerbates this problem by increasing water temperatures, especially in the summer months. Water's ability to absorb dissolved oxygen decreases as temperature increases. Salinity intrusion occurs whenever salinity is present in the adjacent Columbia River waters. Despite the low fresh water flow, strong vertical differences in salinity occur during the fall, and bottom waters may also become stagnant. Dissolved oxygen levels well below state and federal standards have been observed (Boley, 1975). Water quality and dissolved oxygen has been a major concern in the City's many sloughs, particularly during the drier summer months.

In the Skipanon River watershed, slope instability, road instability, and rural road runoff were determined to be the most significant sediment sources based on the location of the watersheds (Oregon Coast Range) and the local land use. (Skipanon River Watershed Assessment, 2000) Streamside landslides and slumps can be major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Rural roads are a common feature of this watershed. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of rural roads in the upper watershed, especially unpaved gravel and dirt roads, indicates a high potential for sediment contribution to the stream network, which could impact water quality downstream within the study area.

2.9 Soils

Knowledge of local soil conditions and their response to precipitation is essential for evaluating a drainage system. Many disposal paths are possible for precipitation. Precipitation may evaporate, collect in depressions, be intercepted and used by plants or infiltrate into the soil. Stormwater runoff occurs when precipitation exceeds the capacity of these paths. The existing degree of soil saturation and the slope of the drainage basin also affect runoff rates. Runoff potential is based on the soil's capacity to absorb precipitation. Sandy soils have higher infiltration capacity and lower potential than soils with a high percentage of clay.

A portion of the Study Area is made up of the Clatsop Plains, which are comprised of sand dunes, tidal flats and floodplain alluvium. The Clatsop Dunes are a series of sand ridges formed by wind. The source of these dunes is sediment from the Columbia River deposited since Pleistocene time that is constantly reworked by wind, waves and rain. In some parts of the dunes the sand is over 150 feet deep. Floodplain alluvium occurs along the Columbia River and Skipanon River at the Northern End of the Clatsop Plains (Skipanon River Watershed Assessment, 2000).

The primary soils of the Study Area are the Coquille-Clatsop(C-C), Grindbrook-Walluski-Hebo(G-W-H), and Waldport-Gearhart-Brailler (W-G-B). The C-C soils are very deep, very poorly drained silt loam and muck and are located on tidally influenced flood plains. The G-W-H soils are deep to very deep soils, moderately well drained or poorly drained silt loam and silty clay loam found on terraces. The W-G-B soils are very deep, and are either: excessively drained, somewhat excessively drained, or poorly drained fine sand, fine sandy loam, or mucky peat found in dunes and swales (Smith and Shipman, 1988).

The Natural Resource Conservation Service (NRCS) rates soils into four categories based on their infiltration capacity, water transmission rate and runoff potential. Hydrologic Soil Group (HSG) D produces the greatest amount of runoff and HSG A produces the least amount. Within the study area, approximately 53.6 percent is HSG D, 7.5 percent is HSG C, less than 1 percent is HSG B and 34.5 percent is HSG A. The remainder is water. Figure 8 is a map of the soil types for the study area.

Section 3—Stormwater Model Development

3.1 Introduction

The City of Warrenton stormwater system is a complex series of sloughs, vegetated channels, stormwater pipes, roadside ditches, tide gate culverts and pump stations. Tide levels in the Columbia River routinely reach elevations that close the tide gates and prevent the City from draining. Some tide gates are in disrepair, allowing Columbia River water to flow into the City during high tides. Debris filled channels and pipes and tide gates cause backwater conditions and localized flooding. The lack of significant elevation change in most areas of the City results in ditches and pipe with little slope. This magnifies the stormwater conveyance problems. Large portions of the City are classified as wetland, and these areas are typically saturated during the wet winter months. Many subbasins of the City are linked through direct or indirect pathways, further complicating the drainage patterns.

To accurately model the City's entire stormwater system with all of its intricacies would require extensive survey and time-intensive model building and calibration runs. To do so would not be economically feasible. Detailed modeling of areas of the City that are undeveloped and un-buildable is unnecessary. The solution was to simplify the City-wide model down to a network of storage nodes for each subbasin and links connecting each subbasin hydraulically. The storage areas where connected to the tidally influenced Skipanon and Columbia Rivers through culverts and tide gates. This approach allowed the entire City to be modeled, focusing on the hydrologic results and the influence of the tides and tide gates. Links were placed at key points between subbasins to simulate the interconnectivity of the City's drainage patterns. Once the city-wide hydrologic model was completed, it provided the flow inputs for smaller, more detailed stormwater models in areas that required a more thorough analysis. Using this strategy, the many factors influencing stormwater drainage in the City were simulated. The detailed modeling effort was focused on problem areas and potential Capital Improvement Projects.

Elevation data for this study came from many different sources, with many different datum. NAVD-88 was chosen as the standard datum for all modeling and mapping. Information used from sources referenced to different datum's were converted to NAVD-88 using Table 3.1.

Table 3.1 – Datum Conversion Factors					
TO / FROM	NGVD-29 (FEMA)	NAVD-88	Astoria Tide Station Datum	USACOE tide gate as-builts	MLLW (Tide Chart)
NGVD-29 (FEMA)	--	+3.67	+1.65	-1.00	+3.88
NAVD-88	-3.67	--	-2.02	-4.67	+0.21
Astoria Tide Station Datum	-1.65	+2.02	--	-2.65	+2.23
USACOE tide gate as-builts	+1.00	+4.67	+2.65	--	+4.88
MLLW (Tide Chart)	-3.88	-0.21	-2.23	-4.88	--

3.2 Hydrology

3.2.1 Methodology

Runoff rates for the City were determined using the Santa Barbara Urban Hydrograph (SBUH) method. The SBUH method is a popular and commonly accepted method for calculating runoff, since it can be done with a spreadsheet or by hand relatively easily. The SBUH method is the standard method for calculating runoff rates throughout Oregon and eastern Washington.

The SBUH method uses two steps to synthesize the runoff hydrograph (from City of Seattle stormwater manual):

There are four key inputs to the SBUH method:

- Pervious and impervious land acreage quantities
- Time of concentration (T_c) calculations
- Design storm intensity and hyetograph
- Runoff curve numbers (CN) applicable to the site

All land areas were determined through GIS data from public and private sources. Per the scope of work for this phase of the project, precise quantities of pervious and impervious area were not determined. Instead an assumption of impervious percentage was made for each of the four land use categories. This percentage is based on City developmental code and Portland BES standards. The pervious portion was split into forest, brush, grassland.

Table 3.2 summarizes the percentages used in the model.

Table 3.2: Cover Type Percentage for Land Use Categories				
Cover Type	Impervious	Forest	Brush	Grassland
Low Density Residential	38%	20%	42%	0%
Medium Density Residential	65%	10%	25%	0%
Rural	10%	10%	10%	70%
Commercial and Industrial	80%	10%	10%	0%
Roadway (includes ROW)	70%	0%	30%	0%

Time of concentration (T_c) represents the time for runoff to travel from the hydraulically most distant point of the watershed. The calculation is based on the method described in Soil Conservation Service (now NRCS) publication 210-VI-TR-55, 2nd Ed., 1986. Slopes in each subbasin were determined using the LIDAR data and GIS. Sheet flow was allowed for a maximum of 300 feet. Survey information, aerial photography and LIDAR data were used to determine shallow concentrated flow and open channel flow for the remainder of each subbasin's flow path. The time of concentration was assumed to be identical for current and future land use conditions.

The NRCS curve number relates a land area's runoff depth (precipitation excess) to the precipitation it receives and to its natural storage capacity; the more natural storage capacity available, the lower the curve number. Natural storage can take the form of voids in the soil column, local depressions in the topography, interception storage in the tree canopy and other forms. Table 3.3 summarizes the curve numbers used for the hydrologic modeling effort. These values are from the NRCS TR-55 manual. High antecedent moisture conditions, representing the extremely wet conditions Warrenton sees in the winter and early spring, were factored into the curve number determination. It was assumed that soil type did not change from current to future land use conditions.

Table 3.3: Curve Numbers				
	Hydrologic Soil Group			
Land Type	A	B	C	D
Impervious	98	98	98	98
Wetland	100	100	100	100
Forest	30	55	70	77
Brush	35	56	70	77
Farmland / Grassland	49	69	79	84
Commercial / Industrial	85	90	93	94
Low Density Residential	61	75	83	87
Medium Density Residential	77	85	90	92
Rural	49	69	79	84

Source: NRCS

The design storm hyetograph is essentially a plot of rainfall depth versus time for a given design storm frequency and duration. It is usually presented as a dimensionless plot of unit rainfall depth (increment rainfall depth for each time interval divided by the total rainfall depth) versus time. This study utilized the Type 1A design storm distribution for all hydrologic calculations. The Type 1A curve is the accepted design storm hyetograph for western Oregon. Figure 3.1 shows a sample Type 1A distribution. Precipitation depths are discussed in Section 3.2.2.

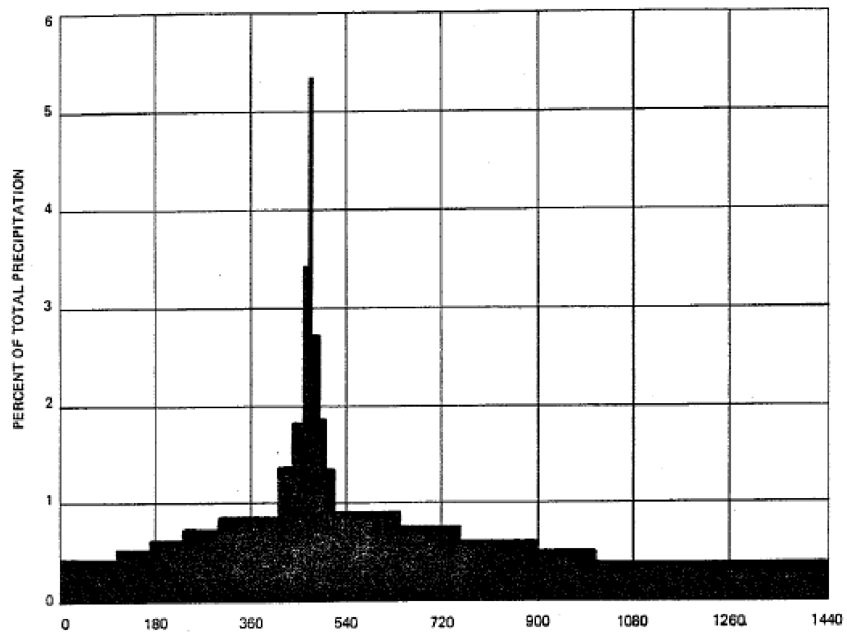


Figure 3.1: Sample Type 1A Rainfall Distribution Curve (from King County SWM)

As was discussed in Chapter 2, each basin was divided into subbasins based on topography and locations of levees, roads and existing conveyance features such as pipes and ditches. City staff also provided input about subbasin boundary locations. Topography and basin interactions make basin delineation fairly difficult, especially in the flat, marshy area west of downtown.

All developed or potentially developed land was grouped into one of four land use categories. These are Low Density Residential, Medium Density Residential, Commercial/Industrial and Rural. Clatsop County Zoning Data is more detailed than this, with 17 zoning classifications. These were grouped into the four desired categories by comparing descriptions of the classifications in the development code with curve number tables in WRCS TR-55. Table 3.4 how the Clatsop County Zoning classifications were grouped into one of the four categories used for this study.

Table 3.4 – Zone Grouping	
Project Zoning Category	Clatsop County Zoning Classification
Low Density Residential	R10, R40
Medium Density Residential	RM, RH
Commercial / Industrial	I1, I2, C1, C2, CMU, RC
Rural	RGM, URR, OSI
Other (not used in hydrologic calculations)	A-1, A-2, A-3, A-5

3.2.2 Precipitation Design Events and Rainfall-runoff model

The precipitation depths used for the hydrologic model and summarized in Table 3.5 are from a digitized map of the National Oceanic and Atmospheric Administration (NOAA) Atlas 2, Volume 10 (1973). An attempt was made to compare the isopluvial maps to local standards, but research uncovered that no north coast city has set standards for design storm intensities. A review of past HLB-Otak projects in surrounding cities revealed that the NOAA atlas is the standard for runoff calculations when the unit hydrograph method is utilized.

Table 3.5 – NOAA 24-hr Precipitation Depths	
Design Storm Return Period	Depth (inches)
2-year	3.1
10-year	4.35
25-year	5.1
100-year	6.1

The Oregon Climate Center is in the process of updating design storms in Oregon. The City should check back with the OCS periodically to see if new design storms are available for Warrenton.

3.2.3 Current Land Use Hydrology

The current land use was determined using data from several sources, including zoning data from Clatsop County, wetland locations from the local wetland inventory (LWI), current land-occupation status (i.e. vacant or non-vacant) from Cogan Owens Cogan, and satellite imagery for determining land use on vacant and non-categorized areas of the city. These data sets were combined into one GIS dataset using ArcMap, forming individual parcels with specific characteristics. An Excel spreadsheet was used to determine each parcel's curve number based on the soil type and land use shown in Table 3.3.

Parcels were then grouped by subbasin to determine composite curve numbers and total contributing area for each subbasin. These values, along with subbasin time of concentration, were imported into XP-SWMM for use in the SBUH hydrologic model. Model runs yielded current land use peak runoff rates for each design storm.

3.2.4 Future Land-use Hydrology

Hydrologic calculations for future land use assumed full build-out of the City. Full build-out assumptions are based on Cogan Owens Cogan's July 2007 City of Warrenton Buildable Lands Inventory. In this study each parcel was categorized as "buildable" or "non-buildable" based on various factors, with the primary factor being the location of the City's extensive wetlands. All currently developed land and all "buildable" land was considered developed for the future land-use analysis. With this information, the Current Land Use curve number dataset was modified to determine subbasin composite curve numbers for Future Land Use conditions. These curve numbers, along with subbasin area and time of concentration, were inputted into the SBUH hydrologic model. Model runs yielded future land use peak runoff rate for each design storm.

Many of the subbasins saw little change from existing to full build-out condition. This is because much of the City's undeveloped land is considered wetland in the rainy winter months. These wetland areas actually have a higher curve number than most development because the ground in wetland areas is already saturated or even has standing water. Rainfall in these areas is not absorbed and immediately becomes runoff. Areas with fewer wetlands, such as Hammond, saw a greater increase as a result of projected development. Comparison of peak flowrates for the 25-year design storm in key basins is shown in Table 3.6. These flow rates represent the runoff generated for each subbasin from the hydrologic model and do not account for hydraulic routing from other basins or tidal conditions. It is meant as a comparison of the runoff generated in current and future conditions. The complete set of hydrologic model results can be found in the Appendix C.

Table 3.6: Hydrologic Model Comparison – 10-yr Design Storm			
Subbasin	Current Land Use (cfs)	Future Land Use (cfs)	Percent Increase
HamWSA	24.2	67.6	180%
HamESA	34.2	43.5	27%
EntSA	89.6	92.3	3.1%
NE1st1	13.5	15.9	17.8%
NE1st2	23.8	25.1	5.5%
SE3rd1	77.3	79.0	2.2%
SE3rd2	9.7	10.2	5.6%
KingSA	26.5	38.6	45.6%
HB1	39.8	45.2	13.6%
HB2	38.5	41.7	8.4%

3.3 Hydraulics

A City-wide hydraulic model was built in XP-SWMM v10.0. Establishing a hydraulic portion of the model allowed for the connection of subbasins and the simulation of the tides and tide gate influences. The hydraulic model was created using the EXTRAN module, which allows for varied flow, varied tailwater conditions, backwater effects and hydraulic structures such as weirs and pumps.

