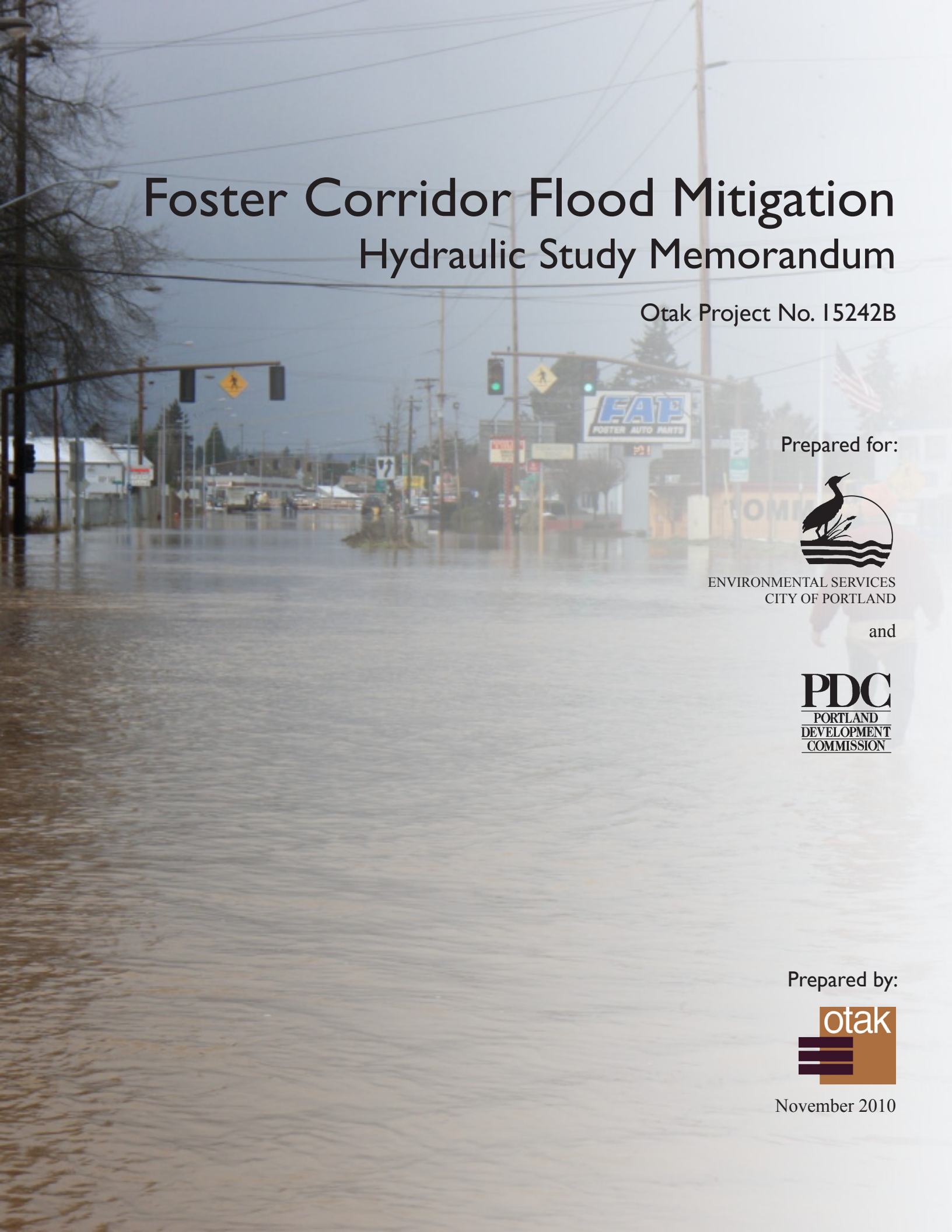

Foster Corridor Flood Mitigation

Hydraulic Study Memorandum

Otak Project No. 15242B

Prepared for:

ENVIRONMENTAL SERVICES
CITY OF PORTLAND

and

PDC
PORTLAND DEVELOPMENT COMMISSION

Prepared by:

otak

November 2010

Acknowledgements

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Section 1 — Introduction

1.1. Background

Johnson Creek's long history of flooding, water quality, and environmental problems attributable to development in the watershed began with forestry and agriculture practices and has gradually transitioned to more urban residential, commercial, and industrial land uses. Several large scale attempts with varying degrees of success were made during the past 80 years to manage flooding in the basin. However, flooding, water quality and other environmental problems continue to be significant issues. Flooding is particularly severe in the East Lents area that includes the SE Foster Road corridor east of Interstate 205. Since 1941 SE Foster Road has been flooded roughly six out of 10 years, making the road impassable and having a significant impact on the local economy. Frequent flooding is a significant constraint on redevelopment of the East Lents area, and any comprehensive redevelopment plan must address the flooding problem.

The 2001 Johnson Creek Restoration Plan (JCRP) provides comprehensive guidance to achieve multiple objectives in the watershed that include reducing nuisance flooding, increasing water quality, and improving fish and wildlife habitat [Bureau of Environmental Services (BES), 2001]. A more complete history of the watershed is provided in the JCRP. BES recently completed the design of Phase 1 of the East Lents Floodplain Restoration Project (East Lents Project) that is one of the high priority projects identified in the JCRP. The project goal is to reduce the frequency of nuisance flooding in the East Lents area, including the flooding on SE Foster Road. The project will achieve this goal by a combination of floodplain benching along the creek, construction of earthen berms along SE Foster Road, creation of an elevated sidewalk along SE 112th Avenue to block floodwaters, and excavating and regrading an area south of the creek to create flood storage. This approach to floodplain restoration also improves water quality and fish and wildlife habitat. The $2.4 million East Lents project is partially funded by a $2.7 million grant from the Federal Emergency Management Agency (FEMA). Site preparation work to remove the last residential structures and salvage trees began in 2010. Construction of Phase 1 improvements is scheduled for the summer of 2011.

Phase 1 of the East Lents Project is designed to alleviate flooding up to 1,500 cfs, or statistically a 3.1-year flood event based upon the flood frequency curve for the USGS Sycamore stream gauge on Johnson Creek. Under existing conditions, flooding begins to occur when flows exceed 900 cfs. Statistically this occurs 2 out of every 3 years. The City is currently in the design of Phase 2 of that project, but significantly greater flood reduction is not expected.

The ability to achieve a higher level of protection by the East Lents Project is constrained by the topography of the area and the storage potential south of the creek relative to the total volume of flood waters being stored in the area (north, south, and in-between). As will be described in more detail below, the East Lents area of Johnson Creek takes on significant

storage of flood waters during large events, with much of that occurring north of SE Foster Road. Any flood mitigation projects in the area must provide enough flood storage to ensure that discharges and flooding are not increased downstream. The East Lents Project is focused in the area south of SE Foster Road where the amount of storage that could be created is limited, and addresses smaller flood events. Larger floods need access to the storage north of SE Foster Road, and will continue to access that storage by flooding across SE Foster Road when the design event is exceeded. Comprehensive plans to address the flooding for larger events must provide a way for flood waters to access the storage north of SE Foster Road.

1.2. Foster Lents Integration Partnership (FLIP)

Inner Foster Corridor (SE 50th Ave to Lents Town Center), Outer Foster Corridor (I-205 to SE 122nd Ave), and the MAX Green Line Corridor (Powell to Flavel Stations) radiate from the Lents Town Center. SE Foster Road is the common thread that ties all the corridors together. A designated 2040 —main street and commercial corridor, SE Foster Road connects six city neighborhoods and one extended business association, Lents Town Center, significant employment lands east of I-205, and regionally significant industrial lands (Freeway Land) for redevelopment. Within the Portland city limits, SE Foster Road is seven miles long and a major transportation facility carrying 25,500 motor vehicles per day and 2,200 bus passengers on a typical weekday.

The Outer Foster Road Corridor is characterized as a post-war, auto-oriented commercial and industrial corridor that has high impact, low intensity land uses (wrecking yards and strips malls) and lacks a sense of place. The Outer Foster Corridor also includes City owned wetlands, natural areas, and key acquisition sites for a planned Johnson Creek restoration project (East Lents Floodplain Project) south of SE Foster Road between SE 106th – 112th Avenues. Rarely are so many transportation, natural resources, and land use assets co-located in a relatively small geographic area in an urban context.

