University of Portland, Shiley School of Engineering, Capstone Project

International Way Stormwater Study

Spring 2021

Prepared For

City of Milwaukie

Milwaukie, OR

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Table of Contents

Executive Summary

The City of Milwaukie tasked the University of Portland capstone team with a project to recommend design alternatives that would incorporate both stormwater and transportation improvements along International Way between 37th Avenue and Lake Road. The city is planning to make these improvements in the next few years and has assigned the team two deliverables:

(1) a computational model of the site's stormwater network, and

(2) preliminary design plans to improve the stormwater network when improving the transportation corridor.

International Way has experienced an increased amount of traffic due to the expansion of commercial and industrial businesses, which has made it more dangerous for pedestrians and bikers. The section of roadway from 37th Avenue to Lake Road has discontinuous sidewalks so the city is implementing a Safe Access for Everyone (SAFE) improvement project.

The city has limited understanding of stormwater flows throughout this business park but knows that the businesses in this area have experienced flooding. The business park is surrounded by highly channelized and modified stream channels? which flow into Minthorn Creek that drains southeast into the larger Mount Scott Creek. The city's stormwater system utilizes Minthorn Creek and other existing channels but has been modified by weirs, culverts, bypass pipes, and roadways.

A better understanding of the existing stormwater system is needed before the city can stormwater improvements. This will be provided with a computerized model of the site. Stormwater information was compiled into ArcMap and Personal Computer Stormwater Management software (PC SWMM) to model the study area. Several data sources, including data provided by the city, national datasets, and field data were utilized and results were generated by running the model with ten years of continuous rainfall data.

In addition to modeling the current system, transportation cross-sections along International Way were designed using the city's 2016 Transportation System Master Plan (TSP) as well as Public Works Standards for collector roads. The proposed cross-sections defined location and dimensions of parking, landscaping, sidewalks, bike lanes, and travel lanes. City of Milwaukie tax lot data will be used to ensure that the cross-sections will fit within city owned right-of-way.

Lastly, based on the stormwater model, three preliminary design alternatives were identified and one preliminary design was evaluated. The design alternatives will adhere to City of Milwaukie design standards. A decision matrix was created and utilized to identify which alternative(s) are the most promising for the city to pursue.

Introduction

Project Overview

The City of Milwaukie tasked the University of Portland capstone team with a project to improve a transportation corridor along International Way between 37th Avenue and Lake Road. International Way has experienced an increased amount of traffic due to the expansion of commercial and industrial businesses. For the city to improve the transportation corridor, they need to understand the current stormwater system with a computational model. With a better understanding of the system, the city is interested in preliminary design plans to improve the stormwater network when improving the transportation corridor. The capstone team has been assigned these two deliverables for the City.

Team's Role in the Project

The City of Milwaukie partnered with the University of Portland capstone team to complete an evaluation of the current stormwater system and analyze proposed designs. Assisting the team was Dr. Jordy Wolfand from the University of Portland and Beth Britell, PE from the City of Milwaukie.

Brief Scope of Work

The scope of work for this project is to develop a stormwater model for the watershed surrounding International Way from 37th Avenue to Lake Road. The scope also includes preliminary design for the roadway cross section and stormwater features within the watershed.

Intent and Organization of the Report

The purpose of this report is to gain an understanding of the current stormwater system and flow paths that can be used to produce preliminary designs for widening the transportation corridor with systems to aid stormwater management and treatment. This document contains details regarding the project background, the modeling approach, design alternatives, and cross-section drawings of the proposed design.

Background

Initial Conditions and History

Project and Area Description

International Way, a collector, in Milwaukie, Oregon is located approximately eight miles southeast of downtown Portland. International Way is a two-lane and three-lane road through a business park. The study area is bordered by 37th Avenue to west, Lake Road to the southeast, a railroad to the northeast, and Highway 224 to the southwest (Figure 1).

Residents and local businesses have experienced flooding on and around International Way during heavy rainfall. The business park is extensively covered with impervious area, generally consisting of parking lots and building rooftops, which has contributed to the flooding issues. Additionally, the business park's traffic has steadily increased recently due to the rise of consumer businesses such as eateries, breweries, and bakeries. Approximately half of International Way has no paved shoulder or sidewalks for foot traffic. South of Freeman Way, gravel embankments mark the edge of the roadway and are frequently used as local parking, though dangerous.

The city is planning to address both the stormwater and transportation problems in one project, but first needs to gain a better understanding of the stormwater system. The city will be able to implement solutions that will reduce flooding and construct sidewalks and bike lanes that will benefit Milwaukie's residents, customers, and employees in the business park.

