Memorandum

To:	Carolyn Sharp, Marguerite Feuersanger
From:	David Whitaker
Reviewed By:	Greg Savage
Date:	July 7, 2005
Project:	Willamette Watershed Modeling
Subject:	Linnton Hillside Study Area – Hydrologic Evaluation

Introduction

The purpose of the hydrologic evaluation was to assess how development within the study area would affect the receiving stream systems. The evaluation focuses on potential impacts at a subbasin scale, but also reviews stormwater control best management practices that should be followed when developing at a residential lot scale. Three potential stormwater related impacts were evaluated for each of the neighborhoods in the study area. The following three potential impacts are subbasin scale impacts: 1) *Higher peak flows delivered to the receiving stream leading to degradation of the stream system;* 2) *Water quality impairment related to increased impervious area* and 3) *Conveyance capacity issues with existing stormwater piping*. The fourth potential impact: 4) *Groundwater seepage that leads to slope instability*, is mainly a residential lot scale impact and is assessed with a review of stormwater control best management practices.
Subbasins that have been evaluated within the Linnton study area were given the name designations that begin in WIL (which is short for Willamette). The subbasins were named in sequence, beginning in the north part of the study area. The headwaters of these basins are in the heavily forested areas of Forest Park.

The subbasins were evaluated for the changes in impervious area between the existing conditions; the zoning buildout and comprehensive plan buildout conditions. Hydrologic models of the subbasins were developed for the purpose of estimating peak flows at various locations in the subbasins. The Corps of Engineers HEC-HMS model was used to estimate these flows. The model has a number of options for generating rainfall runoff. The SCS Curve Number methodology was used for generating rainfall runoff in this model. Peak flows were generated for the 10-year, 24-hour storm, which is the design storm that is used for sizing stormwater conveyance systems. This storm has a total volume of 3.4 inches and an SCS Type 1A rainfall distribution. The SCS 1A storm is a synthetic rainfall event that was developed by the Soil Conservation Service and is based upon National Weather Service duration-frequency data.

Investigations into the correlation between development and aquatic-system conditions have been pursued for over two decades. Klein (1979) published the first such study, where he reported a rapid decline in biological diversity where watershed imperviousness much exceeded 10 percent. Since that time, much work has been completed by Pacific Northwest researchers to evaluate the relationship between effective impervious area and the properly functioning condition of a stream system (Booth, 2000). Munn (2001) states that because of the ecological significance of upland processes, anything greater than a 5% total impervious area in a watershed will create problems for the stream system.

In the following tables, the “Zone” and “Comp” impervious percent calculations were determined by adding the capacity for the existing developed properties and the properties with the capacity to develop in order to determine the total properties in each zoning code for each subbasin. The number of properties was then multiplied by the impervious area estimates for various codes (R5, R7, etc.) within the SFR zoning designation. These areas come from City Code Ch 33.110, Table 110-6.

Summary of Results

The three subbasin scale potential stormwater related impacts were evaluated for each of the neighborhoods. The following lists summarize the potential impacts for each of the neighborhoods.

Harborton

- *Higher peak flows degrading stream system* – No significant increase in peak flow predicted because of relatively small increase in impervious area.
- *Water quality impairment related to increased impervious area* – No significant increase in impervious area, so significant water quality impairment is not expected.
- *Conveyance capacity issues* – No conveyance capacity issues because there is no significant increase in peak flow predicted.

Linnton

- *Higher peak flows degrading stream system* – Increases in peak flows related to increased impervious area could degrade stream system if stormwater is discharged directly into the WILF stream system.
- *Water quality impairment related to increased impervious area* – There is the potential for water quality impairment related to an increase in automobile traffic and increased peak flows in roadside ditches. The greatest potential for impairment is in the WILF subbasin.
- *Conveyance capacity issues* – Slope data for the highway culvert and private stormwater system is currently not available, so no determination of conveyance capacity was made.

Waldemere-Glen Harbor

- *Higher peak flows degrading stream system* – Increases in peak flows related to increased impervious area has the potential to degrade stream systems in the WILK and WILL basins.
- *Water quality impairment related to increased impervious area* – There is the potential for water quality impairment related to an increase in automobile traffic and increased peak flows in roadside ditches. The greatest potential for impairment is in the WILK and WILL basins.
- *Conveyance capacity issues* – Slope data for the highway culvert and private stormwater system is currently not available, so no definitive determination of conveyance capacity was made.

Whitwood Court

- *Higher peak flows degrading stream system* – The stream system that runs through the Whitwood Court neighborhood has the greatest potential of any of the neighborhoods for negative effects to the stream system due to increased peak flows.
- *Water quality impairment related to increased impervious area* – There is a relatively high potential for water quality impairment related to increased peak flows in roadside ditches. Additional automobile traffic will also contribute to a reduction in stream water quality.
- *Conveyance capacity issues* – Slope data for culverts is currently not available, so no definitive determination of conveyance capacity was made. However, the significant increase in impervious area within the tributary basins could lead to conveyance capacity issues in the culverts under the local access roads.

Fairmont-Willbridge

- *Higher peak flows degrading stream system* – The receiving stream is a ditch along the highway that drains to a small water body west of the Guilds Lake pump station. Higher peak flows in the ditch would contribute greater sediment to this receiving water.
- *Water quality impairment related to increased impervious area* – There is a relatively high potential that the water quality of the receiving water (some type of small lake or pond) could be degraded by increased peak flows in the roadside ditch.
- *Conveyance capacity issues* – The 14-inch stormwater pipe that conveys flow under the highway from basin WILR would have capacity conveyance issues if all residential lots and industrial properties were developed.

Stormwater impacts on the residential lot scale would be associated with concentrated stormwater flows being discharged onto steep slopes. A summary of stormwater best management practices includes recommendations to not discharge roof runoff on steep slopes, to intercept surface drainage at the top of slopes, and to retain existing vegetation with significant root structure.

Subbasin Scale Analysis

Harborton Neighborhood

Two subbasins were evaluated in the Harborton Neighborhood. Figure 1 shows that most of the homes in the neighborhood are located in the WILA1 subbasin. The WILA2 subbasin is to the south of the neighborhood. Table 1 provides a summary of the subbasin impervious area.