Geospatial data for building the hydraulic portion of the model came from several sources. Survey data complied during Phase 1 of the Stormwater Management Plan was the primary source for the existing stormwater conveyance system. Complete data tables of the survey data is provided in the Appendix E. The tide gate and levee data came from USCAOE as-built drawings. Survey data and tide gate photographs from the Phase I portion of the project were also very helpful. Natural channel cross sections, such as Alder Creek and Holbrook Slough were determined using LIDAR data of the City. The LIDAR data was created during a recent USGS project involving the Lower Columbia River. The LIDAR data was also used to estimate available stormwater storage available in each subbasin. By evaluating the available storage at regular elevation intervals, a stage-storage relationship was created for each subbasin and input to the model. Additional stormwater facility locations and sizes were determined through personal communication with City personnel and a site visit in April 2007.

Creating the City-wide stormwater model was a multi-step process. First, the Columbia and Skipanon Rivers were modeled using cross sections generated using LIDAR data. Only the left bank of the Columbia River was simulated, and the upstream input flowrate was adjusted accordingly. The Skipanon River was modeled from the confluence to the Fort Stevens Highway Spur Bridge south of downtown. The tidal fluctuations in these rivers were simulated by varying the outfall tailwater elevation. By putting a zero slope on the modeled rivers, the "tidal" level transferred throughout both river reaches, creating a smooth, sinuous tidal fluctuation that mimics gauge data recorded at the Astoria tidal gauge. Tides are discussed in greater detail below.

Once boundary conditions and the major water ways were defined, storage nodes representing each subbasin were defined in the model. Primary connections between subbasins in the same major basin were created using survey data and LIDAR generated cross sections. Secondary connections between subbasins of different major basins were input where applicable. In cases where a direct connection did not exist, a wide channel or weir was used. Elevations for these links were taken primarily from LIDAR data. Tide gate elevations were based on USACOE as-builts. These structures control the flow into and out of the interior storage areas. Tide gates are discussed in further detail in section 3.4 below. Figure 9 shows a schematic of the City-wide stormwater model.

3.4 Tidal Influence, Levees, Tide Gates and Pump Stations

Tailwater conditions are an important factor in the performance of any drainage system. A high tailwater can greatly reduce the ability of stormwater runoff to pass through a culvert or storm pipe. Backwater effects due to a high tailwater can significantly lower the capacity of open channels and culverts. The City's low elevation and its close proximity to the tidally influenced Columbia River make tailwater conditions a key component of the stormwater puzzle. As Warrenton lies approximately between river miles 5 and 9 of the Columbia River, water elevations in the Columbia River and the Skipanon River are heavily influenced by Pacific Ocean tides. Water elevation can fluctuate 7 feet diurnally, with a mean high water of elevation 8.15 and a mean low water of elevation 1.38 and can differ as much as 15 feet annually, ranging from elevation -2 to elevation 13. Table 3.7 gives some statistics from the Astoria tide station. All reported elevations were converted to NAVD-88. All information was gathered from the NOAA website. (http://tidesandcurrents.noaa.gov/station_info.shtml?stn=9439040%20Astoria,%20OR)

Table 3.7 –Astoria Tide Information	
Statistic	**Elevation (ft)**
Mean Tidal Level	6.74
Mean High Water	8.82
Mean Low Water	8.15
Mean Higher-High Water	1.38
Mean Lower-Low Water	0.21
Maximum Station Water Level	12.58 (1983)
Minimum Station Water Level	-3.64 (1979)

In lieu of using a constant tailwater condition, a time series was created that varied the tailwater elevation at the outfall over a period of several days. This allowed the stormwater model to reflect the varied tidal effects. Tide data was collected from the published NOAA database for the tide station in Astoria, Oregon (Station ID# 9439040). The water surface elevation difference between Astoria and Warrenton is typically only ±0.1 feet, so no correction was made in the data for this study. Approximately 15 years of data was reviewed for use in the model. Statements made during the April 2007 Citizen Advisory Committee meeting about periods of significant flooding in town allowed particular periods to be isolated. November 11-17, 2001 was chosen as the primary time series to use. Three other events were also tested in the model. The November 2001 storm represents a period of high low tides on the Columbia and a 2-year storm event in Warrenton. Table 3.8 gives summary statistics of several tidal events. The City experiences most of its flooding problems when the low tide in a tidal cycle is unusually high. The invert elevations of most of the City's tide gates are below elevation 4. When the low tide does not drop below this elevation, a large portion of the City is unable to drain effectively through the gravity fed tide gates for days at a time. Flooding within the City occurs if this high tide cycle coincides with a large rain event in the City. Adjusting the tide time series and the precipitation intensity allowed the model to test a wide variety of scenarios.

Table 3.8: Tide Events							
Name	Start Date	End Date	Max EL (NAVD-88)	Min EL (NAVD-88)	Diff (ft)	Avg. EL (NAVD-88)	% of time Over EL=4
Tide 1	11/11/01	11/17/01	11.2	-0.97	12.17	5.2	61%
Tide 2	2/17/96	2/24/96	11.95	1.16	10.79	6.7	77%
Tide 3	12/10/99	12/17/99	10.68	1.76	8.92	6.4	84%
Tide 4	12/11/02	12/18/02	11.2	0.25	10.95	6.1	79%

The City's levees range in height from elevation 15 to elevation 17 (NAVD-88). The levees were modeled in conjunction with the City's tide gates. The Columbia and Skipanon Rivers were separated in the model from the City by links representing the tide gates. The levees are effectively modeled by only allowing runoff to drain to the river through the tide gates. The overtopping elevation of the boundary nodes were set at the levee crest elevations. No storm events or tidal conditions were modeled that overtop the levees. LIDAR data was used to estimate available stormwater storage behind the levee in each subbasin at elevation 1 through elevation 11 in 1 foot increments. This allows runoff to fill the available storage area behind the levee and then release to the river as tide gate capacity and tailwater conditions allow. The maximum elevation of the runoff in each storage area for each scenario provides insight into potential flood areas.

The tide gates are critical to the City's stormwater system as the vast majority of the City's stormwater runoff passes through them. The tide gates regulate flow between the City and the rivers, which is dictated by the tide gate culvert's size, material and invert elevation. The majority of Warrenton's tide gate are made of cast iron and hinged at the top. The tide gate itself is attached to a culvert, either wood stave or corrugated metal, which runs through the levee. Tide gates on Alder Creek and Adams Slough are rectangular concrete boxes. "As-built" construction drawings of the levees and tide gates provided by the USACOE were used to populate the model with required tide gate dimensional information. Manning's "n" were estimated based on the construction material and the tide gate photos from the Phase 1 site visits. Typically the older tide gates are constructed of wood stave pipe and the newer tide gates are concrete box culverts or corrugated metal pipes. Entrance and exit loss coefficients were applied when applicable. Exit losses were typically increased to simulate the losses due to the large restorative force associated with cast-iron, top-hinged tide gates. By design, tide gates, when functioning properly, only allow flow in one direction. During high tailwater conditions water pressure and lack of head differential between the inland and river side of the tide gate closes the tide gate flap. XP-SWMM only has a "tide gate" modeling option for the outfall. The software does however have an option to permit "downhill" flow only in conduits. The option allows the model to simulate any number of tide gates without having to create a large number of outfalls. Altering this option enables the model to simulate a combination of tide gates in the City that are either operational or non-operational. It also makes simulating the tidal effects uniformly throughout the model possible. A table found in Appendix D lists the City's tide gates and gives some summary information about material, size and condition. A photographic summary is also found in the Appendix D.

Recognizing the flooding hazard during high tide periods, the City installed two pump stations in the 1970's in the downtown area. The pump stations consist of a grated ditch inlet connected to a wet well. The vertical shaft-driven pump siphons stormwater out of the wet well and pumps the runoff over the levee through ductile iron pipes and into the Skipanon River. Each pump is equipped with a 40 horsepower motor that turns on and shuts off automatically at pre-set water elevations in the wet well. By the mid-1990's the southern pump station's pump motor was no longer operable. The City moved the motor from the northern pump station to the southern pump station, fixing the problem, but leaving the northern pump station out of commission. The southern pump station continues to function as the City's lone stormwater pump, but is susceptible to power outages and periodic mechanical conditions resulting in pro-longed downtime. There is no defined hydraulic connection between the two pump station's subbasins, though several overland routes and small drainage pipes provide an indirect connection during high flows. While these pump stations have the potential of being an integral part of a successful stormwater system, their current condition limits their capabilities and their reliability to function as designed. Figure 3.2 is a schematic of how the current pump stations are configured.

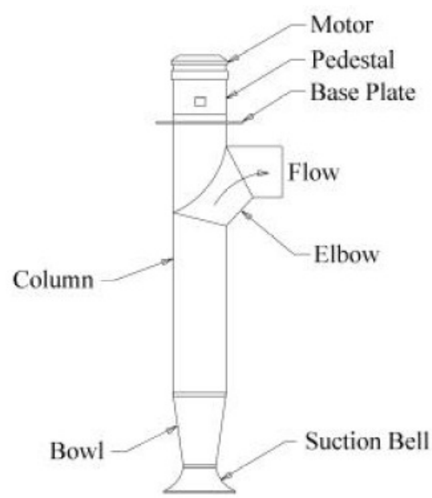


Figure 3.2 – Schematic of existing stormwater pump

The pump stations are modeled in XP-SWMM using the software's pump station feature at their appropriate locations in the stormwater system. They are modeled as "static head pumps" with specific elevations at which the pump turns on and off. The "pump-on" and "pump-off" elevations were taken from as-builts and converted to NAVD-88. Very little information is known about the performance curve of the pump itself, so assumptions were made based on the motor's identification plate. The pump was estimated to have a 50% efficiency rating. The head differential was estimated at 7 feet based on as-built drawings showing water elevations. From this information, the pump's output was calculated to be approximately 20 cfs or 8,750 gpm. The lack of pump performance curve information necessitated the assumption of a constant output flow rate regardless of inlet water elevations (i.e. static head). Upgraded pump stations simulated during the CIP analysis were modeled in XP-SWMM using performance curves provided by a local pump supplier.

3.5 Existing Storm System Evaluation

Warrenton's existing conveyance system was evaluated. It is extremely flat in most places, allowing bi-directional flow depending on tailwater conditions. Only two parts of the city, the downtown area and the Hammond/Enterprise area, have a continuous system of significant pipes and engineered channels. The rest of the City's system is localized and sporadic. It consists primarily of roadside ditches and old drainage canals that have been allowed to return to what resembles a natural channel. These channels are typically filled with vegetation, debris and blockages. Most of the drainage canals have not been maintained in many years and are also clogged with vegetation and sediments. Many of the piped systems in the outlining areas consist of catch basins and pipes with diameters of 8-inches or less. They are primarily used to drain parking lots and other impervious areas and empty to the nearest ditch or channel. Survey revealed that many of the catch basins and pipes have suffered from sedimentation. Two aspects of the City's system lend themselves to evaluation through stormwater modeling.

The first of these is the City-wide system of levees and tide gates. As stated earlier in this chapter, the modeling effort focused on the tide gates, tidal effects, pump stations and available stormwater storage behind the levees. The peak flow rate, passing through each tide gate, was compared to the peak flow rate entering each subbasin through rainfall and inter-basin transfer of runoff. Stormwater accumulations in the storage areas were also analyzed. Limitations were identified and addressed in the recommended Capital Improvement Projects (CIP). The area affected behind the tide gate played a large role in determining which tide gates should be upgraded. For instance, much of the land east side of the Skipanon River is either wetland or forest. These areas had a lower priority than tide gates that served a heavily developed area. Table 3.9 shows the performance of tide gates for the 25-year design storm under existing conditions.

Table 3.9 – Tide Gate Performance (Results from 25-yr Design Storm)			
Tide Gate #	Conduit Model Name	Max Computed Flow (cfs)	Max Compute Velocity (ft/s)
1	1.30inCMP	14.8*	3.1
2	2.30inCMP	9.8*	2.4
3	EntCon	33.9*	3.6
4	D1-A3+24	1083.0	8.7
5	D1-14+12	99.7	6.2
6	42inCMP	58.2*	6.1
7	D2-2+16	12.2*	7.1
8	G3+40	0.9	2.0
9	3rdStTG	92.4	5.8
10	D2-41+90	0.9	1.2
11	8th Street Dam	413.4*	2.5
12	64+85	11.0*	6.5
13	R2+21.2	34.1	7.4
14	111+00	10.5*	6.3
15	37+81	38.3	5.2
16	GalenaTG	4.4*	8.0
17	22+00	131.1	6.0
18	177+00	64.2	6.5
19	125+00	102.5	5.5
20	95+28	250.0	5.9
21	59+88	26.3	5.4
22	26+45	117.8*	9.3
23	Link4	47.6*	4.7
* Indicates max computed flow exceeds design flow – Possible because of head build-up on the upstream end of the culvert			

Two portions of the City's existing system were modeled in detail using XP-SWMM. The downtown subbasins and the Hammond/Enterprise area both have a system of continuous pipes and ditches that drain to specific tide gates. These two areas are shown in detail in Figures 10a and 10b. All major existing conveyance components were included in the evaluation. Three separate XP-SWMM stormwater models were created as part of the CIP evaluation for these two areas. One covered the West Hammond subbasin and tide gate. The second modeled the East Hammond and Enterprise subbasins. The final model covered the two downtown subbasins. See the CIP's in Chapter 5 for a discussion of the existing system and recommended improvements.

Section 4— Stormwater Management Strategy

This section of the Stormwater Management Plan (SWMP) outlines strategies and provides recommendations that will update the City of Warrenton's water quality and natural resource management and regulations guidelines. This information is specifically designed to address the management of stormwater quality in the context of the City's location within the 100-year floodplain of the Columbia River. Accordingly, the need to control the potentially deleterious effects of stormwater runoff as it relates to maintenance and operation of storm and surface water conveyances (ditches, culverts, and tide gates) and the protection of natural resources is discussed.

4.1 Water Quality

This section of the Plan outlines the requirements of each of these various stormwater related obligations of the City. This includes analysis of the City's upcoming stormwater regulatory requirements and activities needed to meet existing surface water management obligations, including compliance with applicable regulations.

4.2.1 Summary of Regulatory Requirements

Clean Water Act

The Federal Clean Water Act (CWA) requires States to set standards for pollution and enforce violations. The goals of the CWA include maintaining surface water that does not threaten the health of fish, shellfish, or wildlife. These goals establish standards for the specific chemical criteria set by the State of Oregon Department of Environmental Quality (DEQ).

DEQ has established water quality criteria for the protection of fresh waters of the state. These surface water criteria are used to highlight discrepancies between the quality of the water body being analyzed and the quality of water needed to support a healthy aquatic ecosystem. Section 303(d) of the CWA requires that a list be developed of all waters not meeting these criteria (considered threatened or impaired).

According to the Federal Clean Water Act, states are to review their water quality standards at least once every three years. This process is often referred to as the "triennial review". During the review, states revise standards to incorporate the latest scientific information and to make any other revisions the State determines are needed. DEQ's last review cycle was from the fall of 1999 until the fall of 2003. Temperature and toxic pollutants criteria and beneficial use designations have been revised. Turbidity criteria are under review and DEQ expects to revise the turbidity criteria in 2005. From 1999 through 2003, DEQ assembled a Policy Advisory Committee (PAC) and Technical Advisory Committees to advise the Department on standards revisions.