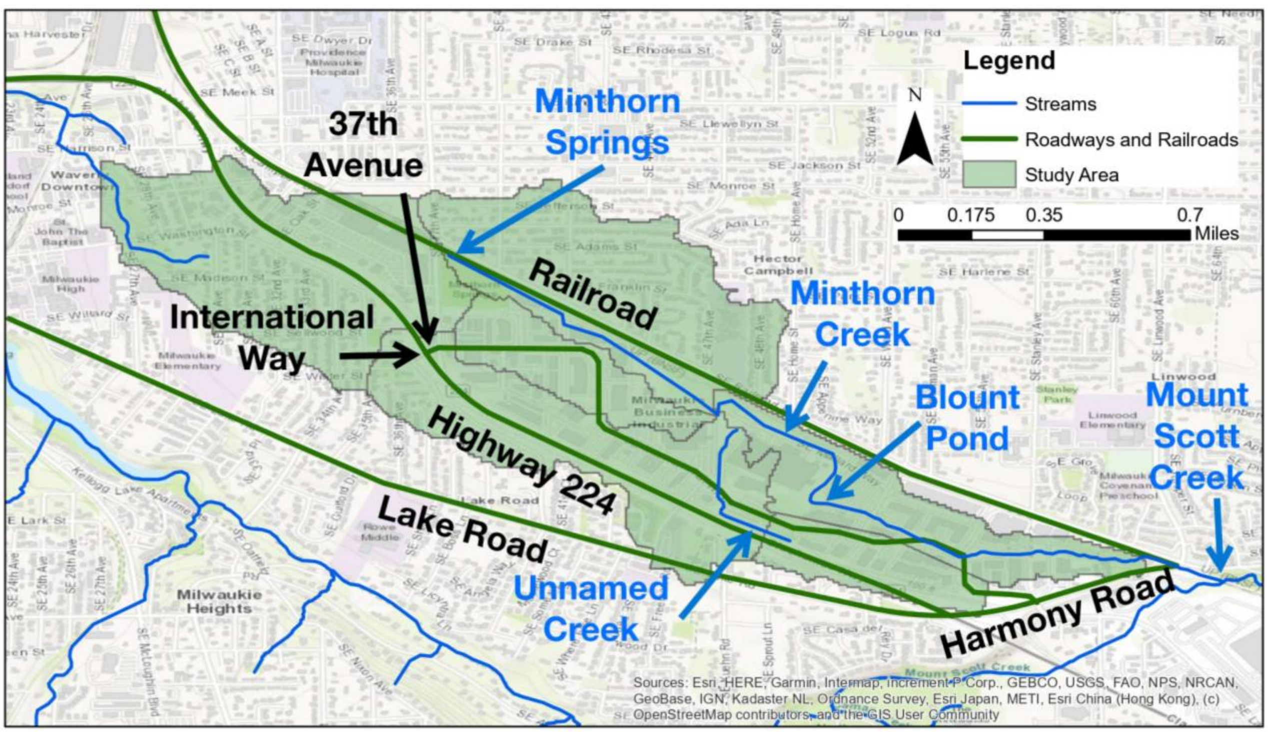

Figure 1: Study area and its points of reference. The locations of Minthorn and the unnamed stream are the blue lines within the study area. The green lines show the roads the border the study area.

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP.

Hydrology

Several wetlands surround the study area. Minthorn Springs is located north of International Way, Minthorn Creek, a tributary of Mount Scott Creek, flows along the side of the railroad at the northwest boundary of the business park, and an unnamed creek flows from the northern side of the business park towards Highway 224 (Figure 1.) International Way crosses over Minthorn Creek twice. Culverts are used to direct flow underneath the roadways. The Minthorn Springs wetlands are owned by The Wetlands Conservatory and are managed by North Clackamas Parks and Recreation.

The business park and surrounding areas can expect up to nine inches of rainfall per month during the wet season, from October through April (USGS, Harney Rain Gage). Runoff from the business park is discharged directly into the two creeks.

<u>Minthorn Creek</u>

- originates at Minthorn Springs
- flows into and out of a large pond at Blount International at 4909 SE International Way
- Pond volume is controlled by a weir upstream of Mallard Way
- perennial flow
- channelized along roadways
- multiple culverts (212 ft total)
- drains to Mount Scott Creek

<u>Unnamed stream, south of the business park.</u>

- flows into and out of a small pond behind Bob's Red Mill at 5000 SE International Way
- intermittent flow
- receives flow from Minthorn Creek via a bypass weir and closed pipe
- drains into 700-foot long culvert under Highway 224 before entering Mount Scott Creek

To address flooding from Minthorn Creek, the city installed a bypass culvert alongside International Way, next to the parking lot for the businesses at 5484 SE International Way (Figure 3). This bypass channel is connected to Minthorn Creek by a rectangular weir (Figure 4).

When flow exceeds the height of the rectangular weir, flow from Minthorn Creek is redirected to the unnamed stream along the path shown in red on Figure 3 before entering Mount Scott Creek in the flow path described above. When flows do not exceed the height of the weir, water flows parallel to International Way in the Minthorn Creek channels shown in the flow path in blue on Figure 3. Minthorn Creek enters a culvert under International Way before continuing southeast until it drains into Mount Scott Creek.