Portland Development Commission (PDC), BES, Portland Parks and Recreation (PPR), Portland Bureau of Transportation (PBOT), and Bureau of Planning and Sustainability (BPS) have worked together since 2008 to coordinate activities in the Outer Foster Corridor, collaborate on projects, and develop relationships with key community members to create a foundation for a larger effort. Originally, this team identified a host of issues to address, but came to realize that future investment in the Outer Foster Corridor would not be possible without addressing the long term flooding issues that have eroded the confidence of the private markets to invest in the area without predictability around future flood damage.

A hydraulic engineering study is needed to derive flood management infrastructure alternatives and the cost associated with implementing resulting infrastructure improvements to address flooding. The infrastructure costs can be factored into a cost benefit analysis that looks at the economic benefits of improved flood management. The flood management infrastructure needs should be based upon a long-term flood management strategy that provides flood protection from at least the 25-year flood and preferably protection from the 100-year flood for SE Foster Road and all adjacent areas currently within the mapped 100-year floodplain. This study is the first step towards completing such an engineering study.

The long-term flood management solution could potentially involve a balanced cut/fill approach to create desirable land for redevelopment and manage flood waters in the storage areas north of SE Foster Road. This would involve a comprehensive look at the best opportunities to place fill and remove highest value land from the floodplain while identifying other locations to provide compensatory flood storage by excavating materials and creating new storage.

1.3. Purpose

The purpose of this study is to identify flood passage and management needs in the Outer Foster Corridor area to improve flood management, wildlife habitat, and vehicular access on SE Foster Road at the 25-year and 100-year level of service. Results of the analyses are used to identify the following:

1. Required road elevations along SE Foster Road that will prevent road inundation during the 25-year or 100-year flood event.
2. Culvert requirements along SE Foster Road to pass sufficient water underneath the road during the 25-year and 100-year floods that would allow access to enough storage north of the road to ensure no increase in downstream flooding.

   Improvements in wildlife passage along SE Foster Road associated with the new culverts were considered.
3. Storage requirements north of SE Foster Road that would allow identification of lands not needed for flood management and therefore available for redevelopment and other community-building needs.

This memorandum and associated maps provide hydraulic recommendations based upon "existing conditions" flooding and documentation that summarizes the results of the study. The hydraulic results are intended to assist in planning level discussions about infrastructure improvements to SE Foster Road and other long-term flood management scenarios that look at balancing cut and fill. The process of arriving at a set of recommended infrastructure improvements is an iterative process. Flood management scenarios resulting from the information being provided will need to be followed-up by a conceptual grading plan and

additional testing of hydraulic performance for a "proposed condition" using the same model Additional information about the process envisioned for arriving at a long-term flood management solution is described later in the Next Steps section of this memorandum.

1.4. Approach

This study builds upon the "Foster Corridor Exploratory Study" (August 2008) and direction provided in the draft project memorandum from the PDC titled "Foster Corridor Flood Mitigation and Redevelopment Scenarios". The Foster Corridor Exploratory Study produced preliminary concepts for alternative development scenarios in the Lents Town Center Urban Renewal Area. Alternative One from that study, titled "Eco Employment," seeks to maximize employment opportunities in what is referred to as the Foster Corridor area. The "Foster Corridor Flood Mitigation and Redevelopment Scenarios" memorandum provides additional details on proposed redevelopment scenarios under Alternative One, including infrastructure improvements, habitat restoration, and flood-mitigation measures. This study further evaluates the engineering feasibility of flood management within the study area.

The extensive unsteady flow HEC-RAS modeling work already completed for the East Lents Project, with a few additions, provided the basis for the analyses presented here. The model was used to provide planning level information that addresses the three items stated in Section 1.2 (SE Foster Road culvert requirements, storage requirements north of the road, and road elevations). This information was developed considering both a 25-year and 100-year level of service.

Section 2 — Hydraulic Analysis

2.1. Description of Existing Flooding

The East Lents area of Johnson Creek is a complex site with unique geomorphic and topographic characteristics, which in turn result in unique flooding characteristics. A short summary of these characteristics is provided here. More detailed information is provided in the "East Lents Floodplain Restoration Project – Phase 1, Draft Hydraulics Report" (Otak, 2009).

Detailed observations of two recent flood events (December 2007 and January 2009) provided valuable information on flooding in the area that was then used to formulate the modeling approach used for the East Lents Project. The attached Figures 2.1 and 2.2 (taken from the East Lents Project Hydraulics Report) show the extent of flooding and overbank flow paths as observed during these events. Based on flow records at the nearest upstream stream gage (Sycamore gage), the December 2007 event had a peak discharge of 1,330 cfs with an estimated return period of 2.3 years and the January 2009 flood had a peak of 2,540 cfs with an estimated return period of 29 years. Although the flood extent was much greater in 2009 due to much greater flows, the basic pattern of flooding and locations of flow breakouts from the main channel were similar. Through most of the stream reach extending from Brookside Park at the upstream (east) end to about SE 106th Avenue at the downstream (west) end, Johnson Creek meanders along a topographic high point or ridge (Missoula Flood feature) with low areas to the north and south of the channel. As flow in the creek reaches the tops of the banks, it spills out over the banks at certain locations and flows away from the channel primarily as sheet flow towards SE Foster Road and low areas to the north (Beggars Tick Marsh, Zenger Farm) and low areas along a historic drainageway at the base of Mount Scott south of the creek. Water in the overbank areas is primarily stored in topographic low points until it is able to return to the channel as flood levels in the channel recede.

The water stored in the topographic low points north and south of the creek plays a significant role in the flood dynamics of Johnson Creek with a major effect being a reduction in peak flows to downstream reaches. It is therefore critical that any flood mitigation projects in the East Lents area capture this storage. The East Lents Project achieves this by increasing the available storage south of the creek to make up for lost storage north of the creek. That project maximized the available storage south of the creek, which in turn limited the design frequency for protecting areas north of the creek from flooding. Larger floods are still allowed to inundate SE Foster Road and access the available storage north of the road. With the available storage south of the creek already utilized, any future projects must provide sufficient storage north of the creek. This is key to the evaluation of storage requirements made in this current study.