TMDL/303d List

Section 303(d) of the CWA mandates that the state establish the Total Maximum Daily Load (TMDL) of pollutants on the 303(d) list. The TMDL determines the amount of a given pollutant that can be discharged to the water body and still meet water quality standards. DEQ is responsible for assessing and compiling this list of impaired and threatened water bodies and submitting the 303(d) list to the EPA for Federal approval. The DEQ then summarizes this information in the Oregon Water Quality Index (OWQI). The OWQI analyzes a defined set of water quality variables and produces a score describing general water quality. The water quality variables included in the OWQI are temperature, dissolved oxygen (percent saturation and concentration), biochemical oxygen demand, pH, total solids, ammonia and nitrate-nitrogens, total phosphorus, and bacteria.

Data used in the OWQI summary that apply to the City of Warrenton were collected at a station located in the Skipanon River a Highway 101 from 1996 through 2006. Water quality at this site has declined over the ten years of monitoring and factors leading to degradation of water quality may include increased levels of point or non-point source activity and/or decreased flows. In 2007, the OWQI rating for this station was "very poor", indicating a significant trend in quality decrease and a designation for the Skipanon River of water quality limited. The Skipanon River was classified as impaired because of the frequency of exceedance for temperature, dissolved oxygen (DO), nutrient levels, bacteria levels, and possible pH. As required by the CWA, impaired water bodies must be further analyzed for the parameters of concern using a Total Maximum Daily Load (TMDL) study.

On June 30, 2003, the North Coast Subbasins Total Maximum Daily Load (TMDL) was issued as an order by DEQ (DEQ 2003). The area covered by the North Coast Subbasins corresponds to four fourth-field hydrologic units that drain to the Lower Columbia River, including the Skipanon River and Young's Bay. The document includes TMDLs for temperature concentrations in tributaries discharging to the Columbia River, including the Skipanon River and Young's Bay. Dissolved oxygen will be treated separately as DEQ determines the full scope of dissolved oxygen limitations throughout the basin, but there is no TMDL for DO at this time.

The TMDL for temperature addresses the migration and rearing temperature criteria of 64°F and the spawning criteria of 55°F. The critical period for these temperatures is the summer through early fall, when low stream flows coincide with maximum solar radiation. Two main sources of thermal loading were identified including: 1) increased loading due to riparian alterations and 2) that from warm water point source discharges. This TMDL requires specific measures be taken to reduce water temperature pollution from entering the Columbia River. Stormwater management and the maintenance of the conveyances that carry that water to the Skipanon River are important components in improving temperature conditions in stormwater draining the City of Warrenton.

Lake Water Quality

Water quality parameters of concern have also been identified in several lakes within the City of Warrenton's boundary. In 1994, DEQ listed three lakes in the Clatsop Plains on the northern Oregon Coast on the 303(d) list for impaired water quality. The specific parameter of concern in these waterbodies is aquatic weeds or algae. The lakes of concern within the Warrenton area are Coffenbury Lake and Smith Lake. To address this problem, the Regional Lake Management Planning for TMDL development (DEQ 2005) was developed.

This TMDL identifies nutrient inputs from surrounding activities as the primary cause of the increase in algal production. Agriculture, septic systems, logging, and runoff from lawns are all likely sources of nutrient to these lakes. Nutrient reduction measures are recommended to improve water quality by reducing algae growth and increasing water clarity.

National Pollutant Discharge Eliminations System MS4

Under the Federal Clean Water Act, The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Under these regulations, local governments, and those subject to the Federal National Pollutant Discharge Elimination System (NPDES) Stormwater Program, are required to have stormwater management programs.

Under the NPDES storm water permit program (Phase I), industrial facilities that were owned or operated by municipalities with a population of less than 100,000 were previously exempted from the requirement to obtain a stormwater discharge permit.

Under the NPDES storm water program Phase II, operators of large, medium and regulated small municipal separate storm sewer systems (MS4s) require authorization to discharge pollutants under an NPDES permit. Medium and large MS4 operators are required to submit comprehensive permit applications and are issued individual permits. NPDES permitting authorities have not yet issued permits for regulated small MS4s. However, under the Phase II rule Under the Small MS4 Stormwater Program, operators of regulated small MS4s are required to:

- Develop a stormwater management program which includes the six minimum control measures which include: 1) Public Education, 2) Outreach Public Participation/Involvement, 3)Illicit Discharge Detection and Elimination, 4)

Construction Site Runoff Control, 5) Post-Construction Runoff Control Pollution Prevention, and 6)Good Housekeeping

- Implement the stormwater management program using appropriate stormwater management controls, or best management practices (BMPs)
- Develop measurable goals for the program
- Evaluate the effectiveness of the program.
- Identify ESA threatened and endangered listed species located in or around the municipality.

Warrenton is a MS4 small operator, although they are not among the listed cities and counties in Oregon that are required to obtain a Phase II Municipal Stormwater Permit. No permit is required at this time because the City is located outside of an urbanized area (as determined by the 2000 U.S. Census) and its population is of less than 10,000 persons. However, Warrenton can be required by the DEQ under its discretionary authority to submit a modified permit. The basis for the requirement is a determination that a community's stormwater discharges violate water quality standards. Currently, Warrenton's efforts to improve stormwater conditions and maintain stormwater conveyance structures are in keeping with the regulatory requirements of DEQ and the TMDL process.

Other NPDES Requirements

Although no permits are required under the NPDES MS4, Warrenton is expected to consider the requirements of the state water discharge baseline general permit for wastewater discharges and minimize impacts that may degrade stormwater quality associated with erosion and sedimentation from construction activities.

The City of Warrenton operates a wastewater treatment facility. Wastewater is treated and discharged to the Columbia River in accordance with NPDES permit number 100874. A stormwater permit is not required for this facility. All stormwater is also treated at the facility before discharge.

Specific construction-related permit conditions that should be considered are a Stormwater Pollution Prevention Plan (SWPP) and Best Management Practices (BMPs) implemented to eliminate or minimize the potential to contaminate stormwater. Construction activities within a floodplain, as designated by the Federal Emergency Management Agency (FEMA), should be coordinated with the agency to ensure compliance with all agency requirements. FEMA's primary concern is to not adversely impact the floodplain. For construction activities that disturb one acre or more, an NPDES General Permit 1200-C is required. This is issued by DEQ and requires the preparation, submittal, and review of an application for the permit. Requirements include: general project and site information, land use compatibility statement signed by the local planning department, and the application fee. An erosion and sedimentation control plan specific to the project must also be prepared. The plan must be approved by DEQ prior to the commencement of any construction activities. These practices will minimize stormwater contamination associated with erosion and sedimentation during construction.

Endangered Species Act

The Endangered Species Act (ESA) was enacted in 1973 to establish a program to identify and conserve species of fish, wildlife, and plants that are declining in population to the point where they are now or maybe within the foreseeable future, at the risk of extinction. The ESA prohibits killing or harming an endangered species in any way, including significant modification of critical habitat for the species. It requires federal agencies to develop programs to conserve and to help recover endangered and threatened species. Under the ESA, a species likely to become extinct in the foreseeable future is categorized as "endangered"; one likely to become endangered is categorized as "threatened."

NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) share responsibility for implementing the ESA. NOAA manages marine species including anadromous salmon, while USFWS manages freshwater species. Listing of an endangered species protects it from a "take" as defined by federal law. "Take" can be construed as harm, harassment, pursuit or hunting, shooting, catching, killing, wounding, trapping, or collecting. A take can also result from actions, which if repeated sufficiently, could result in harm; consequently, activities that reduce habitat, food supply, or affect water quality could also qualify as a "take". All federal agencies, including funding agencies, are required to consult with NOAA Fisheries (or USFWS) on any activity that may affect a listed species.

The Columbia River Estuary subbasin involves a number of federal and state agencies, and regional organizations, and managed primarily by the lead entities: the Lower Columbia River Estuary Partnership (LCREP) in partnership with the Lower Columbia Fish Recovery Board (LCFRB). The Estuary Partnership is a two-state, public/private partnership that has developed a management plan for the lower 146 miles of the Columbia River The Estuary Partnership works to restore habitat, provide education and information, and eliminate pollution from the lower river to recover threatened and endangered species.

Estuary subbasins such as the Skipanon River and Young's Bay involve a number of federal and state agencies, and regional organizations coordinated by the National Marine Fisheries Service Salmon Recovery Division. The Estuary Partnership remains an active member of the "Executive Committee for Lower Columbia and Willamette River Salmonid Recovery" but no longer coordinates or staffs the meetings.

Other Regulations

Removal and Fill Regulations

Removal or fill of 50 cubic yards or more of material in waters of the State requires a permit from the Oregon Department of State Lands (DSL). "Waters of the State" include bays, flowing and intermittent streams, lakes, wetlands, and other natural waterways. Streams that are designated as essential salmon habitat require a permit regardless of the quantity of removal or fill. Certain activities or projects are exempt from state removal-fill requirements. These activities include, but are not limited to: maintenance or reconstruction of existing serviceable structures (such as drainage ditches); maintenance or reconstruction of recently damaged parts of roads or transportation structures; fish passage structures; or maintenance, repair, removal, and replacement of culverts. Permits issued by DSL include various conditions and may require some type of mitigation to compensate for environmental impacts to wetlands. Permits specify when in-water work can be conducted consistent with information provided by ODFW. Projects requiring a DSL permit will often require a permit from the U.S. Army Corps of Engineers. DSL and the Corps have a joint permit application form which streamlines the application process.

Right-Of-Way (ROW) Crossings

Crossings of state highways require coordination and approval by the Oregon Department of Transportation (ODOT). ODOT maintains stringent design standards that must be incorporated into approved projects. ODOT also coordinates with other agencies such as ODFW on issues and requirements applicable to the project.

Railroads also have minimum design standards for crossings to ensure the integrity of the railway. Railways often view crossings as a source of income. Negotiations for crossings of rail ROWs often focus more on contractual terms and easement costs rather than on technical or design issues.

Summary of Personal Communications

- Etsegenet Belete, Water Quality Permit Specialist, DEQ, August 2007.
- Beth Moore, NPDES Wastewater Permit Specialist, DEQ, October 2007.
- Judy Linton, US Army Corps of Engineers, September 2007
- Robert Anderson, NOAA Fisheries, September 2007

Potential Future Regulatory Changes

- Potential future regulatory changes that may affect the stormwater management strategy for Warrenton are:
  - Revised TMDL waste load allocations under section 303(d) of the CWA
  - The State of Oregon is currently updating their water quality criteria. These changes may include more stringent requirements on stormwater discharge.
  - Upgraded listing of candidate species under ESA
  - More stringent regulations of construction impacts and activities
  - Changes in statewide development practices requiring alternative treatment and monitoring of stormwater discharge.
  - New NPDES requirements which are specific to permitting of MS4.

4.2.2 Develop Recommended Development Guidelines for Stormwater Quality

The Skipanon River, Lower Columbia River, and Coffenbery Lake are all on the 303(d) list

303(d) Listed Water Bodies

The Skipanon River, Lower Columbia River, and Coffenbery Lake are all on the 303(d) list and have been designated for TMDL studies. Particular attention should be given to the specific parameters of concern in these areas, and, where possible, measures should be taken to improve water quality conditions in these water bodies.

Pollutants of Concern

The parameters of concern for the Skipanon and Columbia Rivers are primarily temperature and dissolved oxygen (Table 4.1). The Skipanon system has also been placed on the 303(d) list for nutrients and bacteria exceedances. Stormwater runoff associated with a variety of land uses may be associated with non-point source contributions of these parameters.

Table 4.1 - 303 (d) Listed Parameters of Concern and TMDL Association

Water Body	303 (d) Listed Parameter(s)	TMDL Study
Skipanon River	Temperature, DO, nutrients, bacteria	North Coast Subbasins (TMDL)
Lower Columbia River	Temperature, DO	North Coast Subbasins (TMDL)
Coffenbery Lake	Algae	Regional Lake Management Plan (TMDL)

One likely source of contamination from stormwater runoff into the Skipanon River is associated with urban development and future growth within the City of Warrenton.

Impacts of Projected Growth on Water Quality

In natural (undeveloped) conditions, rainfall infiltrates slowly into the ground. Natural processes cleanse the water as it moves through vegetation and soil and into groundwater. In the Pacific Northwest rainstorms are not typically large enough to cause the soil to reach saturation. Consequently, the majority of the rainfall infiltrates into the ground leaving only a small percentage as surface water runoff. Particles and sediments within this runoff settle out in vegetation and wetlands as they move toward receiving water, and the water is purified before it flows into rivers and streams.

Development of the landscape from its natural condition alters these conditions. Impervious surfaces associated with development such as buildings, roads, parking lots, and sidewalks prevent rain from infiltrating to the ground. There is also less vegetation to absorb, store, and evaporate the stormwater. As a result, stormwater runoff over the land surface greatly increases, even during small rainstorms.

This alteration in the way water is stored and moves across the landscape has significant impacts on receiving waters such as lakes, streams, and estuaries. For example, when impervious areas in a watershed reached 10 percent, stream ecosystems begin to show evidence of degradation. Coverage of more than 30 percent is associated with significant degradation. Developed urban areas typically have impervious surface coverage of well over 30 percent.

The way the water moves across the land is also altered. The increased volume of runoff also has an associated increase in speed as it drains to receiving waters. No longer slowed by vegetation and wetlands, this water can cause flooding and erosion and destroy natural habitat. Greater runoff volume is equates to less water available to infiltrate into the ground and results in less groundwater recharge. This reduces stream base flows and can increase stagnation, which is harmful to fish and aquatic organisms.

Water quality is also impacted as impervious surfaces retain heat, which increases runoff temperature during warm weather. This in turn raises the temperature of the receiving waters, negatively impacting aquatic life. Stormwater runoff also collects oil, fertilizers, pesticides, metals, chemicals, sediments, bacteria, and other pollutants and carries them into rivers and streams.

Traditional stormwater management does not address all of the problems associated with stormwater runoff. Gutters, drains, and pipes collect runoff from impervious surfaces and convey it to discharge points. Large volumes of untreated stormwater rapidly discharge into natural water bodies.

A national review of stormwater studies was conducted (Glasoe and Christy 2004) examining the effects of growth and development on receiving waters. They identified strong correlations that stormwater related to development in coastal areas is impacting water quality and natural ecosystems. Below are their specific conclusions:

- Coastal areas are highly productive and sensitive environments. They are also highly valued places to live, work, and play. Two dramatic and related trends—population growth and urbanization—are stressing and degrading coastal ecosystems.
- Urbanization is perhaps the most significant of all land use changes, dramatically altering the natural capacity of watersheds to absorb and attenuate flows and contaminants. The imprint of urbanization is generally permanent and many of the related environmental impacts, including the contamination of shellfish growing areas, are difficult to mitigate or reverse.
- Microbial contamination is chronic and pervasive in many coastal areas of the United States and is closely correlated with population densities, development levels, rainfall events, stormwater runoff, and river flows.
- Research documenting the effects of human development on the health of stream systems is extensive and compelling. The available research examining the effects of development on the health of estuarine systems is more limited, but reveals strong and similar correlations.
- Impervious cover is the most widely researched landscape indicator for gauging the effects of development on aquatic ecosystems. Studies indicate that moderate levels of development in the range of 10 to 25 percent impervious cover degrade aquatic habitats of all kinds and the degradation increases as development intensifies.
- Stormwater runoff is a defining characteristic of urbanizing landscapes that results from the conversion of natural land cover to impervious cover.
- Pollution impacts can be prevented and mitigated using a variety of approaches and techniques, but there are practical limits to our ability and willingness to preserve coastal habitats and resources as development progresses. There is no replacement for sound land use planning and personal stewardship that recognizes and preserves the inherent qualities of natural systems for buffering impacts and preserving clean water and healthy aquatic habitats.