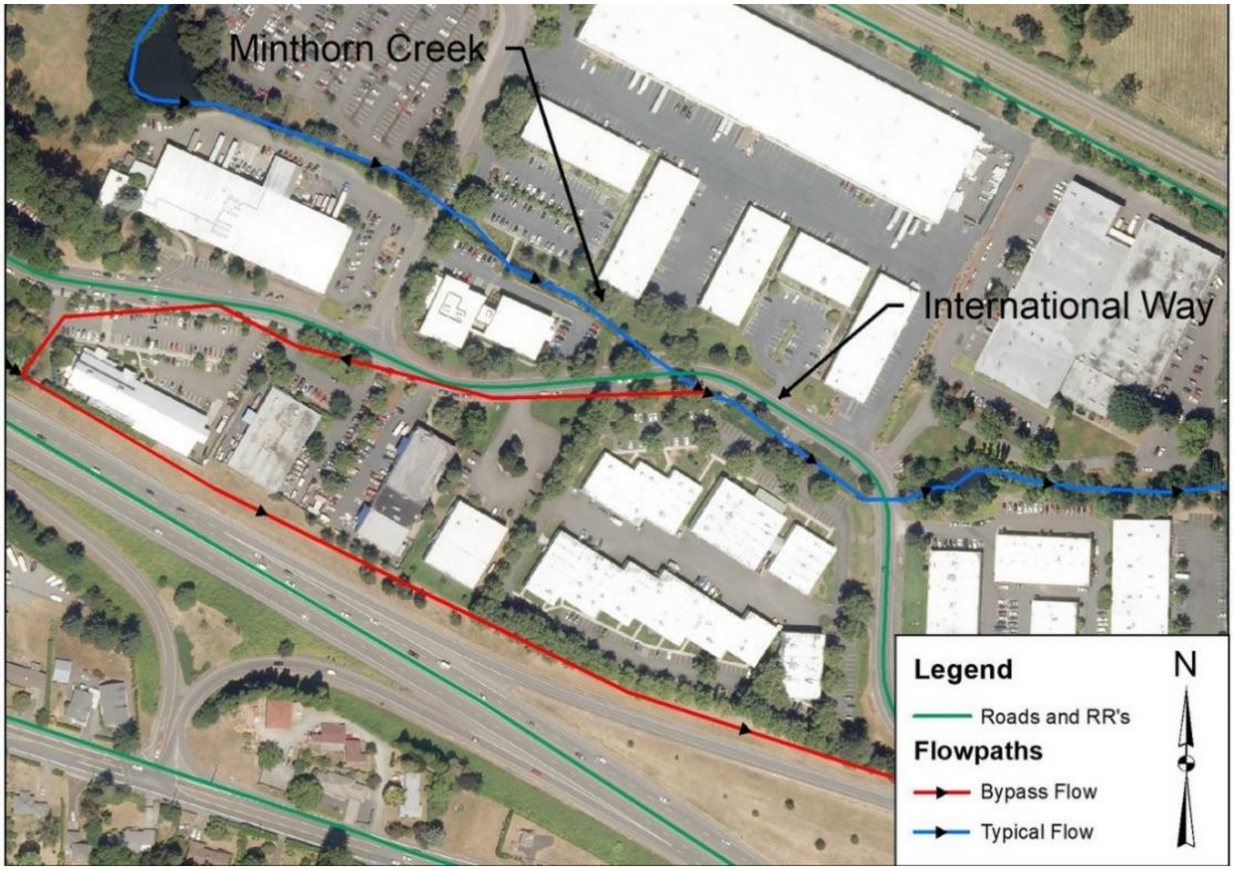

Figure 1: Overhead View of the Bypass Weir. Blue arrows indicate flow direction of streams. Red arrows indicate flow direction in pipes. Basemap Source: Google Maps, 2017. Scale: 1" =375' Google Maps [online] [Accessed March 2020].

Jurisdictional and Regulatory Aspects

The city ensures that roadway and stormwater projects adhere to specific standards. The city follows the Bureau of Environmental Services (BES) Stormwater Management Manual from 2016 for the construction of stormwater facilities. This manual also references how infrastructure, including roadways, need to account for impervious runoff in their design. The Clean Water Services Low Impact Development Approaches Handbook from 2016 was used for additional guidance on the design of stormwater features.

The city also adheres to internal Public Works Standards effective March 1, 2021. These standards dictate the size of roadway and stormwater design elements placed within the public right-of-way based on the classification of the capacity of the road.

Lastly, the city can only make improvements within their right-of-way, the property that belongs to the city. In some cases, property may be purchased temporarily for construction or permanently if the city can come to an agreement with the property owner. The City of Milwaukie, however, would like to minimize the necessary right-of-way acquisition needed in this project.

Stakeholders

Six stakeholders were identified in this project: pedestrians, cyclists, transit riders, car owners, local businesses, and the City of Milwaukie. Stakeholders will benefit from the project in the following ways:

1. Pedestrians: Continuous sidewalks with marked crossings will add to the safety of the transportation corridor. When sidewalks are installed, pedestrian access will be separated from the roadway and they can access transit stops and businesses more easily.
2. Cyclists: Currently, bikers must ride in the same lane as cars along sections of International Way Continuous bike lanes will reduce the current risk for cyclists on International Way and make businesses more easily accessible by bike.
3. Transit Riders: There are currently seven bus stops on either side of International Way which are part of bus line #152. The addition of sidewalks and bike lanes will make access to those bus stops safer, easier, and more equitable for people of all levels of mobility.
4. Car Owners: Currently car owners have the option to parallel park on the gravel shoulder of International Way, and there is limited paved parallel parking. Adding more paved and striped parking will make the area more accessible for those traveling by car, and a sidewalk will make it safer to navigate once they leave the car.
5. Local Businesses: The addition of sidewalks and bike lanes will make access to local businesses safer and easier. Additionally, if planters or other additions make the transportation corridor more attractive more customers may want to see the improvements and may also utilize nearby businesses. Finally, Dave Elkin, a consultant working with Dave's Killer Bread, expressed that the business has been affected by flooding in the past, so improvements to the stormwater system could save businesses money from damages.
6. City of Milwaukie (COM): COM is a stakeholder because they are responsible for providing and maintaining the infrastructure built in this project. Flooding along International Way creates more work for COM maintenance crews who must respond to the site and attempt to clear debris and negate the flooding. A major goal of the city is to minimize the need for right-of-way acquisition when evaluating recommended improvements to the area.

Design Approach

Scope of Work

The scope of work includes three main tasks: developing a stormwater model, redesigning the roadway cross-section, and developing preliminary design for stormwater infrastructure that need improvement or replacement.

Task 1: Stormwater Model

- Gather necessary input data through field investigation and City of Milwaukie GIS databases.
- Develop sub-basins and flow paths using ArcMap.
- Import sub-basins, flow paths, and other necessary inputs from GIS into PCSWMM
- Identify areas most prone to flooding.
- Identify infrastructure causing flooding.