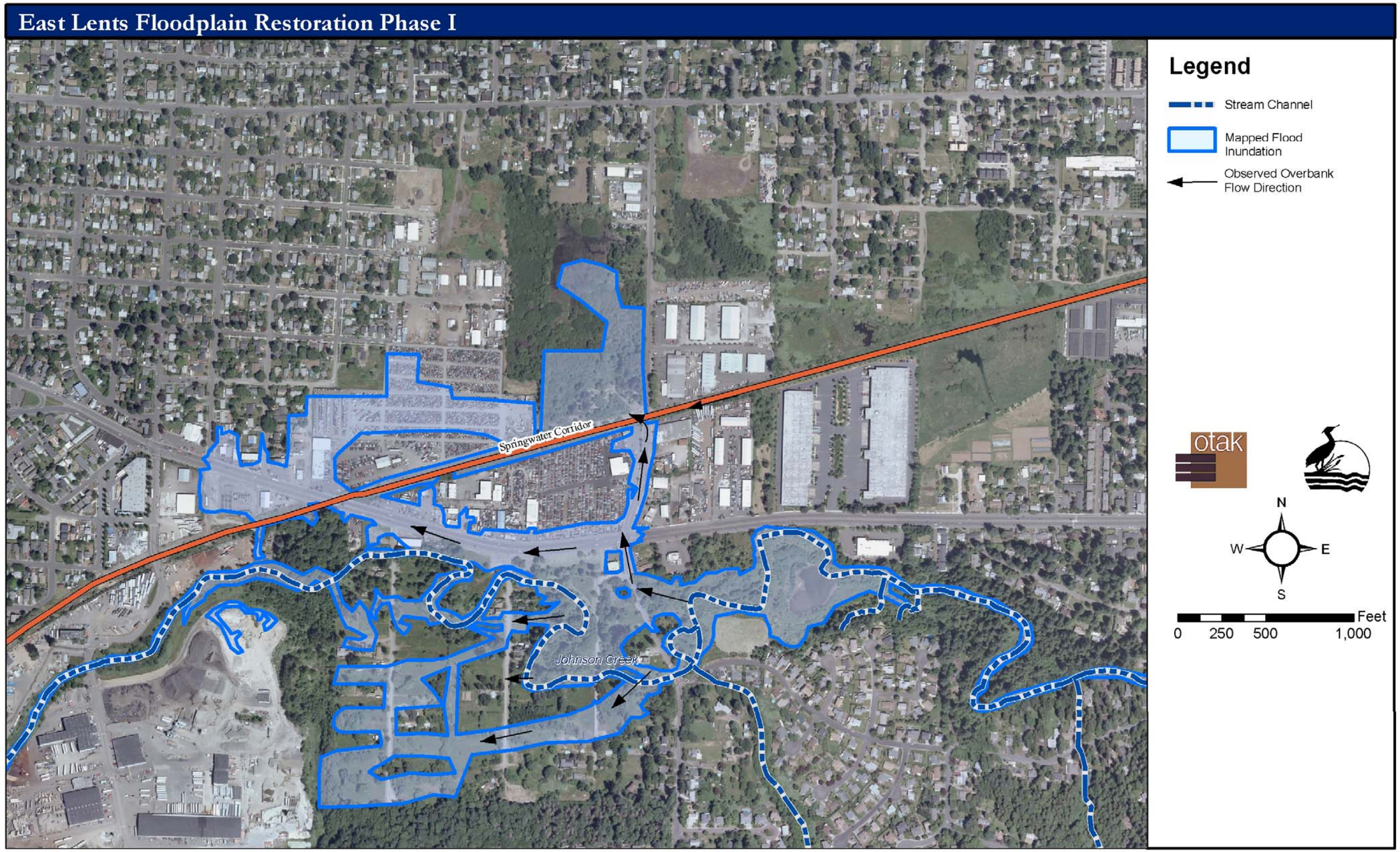


Figure 2.1: Extent of Flooding in the East Lents Area of Johnson Creek during the December 2007 Flood

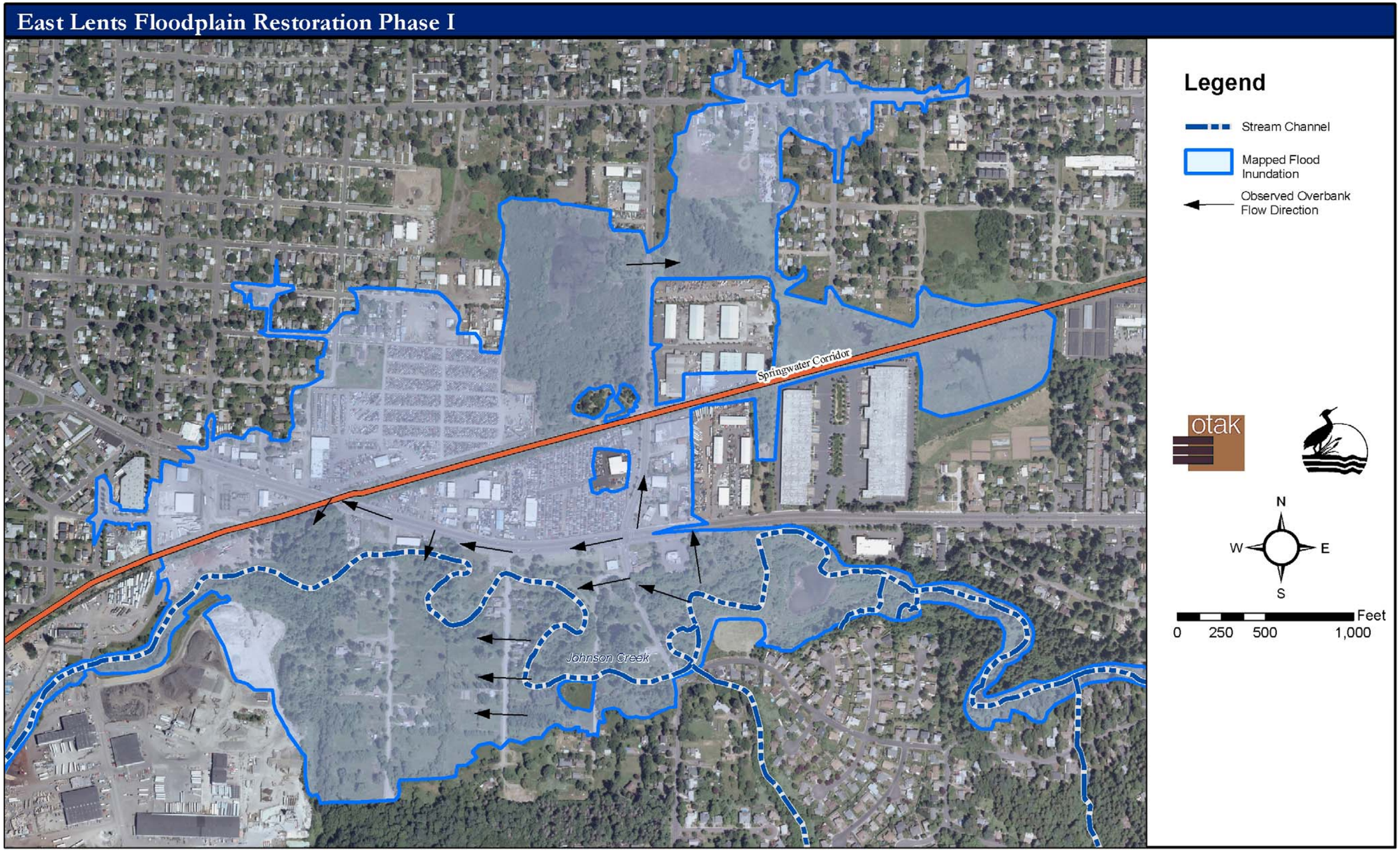


Figure 2.2: Extent of Flooding in the East Lents Area of Johnson Creek during the January 2009 Flood

2.2. East Lents Hydraulic Modeling Approach

The complex topographic and hydraulic conditions in the area required a unique approach to the hydraulic modeling carried out for the East Lents Project. A detailed description of that approach is included in the East Lents Project Hydraulics Report (Otak, 2009). A short summary of the modeling is provided here.

Hydraulic modeling of Johnson Creek in the East Lents area is difficult due to the complex flow characteristics. However, through careful observation of the significant features of the flow during the recent flood events (2007 and 2009); a one-dimensional (1-D) modeling approach was formulated to capture the salient features of the flow for the project design. The approach taken makes use of the U.S. Army Corps of Engineers (USACE) HEC-RAS hydraulic modeling software (USACE, 2008). The model was run in unsteady-flow mode to capture the storage effects of the low areas north and south of the creek that are such an important component of the flood dynamics of the area.

For discharges up to bankfull conditions, flow in Johnson Creek follows the meandering path of the channel with relatively parallel flowlines. This type of flow can be represented well with a 1-D model as is routinely done on many projects with success. As described above, once flow breaks out of the main channel, it tends to flow away from the channel as shallow sheet flow towards low storage areas north and south of the channel. High ground near the top of the channel banks generally forms the hydraulic controls that determine the amount of flow leaving the channel. This can be captured with a 1-D model using lateral weirs defined along the tops of the banks between cross-sections. The lateral weirs are connected to off-channel storage areas that capture the storage characteristics of the overbank areas where water is stored during large floods (e.g., Beggars Tick Marsh, low area at the base of Mount Scott).

2.3. East Lents Model Application

The East Lents Project hydraulic model was adapted for use in this study to develop planning-level estimates for the following items:

1. Recommended minimum road elevations to provide vehicular access on SE Foster Road.
2. Culvert requirements along a raised SE Foster Road that will pass the necessary flow into the storage areas north of the road and improve wildlife passage.
3. Existing flood storage north of the road to develop balanced cut and fill strategies for meeting compensatory flood storage requirements.

Items (1) and (3) were evaluated using a version of the East Lents Project HEC-RAS model that represents site conditions after construction of the Phase 1 project design. Other than

re-running the model for the 25-year event (see below), there were no changes made to the model as part of this study. The key assumption here is that a future design that raises SE Foster Road out of the floodplain will need to maintain roughly the same volume of water stored north of the road (and hence elevations and volume of water stored will remain roughly unchanged). Item (2) was evaluated by reconfiguring the model to reflect a raised SE Foster Road with culverts connecting the north storage areas with the creek south of the road. The modeling assumes that all flow exchange occurs through the connecting culverts with no road overtopping. Actual design would have to consider the road profile and road overtopping for events larger than the design flood (e.g., a 25-year design would have to ensure proper flow exchange over the road for the 100-year event to meet a "no-rise" condition).