TABLE 1				
Harborton Neighborhood – Subbasin Characteristics				
Subbasin	**Area (acres)**	**Existing Imp %**	**Zone Imp %**	**Comp Imp %**
WILA1	45.6	4.32%	5.07%	5.07%
WILA2	77.2	0.00%	0.16%	0.16%

Flow from the main stream in the WILA1 subbasin is directed to an inlet near the intersection of Mountain View Rd and Harborton Dr. It is conveyed in a private culvert until it reaches Harborton Rd, where it commingles with ditch flow and enters an 18-inch diameter corrugated metal pipe (CMP). The CMP discharges along the west side of St Helens Hwy and then enters another 18-inch diameter CMP under the Highway. It is assumed that discharge from most roof and driveways is routed to the ditch system prior to entering the CMP.
The increase in flow that comes with additional impervious area related to full zoning or comp plan development is not significant and is not expected to cause conveyance capacity problems in the stormwater system.

The increase in impervious area in subbasin WILA2 is insignificant and is not expected to lead to degradation of the stream system or cause conveyance capacity problems.

Discharge from both subbasins meets on the east side of the highway in what appears to be a properly functioning forested riparian/wetland system. The additional impervious area related to full zoning or comp plan development is not expected to cause a significant negative affect on this system.

Linnton Neighborhood

Four subbasins were evaluated in the Linnton Neighborhood. Figure 2 shows that most of the homes in the neighborhood are located in the WILE and WILF1 subbasins. The WILF3 subbasin drains to the WILF1 subbasin and the WILG1 subbasin is south of the neighborhood. Table 2 provides a summary of the subbasin impervious area.

TABLE 2				
Linnton Neighborhood – Subbasin Characteristics				
Subbasin	**Area (acres)**	**Existing Imp %**	**Zone Imp %**	**Comp Imp %**
WILE	29.9	8.47%	10.52%	10.89%
WILF1	13.7	12.22%	22.32%	22.32%
WILF3	80.4	0.16%	2.80%	2.83%
WILG1	376.7	0.01%	0.34%	0.39%

Runoff from the WILE subbasin is currently collected by a number of inlets that are typically located along the upslope side of the roads. These inlets are connected to the combined sewer, which routes combined flow to the Linnton pump station. It is assumed that roof runoff is either discharged directly to the combined system or is conveyed to the road system, where it is routed to the combined system. The Linnton pump station is currently at capacity, so it doesn't have capacity for additional stormwater flows. When additional development occurs in this subbasin, stormwater flows from newly developed properties could be routed to the stormwater system in the WILF1 subbasin. This 24-inch diameter HDPE pipe system appears to have adequate capacity to convey these additional flows. However, the flows are conveyed to a 30-inch concrete culvert that conveys flow under the highway. This culvert also conveys runoff from about 1.5 acres of the Highway. There may be a conveyance capacity problem at this crossing since the flows from the WILF3 subbasin also are conveyed through this culvert (*Slope data for this culvert is needed to make this determination*). After the flow crosses under the highway, it is routed through a short section of open channel and then is conveyed through a private stormwater system under the Linnton Plywood property. If this property were redeveloped, there would be an opportunity to daylight this stream. At the time that this report was developed, data on this private stormwater system was no available.

If flow from the additional impervious area related to full zoning or comp plan development is routed to the existing 24-inch diameter HDPE stormwater system, there should not be a negative impact to the stream system in the WILF subbasins. However, if the stormwater were to be discharged directly into the WILF stream, the additional flows could potentially negatively impact approximately 500 feet of the stream channel that is upstream of the highway crossing. The increase in impervious area would lead to higher peak flows and also high flows that occur more often. This could potentially lead to scouring of the streambed and banks. This portion of the stream runs through private properties.

There is not a significant difference between the zoning full buildout and comp plan full buildout impervious areas, so comp plan densities would not cause notably greater negative impacts.

Subbasin WILG1 along the south side of the neighborhood would see a small increase in impervious area that most likely would not cause a significant affect on the health of the receiving stream.

Waldemere – Glen Harbor Neighborhood

There are five stream systems that run through or adjacent to the neighborhood. Figure 3 shows that three of the subbasins are fairly small (WILI, WILK and WILL) and the other two are more significant in size. Table 3 provides a summary of the subbasin impervious area.

TABLE 3

Waldemere-Glen Harbor Neighborhood – Subbasin Characteristics

Subbasin	Area (acres)	Existing Imp %	Zone Imp %	Comp Imp %
WILG2	6.8	9.36%	20.05%	21.78%
WILI	31.5	0.61%	2.88%	3.19%
WILJ1	128.5	2.78%	5.34%	6.13%
WILJ2	15.7	0.00%	0.00%	0.00%
WILK1	8.5	19.20%	31.68%	37.88%
WILK2	39.3	3.58%	8.93%	9.31%
WILL1	12.1	14.24%	25.39%	31.29%
WILL2	43.5	0.12%	0.29%	0.29%
WILM	287.5	0.87%	1.81%	1.94%

In the WILI subbasin there is a small stream that crosses through the neighborhood near the northern edge. It originates in Forest Park and at one time flowed through a small reservoir just upslope of NW MacKay Ave. The reservoir has been abandoned and the stream now flows in a ditch that has a gravel/cobble bed and is adjacent to a forest access road prior to entering the neighborhood. Road runoff and runoff from driveways and roofs in the neighborhood appears to be conveyed to the stream through ditches adjacent to the road. The stream flows through the neighborhood in open channels except where it crosses under local access roads and driveways in 12- to 18-inch culverts. It flows under the highway in an 18-inch culvert. The increase in impervious area associated with full zoning or full comp plan buildout would not significantly increase flows. It appears that there would be adequate flow capacity in the highway culvert for a full buildout condition. The increase in impervious area does not bring the total impervious area above 10 percent, so the likelihood of a significant impact to the biota in the stream is low.