Task 2: Roadway Cross-Section

- Identify areas with environmental constraints or right-of way constraints through field investigation and by using city tax lot data.
- Use the 2016 Transportation System Master Plan and Public Works Standards for collector roads to develop a cross-section that fit within city-owned right-of-way.
- Specify placement and dimensions of parking, landscaping, sidewalks, bike lanes, and travel lanes.

Task 3: Stormwater Feature Design

- Develop design alternatives for critical infrastructure identified in Task 1 using flows determined in Task 1 that adhere to City of Milwaukie design standards.
- Provide cost estimates and a decision matrix to identify which alternative(s) are the most promising for the City to pursue.

Modeling Approach

A stormwater model was created for the study area to identify the locations along International Way that experienced the flooding. The model was originally created in ArcMap, a geographic information system (GIS) software, with the city's existing stormwater GIS data. With light detection and ranging (LIDAR) elevation data provided by the United State Geological Survey's (USGS) National Elevation Dataset (NED) and ArcHydro, a plugin for ArcMap, catchments were delineated along the entire length of International Way. Eventually, these inputs were moved into the Personal Computer Stormwater Management Model software (PCSWMM), where the scope of the project was focused on certain areas that had been experiencing flooding and the model was tested against design storm events as well as continuous rainfall data.

ArcMap Inputs

PCSWMM was chosen to model the study area because of the program's integration with ArcMap. The following components were imported from ArcMap:

1. Catchments: Areas within a larger watershed in which all the runoff within the catchment drains to the same point.
2. Conduits: All predefined drainage pathways, including streams, stormwater pipes, and open drains.
3. Junctions: The intersection of two different types of conduits, the point to which one catchment drains, or another feature like a storage facility or weir.
4. Outfalls: the points at which flow leaves the study area.

Simplification and Assumptions

The model area was determined by focusing on the catchments that surrounded locations prone to flooding and stormwater infrastructure that will need to be relocated or reconstructed before transportation improvements can be built.

The model area was determined by focusing on the catchments that surrounded the pond behind Dave's Killer Bread and the bypass weir at STA 20+85 (see Appendix B), or were connected to these two features through culverts, channels, or other conduits. It was decided to focus on this area because it was not studied in the city's Stormwater Master Plan and because this area experienced the most flooding.

Following simplification of the model area, simplifications were made to the conduit systems. Many of the stormwater laterals were removed, and the mains were joined into a single conduit, one for each catchment. For catchments with multiple conduits, only the longest continuous flow path and known bypass conduits were included in the model. The longest flow path is important for the model to calculate the time of concentration, which is then used to calculate the peak runoff flow. The simplified model with all assumptions considered can be seen in Figure 5.

Once all the features of the model were imported and simplified, attributes were defined for each catchment, junction, and conduit.