Modeling was carried out to determine the design requirements for a 25-year and 100-year level of service. The recorded January 2, 2009 flood, had a peak discharge of 2,590 cfs, and was used to represent the 25-year event (actual estimated return period is about 29 years). The 100-year event was derived from the original USACE study used for the Effective Flood Insurance Study that FEMA uses to help administer the National Flood Insurance Program and has a peak discharge of 3,180 cfs (see Otak, 2009). Significant findings are discussed in the following section.

Section 3 — Study Results

Results of the study are summarized on MAPs 1 and 2 included with this submittal. MAP 1 shows hydraulic recommendations to evaluate flood management solutions to achieve a 25-year level of service and Map 2 shows the same set of recommendations to achieve a 100-year level of service. The following sections discuss the various types of information contained on the maps.

3.1. SE Foster Road Elevations

To prevent flooding on SE Foster Road the road will have to be raised. MAPs 1 and 2 show elevations along SE Foster Road required to raise the road above the predicted flood elevations. The elevations shown on MAP 1 are based on predicted 25-year water-surface elevations.

The elevations on MAP 2 reflect 100-year water-surface elevations with 1.0 feet added for freeboard. Freeboard is a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. "Freeboard" tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed.

The recommended minimum elevations for the 25-year level of service on MAP 1 do not include freeboard. This is because the 25-year level of service must also consider how the design would affect larger flood events up through the 100-year flood. The roadway profile must be designed to allow larger flood events to cross SE Foster right-of-way and access storage areas on the north side. Future design concepts will need to be tested because allowing too much flood water to cross Foster Road can result in water level increases on the north side.

Design of the road profile in either case will need to consider other needs such as drainage, cover requirements for culvert connections, side streets, driveways, and utilities.

3.2. Conveyance under SE Foster Road

Raising SE Foster Road creates a need for new conveyance connections to maintain access to the storage areas on the north side. Planning and design of conveyance connections under SE Foster Road must consider hydraulic requirements and fish and wildlife passage needs.

3.2.1. Hydraulic Requirements

Three locations along SE Foster Road were identified as possible culvert connections between the creek and the storage areas to the north. These culvert connections are shown on MAPs 1 and 2. The locations were identified by examining the local topography, existing connections between the creek and the areas to the north, and existing land use.

Section 3—Study Results
Continued

Culvert A was chosen where water stored north of the road naturally drains back to the creek. The culvert connection here would likely need to connect the drainageway along the Springwater Trail north of the road with the floodplain south of the road.

Culvert B was located at a significant flow exchange between the creek and SE Foster Road under existing conditions and will continue to be so for larger flood events after the Phase 1 implementation. The connection here would simply be a culvert long enough to make the connection underneath the raised road.

Culvert C was located for water to access the north storage areas along a natural low area or drainageway between industrial parcels that appear to have been raised by fill. This connection was modeled as a 900 foot culvert connecting the wetlands north of the Springwater Trail with the creek south of SE Foster Road. Alternatively, a significant portion of this connection could be an open-channel ditch with culverts at SE Foster Road and the Springwater Trail.

The reconfigured hydraulic model was used to estimate the approximate size of the culvert connections. This was done by first setting the culvert inverts high enough so that floodwaters would not access the areas north of the road for events less than the Phase 1 design event (1,500 cfs). The culvert height at each location was set equal to 2.0 feet with the goal of ensuring a large enough opening for maintenance and fish and wildlife passage yet not too high as to raise the required road grade more than necessary. For each design, the culvert widths were adjusted in the model until just enough water was stored north of the road to ensure no increases in downstream discharges while not sending too much water north as to increase the flood potential there. Given the planning-level nature of the analysis, tolerances of about 10 cfs on downstream discharges and 0.1 feet on storage area elevations were used to estimate the culvert sizes. Actual design will depend on many factors that will need further consideration with the potential need to mitigate any increases in either downstream discharges or storage area elevations.

Two culvert alternatives were considered for each level of service considered in the analysis (25-year and 100-year). Culvert Option 1 uses Culverts A and C while Culvert Option 2 uses culverts at all three locations. Design information for each option is provided on the maps for the two levels of service.

The culvert design options shown on Maps 1 and 2 are based mainly on hydraulic considerations and do not take into account specific fish or wildlife passage requirements.

3.2.2. Fish passage

The City should consider consulting with National Marine Fisheries Service (NMFS) and the streamlining team regarding any conceptual flood management alternatives considered to address Johnson Creek flooding along the Outer Foster Corridor. It is likely that many of the alternatives may trigger concerns by NMFS regarding stranding of listed fish species in areas north of SE Foster Road. Fish stranding was a design concern that the project team had to overcome on the East Lents Floodplain Restoration project and worked closely with NMFS to modify the design to the satisfaction of Agency representatives.

NMFS may express a desire to incorporate barriers to fish passage so that fish cannot access areas north of SE Foster Road, or there may be special design considerations that need to be incorporated to the degree possible. Regardless, it should be noted that under current conditions there is nothing preventing fish from crossing over SE Foster Road during a flood event and becoming trapped in areas north of SE Foster Road with no return access to Johnson Creek. Well defined connectivity between Johnson Creek and areas north of SE Foster Road should be able to be planned and designed in a manner that is a significant improvement over current conditions.

Providing fish passage might require larger culverts than were considered in this planning-level study. In addition to the culverts, grading or other drainage improvements would have to be considered to reduce the potential for fish stranding in low areas that do not connect back to the creek. An alternative might be to provide fish screens to prevent fish from entering the culverts. Consultation with NMFS would be required to determine the actual fish passage requirements. In any case, use of fish passage culverts with other drainage improvements or use of fish screens would be an improvement over the existing condition where fish entering the north overbank areas have to traverse streets and other features that contain pollutants, shallow depths, and other unsafe conditions.

3.2.3. Wildlife Passage

The commercial and industrial development along the north side of SE Foster Road probably acts like a wall, limiting wildlife movement between Johnson Creek south of SE Foster Road and the open space areas north of SE Foster Road (i.e., Beggars Tick Marsh and Zenger Farms). The Springwater Trail crossing of SE Foster Road is the most likely location for wildlife to cross SE Foster Road under the existing conditions. This could be studied further through evaluation of road kill records (if they exist) or wildlife studies. Regardless, habitat connectivity for wildlife between the large open space being created by the East Lents Floodplain Restoration project and new and existing open space areas north of SE Foster Road can greatly be improved, and should be considered as part of the planning efforts for the Foster Corridor.

New conveyance connections made for passing floodwater beneath an elevated SE Foster Road provide good opportunity for improving wildlife connectivity as well, and should include some open space corridor enhancements for wildlife between each end of the conveyance structure (culvert or bridge) and the nearest open space area to the north.

Considerations for wildlife passage under roadways are somewhat in its infancy and design guidelines for wildlife crossings are limited. A useful and succinct summary table based on a wildlife literature review is contained within a Wildlife Passage Assessment memorandum for the Port Mann Highway 1 project in British Columbia (BC Ministry of Transportation, 2008). A portion of that table which summarizes key culvert characteristics for amphibians, reptiles, and small mammals has been provided in Table 3.1 below, complete with the original citations included in the Wildlife Passage Assessment memorandum.

According to the literature referenced above, the range of culvert sizes identified for meeting flood conveyance needs (2 foot rise by 10 feet to 12 feet span) are large enough to accommodate terrestrial amphibians, small terrestrial mammals, and small aquatic mammals. Medium aquatic mammals may be able to utilize the proposed conveyance structure, depending upon how long it is. Aquatic amphibians might be able to use it, but if the structure is dry most of the time, it is unlikely that they will. The future design of SE Foster Road should consider ways to reduce the culvert length, such as reducing the roadway cross-section by eliminating parking, planter strips, and through the use of headwalls and wingwalls at the culvert entrance and exit. Fish passage design criteria will also need to be considered. If fish screens are necessary to prevent fish from using the culverts, then wildlife access may also be prevented.