Recommendations to Improve Stormwater Impacts

The most effective and efficient way for the City of Warrenton to address stormwater water quality problems is through new development and re-development within the City; making stormwater quality a requirement of every land altering project that occurs within the City limits.

There are several strategies put forward by the Lower Columbia River Estuary Partnership in the Lower Columbia River Field Guide to Water Quality Friendly Development (http://www.lcrep.org/fieldguide/index.htm). This work was developed through collaboration between the Portland Bureau of Environmental Services, Oregon State University, Sea Grant Extension, Oregon Department of Land Conservation and Development, Clark County, and Metro.

Several larger municipal agencies have developed guidance documents that are intended for use by engineers and architects in the design of stormwater best management practices to mitigate water quality impacts resulting from development. The following are a recommended list of design guideline for reference:

- King County Surface Water Design Manual
- Western Washington Stormwater Management Manual
- Portland BES Stormwater Management Manual
- CleanWater Services Design and Construction Standards

It is recommended the City amend their development code to include requirements for mitigating water quality impacts. This recommendation is discussed later in the development code review section of this report.

4.3 Natural Resources

4.3.1 Summary of Regulatory Requirements

This section summarizes applicable state and federal statutes and regulations for management of stormwater as they relate to protection of natural resources and statewide planning goals. Natural resources described in this section include wetlands and ESA species.

Clean Water Act

For regulatory purposes under the Clean Water Act, the term wetlands means "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." In Oregon, the DSL and the Portland District US Army Corps of Engineers (COE) regulate wetlands. DSL administers the State Removal-Fill Law and the COE administers Section 404 of the CWA.

Endangered Species Act

Under ESA, NOAA Fisheries is responsible for the protection of marine life, including anadromous salmon within the Columbia River, Columbia River Estuary and Coastal areas. When a species is listed as "endangered", the prohibitions against "take" of that species are immediate under Section 9 of ESA. Should a species be listed as "threatened", NOAA Fisheries may be more flexible in establishing regulations for protection. These regulations are known as Section 4(d).

One of the limitations in the 4(d) rule is Limit Number 12 – Municipal, Residential, Commercial, and Industrial development and redevelopment (MRCI). This 4(d) rule states that, with appropriate safeguards, MRCI development can minimize impacts and meet the requirements of ESA.

State of Oregon Regulation and Policies

The Oregon Land Conservation and Development Commission (LCDC) is a statewide program for land use planning. The program consists of a set of 19 Statewide Planning Goals. The goals are accompanied by guidelines, which are not mandatory, describing how a goal may be applied.

The goals are achieved through the local comprehensive planning process. State law requires each city and county to adopt a comprehensive plan and the zoning and land-division ordinances needed to put the plan into effect. The City of Warrenton is currently in the process of updating their comprehensive plan and these goals are addressed fully in that document.

There are six goals that pertain to natural resources and stormwater management within the City of Warrenton. These include Goal 5, Goal 6, Goal 11, Goal 16, Goal 17, and Goal 18. A brief description of each of these goals, how they apply to Warrenton, and how they may effect the management of stormwater are presented below.

Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces

Goal 5 covers more than a dozen natural and cultural resources. Natural resources covered include river and stream riparian corridors, groundwater, fish and wildlife habitats, and wetlands. Fish and wildlife areas should be managed in accordance with the Oregon Wildlife

Commission's fish and wildlife management plans. Stormwater improvements often involve natural waters such as streams or rivers, and may directly impact fish passage or health. In 2001, Oregon adopted laws regarding fish passage requirements that must be addressed prior to the installation, replacement, or abandonment of an artificial obstruction. This applies to waters in which native, migrating fish are currently or historically present. ODFW has developed a set of fish passage guidelines that reflect the new laws.

Goal 5 also establishes a process for each resource to be inventoried and evaluated to determine its significance. In 1990, DSL adopted guidelines and rules for conducting Department of State Lands Wetland Inventory (LWIs) within urban growth boundaries. The LWI rules were updated in February 2001. Wetlands are to be inventoried as part of the LWI. The LWI report identifies significant wetlands within the City limits. If a resource or site is found to be significant, a local government has three policy choices: preserve the resource, allow proposed uses that conflict with it, or determine a means of both protecting the resource and providing the uses. The City of Warrenton started its LWI process in 1991. The Oregon Natural Heritage Center also provides information on wetland communities of concern that should be considered.

The LWI will be used to provide guidance in determining the placement of stormwater facilities and the location of future development within Warrenton. The presence of a large amount of wetland habitat and wetland soil within the City limits will dictate the options for stormwater treatment and conveyance.

Goal 6: Air and Water Quality
Goal 6 requires local comprehensive plans and implementing measures to be consistent with state and federal regulations on matters such as water pollution. The City of Warrenton is following the guidelines for water quality protection through the DEQ and TMDL process.

Individual projects within the City could be required to provide stormwater quality measures in order to qualify for a federal permit. However, the City is currently in compliance with state and federal regulations because there are no regulations the City is obligated to enforce.

Goal 11: Public Facilities and Services
Goal 11 calls for efficient planning of public services such as sewers, water, law enforcement, and fire protection. This provides guidelines for developing public services in a manner that is planned and in accordance with a community's needs and capacities. The development of this stormwater management plan is a major piece of information necessary for the City to prepare a public facilities plan.

Goal 16: Estuaries
To maintain diversity among Oregon's estuaries, Goal 16 directs the LCDC to set overall limits on the amount of development that can occur in each estuary. The classification sets an upper limit on the types and intensities of development that can occur and serves as a guide to preparation of plans for each estuary. This goal requires local governments to classify Oregon's 22 major estuaries in four categories: natural, conservation, shallow-draft development, and deep-draft development. It then describes types of land uses and activities that are permissible in those "management units".

The Columbia River Estuary is considered a Deep Draft Estuary. These types of estuaries have maintained jetties and a main channel maintained by dredging to deeper than 22 feet. Deep draft development estuaries have development, conservation and natural management units. These should be discussed in the City's Comprehensive Plan. Stormwater facilities may only be located within areas that have been designated for development.

Goal 17: Coastal Shorelands
The goal defines a planning area bounded by the ocean beaches on the west and the coast highway (State Route 101) on the east. The objective of this goal is to conserve, protect and restore the beneficial uses of coastal shorelands. These include water quality benefits, fish and wildlife habitat, water-dependant resources, economic resources, recreation, and aesthetic value. The goal requires an inventory of all of these resources and uses. This information is then used in the comprehensive planning process to establish policies and designated uses. This goal also specifies how certain types of land and resources are to be managed. For example, major marshes are to be protected. Sites best suited for unique coastal land uses such as stormwater facilities are reserved for areas designated for "water-dependent" or "water related" uses.

Goal 17 would apply for the City of Warrenton should the City choose to revise the boundary of allowed uses of a designated water-dependant shoreland sites. They may also determine if there are any existing areas suitable for redevelopment and well suited for water-dependant uses. These might include stormwater facilities located outside of the currently designated area or the placement of a site along the Skipanon River.

Goal 18: Beaches and Dunes
Goal 18 sets planning standards for development on various types of dunes. It prohibits residential development on beaches and active foredunes, but allows some other types of development if they meet key criteria. The goal also deals with dune grading, groundwater drawdown in dunal aquifers, and the breaching of foredunes. The specific management guidelines for beaches and dunes would be identified in Warrenton's Comprehensive Plan.

4.3.2 Wetlands

The City of Warrenton contracted in August 1991 with SRI, Inc. to conduct a wetland conservation plan (WCP) inventory. This inventory was approved by DSL on February 8, 1994. The WCP inventory was later revised in 1997.

The City of Warrenton WCP Inventory contains two parts:

1) A wetland determination / delineation, which consists of a map and discussion showing the location and boundaries of the wetlands; and.
2) A wetland functional assessment, which is a report listing the functions provided by each mapped wetland.

SRI, Inc. used a combination of aerial photograph analysis, topographic mapping, U.S. Natural Resources Conservation Service (NRCS) mapping and site-by-site field data collection to conduct this study in determining or delineating the City of Warrenton's wetlands. Detailed maps of these wetlands are available for review and are located in the City of Warrenton's Planning office and at the Oregon Division of State Lands offices. The Corps and DSL have the final decision-making capability on whether or not an area is a wetland under their respective jurisdictions.

4.3.3 Threatened or Endangered Species

Several ESA listed species have been identified by NOAA Fisheries within the Lower Columbia River Estuary. Chinook Salmon (*Oncorhynchus tshawytscha*), Chum Salmon (*O. Keta*), Coho Salmon (*O. kisutch*), and Steelhead Trout (*O. mykiss*) are all listed as threatened (NOAA Fisheries 2007). In addition, The USFWS listed Bull Trout (*Salvelinus confluentus*) as threatened in 1999. In addition, rare, Threatened and Endangered species have been identified in Clatsop County by the State Natural Area Preserves Advisory Committee.

Under ESA, NOAA Fisheries would apply 12-evaluation considerations when determining whether development ordinances or plans are adequate to protect these species and their associated critical habitat. The following should be considered for developing City ordinances that protect endangered species:

1) Development ordinance to avoid inappropriate areas such as unstable slopes, wetlands, areas of high habitat value, and similarly constrained sites.
2) Development ordinance to minimize stormwater impacts on water quality and quantity as well as stream flow patterns in a watershed – including peak and base flows in perennial streams.
3) Development ordinance to protect riparian areas well enough to attain or maintain Proper Functioning Conditions (PFC), habitat that provides for biological requirements

of the fish around all rivers, estuaries, streams, lakes, deepwater habitats, and intermittent streams.

4) Development ordinance to avoid stream crossings – whether by roads, utilities, or other linear development – wherever possible and, where crossings must be provided, minimize their impact.
5) Development ordinance to protect historic stream meander patterns and channel migration zones and avoid hardening stream banks and shorelines.
6) Development ordinance to protect wetlands, wetland buffers, and wetland function – including isolated wetlands.
7) Development ordinance to preserve permanent and intermittent streams' ability to pass peak flows.
8) Development ordinance to maximize the use of native vegetation in landscaping to reduce the need to water and apply herbicides, pesticides, and fertilizers.
9) Development ordinance to require control of erosion and sedimentation in stormwater runoff during and post-construction; thereby, preventing pollutant discharge to stream, wetlands, and other water bodies which support fish.
10) Development ordinance to reduce water consumption so that demands on water supply can be met without affecting water directly or through groundwater withdrawals – the flows required by salmon.
11) Development ordinance to provide a means of monitoring, enforcing, funding, reporting, and implementing the stormwater plan.
12) Development ordinance to comply with all State and Federal environmental and natural resource laws and permits.

Recommendations for integrating stormwater management

To minimize stormwater-related impacts and provide for greater protections of natural resources including ESA listed species the following recommendations have been compiled:

- Adopt critical areas ordinances to protect critical habitat.
- Amend ordinances to include riparian buffers, vegetation retention, soil retention, maximum road density limits, maximum impervious area limits, and limits on road crossings of streams.
- Adopt stormwater operation and maintenance ordinances requiring regular, frequent maintenance of facilities.
- Provide for inspection, monitoring, and enforcement of stormwater BMPs.
- Provide adequate funding for stormwater infrastructure.

4.3.4 Summary of Personal Communications

Jevra Brown, Wetland Specialist, Oregon Department of State Lands, October 2007

John A. Christy, Oregon Natural Heritage Information Center, October 2007

Heather Howard, Wetlands Support Staff, Department of State Lands, October 2007

4.3.5 Recreational and Educational Facilities

Stormwater facilities can often be integrated into open space areas that have other uses. These can be recreational, educational, or both. Stormwater management can be the central theme for developing recreational programs or recreation can take place on land used to construct stormwater facilities.

Education is one of the most effective stormwater best management practices. Warrenton has numerous opportunities to create beneficial educational opportunities. Education, Involvement and Stewardship strategy will yield multiple benefits. It will help raise the awareness and increase interest in community watershed issues and the importance of healthy watersheds. An educated community will:

- more readily understand how their projects, individual behaviors, and actions can promote healthy watersheds
- recognize their responsibility in effective stormwater management
- more likely participate in public decision-making regarding stormwater management, thus leading to better decisions; and
- more likely implement stormwater management decisions and support stormwater management strategies.

Warrenton has already implemented several education and outreach programs. These include educational/interpretive signs at the Hammond Marina and the 8th Street Dam and educational programs at the City's new waste water treatment facility.

Recommended Education and Outreach Opportunities

The success of the Warrenton Stormwater Management Plan will be dependent upon awareness and support of the community at large. Several conceptual education and outreach opportunities targeting these primary audiences are proposed. The list include:

- Awareness Surveys
- Storm Drain Stenciling
- Website Information
- Articles for Publication

- Walking and Bicycle Tours
- Education plaques and signage

These opportunities were selected to maximize effectiveness by providing a diverse set of offerings that would appeal to a range of audiences and utilize a variety of media. For each opportunity, information is provided on recommended activities, target audience, potential resources, and expected benefit or outcome. Detailed description of each of these programs can be found in Appendix G.

4.3.6 Floodplains, Tsunami and Coastal Flood Hazards

Floodplains

The Federal Emergency Management Agency (FEMA) is the designated administrator of the National Flood Insurance Program (NFIP). The City of Warrenton (including the former City of Hammond) participates in the NFIP. The most recent flood insurance study was published in 1978.

Flood insurance rates are established per flood zones. Flood zones are geographic areas that the FEMA has defined according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area.

Local communities participating in the NFIP are required to adopt local ordinances that restrict floodplain development activity and enforce development practices consistent with, or more restrictive than, the NFIP requirements.

Most of Warrenton east of the Skipanon is within Zone A, meaning it is inside the 100-yr floodplain. Most of Warrenton west of the Skipanon is Zone X.

Tsunami

Tsunami is a set of ocean waves caused by any large, abrupt disturbance of the sea-surface. If the disturbance is close to the coastline, local tsunamis can demolish coastal communities within minutes. A very large disturbance can cause local devastation AND export tsunami destruction thousands of miles away. The word tsunami is a Japanese word, represented by two characters: tsu, meaning, "harbor", and nami meaning, "wave". Tsunamis rank high on the scale of natural disasters. Since 1850 alone, tsunamis have been responsible for the loss of over 420,000 lives and billions of dollars of damage to coastal structures and habitats. Most of these casualties were caused by local tsunamis that occur about once per year somewhere in the world. For example, the December 26, 2004, tsunami killed about 130,000 people close to the earthquake and about 58,000 people on distant shores. Predicting when and where the next tsunami will strike is currently impossible. Once the tsunami is generated, forecasting tsunami arrival and impact is possible through modeling and measurement technologies.