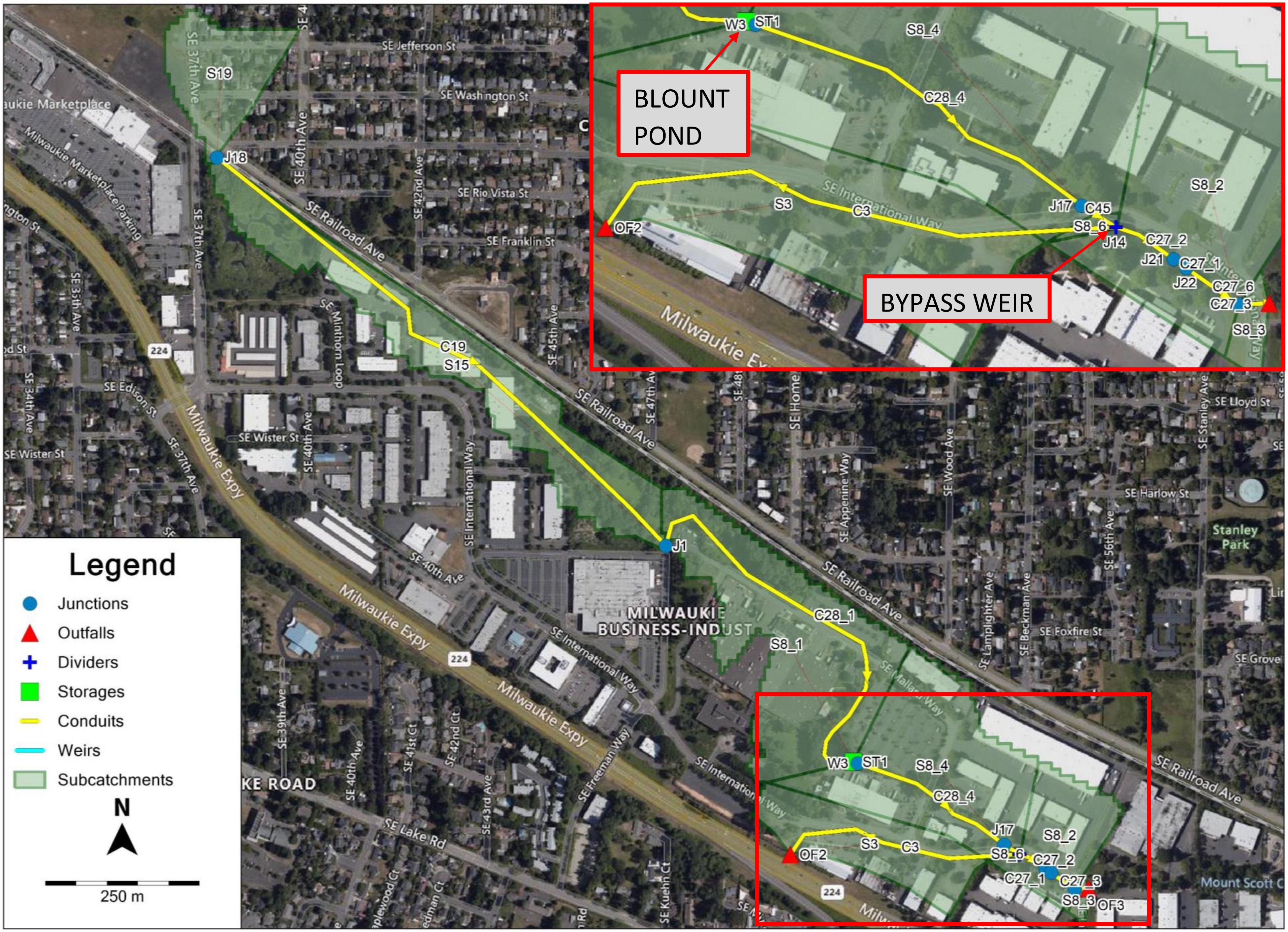

Figure 5: Model Area with inset map to show all junction and conduit labels. Image generated in PCSWMM.

Rainfall Data

The model was run with both continuous precipitation data as well as with event-based precipitation using the 2-year, 5-year, 10-year, and 25-year design storms.

Continuous data is available from City of Portland rain gages, referred to as the HYDRA Rainfall Network. Data is available from 1998 to present for most rain gages in the network. The closest gage to the project site is the Harney gage in southeast Portland which is approximately 2.5 miles from the project site. Ten years of rainfall data was selected, from October 2008 to September 2019 (water year 2009 to 2019) to gain an understanding of the stormwater system in a variety of hydrologic conditions.

Design storms were defined by the City of Portland Stormwater Manual (Table 6). In PCSWMM, separate rainfall events were created for the 2-year, 5-year, 10-year, 25-year, and 100-year design storms defined in the 2016 City of Portland Stormwater Management Manual (Table 7). The 25-year storm event was run through the model because several stormwater facilities are required to accommodate flows from the 25-year design storm.

Table 6: Design Storm Definitions from the City of Portland Stormwater Management Manual

Recurrence Interval	Total Rainfall in 24 Hours (in)
2-Year	2.4
5-Year	2.9
10-Year	3.4
25-Year	3.9
100-Year	4.4

Model Calibration

The model was run for the 25-year storm event and calibrated manually for flows defined for the 25-year storm from the city's 2014 Stormwater Master Plan (SWMP). Outfall 2 (OF2) in model coincides with node 66026 of the SWMP, at the downstream end of the bypass conduit, where it meets the unnamed creek (Figure 3). By manipulating "how full" the junctions and conduits where, the model flows at OF2 match flows from the SWMP at 66026.

Design

Roadway Improvements

The city has the following goals for International Way: (1) construct a continuous sidewalk and (2) create bike connectivity. The project is part of the city's Safe Access for Everyone (SAFE) program of pedestrian and biker improvements. The city's 2016 Transportation System Master Plan (TSP) proposes that bike lanes will be constructed on International Way.

Existing:

- (2) 12 ft travel lanes
- 8 ft parallel parking and 5 ft sidewalk on southside of roadway from STA 10+00 to 14+00
    - 3.5 ft landscape strip between parking and sidewalk

The paved roadway width needs to be widened by an average of 15 ft to accommodate new sidewalks, bike lanes, and flow through planters. Within the roadway widening section, there are two existing pinch points based on environmental constraints. These constraints include the existing sidewalk at STA 10+00 and the culvert and pond at STA 20+85.

The constraint at the existing sidewalk is based on available right-of-way. The back of the existing sidewalk is about 10 ft inside the right-of-way boundary and the sidewalk should not be demolished because of the waste this would create. The placement of the existing sidewalk and landscape strip leaves about 40 ft from the edge of the landscape strip to the north extent of the right-of-way.

The constraint at the culvert and pond is based on the distance from the existing edge of pavement to the edge of the pond. On the north side of the roadway the edge of the pond is 10 ft from the existing edge of pavement.

To accommodate these environmental constraints, the following cross-section is proposed:

- (2) 11 ft travel lanes
- Sidewalk, 5 ft on south side of road
- Parking, 6 ft from Station 0+00 to 20+50 on south side of road
- (2) Bike lanes, 6 ft
- Discontinuous flow-through planters, 3 ft on north side of road

The proposed cross section (Appendix B) has multiple benefits, including:

1. The flow-through planters will provide enough treatment for all additional impervious area created by this project. This allows stormwater
2. The section will connect to the the existing conditions at STA 10+00.
3. The section will fit within the existing right-of-way for the entire project extents.
4. No existing stormwater infrastructure will need to be relocated.

The proposed cross-section will eliminate the need for right-of-way acquisition for this project. The proposed planters are sized using the CWS LIDA Handbook from 2016 which states that the planter area must be at least 6% of the impervious that it will treat. The proposed planters exceed 6% of the new impervious area that will be added by the construction of a new sidewalk and bike lanes. The proposed planters will treat any additional runoff created by the new impervious area which allows further proposed stormwater infrastructure to be designed based on existing conditions.

SWMM Model Results

The model was run using the 10 years of continuous rainfall data from the Harney gage. To evaluate the quality of the model, PCSWMM calculates runoff continuity. This process compares the total inflows of water to the total outflows of water. The total continuity error, the percentage difference between the inflows and outflows, was -0.005%. This means that almost all of the water that came into the model as precipitation was accounted for.

The model area was run and analyzed for ponding. The run of 10 years of continuous rainfall data showed that several junctions and conduits experienced flooding. Table 9 below shows that four junctions experienced ponding, but the junctions experienced ponding for less than 6% of the 10-year simulation (Table 9). The two conduits shown to be limited, C27_1 and C45, are culverts, stretching from immediately before the bypass weir to the model's outfall. The conduits were limited for less than 10% of the 10-year run, but this is still a significant amount of time for certain areas to be flooded.