The WILJ subbasin is a larger basin that runs through the middle of the neighborhood. In the existing condition, flow from the portion of the neighborhood that is north of the stream is routed in ditches and discharged to the culvert that runs under the highway. The portion of the neighborhood that is south of the stream has runoff collected in a storm sewer system that discharges to the culvert under the highway. It is assumed that for the future condition, the drainage patterns would remain the same. Therefore, any increased flow brought about by additional impervious area would flow directly to the culvert and would not affect the condition of the stream west of the highway. The stream flows through a pipe east of the highway to the discharge at the Willamette River.

Flows from subbasin WILJ and subbasin WILK combine east of the highway. The flow then is conveyed through a 42-inch pipe that is routed through a tank farm. The slope of the 42-inch pipe is not known, so the flow conveyance capacity is difficult to calculate. This initial evaluation indicates that the increase in impervious area brought about by the full comp plan buildout would increase the design storm flows about 10 percent. The estimated peak design flow for the full-buildout condition is approximately 18 cfs. Assuming that the 42-inch pipe slope follows the ground surface slope, there is adequate capacity to convey the design flow.

The WILK and WILL subbasins are smaller basins where the streams run through the yards of a number of private properties. There are limited stormwater pipes in the basin, so it appears that runoff from the roads, driveways and roofs drain to ditch systems, which conveys the flow to the streams. As in basin WILJ, the analysis indicates that the increase in impervious area brought about by the full comp plan buildout would increase the design storm flows about 10 percent. The peak flow increase brought about full zoning buildout is approximately 7 percent. The increase in impervious area and related increases in peak flows within these basins may lead to degradation of the lower portions of the stream systems by eroding the stream bed and banks.

Subbasin WILM along the south side of the neighborhood would see a small increase in impervious area that most likely would not cause a significant affect on the health of the receiving stream and would not cause a significant increase in peak flow rate.

Whitwood Court Neighborhood

There is one stream system in the neighborhood that has two branches and a mainstem stream. After the confluence of the branches with the mainstem, the stream flows under the north approach ramp to the St Johns Bridge and then into a 60-inch culvert under the highway (see Figure 4). Table 4 provides a summary of the subbasin impervious area.

TABLE 4				
Whitwood Court Neighborhood – Subbasin Characteristics				
Subbasin	**Area (acres)**	**Existing Imp %**	**Zone Imp %**	**Comp Imp %**
WILN1	179.2	0.62%	1.09%	1.25%
WILN2	19.9	6.87%	16.72%	18.63%
WILN3	28.0	7.27%	18.08%	20.30%

Under the existing condition, the WILN subbasins have a combined impervious surface of about 2 percent. This would be increased to over 5 percent under the comp plan buildout. This degree of change could cause a negative effect in the mainstem portion of the stream between the confluence with the stream branches and the culvert crossing. The stream is in relatively good condition at this location. Model results indicate that the 10-year design storm peak flow would increase 7 percent at comp plan buildout.

The stream branches would see a much more significant impact from future development. The impervious area surpasses the 10 percent impervious area threshold for rapid decline in biodiversity set by Booth and others. Also, the 10-year design storm peak design flow in WILN2 is estimated to increase by 30 percent and the peak design flow for WILN3 is estimated to increase by 34 percent. The stream system that runs through the Whitwood Court neighborhood has the greatest potential of any of the neighborhoods for negative effects to the stream biota and change in peak flows due increased impervious area.

Fairmont-Willbridge Neighborhood

The SFR properties with the capacity to develop in this neighborhood are mostly adjacent to the highway, with a few up along Saltzman Road. The greatest concentration of properties to be evaluated is just north of Saltzman Creek. Figure 5 shows those properties in relation to the Creek (runs along NW Saltzman Rd and NW Balboa St). Table 5 provides a summary of the subbasin impervious area for all SFR zoned properties.

The only portion of a subbasin to be evaluated is WILR2, since it has the greatest concentration of properties with the capacity to divide. There are so few properties that drain to Saltzman Creek in relation to the size of the drainage basin (~1,000 acres), it was decided to not evaluate the potential changes in peak flows since these properties would contribute only a small fraction of the total peak flow in the Saltzman Creek watershed.

TABLE 5				
Fairmont-Willbridge Neighborhood – Subbasin Characteristics				
Subbasin	**Area (acres)**	**Existing Imp %**	**Zone Imp %**	**Comp Imp %**
WILR1	264.6	0.06%	0.09%	0.09%
WILR2	27.9	2.07%	10.46%	10.46%

It appears from the mapping that runoff from WILR2 is routed to a small drainage system along the highway and then conveyed across the highway in a 14-inch culvert pipe. Once the flow crosses the highway, it is directed to the north in a ditch, where it discharges to a triangular shaped water body just west of the Guilds Lake pump station. It appears that this water body could be the last remnant of the historical Guilds Lake.

When reviewing Table 5 it appears that only 10.46% of WILR2 will be impervious for the comp plan buildout scenario. However, much of the property in the subbasin is zoned industrial and is not included in the table. If the industrial properties were included in the calculation, the total impervious area would be approximately 85% under comp plan buildout conditions. Flow from this much impervious area would overwhelm the 14-inch pipe crossing, so there would be a need to upsize the crossing.

Stormwater Control Best Management Practices

Since much of the study area is located on steep slopes with potential for landslide problems, it is important that roof, driveway and street runoff be controlled so that concentrated flow is not conveyed onto these steep and potentially weak slopes. Also, it is important to maintain existing vegetation since it typically has well developed root structure that helps to stabilize slopes. This vegetation will also intercept some of the rainfall onto the slope, thereby reducing the potential for slope saturation.

During the design and construction of new residential lots, the stormwater conveyance systems should be integrated into the overall design in such a manner that doesn't allow for concentrated stormwater to be discharged in a way that would lead to saturation of a slope. In addition, stormwater conveyance systems such as roof gutters and downspouts, water quality facilities, and roadside swales should be maintained on a regular basis so that they do not become clogged and discharge concentrated flow at unintended locations. The following best management practices for the control of stormwater runoff from residential lots are recommended (Burns):

- Direct roof and downspout drainage to a safe place – NOT INTO THE GROUND OR ONTO A SLOPE AREA.
- Direct road, driveway and patio runoff away from slopes and into stormwater conveyance systems.
- Intercept surface drainage at the top of all slopes. Drain away from the slope.
- Clean gutters on a regular basis. Fix broken and leaking downspouts.
- Retain existing vegetation that has significant root structure to help stabilize the slope and intercept rainfall.