Since 1946, the tsunami warning system has provided warnings of potential tsunami danger in the pacific basin by monitoring earthquake activity and the passage of tsunami waves at tide gauges. However, neither seismometers nor coastal tide gauges provide data that allow accurate prediction of the impact of a tsunami at a particular coastal location. Monitoring earthquakes gives a good estimate of the potential for tsunami generation, based on earthquake size and location, but gives no direct information about the tsunami itself. Tide gauges in harbors provide direct measurements of the tsunami, but the tsunami is significantly altered by local bathymetry and harbor shapes, which severely limits their use in forecasting tsunami impact at other locations. Partly because of these data limitations, 15 of 20 tsunami warnings issued since 1946 were considered false alarms because the tsunami that arrived was too weak to cause damage.

NOAA has primary responsibility for providing tsunami warnings to the Nation, and a leadership role in tsunami observations, research. The USGS monitors earthquakes through a network of seismic detectors. The States also monitor seismic activity. This information is critical to understanding when a Tsunami wave might be generated.

The USGS and NOAA's National Ocean Service have responsibilities for providing ocean bathymetry, coastlines and topography. This information is critical to understanding how and where a Tsunami wave will come ashore.

NOAA Research develops models that forecast tsunamis and create tsunami inundation maps. NOAA Research provides the forecast models to the NOAA's Weather Service forecasters and the inundation models and maps to the State and national planners and emergency managers. This information is critical to issuing warnings to communities at risk.

NOAA monitors sea height through a network of buoys and tide gauges (NOAA Research/Pacific Marine Environmental Laboratory, NOAA Weather Service/National Data Buoy Center, and NOAA National Ocean Service). This information is critical to understanding the height the Tsunami wave will be when it comes ashore.

NOAA Tsunami Warning Centers use observations of seismic activity and sea height with forecast models and issue Watches and Warnings where appropriate.

NOAA's National Weather Service promotes tsunami hazard preparedness through Tsunami Ready, an active collaboration among Federal, state and local emergency management agencies, the public, and the NWS tsunami warning system.

A Tsunami resilient community is educated about Tsunami risks, has plans for securing property and evacuating people in the event of a forecast or warning, and maintains an alertness and readiness to respond to forecasts and warnings.

State emergency managers use inundation maps together with information about civil infrastructure, and make effective plans for responding to a Tsunami forecast or warning, using guidance from the National Response Plan and FEMA. Emergency planning includes educating the community about the danger, and informing them of appropriate response to forecasts and warnings.

Once a Tsunami has occurred, FEMA coordinates measures to mitigate the damage.

An evacuation zone map was developed for Warrenton by the Oregon Department of Geology and Mineral Industries in consultation with local officials. It is intended to represent a worst-case scenario for a tsunami caused by an undersea earthquake near the Oregon Coast. The map includes recommendations for emergency preparedness in the event of a tsunami. A copy of the map is provided in Appendix B.

Coastal Flood Hazards

Flood hazards in the coastal zone not only considers ground elevation of the subject area with relation to the 100-year Base Flood Elevation (BFE) as shown on the effective Flood Insurance Rate Map (FIRM), but also considers the inland limit of the Primary Frontal Dune and high velocity wave action which constitutes the Coastal High Hazard Area, or V zone. Mapping of this type of hazard zone considers tidal fluctuations, storm surges, nearshore wave action, and coastal dune erosion. This type of flood hazard zone mapping would apply to the western most edge of Warrenton, where Fort Steven's is located and has not been included in the current FIRM for Hammond or Warrenton.

Recommendations

It is recommended that the City continue to work with the Oregon Department of Emergency Management and other federal agencies on emergency preparedness, and educating the citizenry about flood hazards.

It is recommended that the City update their FIRM to combine Hammond and Warrenton. A copy of the detailed data used in the current flood insurance study to create the FIRM was requested from FEMA. FEMA responded that they have no detailed data in their records. The City should try to locate copies of this data in their records.

It is recommended the City continue to require development located within flood hazard zones to comply with National Flood Insurance Program development requirements.

4.4 Development Code Review

4.4.1 Review of Current Code Language

The City of Warrenton land use code and ordinance language was reviewed to determine its applicability to stormwater and the protection of water quality and natural resources.

The current code language contains several references to drainage, storm drainage, and surface water management. They are very general requirements and leave it up to the City to decide when certain stormwater management requirements should be imposed upon a development.

The City code has established riparian corridors and restricts development within the riparian corridors. Maintaining riparian corridors is one of the few best management practices that have been found to be very effective at reducing the types of water quality problems identified in the waterways in Warrenton. Following the completion of the Comprehensive Plan, this code may need updating to be consistent with new regulations guiding stormwater treatment and wetlands.

4.4.2 Recommendations and Discussion

It is recommended that the City code, or at least City policy, be amended to require stormwater best management practices with all development (or redevelopment) activities to provide treatment of stormwater runoff and reduce pollutant concentrations before discharge from a site.

Stormwater facility placement and designs are not currently part of Warrenton Development Code. There are many different types of stormwater best management practices suitable for treating runoff from site development. Given the high concentration of wetlands within the City limits, conditions are not conducive to facilities that rely on infiltration due to high groundwater levels.

It is recommended that the City adopt some guidance for design of stormwater facilities. This could be by reference to existing guidelines published by others, in collaboration with other northern coast communities, or in guidelines developed specifically for the City of Warrenton.

Multiple jurisdictions have published stormwater design standard that may be helpful in selection and design of stormwater BMPs for water quality requirements for sites involving development and redevelopment. A few northwest communities have published excellent, detailed guidance documents for the design of stormwater treatment facilities. Several smaller communities have adopted these guidelines by reference. The recommended guidance documents are from:

- King County, Washington
  http://dnr.metrokc.gov/wlr/dss/manual.htm
- City of Portland Bureau of Environmental Services
  http://www.portlandonline.com/bes/index.cfm?c=43271&
- CleanWater Services
  http://www.cleanwaterservices.org/content/documents/Permit/Design%20and%20Construction%20Standards%202007.pdf

It is recommend that the City adopt a local water quality design storm for sizing the various stormwater facilities described in the guidance documents. The recommended water quality design storm is based upon the City of Portland water quality design storm, scaled up based on the ratio of the average annual rainfall between in Warrenton (Astoria) relative to Portland (PDX).

Average Annual rainfall in Warrenton (Astoria AP) = 67.13
Average Annual rainfall in Portland (PDX) = 37.07
Ratio = 1.81

<u>Flow-rate Based Facilities – for example: swales or filters</u>
Portland Water Quality design storm = 0.19 inches per hour (intensity)
Recommended design storm for Warrenton = **0.34 inches per hour (intensity)**

<u>Volume Base Facilities – for example: wet ponds</u>
Portland Water Quality design storm = 0.83 inches for a 24-hr design storm
Recommended design storm for Warrenton = **1.50 inches for a 24-hr design storm**

It is recommended that reference to other design guidelines be considered an interim step. Ultimately, it is recommended that the City would collaborate with other coastal communities to pool the resources necessary to develop a stormwater design manual specific to conditions on the coast.

It is recommended that a drainage design report or memorandum become part of the standard development review submittal as a means to document design calculations and conditions at the time of development. It is recommended that the report includes a downstream analysis describing conditions downstream of the site for one-quarter of a mile.

Both CleanWater Services and King County design standards could be referenced as examples for a downstream analysis. The downstream analysis would also discuss any potential impacts to natural resources, water quality and any potential changes in downstream flow conditions.

Example development code from the following jurisdictions: Gresham, Seaside, Troutdale and Ilwaco are included in Appendix A for reference.

Section 5— Existing Facility Maintenance and Capital Improvement Projects

5.1 Introduction

A key piece to the City's Stormwater Management Plan is the recommended Existing Facility Maintenance and Capital Improvement Projects (CIP). The CIP's were selected based on their ability to meet the City's stormwater goals. Factors included in the decision were the City's stormwater needs, modeling results, capacity calculations, inputs from City staff, inputs from the general public, observations during site visits conducted by HLB-Otak staff, and project costs. Table 5.1 summarizes the 12 CIP's chosen for detailed study. Figure 2 shows the approximate location of each CIP.

5.2 Existing Facility Maintenance

As discussed in Chapter 2, there are two key components to the City' stormwater system: the levees and tide gates which protect the City from high tides in the Columbia and Skipanon River, and the conveyance system, which drains the City and directs stormwater runoff to the tide gates. The tide gates and levees are under a constant barrage of destructive forces, including corrosion from the salt water, erosion caused by the tidal cycle and waves, runoff flowing through the tide gates, water and wind erosion during storm events, and the erosive effects of vegetation and burrowing creatures. The City's stormwater conveyance is also constantly having its effectiveness and efficiency reduced through a myriad of factors. The flatness of the City's system is a perfect recipe for sedimentation in channels, ditches, storm pipes, inlets and manholes. The wet, nutrient rich environment encourages rapid and dense vegetation growth in channels and ditches. Individuals, not fully understanding the impacts, place debris, such as dirt and grass clippings, into roadside ditches, blocking the flow path. The City must continue to aggressively maintain its levees, tide gates and conveyance system. Recent interpretations of environmental laws have resulted in regulation of more waterways, including many ditches. This change in regulation requires additional permitting hassles and has discouraged the City from regular maintenance of many ditches. .

The USACOE inspects the levee system once a year. Inspection reports for the period 1995-2006 show Warrenton has received an "A" or "B" grade. Typically one or two discrepancies are discovered per inspection and the City's Public Works staff quickly goes out to make the needed repairs. The repairs have included: removing vegetation, replacing tide gates, and repairing slumps and slides. The last ten years of inspection reports are included in the Appendix F. The City should continue the diligence it has shown in maintaining its levees and tide gates.

A comprehensive, look at the City's complete inventory of levees and tide gates should be completed to evaluate condition and develop an implementation plan for replacement and repair of tide gates, culverts and headworks. Many of the tide gates are leaking and most of the tide gate headwalls are eroded or in need of repair. A majority of the City's tide gate culverts are constructed of wood stave pipe and are nearing the end of their service life. A plan to replace them should be developed. Replacement should be based on current condition and the associated flood protection value of areas serviced by a particular tide gate. It also should consider factors such as upstream natural resources to determine fish passage requirements and/or mitigation opportunities. Two of the City's tide gates, the 8th Street Dam and the Adams (Vera) Slough, have already undergone modification to allow for better fish passage, as well as improved water quality due to increased flushing. While these changes have positive effects, there can also be potentially negative results, such as higher water levels upstream of the tide gate, especially during high tide. Understanding the impacts of changes to tide gate construction and operation is critical to maintaining the City's current level of flood protection. A tide gate repair and replacement plan for the City of Warrenton is recommended as a CIP. It has been given a high priority ranking.

The City's stormwater conveyance system is in need of extensive restoration, especially its ditches and channels, many of which are filled with vegetation and sediments. This results in decreased capacity of the system, as well as decreased water quality due to stagnant water and lack of flushing between tidal cycles. Not all of these channels are on City owned property. A GIS map showing City easements would be helpful to determine which ditches are the responsibilities of the City, and which would be maintained by private land owners. The City should consider purchasing an easement for critical channels that are on private land to ensure they are properly maintained. There are concerns about permits required to conduct maintenance within the channels and ditches, primarily due to the high density of wetlands within the City boundaries. This issue must be resolved before a restoration/maintenance plan can begin in earnest. A programmatic maintenance permit is recommended as a CIP. This would allow the City to perform routine maintenance of all ditches and channels where conditions dictated in the permit are met. A programmatic maintenance permit, or Nationwide Permit, can be approved for a five or ten year period. Conversations with the USACOE and NOAA revealed that the approving regulatory agencies are extremely open to the idea. The CIP has been given a high priority. Once a permit is in place, the City should set aside an annual budget to restore all of the ditches and channels, first focusing its effort on those channels which impact the City's stormwater system the most. Many of these key channels are identified in the drainage system improvement CIP's for the downtown, Enterprise and Hammond areas.

5.3 Capital Improvement Projects

Table 5.1 lists the recommended CIP's, provides a priority, and estimated implementation cost. A City map with CIP locations is shown in Figure 2. There are two basic categories of Capital Improvement Projects; those that deal with the regulatory and planning aspects of stormwater management, and those that involve the improvements of structures and facilities in the City's stormwater drainage system. It is recommended that the regulatory and permit related CIP's be implemented before physical upgrades to the system are accomplished. This will allow the City to be in full compliance with regulatory requirements, and fully aware of what can and cannot be done within the City's tide gates, channels, ditches and wetlands. Implementing the O&M plans for the tide gates and ditches will ensure the City's complete inventory has been studied and the most critical conveyance system components are modified first. When considering system upgrades, it is recommended that downstream projects such as tide gate repair and pump station upgrades be implemented first. Increasing the capacity at the downstream end of the drainage system will ensure that any later changes to the upstream channels and pipes will result in real changes to the water surface elevations in town during flood events. If pipes and channels are upsized before the downstream outlets are improved, backwater effects from the broken tide gate or off-line pump station would neutralize any intended flood reduction.

All of the CIP's that recommend physical improvements to the drainage system can be done in phases, as time and finances allow. For this study, the cost estimates were determined for a complete upgrade of each system. It is entirely feasible to split these subbasin wide projects into pieces and upgrade specific ditches and pipes as needed. Unit costs were based on bid tabulations from recent projects on the north Oregon coast from and ODOT Region 2 data. These prices reflect the cost for a contractor to be hired to do the work. Significant cost savings could be realized for any portion of a CIP which could be constructed in-house by Public Works staff. Many of these improvements are within City streets, especially in the downtown area. The CIP implementation could occur in conjunction with street improvements, such as resurfacing or upgrades to other utilities like water and sewer. Such combined projects would reduce engineering and construction fees for the stormwater piece of the improvements. This would allow the City to use other funding sources for the project, such as the gas tax. Along this line of thinking, it is also feasible to place new storm pipes and ditches in a parallel street, if a street improvement project is planned for that particular street. A good example of this would be 8th Avenue in Hammond. A key ditch that connects the East Hammond subbasin to the Enterprise subbasin runs along the north side of 8th Avenue. A CIP recommends this ditch to be cleaned and regraded. It would be conceivable to place a storm pipe or ditch on 7th Avenue instead if this street was scheduled to be improved.

Several of the main conveyance channels, especially in the Hammond/Enterprise area, do not appear to be in the City rights-of-way. It is recommended that easements are acquired for these facilities. This will ensure the City has continued access for maintenance and upkeep.