Table 9: Flows at Ponded Junctions. Data Exported from PCSWMM.

	Time Ponded Over 10 Years	Maximum Rate	Total Flood Volume
Node	%	CFS	10^6 gal
J1	3.7%	27.01	3.01
J17	5.4%	4.71	12.59
J19	0.3%	0.56	0.01
W3	4.2%	4.69	7.61
ST1	2.6%	64.10	875.40

Table 10: Flows at the Limited Conduits. Data Exported from PCSWMM.

	Maximum Flow	Maximum Velocity	Maximum Depth of Water in the Conduit	Time Capacity Limited over 10 Years
Link	CFS	ft/sec	%	%
C27_1	14.35	6.55	1.0	8.6%
C45	18.51	5.77	1.0	6.6%

The model shows that frequent flooding occurs along the open channels and culverts around International Way. This conclusion was expected, as observational data from the city's Public Works Department and from Dave's Killer Bread and observations by the project team during site visits support the model's results. The city should be concerned about this flooding, as it is likely to get worse if maintenance is never provided.

Stormwater Infrastructure Improvements:

The stormwater infrastructure improvement preliminary designs address flooding from Minthorn Creek on and around International Way. Preliminary stormwater infrastructure improvements are investigated to identify the most feasible design options for the project moving forward. The preliminary designs are qualitatively assessed, backed up by quantitative data from engineering calculations drawn from design manuals for minimum project area, max flow rate, depths, and volume requirements.

Preliminary Design Options:

To address the concern of stormwater flooding in Minthorn Creek, four preliminary design alternatives were assessed:

1. Upsize existing culverts (culvert resize)
2. Sized up piping and new manhole to replace the bypass weir (manhole junction)
3. Grassed swales along the roadway (swale improvement)
4. Underground storage and infiltration (underground storage)

Culvert Resize:

The culvert resizing design focuses on replacing the existing, 20-inch corrugated metal culverts that currently guide Minthorn Creek under International Way at STA 20+85, 23+40, and 25+95 with 30-inch HDPE culverts.

Hydrologic modeling confirmed that these culverts are the primary pinch-point of the system and are most susceptible to flooding from large storm events. In the 10-yr continuous data run, culverts C45 and C27_1 are shown to be at full, 100% capacity 6.6% and 8.6% of the time, respectively (Table 10). By sizing up the culverts from 20-inch to 30-inch HDPE, the maximum flow increases from 14 cfs to 60 cfs, allowing all peak flows from the surrounding nodes to easily pass through (Table 9).

Manhole Junction:

The manhole junction design focused on redirecting excess flow from Minthorn Creek to the existing bypass located at STA 20+85. A new 6 ft diameter precast manhole would replace the existing bypass weir. The existing 28-inch bypass concrete culvert that redirects excess flow from Minthorn Creek will be connected to the manhole and the existing bypass weir would be replaced with a weir within the manhole. The existing 20-inch corrugated metal culvert, C45 will be replaced with new 30-inch HDPE culvert and connected to the manhole. To properly place the manhole, private property adjacent to the right-of-way would need to be purchased by the city to install and maintain the system. Approximately 600 sq ft of land would need to be purchased as right-of-way for the manhole to be properly placed, as the existing bypass is located outside of the city’s right-of-way.

Swale Improvement:

The swale improvement focuses on adding above ground, vegetated treatment facilities to the stormwater system designed based on the vegetated swale section of the CWS LIDA Handbook from 2016. By directing flow through these swales, a limited amount of infiltration can be achieved as well as some stormwater treatment. The swales would be constructed along the existing open-channel center line between the culverts at STA 21+70 and STA 23+75 and retain the existing slope of the open channel. This vegetated swale would replace a minimally managed stormwater ditch that contains invasive cattail species and steep, gravelly banks. This gently sloped and widened swale would allow more water to build up along its banks before spilling over and flooding surrounding areas. To provide adequate storage, the swale would need to be 25 feet wide and 1.5 feet deep. This design adds natural habitat to the watershed but would require at least 3000 sq ft of right-of-way acquisition due to the existing roadway already being within 12 ft of the right-of-way boundary at the narrowest point and the existing channel being outside of the existing right-of-way boundary.

Underground Storage:
The underground storage design utilizes large underground basins to absorb excess flow from large storm events, relieving the pinch-point of flooding. This stored water is stored then can either be released above ground or into dry wells where water is returned to the water table. All underground storage would be placed under new roadway improvements such as sidewalks, bike lanes, or shoulder parking, meaning no new property would be needed to complete this design. To handle flow from 9000 sq ft of newly impervious area along the roadway between the 2 culverts, a 48-inch drywell would need to be 20-ft deep in soil that has infiltration rates above 2 in/hr. The soil of the area is primarily loams, silts, and clays, all soils with low infiltration rates. Specifically, the model area mainly consists of Manita (Soil type 53C) and Drewsgap (76B), both loams with infiltration rates of 0.15 and 0.35 in/hr, respectively. Furthermore, the project site showed signs of a high-water table, such as standing water in Minthorn creek year-round.

Preliminary Designs Analysis:
A decision matrix was created to compare design options (Table 9). The design considerations were determined with the city as the primary interests of each design. They are weighed higher in the columns on the left side of the matrix as opposed to the columns on the right side. For example, right-of-way acquisition is the most important consideration, while ENVISION Natural World rating is the lowest weighed. The design with the lowest total score has overall the best weighed grade. Design alternatives (rows) are given a rating in each design consideration (columns) based on quantitative numbers such as a preliminary construction cost estimate, or area of right-of-way needed to be acquired. The ratings, with 1 being the best choice and 5 being the worst, are multiplied by the weight of the design consideration with 5 being the highest multiplier and 1 being the lowest.