Also, it is important to maintain the road system so that low or settled curbs on roads or driveways don't allow storm drainage to spill onto steep slopes. The condition of the stormwater pipe systems within the neighborhoods also should be maintained. However, the condition of the stormwater pipes within the neighborhoods is not known. It is not standard operating procedure for BES or the maintenance bureau to assess the condition of stormwater pipe systems.

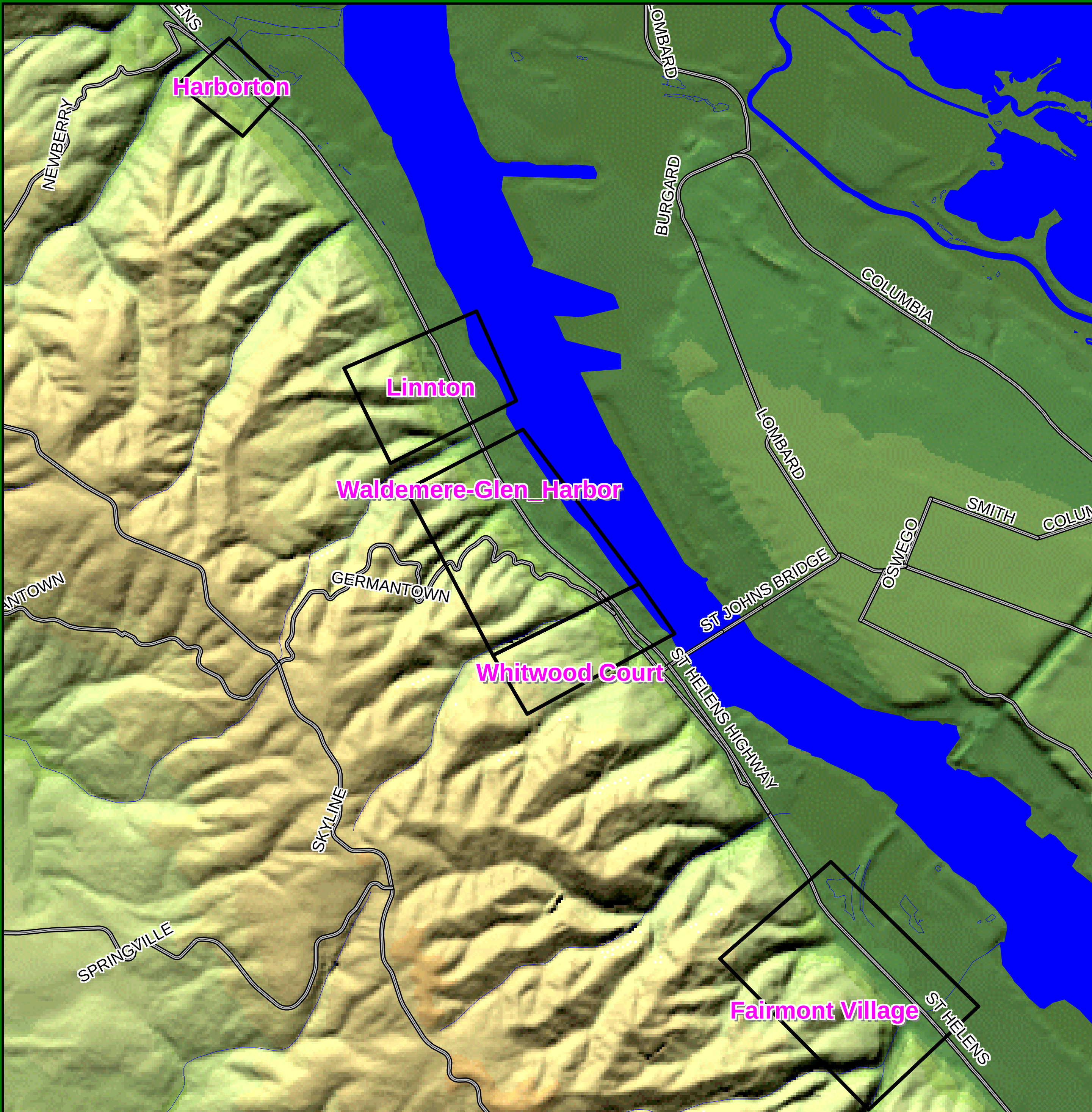
References:

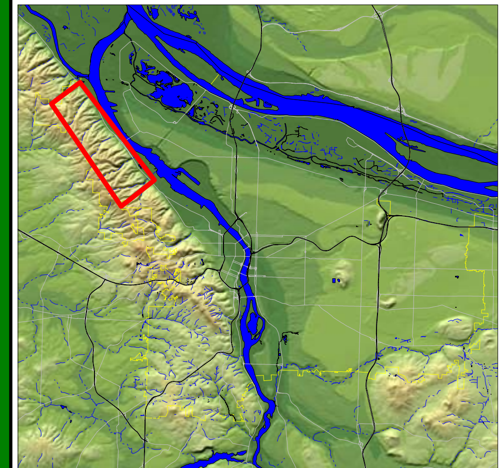
Booth, D.B., 2000, *Forest Cover, Impervious-Surface Area and the Mitigation of Urbanization Impacts in King County, Washington*, September 2000

Burns, S., Homeowners Landslide Guide, Oregon Emergency Management, Federal Emergency Management Agency, Region 10

Klein, R., 1979, *Urbanization and stream quality impairment*: Water Resources Bulletin, v. 15, p. 948-963

Munn, N., 2001, Presentation titled "*What does 'Properly Functioning Condition' mean in an Urban Setting*", presented at At the Waters Edge – Science based approaches to managing urban riparian zones for salmonid protection and recovery, October 2001