Table 5.1: CIP Summary			
CIP #	Priority	Description	Estimated Cost (2007 dollars)
1	High	Repair/Refurbish West Hammond Marina Tide gate	$344,190
2	High	Repair/Refurbish East Hammond Marina Tide gate	$349,033
3	High	Tide Gate Repair & Replacement Plan	$115,050
4	High	Evaluate and upgrade existing pump station adjacent to SE 3rd/4th St.	$721,762
5	High	Refurbish existing pump station adjacent to NE 1st St.	$721,762
6	Low	Upsize storm system in west portion of Hammond Marina subbasin.	$135,879
7	Low	Relieve stormwater drainage issue in the East Hammond/Enterprise Ditch Area.	$494,086 – Sys $1,944,854 – PS
8	High	Obtain programmatic permit to allow O&M routine maintenance of City ditches.	$52,000
9	Low	Create and Implement Monitoring Plan for City of Warrenton	$87,029
10	Low	Upgrade downtown conveyance system and create definitive connection between north and south downtown pump stations	$861,794
11	High	Sanitary Sewer Inflow/Infiltration Study	$96,466
12	High	Stormwater Rate Study	$15,000 - $20,000

5.3 CIP Modeling Effort

When appropriate, the CIP's were modeled using XP-SWMM. Three detailed models were created: one for West Hammond subbasins, one for the East Hammond/Enterprise subbasins and a final one for the two downtown subbasins. Only key pipes and ditches were included in the model. Elevations, lengths, and sizes were collected from Phase I survey data, GIS data, construction drawings, and conversations with Warrenton Public Works personnel. The input parameters for each of the three models and a schematic from XP-SWMM can be found in the Appendix C. These models cover a majority of the City's continuous storm system. While other sections of the City have pipes and ditches, these are typically localized and not part of a larger system. Hydrologic inputs (i.e. runoff) where used from the City-wide XP-SWMM model and incorporate the affects of rainfall intensity, tidal fluctuations, tide gates and interbasin stormwater routing. Tailwater affects of the Columbia and Skipanon Rivers were modeled similarly to the City-wide model as described in Chapter 3. For the purpose of CIP evaluation, the future conditions hydrology representing full-build out conditions was used. The 25-year design storm was chosen for comparisons because it ensured that most of the City's stormwater system was fully inundated under existing conditions. This allowed changes due to proposed improvements to be readily apparent.

For each of the three models, an existing conditions model was first created to establish a baseline for comparisons. Key locations in the model were chosen for water surface and peak flow rate comparisons. Undersized pipes and ditches were identified. Several iterations of pipe and ditch upgrades were analyzed. For the Enterprise and Downtown subbasins, several sizes of pumps were modeled. Appendix C includes brief summary output tables for each model, as well as comparison values and averages.

5.4 CIP Fact Sheets

5.4.1 West Hammond Tide Gate [CIP 1]

The tide gate on the western side of the Hammond Marina drains approximately 320 acres, which includes the Hammond area and parts of Fort Stevens State Park. The current tide gate is corrugated metal and 30-inches in diameter. Its inlet is west of Lake Drive just north of Second Avenue and has a length of 650 feet. The tide gate is missing. The last 15 feet of the culvert is severely corroded, with large holes in the bottom and top of the culvert. The corrosion and lack of tide gate allows bi-directional flow at this location. At elevation 6.78, the invert of this tide gate is one of the highest in the City, and therefore inflow only occurs during the highest tides.

The proposed CIP would improve this portion of the City's drainage system in several ways. The installation of a new tide gate will eliminate unwanted bi-directional flow due to high tides. Several configurations are possible, such as side-hinged tide gates, which could allow for more flushing during low-flow months and improving water quality. Upsizing the culvert from 30-inches to 36- or even 48-inches will improve drainage and reduce backwater effects upstream. Re-routing the culvert underneath the cross street north of Iredale Drive will shorten the culvert distance and place it in the public right-of-way for easier access. The possibility of lowering the invert elevation could also be considered. The added elevation drop in the upstream conveyance system would also improve drainage and increase storage.

Model results show that replacing the tide gate and increasing the culvert size to 36-inch reduces flood levels upstream by approximately **0.5 feet** for the 25-year storm. This drop increases to **1.8 feet** for a 48-inch culvert. Shortening the culvert by re-routing it and lowering the invert elevation by one foot reduces flooding by **0.8 feet** and **2.3 feet** for the 36-inch and 48-inch culvert option respectively. Figure 11 shows the most likely location for a re-route of this tide gate culvert.

Cost Estimate for CIP 1 – Replacement of West Hammond Tide gate and Culvert

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (10%)	1	LS	$22,206	$22,206
Erosion Control (5%)	1	LS	$11,103	$11,103
Demolition and Removal of Existing Structures	1	LS	$410	$410
Drainage				
48-inch Storm Pipe	614	LF	$155	$95,170
Manhole, 72-inch	1	EA	$7,000	$7,000
Concrete Inlets	1	EA	$1,200	$1,200
Tide gate Structure	1	EA	$4,000	$4,000
Earthwork				
Channel / Ditch Clearing	0.2	Acre	$11,000	$2,200
Ditch Excavation	417	CY	$15	$6,255
Surface Restoration				
Pavement Restoration (Asphalt Concrete)	74	Tons	$280	$20,720
Landscape Restoration (Seeding)	0.11	Acre	$5,000	$550
			Sub-total	$170,814
Construction Contingency (30%)				$51,244
			Construction Total	**$222,058**
Engineering (25%)				$55,514
Construction Management (20%)				$44,412
Permitting (10 %)				$22,206
		TOTAL		**$344,190**
NOTE: Assumes fish passage is not required as part of replacement.				

5.4.2 East Hammond Tide gate [CIP 2]

The tide gate on the eastern side of the Hammond Marina drains approximately 147 acres that includes a portion of Hammond and some non-developed areas west of Ridge Road. The current tide gate is corrugated metal and 30-inches in diameter. Its inlet is at the intersection of Pacific Drive and Iredale Drive. The tide gate is in fair condition. Until the summer of 2007, the culvert was heavily corroded, allowing bi-directional flow. Warrenton Public Works temporarily repaired the culvert by removing the failed section of pipe and re-hanging the tide gate closer to where the culvert daylights from the banks of the shore. The culvert is over 1000 feet in length and includes at least one bend. The condition of the culvert underneath the Hammond area is unknown. Surveyors were unable to find the exact location of the culvert inlet during the Phase 1 data collection due to sedimentation and vegetation in the ditch upstream of the inlet.

The proposed CIP would repair and refurbish the tide gate on a more permanent basis, including replacing the culvert if necessary. Unwanted bi-directional flows during high tide will be minimized. Design should include an alternative analysis that considers different tide gate options to identify one that allows for the most flushing while meeting flood control needs. An upsized culvert would allow greater capacity in the system. The upsize might not be necessary because this area could drain east to the Enterprise Ditch if some conveyance connections were constructed and benefits from improvements made in that subbasin.

Cost Estimate for CIP 2 – Replacement of East Hammond Tide gate and Culvert

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (10%)	1	LS	$22,518	$22,518
Erosion Control (5%)	1	LS	$11,259	$11,259
Demolition and Removal of Existing Structures	1	LS	$17,850	$17,850
Drainage				
36-inch Storm Pipe	1050	LF	$95	$99,750
Manhole, 60-inch	2	EA	$4,000	$8,000
Concrete Inlets	1	EA	$1,200	$1,200
Tide gate Structure	1	EA	$4,000	$4,000
Outlet Protection	1	LS	$2,500	$2,500
Surface Restoration				
Pavement Restoration (Asphalt Concrete)	13	Tons	$280	$3,640
Landscape Restoration (Seeding)	0.5	Acre	$5,000	$2,500
			Sub-total	$173,217
Construction Contingency (30%)				$51,965
	Construction Total			**$225,183**
Engineering (25%)				$56,296
Construction Management (20%)				$45,037
Permitting (10 %)				$22,518
			TOTAL	**$349,033**
NOTE: Assumes fish passage is not required as part of replacement.				

5.4.3 Tide Gate Repair and Replacement Plan [CIP 3]

The levees around Warrenton protect the City from tidal fluctuations of the Columbia River. Several culverts regulated by tide gates allow stormwater runoff generated within the City to pass through the levees and into the Columbia or Skipanon Rivers. The levees are inspected annually by the USACOE and are reported by the USACOE to be in very good condition, with only minor repairs required after each inspection, which are typically completed by the City soon after receiving the report. In addition, the Portland District is in the process of surveying all of their levees and beginning a risk assessment. Warrenton Levees have been surveyed, but are reportedly not among the first to be evaluated for risk.

The culverts and tide gates are integral to the City's drainage system and a potential week point in the levees. The age and condition of several of the existing culverts is questionable. It is recommended that the City initiate a condition assessment of the culverts, tide gates, and headwalls to determine a priority for repair and/or replacement. This effort should be coordinated with the Corps of Engineers.

A tide gate repair and replacement plan would identify tide gates and culverts with structural discrepancies for repair or replacement, and clarify the permitting process required to make the repairs. A preliminary inventory of the tide gates was accomplished during the Phase 1 portion of the project but did not prioritize the repairs to be made. Localized structural failures of the levees associated with leaking tide gates can be minimized. Repairs would diminish unwanted bi-directional flow and reduce flooding in areas behind the tide gates.

NOAA Fisheries is the primary agency regulating tide gates. The agency has been contacted and has specific guidelines related to tide gate management, maintenance, and replacement. NOAA Fisheries recommends that some of Warrenton's tide gates which require replacement be replaced with "fish-friendly" structures to protect and enhance habitat for ESA listed species. However, NOAA also recognizes that not all of the City's tide gates will warrant this level of structure during replacement. In order to determine the appropriate plan it is recommended that Warrenton conduct an inventory of the tide gates and their upstream and downstream associated resources. This effort will identify which tide gates may require "fish-friendly" replacement gates and which ones can be replaced in-kind.

The scope of this CIP could include: TV Inspection of Culverts, Condition Assessment of Headwalls/Pipes, natural resources inventory, Cost estimates & Implementation priority, and programmatic Biological Assessment for replacement plan.

Cost Estimate for CIP 3 – Tide Gate Repair and Replacement Plan

Item Description	Qty	Unit	Unit Cost	Total Cost
Project Management (10%)	1	LS	$11,505	$11,505
Project Meetings	1	LS	$5,000	$5,000
Data Collection	1	LS	$2,500	$2,500
Upstream Natural Resource Inventory	1	LS	$8,000	$8,000
Programmatic Biological Assessment	1	LS	$15,000	$15,000
TV Inspection	3,100	LF	$5	$15,500
Structural Condition Assessment	1	LS	$20,000	$20,000
Agency Coordination	1	LS	$10,000	$10,000
Report	1	LS	$15,000	$15,000
Permitting Support	1	LS	$2,500	$2,500
			Sub-total	$88,500
Contingency (30%)				$26,550
			TOTAL	**$115,050**

5.4.4 3rd/4th Street Pump Station [CIP 4]

The pump station west of Main Street between SE 3rd Street and SE 4th Street was installed in 1975. It drains an estimated area of at least 186 acres, including most of downtown south of SW 2nd Street, plus some inter-basin flow from surrounding subbasins. The current pump has a 40 horsepower, single-speed motor. Information about the performance of the pump was unavailable for this analysis. Pump performance was estimated at 9,000 gpm (20 cfs) based on information available. The pump is powered through the City's electrical grid and there is not a back-up generator currently on site. The pump must be taken offline for periodic and emergency maintenance. There is always the chance of power outage during a storm event. Because the NE 1st Street pump station is currently inoperable, this facility is the City's only method of draining stormwater out of the downtown area during tides high enough to close the tide gates.

An upgrade of the pump station is a recommended to improve reliability of the stormwater management system in the downtown area. Pump technology has advanced dramatically since the 1970's. Multi-speed motors, high-efficiency pumps, and back-up power would increase the performance and reliability of this pump station. Several smaller pumps that cycle on as needed would increase energy efficiency and reduce wear on the system as a whole. An upgraded pump station would increase outflow of stormwater from the downtown area during high tide conditions and reduce backwater effects and localized flooding. New technologies would add redundancy to the system and ensure the required pump capacity is always available as needed.

XP-SWMM was used to model this CIP and compare results with an existing conditions model. The pump station was conservatively sized to handle a peak flowrate of 50 cfs (36,000 gpm) at 25 feet of head. Preliminary modeling of the downtown area shows the potential to reduce flooding by an average of **1.2 feet** in the southern downtown drainage system.

Cost Estimate for CIP 4 – 3rd/4th Street Pump Station

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (8%)	1	LS	$42,771	$42,771
Erosion Control (3%)	1	LS	$16,039	$16,039
Pump Station				
Submersible Stormwater Pumps	2	EA	$95,000	$190,000
Discharge Assembly	2	LF	$14,000	$28,000
Stainless Steel Guide Rails	2	LF	$575	$1,150
Control Panel	1	EA	$70,000	$70,000
Facility				
Excavation and Backfill	1	LS	$8,000	$8,000
36-inch Storm Pipe - Inlet	20	LF	$115	$2,300
Wet Vault	1	EA	$30,000	$30,000
30-inch Ductile Iron Pipe - Outlet	150	LF	$120	$18,000
Outfall Protection	1	LS	$5,000	$5,000
			Sub-total	$411,260
Construction Contingency (30%)				$123,378
	Construction Total			**$534,638**
Engineering (20%)				$106,928
Construction Management (10%)				$53,464
Permitting (5 %)				$26,732
TOTAL				**$721,762**
NOTE: This pump station is a concept design intended to handle the 25-year design storm, resulting in a conservative cost estimate. An alternative analysis will need to be performed during design to optimize the pump station design. This would likely result in a lower cost alternative.				

5.4.5 NE 1st Street Pump Station [CIP 5]

The pump station at the intersection of NE 1st Street and NE Skipanon Drive serves the northern portion of the downtown area and was installed in 1975. The pump station and its tide gate drains approximately 94 acres, including most of downtown north of SW 2nd Street, plus some inter-basin flow from surrounding subbasins. It is believed that overflow from the Alder Creek basin can potentially drain to this pump station during high flows. The pump station itself is currently inoperable because the motor was moved to the SW 3rd/4th pump station in the mid-1990's. Runoff continues to drain through the 42-inch tide gate when possible and backs-up the upstream system when the tide gate is closed because of high tide. Public works staff has stated that much of the upstream system is typically full of water during most of the year, including the manholes and pipes associated with the NW 1st Street and Highway 104 crossings.

An upgrade of the pump station is a recommended to improve reliability of the stormwater management system in the downtown area. Pump technology has advanced dramatically since the 1970's. Multi-speed motors, high-efficiency pumps, and back-up power would increase the performance and reliability of this pump station. Several smaller pumps that cycle on as needed would increase energy efficiency and reduce wear on the system as a whole. An upgraded pump station would increase outflow of stormwater from the downtown area during high tide conditions and reduce backwater effects and localized flooding. New technologies would add redundancy to the system and ensure the required pump capacity is always available as needed.

XP-SWMM was used to model this CIP and compare results with an existing conditions model. The pump station was conservatively sized to handle a peak flowrate of 50 cfs (36,000 gpm) at 25 feet of head. Preliminary modeling of the downtown area shows the potential to reduce flooding by an average of **0.7 feet** in the northern downtown drainage system.

Cost Estimate for CIP 5 – NE 1st Street Pump Station

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (8%)	1	LS	$42,771	$42,771
Erosion Control (3%)	1	LS	$16,039	$16,039
Pump Station				
Submersible Stormwater Pumps	2	EA	$95,000	$190,000
Discharge Assembly	2	LF	$14,000	$28,000
Stainless Steel Guide Rails	2	LF	$575	$1,150
Control Panel	1	EA	$70,000	$70,000
Facility				
Excavation and Backfill	1	LS	$8,000	$8,000
36-inch Storm Pipe - Inlet	20	LF	$115	$2,300
Wet Vault	1	EA	$30,000	$30,000
30-inch Ductile Iron Pipe - Outlet	150	LF	$120	$18,000
Outfall Protection	1	LS	$5,000	$5,000
			Sub-total	$411,260
Construction Contingency (30%)				$123,378
			Construction Total	**$534,638**
Engineering (20%)				$106,928
Construction Management (10%)				$53,464
Permitting (5 %)				$26,732
		TOTAL		**$721,762**
NOTE: This pump station is a concept design intended to handle the 25-year design storm, resulting in a conservative cost estimate. An alternative analysis will need to be performed during design to optimize the pump station design. This would likely result in a lower cost alternative.				