Table 3.1: Key Culvert Characteristics for Wildlife Passage

Wildlife Group	Cover Conditions/Limits	Culvert Material	Culvert Size Limits	Biophysical Conditions and Limits	Water Conditions/Limits	Funneling and Fencing	General Comments
Terrestrial Amphibians	Need low cover vegetation.[1,2]	Natural bottom culverts preferred. Rocks, logs, gravel make culvert more attractive.[3, 15]	Minimum height 0.3.[4]	Temperature, light, and moisture levels should be similar to natural habitat.[4]	Appropriate moisture conditions to be maintained; high water velocities and improper drainage may deter usage.[1]	Fences should be 0.46-0.76m high and should be buried. Vegetation on and around fencing should be cleared regularly. Materials: fine mesh, concrete, plastic, galvanized tin, aluminum flashing.[5]	Knowledge of breeding sites and movement patterns is important when planning tunnel locations.[15]
Aquatic Amphibians	Same as terrestrial amphibians.	Same as terrestrial amphibians.	Same as terrestrial amphibians.	Low light levels and moist soils are optimal for encouraging movement.[13]	Require water movement through culvert.[1]	Same as terrestrial amphibians.	n/a
Small Aquatic Mammals	Same as small terrestrial mammals.	Same as small terrestrial mammals.	Same as small terrestrial mammals.	Moist.	Culverts that serve as stream crossings are ideal.	Same as small terrestrial mammals.	n/a
Medium Aquatic Mammals	n/a	n/a	20m long – 600mm internal diameter, 20-50m – 900mm internal diameter, and over 50m – 1000mm x 2-5 box section.[12]	Moist.	High water velocities may prevent from entering culvert.[11]	High enough to prevent mammals from climbing over, deep enough to prevent digging underneath. Direct towards culvert, not only block from the road.[10]	Ledges along sides and ramps at entrances or over weirs may be important.[12]
Small Terrestrial Mammals	Natural low vegetation and debris (stumps, hollow logs, rocks, etc.) around the openings of and within culverts.[6,7,8,4]	Preference for box (concrete or pipe or metal) culverts.[4]	0.5 to 1.0m in diameter with small cross-sectional areas and small openness ratios.[6,4]	n/a	Passage encouraged by the presence of ledges along culvert interior walls. Higher elevation pipes of multi-cell culverts can also provide dry passage to terrestrial mammals.[9]	Fences should be 3-4 ft high and buried. Construction with mesh prevents small mammals from passing through the fence. Fences must extend from the opening of the culvert to a point beyond the target animal's natural range.[4]	Culverts should be placed every 150-300m.[6]
Medium Terrestrial Mammals	Natural vegetation growing around the entrances and approach to culverts provide habitat continuity. Some animals wary of vegetation that can serve as predator ambush sites.[1,6,7,14]	Easily accessible box or pipe culverts.[4]	Structures tall in height and short in length with a large cross-sectional area. An openness ratio of at least 0.4 is recommended.[4]	Reluctant to enter underpasses with low light levels. Installation of open top grates to improve light without artificial lighting.[1]	Stream crossing culverts must include a dry passage (such as a raised ledge).[1,3]	n/a	n/a

Source References

1 – Jackson *et al.* 2000;
2 – Yanes *et al.* 1995
3 – Taylor and Goldingay. 2003;
4 – Cavallaro *et al.* 2005;
5 – Puky. 2003;
6 – Clevenger *et al.* 2001;
7 – Clevenger *et al.* 2003
8 – McDonald & St. Clair, 2004;
9 – Bakeman *et al.* 2007;
10 – Chanin. 2006;
11 – Garcia *et al.* 2006;
12 – Philcox *et al.* 1999;
13 – Jackson. 1996;
14 – Veenbaas and Branjes (undated)
15 – MWLAP. 2004

3.3. Storage Requirements North of SE Foster Road

Principles of compensatory storage suggest that a volume of storage filled can be mitigated by creating a volume of storage elsewhere in the floodplain. The City of Portland has a balanced cut/fill requirement in their development code that applies to each individual property within the Foster Corridor study area. Filling properties to remove them from the floodplain and create attractive redevelopment sites will require compensatory storage. A balanced cut and fill strategy for the entire area is one tool to consider for addressing the flood management challenges in the Foster Corridor area. Implementation of such a strategy may require a new district wide policy for cut and fill that allows the cut to take place on a different property than the fill occurs. To help facilitate the discussion, this hydraulic study includes information about cut and fill volumes on a per lot basis. The information can be used to quickly come up with a balanced cut and fill strategy for different redevelopment scenarios, as will be demonstrated.

To obtain the cut and fill information, Otak utilized hydraulic model results from the East Lents Floodplain project along with GIS data provided by the City of Portland. Water-surface elevations predicted by the hydraulic model for the areas north of SE Foster Road were used to determine the existing volume of water stored and the volume of additional storage that could be created on a per lot basis for a given flood event by excavation to an assumed minimum elevation.

Figure 3.1 and Figure 3.2 illustrate how the storage requirements for each tax lot were determined. The volume of water stored is simply the existing available storage below the modeled water-surface elevation. The volume of additional storage available is the additional volume that could be created by excavating the entire lot to an assumed minimum elevation. The volume of material that would have to be excavated to achieve the additional storage volume is also listed for each tax lot.

The minimum elevation for creating storage was assumed to equal 206 feet City of Portland Datum (COP). This elevation was determined by considering a variety of factors including the following:

- Minimum ground elevations were used as a guide to determine practical limits on the amount of excavation.
- Available groundwater data to determine seasonal groundwater elevations that might limit the amount of useable storage. Unfortunately, there was considerable scatter in the groundwater data, with some data obviously affected by surface flooding, limiting its usefulness.
- Ordinary High Water (OHW) elevations along Johnson Creek were used as a guide to evaluate drainage back to the creek after peak flows.

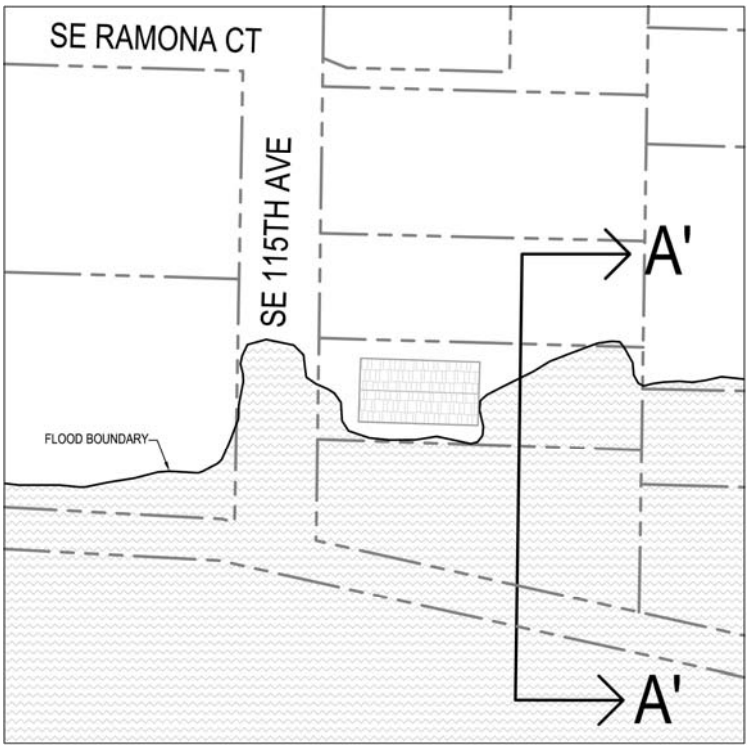


Figure 3.1: Volume Calculation Plan View

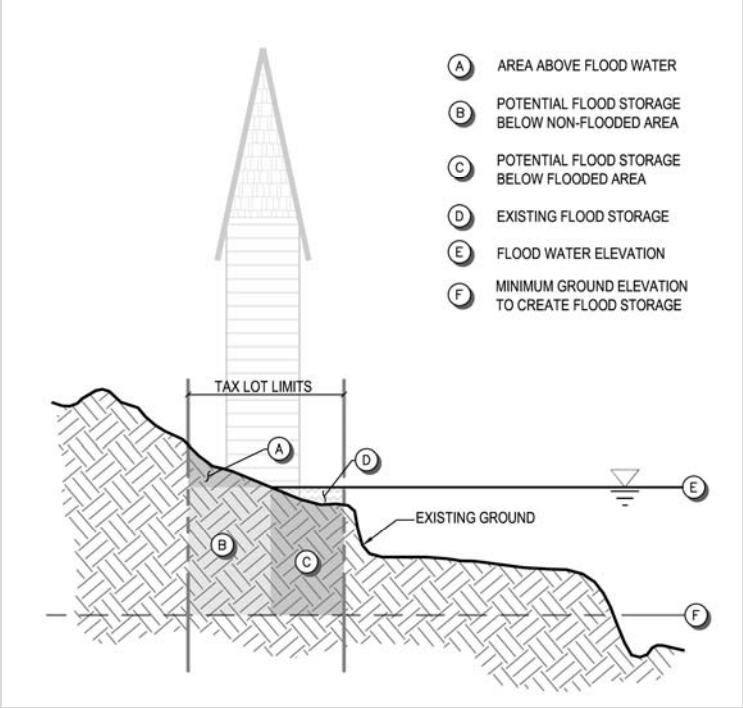


Figure 3.2: Volume Calculation Section A'-A'