Study Area Legend

Neighborhoods

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N S E W

Linnton Area Modeling Evaluation Study Area

Sheet No.	*Date Printed:*
1 of 6	05/13/2005
Ref. No.	
145-32-040	environmental services systems analysis

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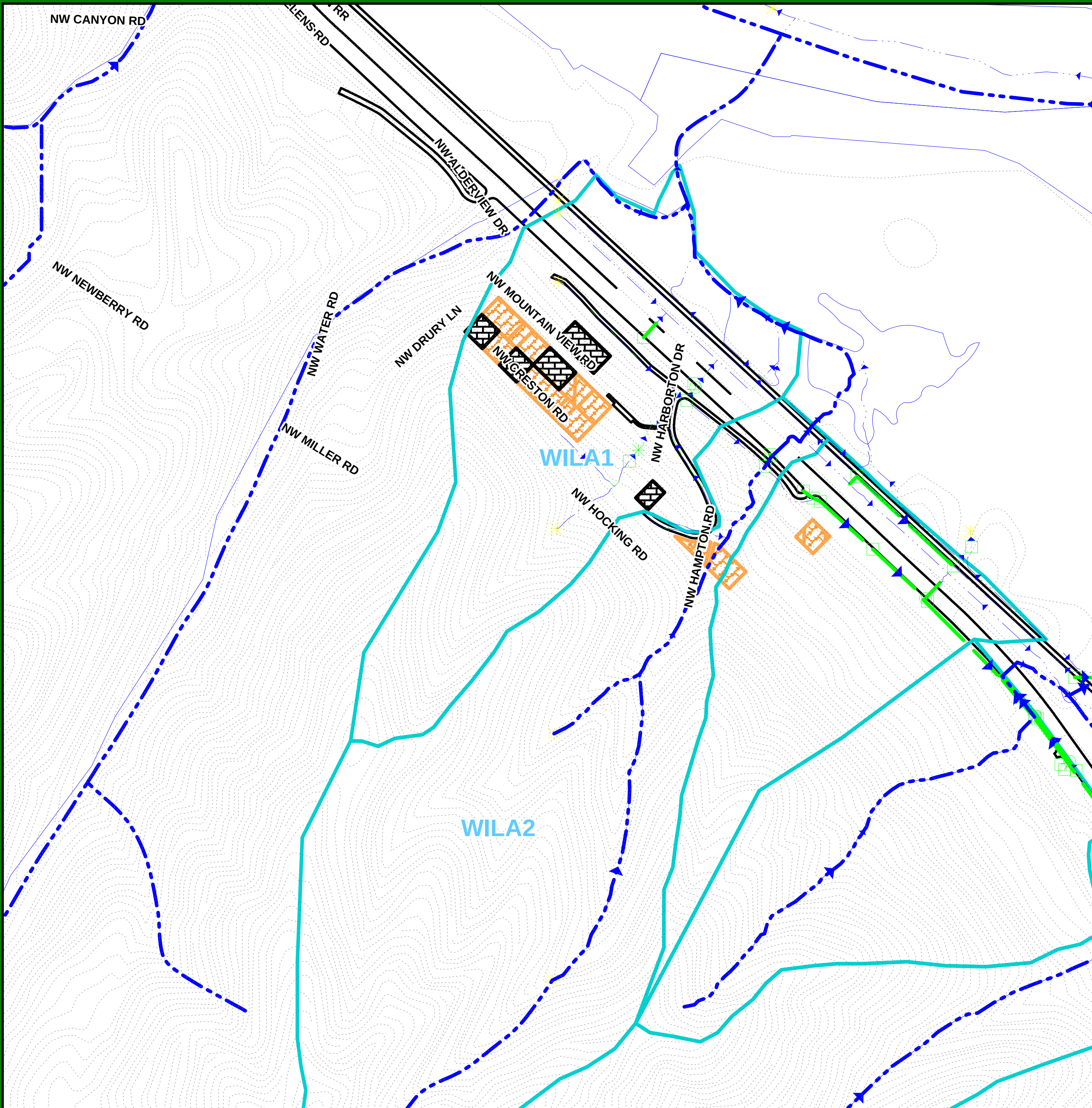

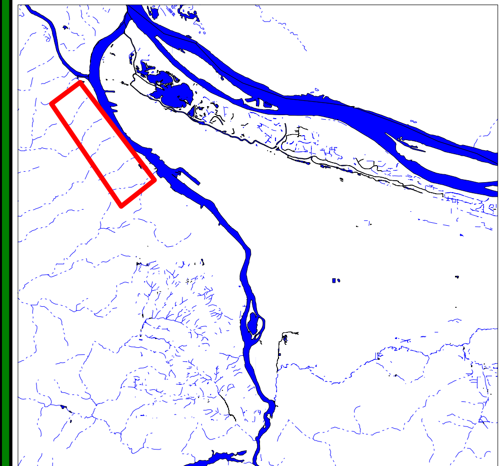

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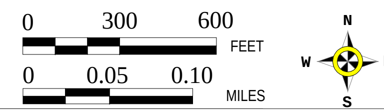
- Stormwater
- Combined Sewer
- Sanitary Sewer



Linnton Hillside Study Area
Harborton Neighborhood

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Figure 1	06/15/2005
Ref. No. 145-32-040	environmental services systems analysis