5.4.6 West Hammond Storm Conveyance [CIP 6]

The west Hammond subbasin consists of approximately 316 acres of urbanized and rural land. This area of Warrenton is at a slightly higher elevation than areas to the east and a smaller percentage of wetlands exist here. As a result, the impacts of full build-out are greater here. For example, the 25-year peak flow rate increases from 35 cfs for current conditions to 88 cfs for full build-out, a 150 percent increase. The current system wraps around the neighborhood to the west of Lake Drive. The street crossings are made using 30-inch pipes and the remainder of the system is open ditch. The channel between 2nd and 3rd Avenue is of adequate size and is in good condition. The channel south of 3rd Avenue and the channel between 2nd Avenue and the tide gate culvert are both undersized and choked with vegetation. The entire conveyance system is almost flat and some of the culverts are reverse grade, sloping slightly upstream. The current system is near capacity and is undersized to handle such an increase in flows. Localized flooding, primarily around the ditches and north of 2nd Avenue occurs during large storm events, especially during high tides when Columbia River water is able to flow up into the system through the missing tide gate.

Upsizing the culverts in the system, cleaning out and re-grading the ditches, and adding more slope to the system will improve drainage conditions during storm events, especially if the tide gate is repaired. An XP-SWMM model was used to simulate the proposed improvements and compare with the existing conditions. Future development conditions were used to predict future runoff rates and volumes. The 25-year storm event was used for the model comparisons. The tide gate was assumed to be operational, upsized, and lowered one foot in elevation (as proposed in CIP 1). Recommendations include upsizing culverts, cleaning and re-grading the ditches, and upsizing the ditch north of 2nd Avenue and the ditch south of 3rd Avenue as shown in Figure 11. Model results show that upstream flooding would be reduced by an average of **1.7 feet**. This is predicted to eliminate localized flooding in the area for events up to the 25-year storm event.

Cost Estimate for CIP 6 – West Hammond Storm Conveyance Improvements

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (10%)	1	LS	$8,766	$8,766
Erosion Control (5%)	1	LS	$4,383	$4,383
Demolition and Removal of Existing Structures	1	LS	$5,495	$5,495
Drainage				
36-inch Storm Pipe	250	LF	$100	$25,000
48-inch Storm Pipe	30	LF	$155	$4,650
Concrete Inlets	4	EA	$1,200	$4,800
Earthwork				
Channel / Ditch Clearing	0.2	Acre	$11,000	$2,200
Ditch Excavation	539	CY	$15	$8,085
Surface Restoration				
Pavement Restoration (Asphalt Concrete)	9.3	Tons	$280	$2,604
Landscape Restoration (Seeding)	0.29	Acre	$5,000	$1,450
			Sub-total	$67,434
Construction Contingency (30%)				$20,230
	Construction Total			**$87,664**
Engineering (25%)				$21,916
Construction Management (20%)				$17,533
Permitting (10 %)				$8,766
		TOTAL		**$135,879**

5.4.7 East Hammond/Enterprise Storm Conveyance & Pump Station [CIP 7]

The East Hammond and Enterprise (Brailer) Ditch subbasins cover a total of almost 600 acres in the Hammond area of Warrenton. They are linked through a series of channels and ditches that run just south of, and parallel to Pacific Drive. This main line of conveyance drains to the east Hammond Marina and Enterprise Ditch tide gates. The Hammond Marina tide gate has experienced corrosion problems that have allowed bi-directional flow at this location. The Enterprise Ditch tide gate has a history of sedimentation problems that require periodic maintenance. The tide gate has at times been stuck open and allowed bi-directional flow or stuck closed. Many of the conveyance channels that drain to these tide gates are choked with vegetation and sediments that prevent certain areas from draining properly. Local observations and modeling shows the existing system is incapable of handling large storm events. Localized flooding occurs in several parts of the Hammond area, including along Pacific Drive between King Salmon St and Iredale Drive, near the intersection of 7th Avenue and Hectea Avenue, and along Pacific Drive in the vicinity of Chinook Street.

The two subbasins cover a large area and a large conveyance system already connects them together. A single pump station could be constructed to benefit both subbasins. Conveyance improvements would mostly involve clearing existing channels. Placing the pump station in the vicinity of the Enterprise tide gate would allow the stormwater pumps to augment the outflow through the tide gate, especially during high tides when the gate is closed. Upsized culverts and ditches are recommended in several places to enhance the flow of runoff to the tide gate and pump station. See Figure 13 for a detailed map of the area and the recommended upgrades.

XP-SWMM was used to model this CIP with and without the pump station. Results were compared with the existing conditions model. The pump station was conservatively sized to handle a peak flowrate of 80 cfs (36,000 gpm). Proposed improvements without the addition of a pump station lowered water surface levels for the 25-year design storm by **0.5 feet** in the east Hammond subbasin but did not improve the flooding situation in the Enterprise subbasin. The addition of a pump station reduces water surface elevations by **0.6 feet** in the east Hammond subbasin and **1.4 feet** in the Enterprise subbasin. Improvements of over **2.0 feet** were seen in areas in the close vicinity of the Enterprise tide gate. The addition of road side ditches along Pacific Drive (Hwy 104) that connect to the Enterprise Ditch will allow the majority of the Highway 104 corridor in Hammond to drain, regardless of tidal conditions or storm intensity.

Cost Estimate for CIP 7 – East Hammond/Enterprise Storm Conveyance Improvements

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (10%)	1	LS	$31,876	$31,876
Erosion Control (5%)	1	LS	$15,938	$15,938
Removal of Existing Structures	1	LS	$9,960	$9,960
Drainage				
18-inch Storm Pipe	77	LF	$75	$5,775
24-inch Storm Pipe	384	LF	$95	$36,480
36-inch Storm Pipe	62	LF	$100	$6,200
Manholes, 48-inch	3	EA	$4,000	$12,000
Concrete Inlets	7	EA	$1,200	$8,400
Repair Tide Gate Structure	1	LS	$10,000	$10,000
Earthwork				
Channel / Ditch Clearing	2.22	Acre	$11,000	$24,420
Channel / Ditch Grading	578	CY	$18	$10,404
Ditch Excavation	66	CY	$15	$990
Surface Restoration				
Pavement Restoration (Asphalt Concrete)	57	Tons	$280	$15,960
Landscape Restoration (Seeding)	0.96	Acre	$5,000	$4,800
Riparian/Wetland Restoration	1.3	Acre	$40,000	$52,000
			Sub-total	$245,204
Construction Contingency (30%)				$73,561
	Construction Total			**$318,765**
Engineering (25%)				$79,691
Construction Management (20%)				$63,753
Permitting (10 %)				$31,876
		TOTAL		**$494,086**
NOTE: Assumes fish passage is not required part of any culvert replacement.				

CIP 7 Cost Estimate - Enterprise Pump Station

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (10%)	1	LS	$99,668	$99,668
Erosion Control (5%)	1	LS	$49,834	$49,834
Pump Station				
Submersible Stormwater Pumps	3	EA	$114,200	$342,600
Discharge Assembly	3	LF	$15,450	$46,350
Stainless Steel Guide Rails	3	LF	$575	$1,725
Control Panel	1	EA	$90,000	$90,000
Facility				
Excavation and Backfill	1	LS	$10,000	$10,000
48-inch Storm Pipe - Inlet	300	LF	$155	$46,500
Wet Vault	1	EA	$40,000	$40,000
36-inch Ductile Iron Pipe - Outlet	200	LF	$150	$30,000
Outfall Protection	1	LS	$10,000	$10,000
			Sub-total	$766,677
Construction Contingency (30%)				$230,003
			Construction Total	**$996,680**
Engineering (25%)				$249,170
Construction Management (20%)				$199,336
Permitting (10 %)				$99,668
Land Acquisition (0.25 Acre)	1	LS	$400,000	$400,000
		TOTAL		**$1,944,854**

NOTE: This pump station is a concept design intended to handle the 25-year design storm, resulting in a conservative cost estimate. An alternative analysis will need to be performed during design to optimize the pump station design. This would likely result in a lower cost alternative.

5.4.8 Ditch Maintenance Permit [CIP 8]

The City of Warrenton needs to be able to operate and maintain ditches for conveying storm water through the City and into receiving waters including the Skipanon and Columbia Rivers. Due to changing regulations the City has not been able to perform routine maintenance on many of their ditches. Many ditches have become overgrown and/or have accumulated sediments and are in need of cleaning. In some cases, the water within these ditches in not able to drain properly leading to degraded water quality and poor fish habitat.

Developing a ditch O&M plan will enable the City to properly upkeep their stormwater conveyance system and can be submitted to the regulatory agencies to obtain a single permit. Thereby avoiding the need for a new permit through USACOE/DSL each time the same activity is required to maintain the ditches. This approach will provide for a long-term (5-year) permitting cycle. NOAA Fisheries and the Portland District of the USACOE are the agencies regulating ditch O&M. Both of these agencies have been contacted and they uniformly recommend adapting relevant portions of the ODOT Routine Road Maintenance Guidelines. These guidelines provide for specific O&M practices related to ditch maintenance including, water quality and stream habitat BMPs. The guidelines were developed in consultation with ODOT, NOAA Fisheries, USACOE, and ODFW. All have approved their use in Oregon.

The guideline for ditch shaping and cleaning (Activity 120) is appropriate for the City to use in pursuing either a Nationwide or Programmatic permit through the USACOE and NOAA Fisheries. Both of these permits are valid for a 5-year cycle and would cover all ditch maintenance activities under one permit for the duration of that permit.

The goal of this approach is to have a long-term permit to maintain ditches which will allow for efficient stormwater passage, storage, and infiltration, while minimizing the impacts to water quality and fish habitat. The work covered under Activity 120 includes use of equipment for cleaning and reshaping of ditches such as loading, hauling, and disposing of excess materials. The material that is removed must be taken to an approved location for disposal or storage. Vegetation removed in the ditch is also included during cleaning. The cost estimate includes the submittal of all permitting documentation associated with the ditch O&M plan.

Cost Estimate for CIP 8 –Ditch Maintenance Permit

Item Description	Qty	Unit	Unit Cost	Total Cost
Project Management (10%)	1	LS	$5,200	$5,200
Data Collection	1	LS	$5,000	$5,000
Project Meetings	1	LS	$5,000	$5,000
Agency Coordination	1	LS	$10,000	$10,000
Draft Permit Preparation	1	LS	$15,000	$15,000
Final Permit Preparation	1	LS	$5,000	$5,000
			Sub-total	$40,000
Contingency (30%)				$12,000
			TOTAL	**$52,000**

5.4.9 Local Monitoring Program [CIP 9]

Very little monitoring data is available to the City of Warrenton to describe hydrologic conditions such as stream flow, precipitation and groundwater. The cost associated with data collection in the past has not been justified. However, data generated by a monitoring program would prove invaluable to the implementation of this Stormwater Management Plan and its associated CIP's. Stormwater models created for CIP design would have data available for model building and calibration, resulting in a higher accuracy. Data would be used to show the effectiveness of tide gates and stormwater facilities. Operation of these facilities could then be adjusted to improve management of the existing infrastructure and available resources.

Recommended monitoring facilities would include:

- Rain gauge for downtown area and Hammond. A rain gage already exists at the airport.
- Streamflow gauges for key streams within the City including the Skipanon River, Alder Creek, and larger sloughs
- Groundwater monitoring wells in areas where rising or dropping water tables are a concern.

The cost estimate includes the installation, monitoring, and maintenance of two rain gages, ten stream gages and three groundwater monitoring wells.

- Recommended rain gage locations: Hammond, Downtown, Airport
- Recommended stream gage locations: two on Alder Creek, two on Skipanon River, one on Holbrook Slough, two on Adams (Vera) Slough, one on Skipanon Slough, one on Tansy Creek, one on Enterprise (Brailer) Ditch
- Recommended groundwater locations: Hammond, Downtown, Costco/Fred Meyer area

Cost Estimate for CIP 9 – Local Monitoring Program

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Ground Water Well, Parts/Installation	2	EA	$1,000	$2,000
Surface Water Stilling Well, Parts/Installation	10	EA	$1,000	$10,000
Rain Gage Platform, Parts and Installation	2	EA	$1,500	$3,000
Initial Survey, Placement of Benchmarks	1	LS	$15,000	$15,000
Monitoring Equipment				
Rain Gauge, Tipping Bucket	2	EA	$500	$1,000
Multi-channel Data Logger	2	EA	$1,000	$2,000
Data Logger Case and 12V Battery	2	EA	$200	$400
Download Package for Data logger	2	EA	$600	$1,200
Water Level Logger	13	EA	$800	$10,400
Digital Water Velocity Meter	1	EA	$1,500	$1,500
Labor				
Instrument Installation - Water Level Gauge	13	EA	$200	$2,600
Instrument Installation - Rain Gauge	2	EA	$800	$1,600
Open Channel Flow Measurements - 3 years	240	HR	$55	$13,200
Data Download / Processing - 3 years	288	HR	$55	$15,840
Equipment Maintenance - 3 years	78	HR	$55	$4,290
			Sub-total	$84,030
Contingency (10%)				$8,403
			Sub-Total	$92,433
Engineering (25%)				$23,108
Permitting (10%)				$9,243
			TOTAL	**$124,785**

5.4.10 Downtown Storm Conveyance Improvements [CIP10]

The downtown area currently drains to one of two tide gates, creating two distinct subbasins. The northern subbasin, which drains to the tide gate on NE 1st Street, is approximately 67 acres. The southern subbasin drains to the tide gate and pump station between SW 3rd Avenue and SW 4th Avenue and is approximately 124 acres. Both basins are developed, particularly the southern portion of the downtown area. The existing conveyance system in the downtown area consists of a series of storm pipes, ditches and culvert crossings. The system was constructed in pieces over time as development occurred. As a result, the system does not function very efficiently. Pipes and ditches are undersized and clogged with vegetation and debris. Some pipes are sloped opposite to the direction of flow. Key manholes and pipes are inundated with water during the wet months of fall, winter and spring because they are unable to drain. Improvements to the system would help the downtown area drain properly, especially in conjunction with upgrades to the pump stations.

Most conveyance improvements are proposed to occur along SW 4th Street and SW Alder Avenue. The downtown area's main drainage conduits run down these streets on their way to the pump station located between SW 3rd and SW 4th Street. Upsizing and re-positioning these pipes will enhance the flow of stormwater out of the downtown area. Cleaning, regrading and upsizing the ditches that are a part of these key flow paths will reduce localized flooding and increase the flow of stormwater to the Skipanon River. The larger stormwater system will also provide more capacity and usable stormwater storage in downtown Warrenton.

This CIP also proposes improved connectivity between the two pump stations that serve the downtown. The downtown area is very flat and the conveyance system allows for bi-directional flow depending hydrologic conditions. Improving the conveyance connection between the two subbasins will create redundancy which will allow stormwater to flow to either pump station during periods of high flow. If a tide gate is clogged or a pump station goes offline in one half of the downtown area, stormwater will be able to flow to the outlet on the other half until the repairs have been made. The best place for this connection is into the u-shaped swale at the intersection of SW Alder Avenue and NW 1st St. The connection could be made with only one piece of pipe approximately 100 feet in length. This CIP would not be beneficial until the downtown pump stations are upgraded.