Section 3—Study Results
Continued

The results of the analysis are presented on MAP 1 for a 25-year level of service and on MAP 2 for a 100-year level of service. Each tax lot includes the following information: 1) the existing available storage, 2) the additional storage available assuming excavation to the minimum elevation of 206 (COP), and 3) the actual excavation required to create the additional storage. The maps also show the volume of storage for segments along SE Foster Road that need to be replaced if fill is placed in the right-of-way to raise the road above the predicted flood elevations.

3.4. Discussion

The results presented here are based on a design level hydraulic model south of Foster road and a flood study model north of Foster Road from the East Lents Floodplain Restoration project. They are intended to be used in planning level efforts to look at SE Foster Road improvements and to create an approximate balanced cut-and-fill strategy associated with various redevelopment scenarios. Conceptual designs derived using the hydraulic data presented in this study should be considered approximate and are not a substitute for actual hydraulic modeling that is needed to test flood management improvements, conceptual or otherwise. Further hydraulic modeling of future redevelopment scenarios is also necessary to demonstrate compliance with the National Flood Insurance Program.

One flood management scenario, shown in Figure 3.3, was considered to demonstrate how the information provided can be incorporated into further planning level discussions and might lead to a conceptual redevelopment scenario that could be conceptually designed and tested using the hydraulic model. In this example scenario, properties around the fringes of the existing floodplain are assumed to be filled for redevelopment. The fill volumes were tallied using information provided for each tax lot within the **red** areas. The mitigation is created through excavation of flood storage on other properties shown in **green**, until the cut and fill are approximately equal. In this example scenario, no considerations were given to presence or value of existing structures.

The next step would be to tally the actual excavation volumes to achieve the mitigation. Then the quantities can be input to a planning level cost estimate and compared with other alternatives. The cost estimate should consider other items of work including but not limited to; demolition of existing structures, relocation of utilities, revegetation, monitoring and maintenance, and contaminated soils.

If the SE Foster Road right-of-way is elevated to achieve 100-year level of service with respect to flood management, then this results in 16, 538 cubic yards of lost storage. This could be reduced by utilizing a narrower street cross-section or by building more of the road section as a bridge structure, and balancing cut/fill within the right-of-way. However, the conveyance connection to the north created by a bridge would need to be hydraulically designed.

The flood management scenario illustrated also assumes that fill is placed to such an elevation and extent to prevent floodwater access to storage toward the northwest and northeast. Conceptually, this might involve elevating some of the residential streets. This results in the equivalent of 4,550 cubic yards and 79,650 cubic yards of lost flood storage to the northwest and northeast, respectively. This is the equal to 52 acre-feet of flood water.

This study assumes future flood inundation of the Springwater Trail will be similar to existing conditions for flood larger than the East Lents Phase 1 design event. When developing and evaluating flood management alternatives the Portland Parks and Recreation has requested that flood management concepts should try to reduce flooding of the Springwater Trail, or at least not make it worse.

3.5 Reliability of Results Discussion

Creation of the hydraulic model used in this study, including the process of model calibration, is documented in the Hydraulics Report for the East Lents Phase 1 project. A sensitivity analysis on certain model parameters (channel roughness & weir coefficients) was performed on the existing conditions model to affirm our confidence in the model. From that process we identified data needs during Phase 1 that we then sought to obtain and refine the model until we arrived at the final model used for design and floodplain mapping.

The existing conditions model and subsequent versions of the model from the East Lents Phase 1 project are considered to be design level models south of Foster Road and upstream of the Freeway Land Company (FLC) property. North of SE Foster Road and downstream of the FLC the models are planning level models that are adequate for mapping the 100-year floodplain, but could be improved for design through data collection and integration with other modeling tools (see Section 4 - Next Steps).

Modifying the existing conditions model to reflect physical changes to the area provides a second model, which becomes the tool for predicting future hydraulic conditions expected to occur given proposed changes to the system. This new "proposed condition" or any other non-existent condition cannot be calibrated because it has not happened and there would be no data to compare against for calibration. The technique for assessing the reliability of model results for future conditions is through a sensitivity analysis and application of a design safety factor.

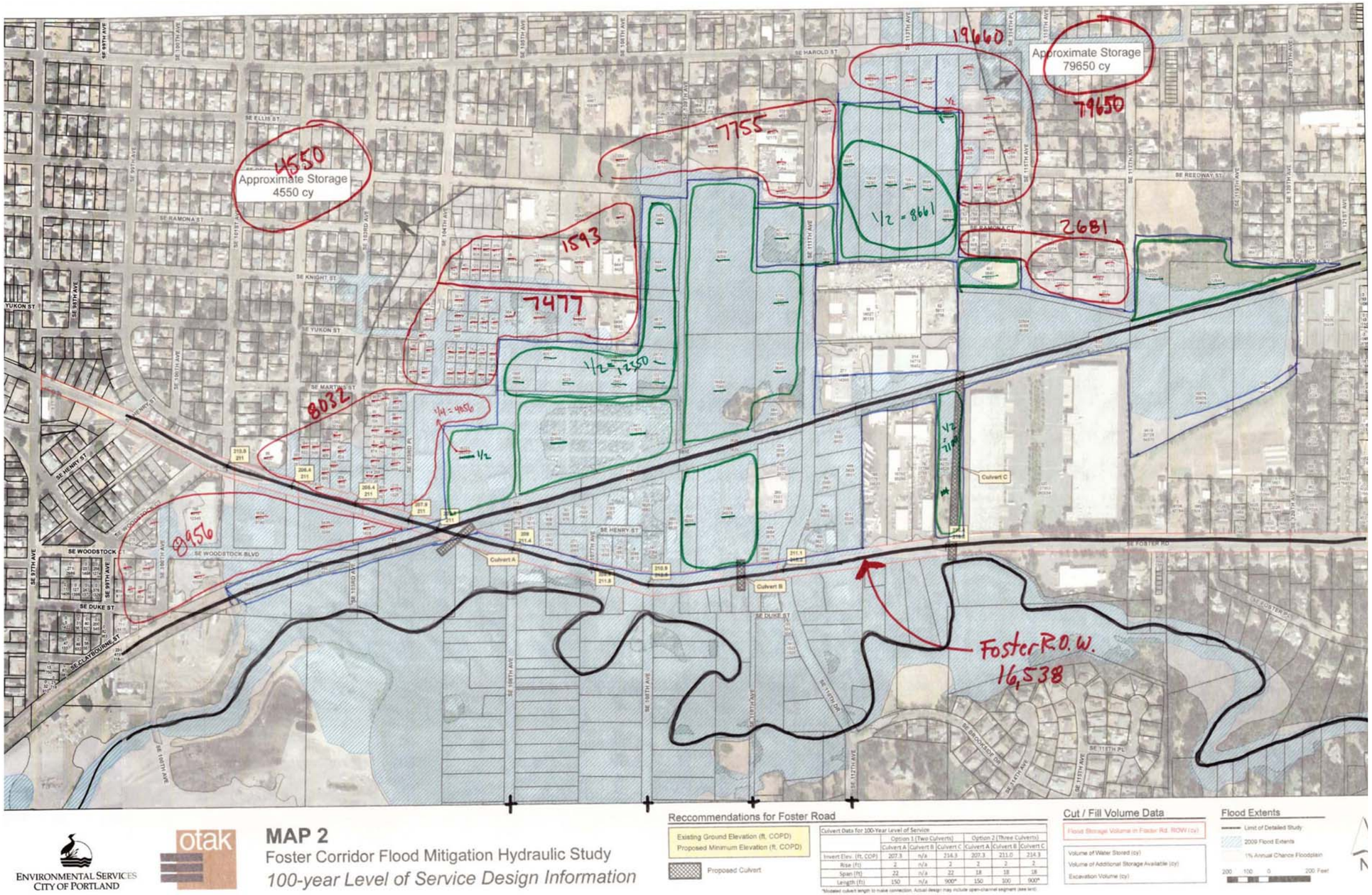
A sensitivity analysis can be used to demonstrate the range of results expected by singling out model input parameters and running the model under a range of values for that particular input parameter. Input variables to consider might include the following:

- Hydrograph – Not every flood has the same peak intensity, duration, or volume. Future development in the upper watershed in City of Gresham is likely to result in some

change to future hydrology. A range of hydrograph sizes and shapes could be run through a hydraulic model to identify the range of water surface elevations predicted for a proposed flood management scenario.