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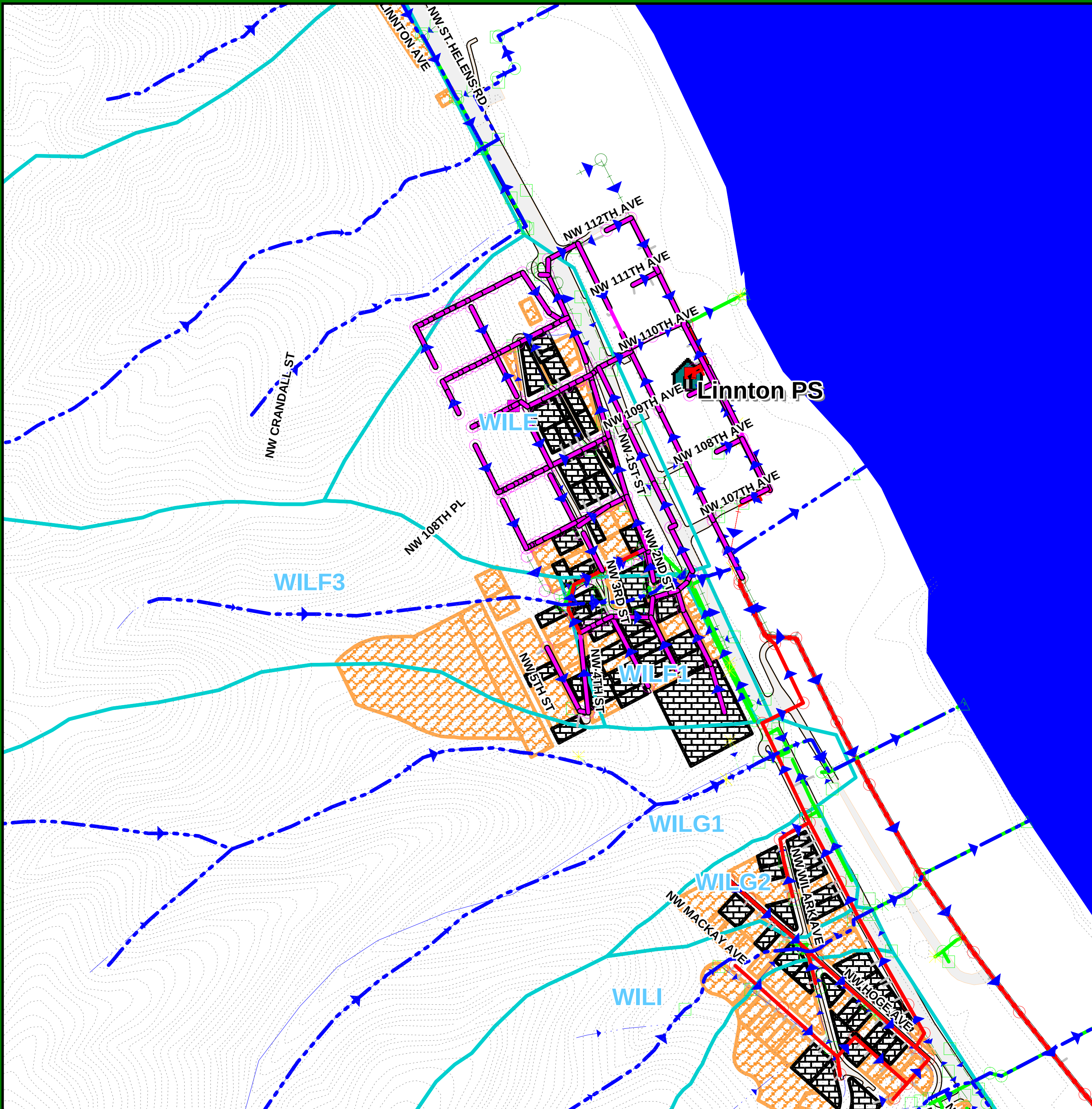

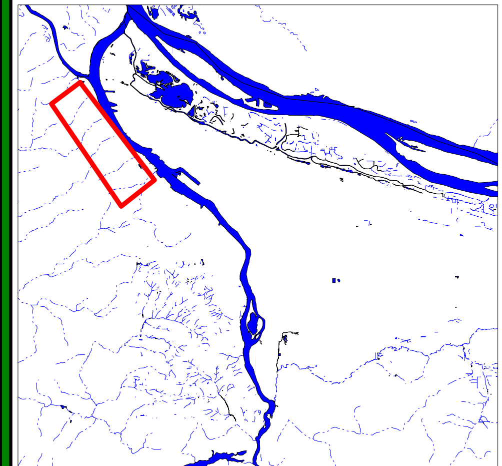

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N E S W

Linnton Hillside Study Area
Linnton Neighborhood

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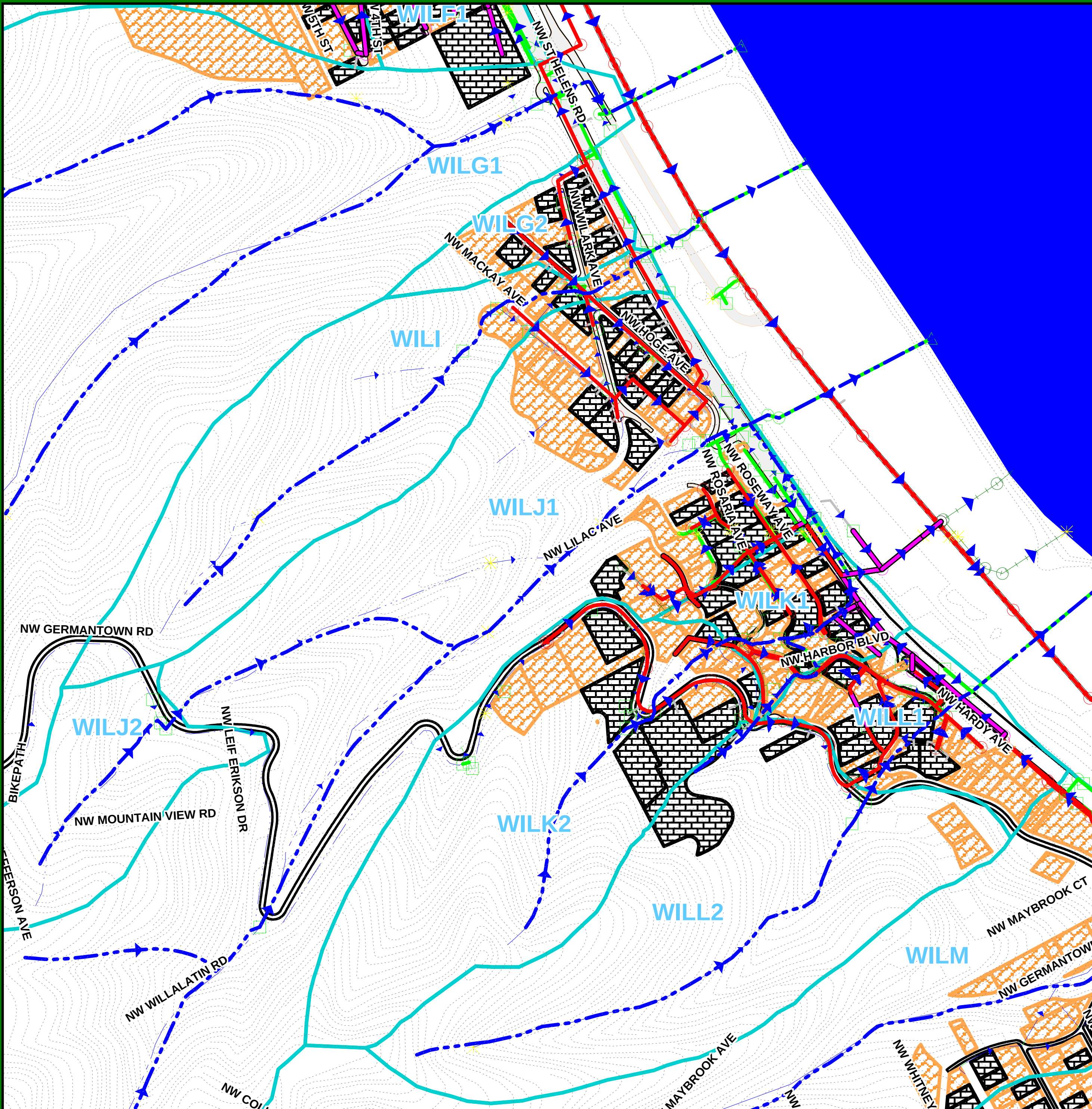