Modeling of the proposed CIP in combination with the pump station upgrades using XP-SWMM result in an average water level reduction of **0.87 feet** for the northern portion of downtown area and **2.00** feet for the southern portion as compared with existing conditions.

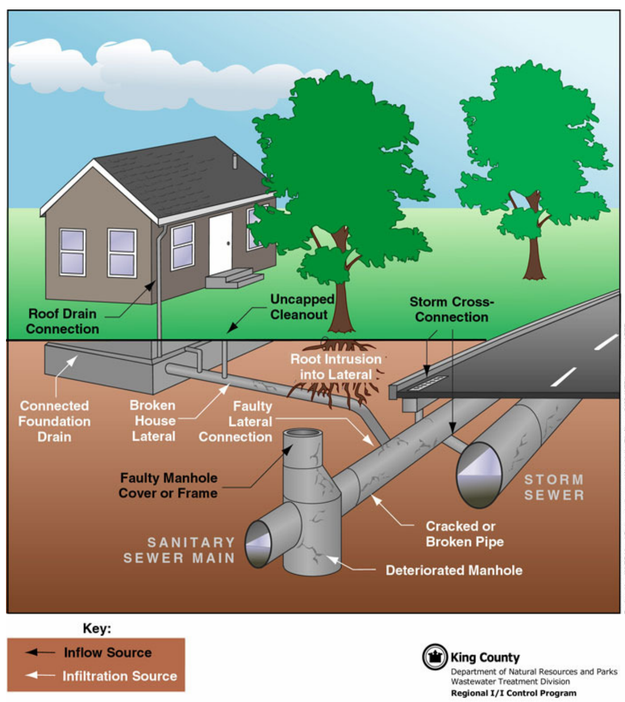
Cost Estimate for CIP 10 – Downtown Storm Conveyance Improvements

Item Description	Qty	Unit	Unit Cost	Total Cost
Site Preparation				
Mobilization (10%)	1	LS	$55,600	$55,600
Erosion Control (3%)	1	LS	$16,680	$16,680
Removal of Structures and Obstructions	1	LS	$5,440	$5,440
Drainage				
18-inch Storm Pipe	837	LF	$65	$54,405
24-inch Storm Pipe	1533	LF	$70	$107,310
30-inch Storm Pipe	490	LF	$90	$44,100
36-inch Storm Pipe	342	LF	$115	$39,330
Manholes, 48-inch	6	EA	$4,000	$24,000
Manholes, 60-inch	3	EA	$5,500	$16,500
Concrete Inlets	8	EA	$1,200	$9,600
Earthwork				
Channel / Ditch Clearing	0.87	Acre	$11,000	$9,570
Ditch Excavation	891	CY	$15	$13,365
Surface Restoration				
Pavement Restoration (Asphalt Concrete)	98	Tons	$280	$27,440
Ditch/Landscape Restoration (Seeding)	0.87	Acre	$5,000	$4,350
			Sub-total	$427,690
Construction Contingency (30%)				$128,307
			Construction Total	**$555,996**
Engineering (25%)				$138,999
Construction Management (20%)				$111,199
Permitting (10 %)				$55,600
			TOTAL	**$861,794**

5.4.11 Sanitary Sewer Inflow/Infiltration (I/I) Study [CIP 11]

The City of Warrenton constructed a new wastewater treatment plant in 2006. Public works staff have indicated that most of the City's system is old and suffers from the typical problems associated with an aging system. Inflow and infiltration of stormwater and groundwater into the sanitary sewer system create additional and unnecessary treatment costs for the City. In addition, sewer lines have the potential to exceed capacity during storm events due to the presence of stormwater runoff. Reducing I/I throughout the City will lower annual wastewater treatment costs and allow the City's sanitary sewer system to function as designed.

There are several methods to determine sources of inflow and infiltration. These include: smoke testing, dye testing, TV inspection, and flow monitoring. In addition, rainfall monitoring is helpful in correlating higher I/I with rain events. Smoke testing pumps smoke into the sanitary sewer system to check for broken pipes, manhole or catch basin. It can also show where roofs and foundations are connected to the sewer system. Dye testing involves using a flourizine dye to discover inappropriate connections in the sewer system. Dye can be introduced to potential sources such as catch basins and roof drains. Sanitary sewer lines downstream of these locations can be checked for evidence of the dye. TV inspections involve first cleaning the sanitary sewer connection and the area to be inspected, then using a closed circuit TV camera to film the sewer line. These inspections can reveal breaks, root intrusion, leaking water and deteriorating conditions. Flow monitoring involves inserting flow meters directly into the sewer lines, typically at manholes, and measuring the flow through the line. This can be helpful in determining where in the City the excess flow is coming from, as well as determining when the peak flow occurs and what the conditions are when it occurs, i.e., rain storm or high tide. Warrenton is already in the process of installing some flow meters in the City system to investigate the I/I problem.



Cost Estimate for CIP 11 – Sanitary Sewer I/I Study

Item Description	Qty	Unit	Unit Cost	Total Cost
Preparation				
Mobilization (10%)	1	LS	$9,126.15	$9,126
Preparatory Cleaning for TV Inspection	10,000	LF	$1.25	$12,500
Sanitary Sewer Inspection				
Smoke Testing	84,500	LF	$0.35	$29,575
TV Inspection	10,000	LF	$1.45	$14,500
Flow Monitoring	10	EA	$250.00	$2,500
Dye Testing and Evaluation	10	EA	$200.00	$2,000
			Sub-total	$70,201
Contingency (30%)				$21,060
			Inspection Total	**$91,261**
Engineering (25%)				$22,815
Permitting (5%)				$4,563
			TOTAL	**$118,640**

5.4.12 Stormwater Rate Study [CIP 12]

The City of Warrenton currently collects a stormwater fee as part of every sewer bill. The rate averages to about $3.76 per household each month to fund operation and maintenance of the City's stormwater system.

To adequately fund their stormwater management system, the City should re-evaluate the cost to operate and maintain their stormwater system including implementation of the recommended CIP's.

The scope of the funding analysis could include:

- An estimate of total and annual Storm Water Management costs, developed by combining the capital project costs and program costs annualized over a ten or twenty year planning period.
- An evaluation of financial alternatives in a matrix format (i.e. - developer impact fees, loans, grants, revenue bonds, and incremental tax financing).
- A comparison of stormwater financial plans from one or more neighboring jurisdictions.
- Revenue needs, cost of service (i.e. financial plan), and rate analyses to support changes to the existing stormwater fee. This would include policies for discounts, credits, and waivers for senior citizens, disabled, handicapped, schools, City roads, State highways, businesses with approved SWM and water quality treatment facilities on site and properly maintained on an annual basis, and other special user groups.
- Review of City's current stormwater rate recovering philosophy and rate structure with recommended revisions.
- Draft revisions to stormwater rate ordinance, and a developer impact fee ordinance (i.e. system development charges (SDC's), as needed to support conclusions of the funding analysis.
- Project Management and Public Involvement

Estimated Cost: $15,000 - $25,000

5.5 CIP Implementation Recommendations

The implementation schedule will be driven by the availability of funds and priority of Stormwater Management relative to other City infrastructure needs. Therefore, implementation recommendations are grouped by level of priority, relative to other CIP's.

Several CIP's should be implemented as quickly as possible. There is very little difference in urgency between LEVEL 1 and LEVEL 2 CIP's. The City has funds available to begin implementation of the Stormwater Management Plan and it is recommended that the LEVEL 1 CIP's identified in Table 5.2 are funded first.

Table 5.2: Recommended LEVEL 1 Capital Improvement Projects
CIP 3 Tidegate Repair & Replacement Plan The City relies upon the levee system along the Columbia River for protection from tidal fluctuations and flooding. A failure in the levee system could be costly in term of damage to property and repair of the levee failure. The Corps of Engineers is undertaking inventory and risk assessment of levees in the Portland District. However, the full scope and timeline for risk assessment of the Warrenton levees is unclear. The tide gates and culverts are the most likely location for a failure due to the ability for water to penetrate into the levee though an eroded head wall or a corroded pipe. It is in the City's interest to complete an evaluation of the condition of the tide gates and associated culverts. The cost and priority for repair or replacement can be determined as a part of the study.
CIP 4 – 3rd/4th Street Pump Station Downtown Warrenton relies upon this pump station to remove stormwater from the downtown area during high tides. This pump station should be upgraded first. In addition, the existing motor can be re-installed on the NE 1st Street pump station until funding becomes available to replace the NE 1st Street pump station.
CIP 8 - Ditch Maintenance Permit Much of the City conveyance system is comprised of open channel conveyances, many of which are regulated by the Corps of Engineers. This CIP would simplify the process involved in performing ditch maintenance by obtaining the regulatory compliance necessary to maintain the City owned ditches.
CIP 12 - Stormwater Rate Study The City needs to identify sufficient funding sources to implement the recommended Capital Improvement Plan, continue on-going maintenance, and maintain/repair the levee system.

The LEVEL 2 CIP's identified in Table 5.3 should also be considered a high priority. However, there are interim measures identified for each one that can be implemented ahead of the complete CIP while the funding source is being determined.

Table 5.3: Recommended LEVEL 2 Capital Improvement Projects
CIP 1 - West Hammond Marina Tide gate If the decision is made to hold off on implementing this CIP, the City should attempt to construct interim repairs to this tide gate similar to those completed during summer 2007 on the East Hammond tide gate. This will improve operations of the existing system until CIP 3 can assess the structural condition and recommend priority for replacement. The study may find that the interim fix will be sufficient for an extended period of time.
CIP 2 - East Hammond Marina Tide gate The summer the City public works removed some length of deteriorated pipe and re-installed the tide gate on a section of pipe that was closer to the banks. This will improve operations of this tide gate for as long as the existing pipe holds together. CIP 3 will assess the structural condition of the pipe and may recommend expediting this CIP or may find that the interim fix will last for an extended period of time.
CIP 5 - NE 1st Street Pump Station Implementation of CIP 4 should include moving the existing pump motor back to the NE 1st Street Pump Station so that it can be partially operational, until such time as funds are identified to replace and upgrade this pump station.

Stormwater system improvements are typically implemented starting at the downstream end, and working upstream through the system. LEVEL 3 CIP's identified in Table 5.4 are important to reducing localized flooding and improving system capacity for future growth of the City, but are less effective if the portions of the downstream system have not been improved. Therefore, it is recommended that LEVEL 3 CIP's are implemented as resources become available. The LEVEL 3 CIP's offer the most opportunity for cost savings because they include elements that can be implemented by City staff without having to go through a design-bid-build process.

Table 5.4: Recommended LEVEL 3 Capital Improvement Projects
CIP 11 – Sanitary Sewer Inflow/Infiltration Study Results of this study may identify high priority stormwater projects that would reduce inflow of surface water to the sanitary sewer system.
CIP 6 – West Hammond Storm Conveyance. This CIP can be implemented in pieces as resources become available. It's importance will increase as further urbanization occurs in the West Hammond subbasin.
CIP 7 –East Hammond/Enterprise Storm Conveyance and Pump Station This CIP is the most expensive and likely to require the most effort to implement. It includes land acquisition and potentially challenging permitting. However, this CIP can be implemented in pieces as resources become available. Partial upgrades to the conveyance system can reduce localized flooding in some areas by connecting low points to the main conveyance routes.
CIP 9 – Local Monitoring Program This CIP can be implemented in pieces. CREST and/or citizen participation may result in significant cost savings and public education.
CIP 10 – Downtown Storm Conveyance Improvements It is recommended that this CIP be implemented as part of street improvement projects throughout the downtown area.

The City hosted an Open House for the Stormwater Management Plan project on October 30, 2007. According to the sign-in sheet, the event was attended by 12 residents of the Warrenton Community. A copy of the sign-in sheet is provided in Appendix I. Each of the twelve capital improvement projects recommended in the Draft Stormwater Management Plan was displayed on easels around the room. Staff from Otak was available to answer questions and explain the projects.

Attendees were each given a red, yellow, and blue sticker to place on the display board for the capital projects that were most important to them. Green stickers were provided to mark areas for which residents wanted to provide a written comment and then they were asked to fill-out a comment form to elaborate on their comment.

Table 5.5 summarizes the feedback received from the residents at the open house on the recommended Capital Improvement projects. An overall score was calculated by assigning 3 points for every 1st priority vote, 2 points for every 2nd priority vote, and 1 point for every 3rd priority vote. This is not an exact science, but generally captures the relative importance that attendees placed on the projects.

Table 5.5: Summary of Capital Project Ranking by Attendees at Open House

		PRIORITY			
CIP	TITLE	1st	2nd	3rd	**Score**
7	East Hammond/Enterprise Subbasin Drainage Improvements	3	5		**19**
8	Ditch Maintenance Permit	4	1	1	**15**
3	Tide Gate Repair and Replacement Plan	1		4	**7**
4	Refurbish SE 3rd Pump Station		3	1	**7**
1	Refurbish West Hammond Tide Gate		2		**4**
2	Refurbish East Hammond Tide Gate	1			**3**
5	Refurbish NE 1st Pump Station	1			**3**
10	Downtown Conveyance System Improvements	1			**3**
9	Monitoring Program			1	**1**
6	West Hammond Storm Conveyance				**0**
11	Sanitary Sewer Inflow/Infiltration (I/I) Study				**0**
12	Stormwater Rates Study				**0**

CIP 7 and CIP 8 are the most important to those attending the open house. It should be noted that a significant element of the East Hammond/Enterprise Drainage Improvements [CIP 7] project involves regrading of ditches to improve conveyance. Based upon this, ditch maintenance seems to be the biggest concern of residents attending the open house and implementation of CIP 8 is recommended as the highest priorities to implement.

There were seven written comment forms received. The comments are summarized in Table 5.6. Copies of the original comment forms are provided in Appendix I.

Table 5.6: Summary of Comments Received
• No drainage on 200 block of Main Court between SW 2nd & SW 4th – SW 3rd St. @ Main Court is underwater during storm events. • Drainage problems SW Birch Ave. & SW 2nd St. during storm events. • SW 2nd Ave. & SW Elm Ave. high water during storm events.
Thank you for this significant effort to understand and manage our stormwater system. I want to confirm that the Skipannon Watershed Council is interested in partnerships to improve salmon passage and connections to sloughs and wetlands. The Council has funding and follows the state "Oregon Plan for Salmon and Watersheds".
I also am interested in opportunities for landscaping ditches near the Warrenton Waterfront trail system such as the north side of NE 1st Street. Possible bioswale and xeriscaping with native wetland plants for some biofiltration of pollutants prior to discharge into the rivers.
I am concerned about the natural filling of all the ditches and sloughs of Warrenton, creating a higher general water table most of the year. This creates soggy soil and fallen large spruce trees, roots and all during our annual winter storms. Also, the higher general water table is detrimental to septic tank systems of which there still are many in the city. When septic systems don't function properly, results in poor general water quality. High tides, days of rain – cause flooding yards, houses, etc. Inadequate drainage & fish friendly tide gates can also contribute to overall higher water table. Thank you for informing us on the storm water drainage plans.
As property owners, we have major issues concerning CIP8 Ditch Maintenance Permit and CIP3 Tide Gate Repair and Replacement Plan.
Concern about the area between SW 3rd and SW 9th along Main Street that floods "every time" it rains substantially. This should be an area of primary concern.
The second area of concern is in Hammond west of Lake Road and towards the river from Pacific Drive that also "floods" "every time" it rains substantially.

Section 6— References

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