- Culvert/Bridge – the size of the opening for conveyance across the Foster Road right-of-way influences the flow exchange between Johnson Creek flood waters and flood storage on the north side. Other related model parameters, such as roughness, could be tested.
- Flowline elevation across Foster Road – the elevation of ground in the Foster Road right-of-way whether it is finished ground of pavement, ground elevation beneath a bridge, or invert of a culvert influences the stage at which floodwater can travel back and forth across Foster Road and interact with storage areas to the north. Other related model parameters, such as roughness or weir coefficients, could be tested.

Results from a sensitivity analysis can demonstrate the range of water surface elevations that are predicted to occur for a given scenario. A safety factor, referred to as "freeboard", can then be applied in design of improvements. The concept of freeboard should be applied to conceptual design alternatives considered in the Outer Foster Corridor.



Culvert Data for 100-Year Level of Service

	Option 1 (Two Culverts)			Option 2 (Three Culverts)		
	Culvert A	Culvert B	Culvert C	Culvert A	Culvert B	Culvert C
Invert Elev. (ft, COP)	207.3	n/a	214.3	207.3	211.0	214.3
Rise (ft)	2	n/a	2	2	2	2
Span (ft)	22	n/a	22	18	18	18
Length (ft)	150	n/a	900*	150	100	900*

*Modeled culvert length to make connection. Actual design may include open-channel segment (see text).

Figure 3.3: Example to demonstrate how to use the MAPs provided with this memorandum to create a flood management scenario (see section 3.4 Discussion).

Section 4 — Next Steps

Otak has identified the following steps to arrive at a strategic infrastructure investment plan for flood management. There is still some planning work to conclude before moving into conceptual design where better cost estimates can be made, performance can be modeled and level of confidence can be better quantified. An implementation plan can then be put forth based upon a preferred flood management concept that is compatible with other land use, transportation, recreation, and ecological objectives defined for the Outer Foster Corridor.

Planning

The results from this study are informational and are all summarized on MAP 1 and MAP 2. The results are intended to be used as a tool to facilitate creation of roadway design concepts, redevelopment concepts, and flood management concepts.

A range of Conceptual Flood Management alternatives can be derived based upon the preferred alternative identified in the "Foster Corridor Exploratory Study" (August 2008) and the maps provided by this study.

A design charette with experts from multiple disciplines participating and informing the placement of fill and locations for cut associated with each flood management alternative is the recommended format.

A range of flood management concepts on the Freeway Land Company property should be identified and considered as part of the overall flood management scheme.

A series of flood protection design concepts can be developed following recommendations from the maps provided in this study. Design concepts for SE Foster Road should include:

- Limits of improvements to SE Foster Road and affected side streets.
- Conceptual Plan and Elevation drawings for Culvert and/or Bridge Structures and adjacent conveyance improvements to connect with flood storage areas.
- Conceptual plan, profile, and typical section of Foster Road Improvements for 25-year Level of Service.
- Conceptual plan, profile, and typical section of Foster Road Improvements for 100-year Level of Service
- Mapped extents of 100-year flooding and predicted water surface levels if Foster is rebuilt to provide 25-year and 100-year flood protection.
- Planning level cost estimates.

Section 4—Next Steps
Continued

Conceptual Design

Develop rough conceptual grading plans for each flood management alternative, including: Foster Road improvements, cut & fill north of Foster Road, and grading on Freeway Land Co. property.

Regulatory Stakeholder Coordination – Discuss flood management design alternatives with NMFS and Streamlining Team to solicit input on environmental permitting challenges with each concept.

Study local site drainage patterns on Foster road and areas to the north that contributes runoff to flood storage areas. Consider how local stormwater runoff from the redeveloped areas would be managed.

Gather additional data to improve model reliability north of Foster Road:

Topography – This applies to the definition of the weirs that spill water to the northwest and northeast. Additional topographic data is being collected during Phase 2 of the East Lents Floodplain Restoration project to perform a check against the LiDAR data previously assumed to represent ground topography in those areas. Other areas of the model that might benefit from additional survey efforts include the stream channel between SE 106th and I-205, the Springwater Trail, Beggars Tick Marsh, and the area of ground between Foster Road and the Freeway Land Co. property.

Groundwater Elevation – Groundwater levels could be measured in areas being considered for excavation to create new flood storage.

Stream Flow – Actual flow measurements could be made within the East Lents project reach of Johnson Creek during a range of flow conditions to develop a stronger correlation with the continuously operating USGS stream gauge upstream (Sycamore).

Use the hydraulic model to test performance of flood management alternatives. This is recommended to include the use of a second modeling application (such as XP-SWMM) that can be used to model local drainage patterns and greater detail for areas north of Foster Road than can be accommodated using the HEC-RAS model.

Make adjustments to the grading plan to meet hydraulic performance objectives (flood storage volume, water surface elevation, and flow rates to downstream reaches of Johnson Creek).

Strategic Infrastructure Plan

Conduct a sensitivity analysis on the preferred flood management alternative.

Make refinements to the preferred flood management alternative based upon results of the sensitivity analysis. This includes updates to cost estimates.

Phasing and Implementation Plan – Identify elements of the flood management plan that are independent of one another.

Prioritize using cost-benefit analysis, ease of implementation, property ownership, and other factors that can be identified. Establish a program with timeline and budget needs for implementation of each piece.

Identify any elements of the flood management plan that are interdependent. For example, one has to happen before the other.