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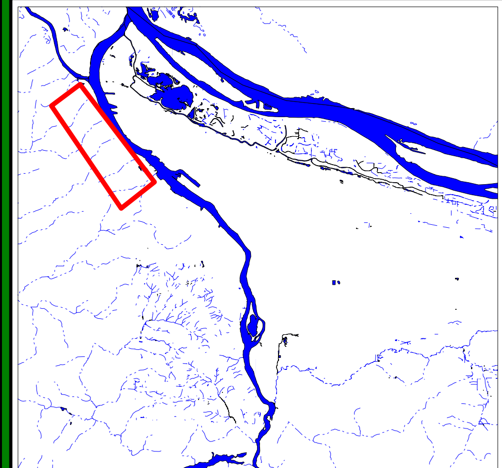

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N E S W

Linnton Hillside Study Area
Waldemere-Glen Harbor Neighborhood

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Figure 3	06/15/2005
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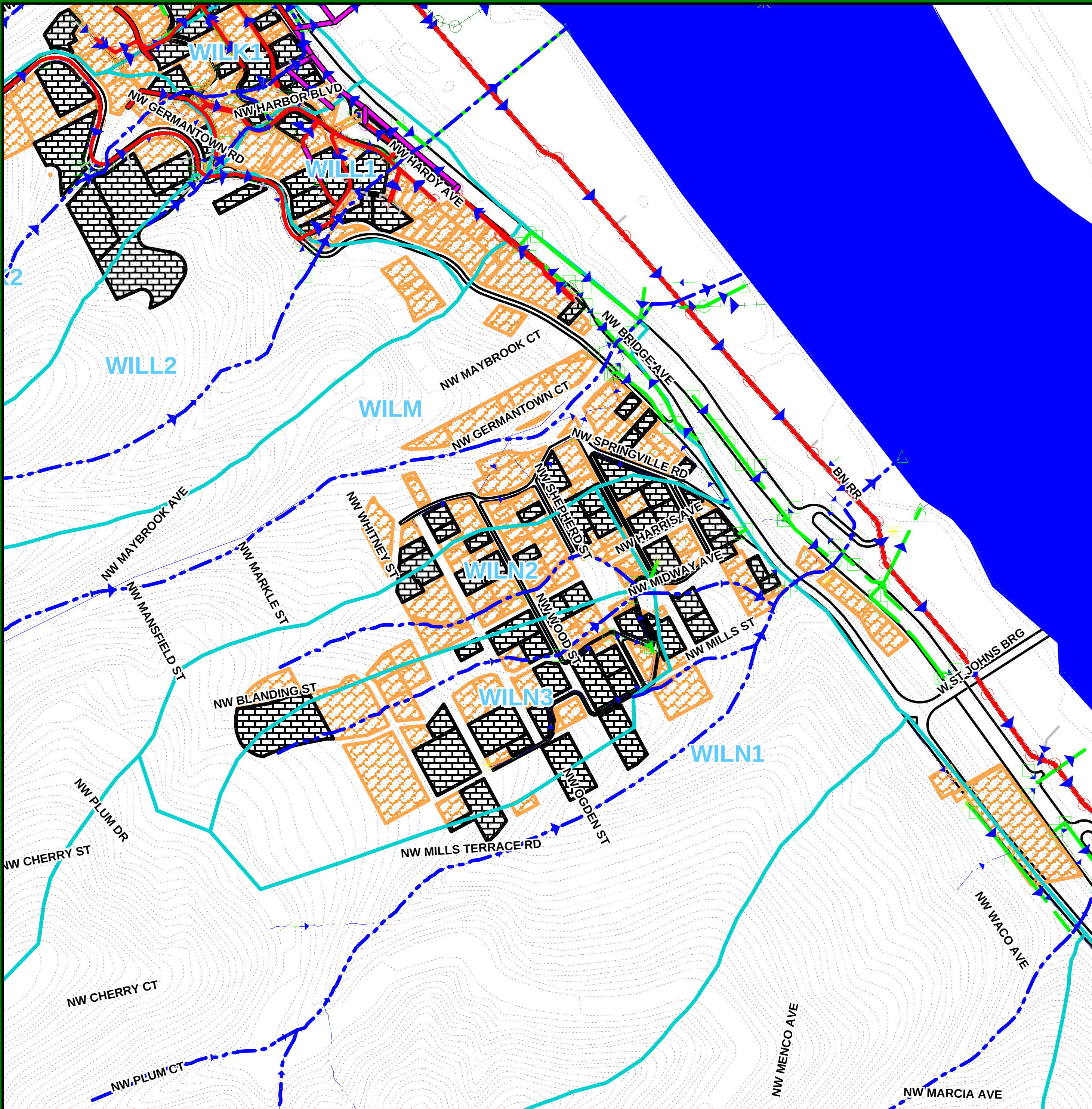