Table 11: Decision Matrix

	ROW Acquisition		Cost		Maintenance		Flood Management		ENVISION rating		Total
	Rating	(sq ft)	Rating	($)	Rating	Description	Rating	Description	Rating	(ENVISION score)	
MH Junction	3	600	3	$50,000	3	Yearly inspection	2	bypass structure underground	3	37%	8.6
Swale Improvement	5	3000	2	$40,000	5	Vegetation clearing/ upkeep ($2000-$5000 yearly)	2	Excess area gives rising water space	1	65%	10.6
Underground Storage	1	0	5	>$60,000	2	Yearly inspection	1	Either fills up and slowly drains during low flows or drains to drywell	3	39%	7.2
Resize culvert	1	0	1	$30,000	3	Yearly inspection, channel dredging	4	bypass still takes excess flow, culvert still choke point	5	35%	6.0

Table 9: Decision Matrix, Ratings were provided on a scale from 1-5, with 1 being the best rating.
1) Construction costs from ODOT 2019 Average Bid prices
2) ENVISION rating, Institute for Sustainable Infrastructure (ISI), 2010

Design Decision:

The culvert resizing design was selected to be the final design suggestion. It was selected due to its ability to address the problem as seen by the decision matrix rating.

The manhole junction design proved to require too much right-of-way to be competitive in the ratings. Furthermore, by putting the weir inside the manhole it would eliminate the versatility of the existing bypass weir.

The swale improvement was eliminated due to right-of-way requirements and maintenance concerns. With minimum preliminary requirement estimates of 3000 sq ft, purchasing additional right-of-way stops the design with additional costs that could be avoided with other alternatives. Maintaining the vegetation within a swale and keeping debris clear of it requires constant maintenance and upkeep.

The underground storage preliminary design was eliminated because of soil type and the suspected high-water table within the area. With low infiltration rates and water standing in Minthorn Creek year-round, the drywell design would unfeasible. Furthermore, due to large amounts of excavation, construction costs of this alternative would be the highest by far. In the future, a geotechnical report of the area is recommended to confirm a drywell design is unsuitable in the area, investigate subsurface conditions, and investigate underground detention facilities that do not utilize drywells but drain via orifices into Minthorn Creek downstream.

The installation of a larger culverts will address the flooding in the immediate area surrounding International Way. It is recommended that the culvert at STA 23+30, C27_1, located on private property at the 5480 block of International Way also be increased in size to prevent it from becoming a new pinch point within the system. This design allows for water to pass under the roadway, preventing flooding and ponding. In addition to this upsize, it is recommended that the surrounding channels, C28_4, C27_2, C27_6 be cleared of debris and sediment. In addition, resizing the culverts will not need any additional right-of-way to be bought, it has the lowest construction cost of all alternatives.

As the selected design suggestion, the upsized culvers were input into the SWMM model, and the model was run with the 10 years of continuous rainfall data. The upsized culverts helped mitigate flooding at both junctions and conduits, with reductions in flooding of up to 10% (Figure 8.) With the increased culverts, all junctions and nodes were flooded for less than 1% of the total 10-year period. The results of this model show the city that increasing the culvert size will be a worthy investment.

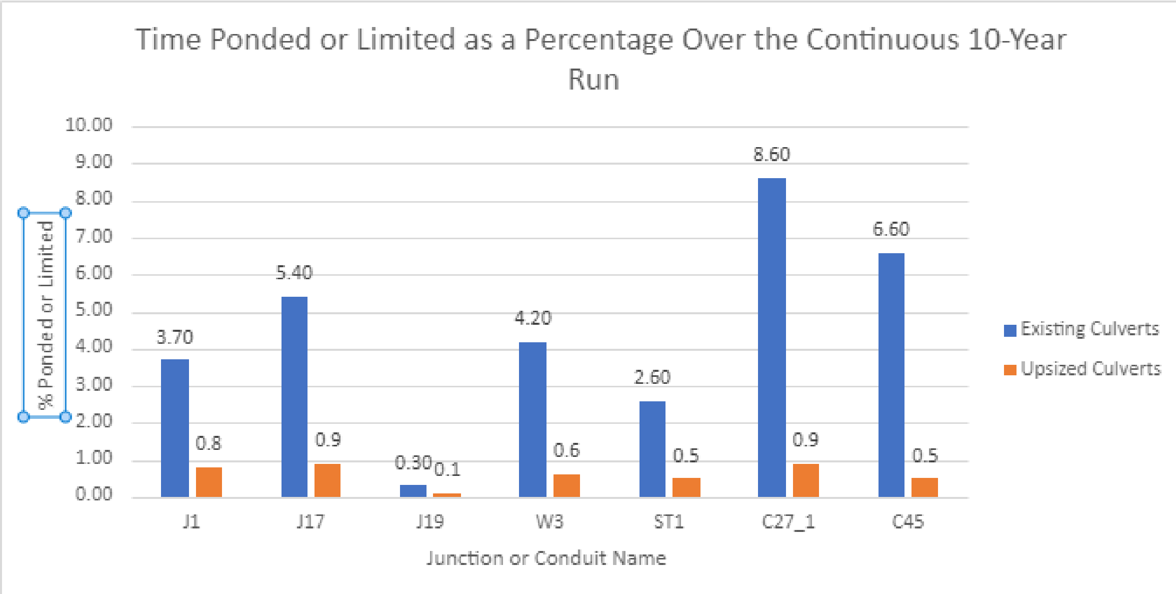

Figure 8: Time Ponded or Limited as a Percentage Over the Continuous 10-Year Run

Summary of Preliminary Design:

It is recommended that International Way be widened from STA 0+00 to 36+58 to add continuous 6 ft bike lanes, a 6 ft sidewalk on the south side, and 53 24-ft parking stalls to tie into existing transportation improvements. By widening the roadway between 12 and 18 feet, all necessary transportation corridor improvements can be met while minimizing the effect on the existing path of Minthorn Creek. To address flooding and the addition of impervious area, it is recommended the existing culverts underneath International Way be replaced with larger, 30-inch HDPE culverts that extend beyond the new road shoulder. This increased flow volume, as well as the utilization of the existing bypass culvert already installed by the city, allows for storm water surges to pass under International Way without flooding or damaging the roadway. See Appendix B for drawings.