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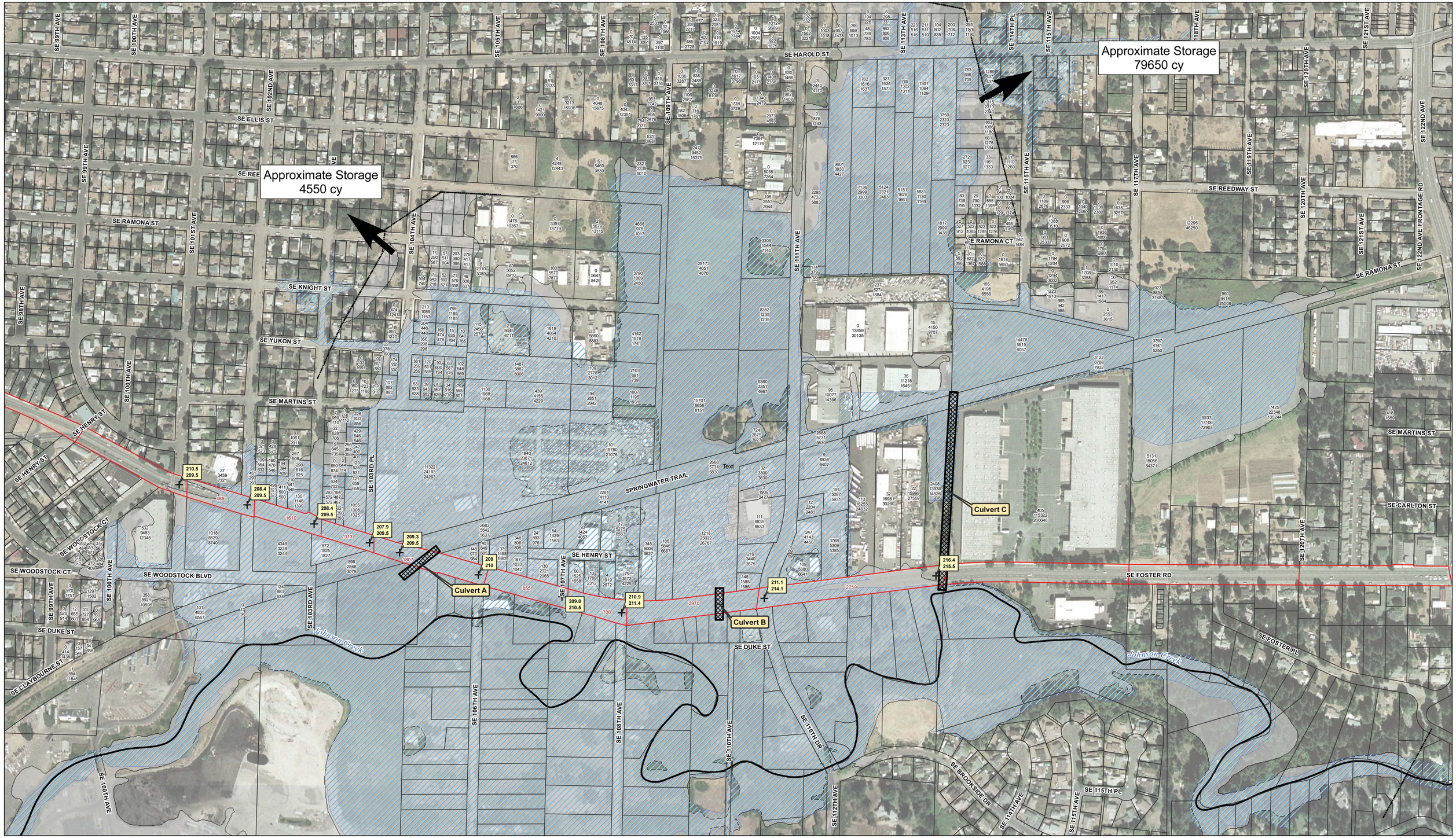

ENVIRONMENTAL SERVICES
CITY OF PORTLAND

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MAP 1

Foster Corridor Flood Mitigation Hydraulic Study

25-year Level of Service Design Information

Reccommendations for Foster Road

Existing Ground Elevation (ft, COPD)
Proposed Minimum Elevation (ft, COPD)

Proposed Culvert

Culvert Data for 25-Year Level of Service						
	Option 1 (Two Culverts)			Option 2 (Three Culverts)		
	Culvert A	Culvert B	Culvert C	Culvert A	Culvert B	Culvert C
Invert Elev. (ft, COP)	207.3	n/a	214.3	207.3	211.0	214.3
Rise (ft)	2	n/a	2	2	2	2
Span (ft)	12	n/a	12	10	10	10
Length (ft)	150	n/a	900*	150	100	900*

*Modeled culvert length to make connection. Actual design may include open-channel segment (see text).

Cut / Fill Volume Data

Flood Storage Volume in Foster Rd. ROW (cy)

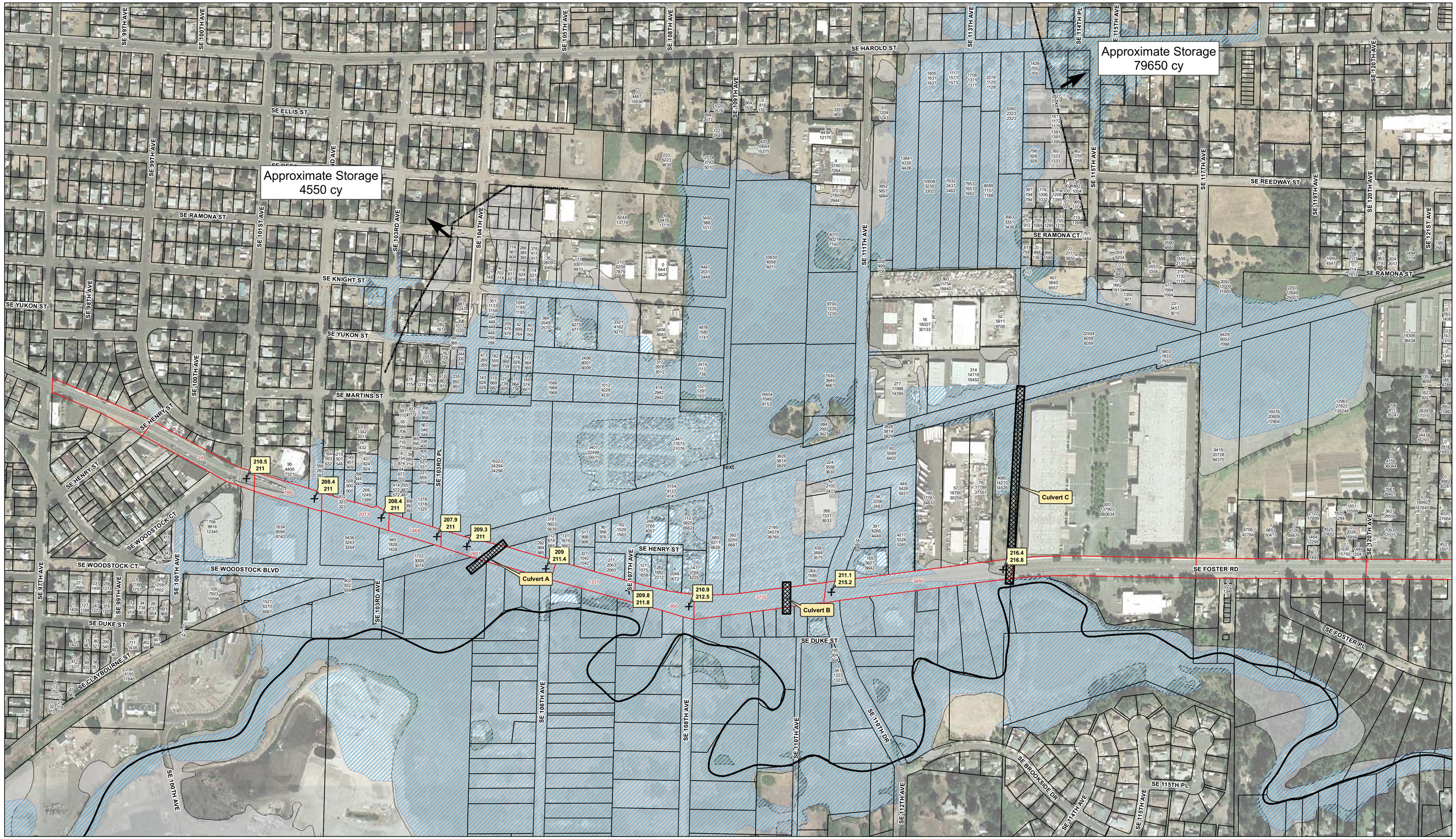
Volume of Water Stored (cy)
Volume of Additional Storage Available (cy)
Excavation Volume (cy)

Flood Extents

Limits of Detailed Study
2009 Flood Extents
1% Annual Chance Floodplain

200 100 0 200 Feet

N



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MAP 2

Foster Corridor Flood Mitigation Hydraulic Study

100-year Level of Service Design Information

Reccommendations for Foster Road

Existing Ground Elevation (ft, COPD)
Proposed Minimum Elevation (ft, COPD)

Proposed Culvert

Culvert Data for 100-Year Level of Service						
	Option 1 (Two Culverts)			Option 2 (Three Culverts)		
	Culvert A	Culvert B	Culvert C	Culvert A	Culvert B	Culvert C
Invert Elev. (ft, COP)	207.3	n/a	214.3	207.3	211.0	214.3
Rise (ft)	2	n/a	2	2	2	2
Span (ft)	22	n/a	22	18	18	18
Length (ft)	150	n/a	900*	150	100	900*

*Modeled culvert length to make connection. Actual design may include open-channel segment (see text).

Cut / Fill Volume Data

Flood Storage Volume in Foster Rd. ROW (cy)

Volume of Water Stored (cy)
Volume of Additional Storage Available (cy)
Excavation Volume (cy)

Flood Extents

Limit of Detailed Study
2009 Flood Extents
1% Annual Chance Floodplain

200 100 0 200 Feet

N