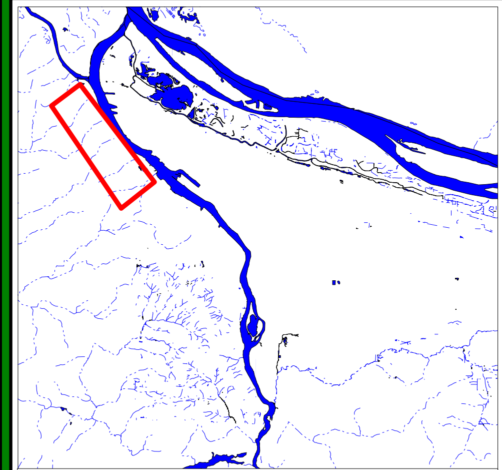

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N E S W

Linnton Hillside Study Area
Whitwood Court Neighborhood

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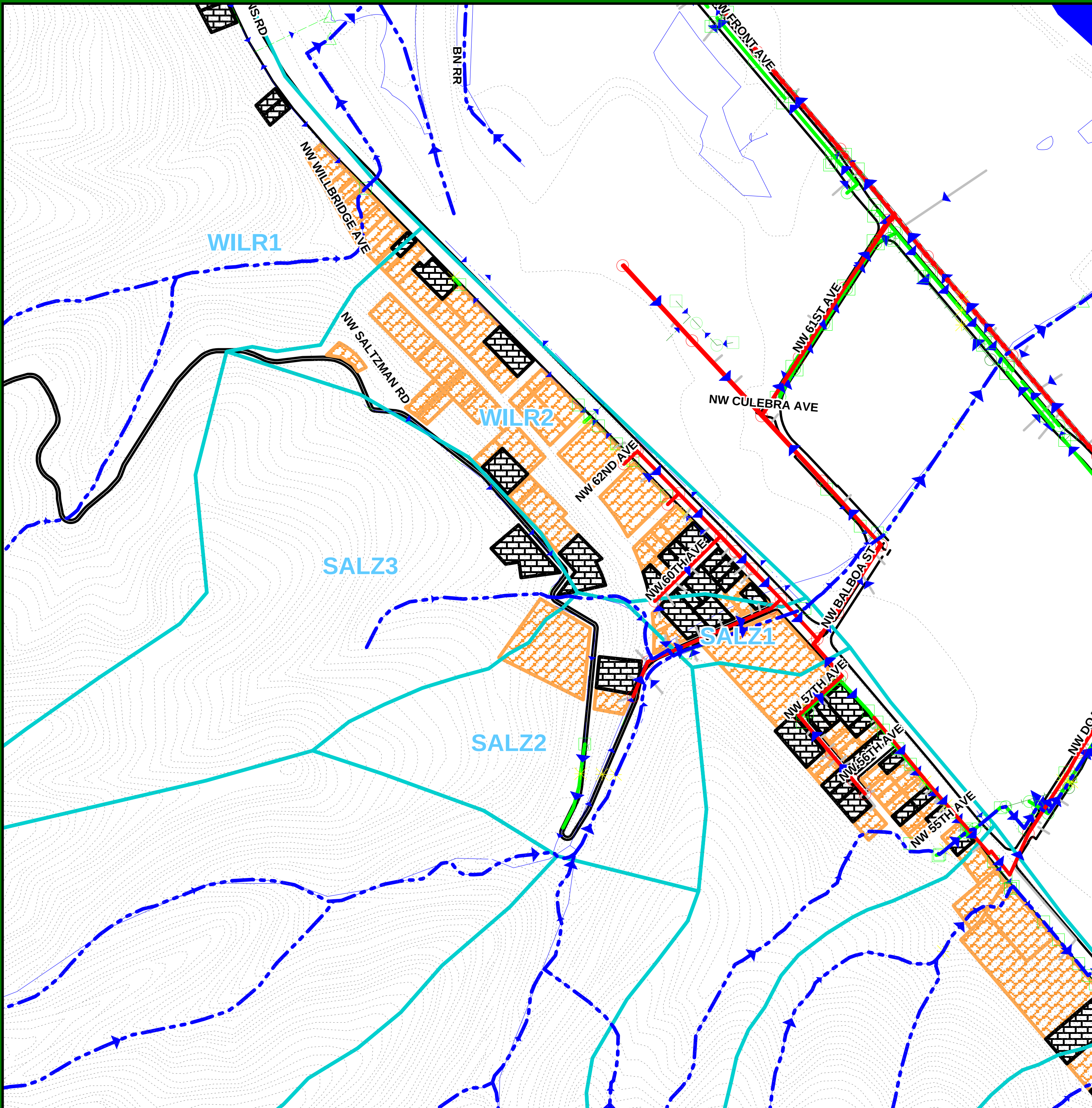

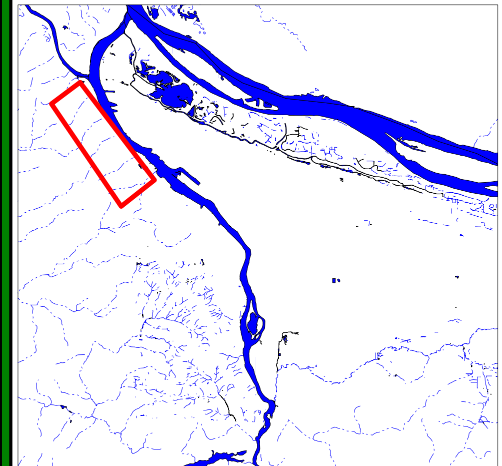

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N E S W

Linnton Hillside Study Area
Fairmont-Willbridge Neighborhood

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Figure 5	**06/15/2005**
Ref. No.	
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