Future Work:

It is recommended that primarily, a professional survey should be taken of International Way as well as surrounding properties that Minthorn Creek passes through. Professional surveys will verify all lengths, alignments, and the layout of any design, furthermore, a survey can locate existing utilities in the area. It is also recommended that a geotechnical investigation is performed in the area where International Way crosses over Minthorn Creek. A full geotechnical investigation will shed light on the subsurface conditions, as well as deliberately decide the feasibility of any underground structure related to storing or percolating stormwater. Furthermore, a detailed design of roadway improvements and culvert resizing should be performed with both survey and geotechnical data available. This will lead to a more thorough design that can address the details this preliminary design couldn’t such as existing utilities (electricity, water, sanitary sewer, gas, fiber optic), existing vegetation, and detailed roadway markings and signage for bus-stops, bike lanes, turn lanes and parking stalls.

Acknowledgements

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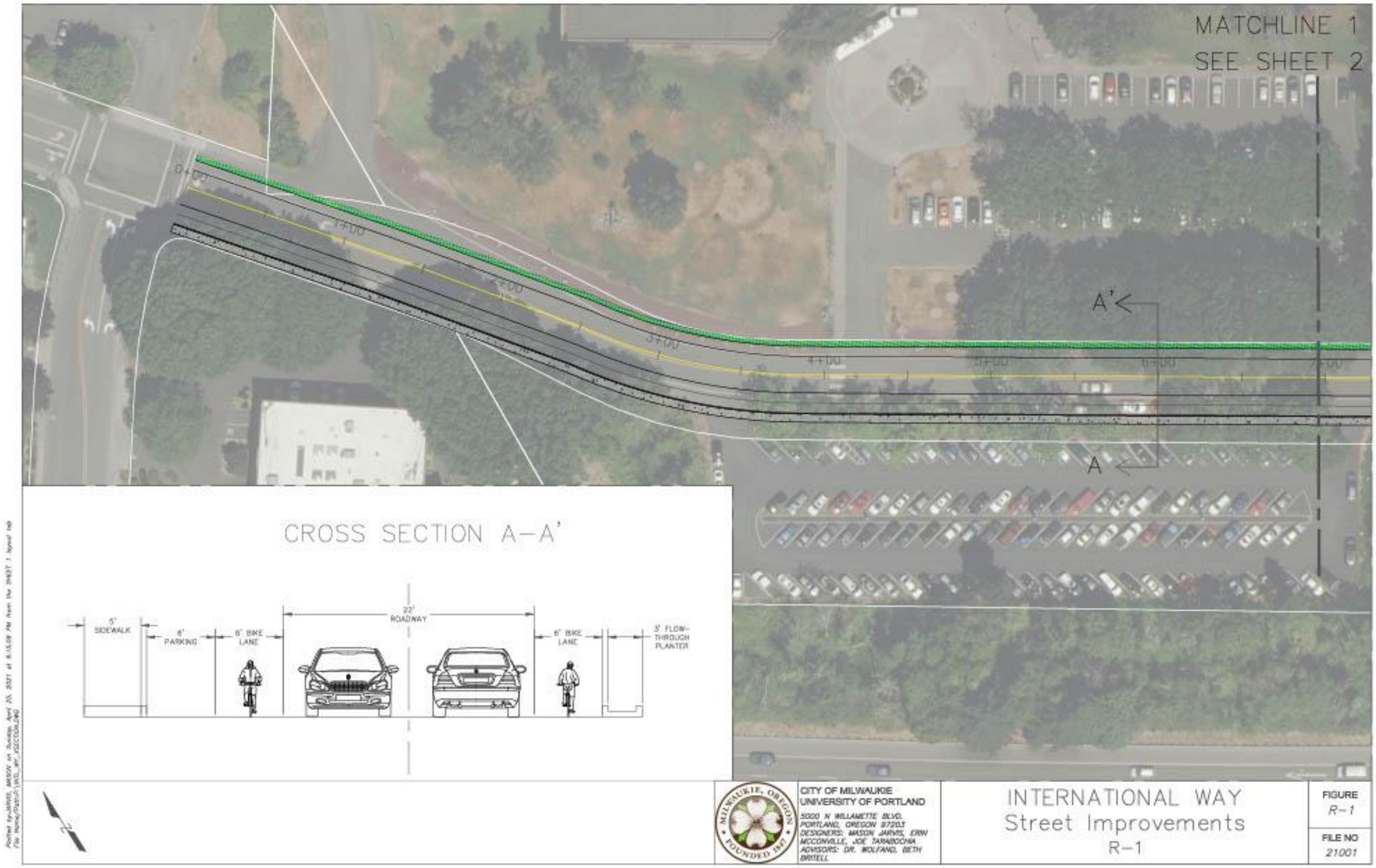
Drawings:


MATCHLINE 1
SEE SHEET 2
A'
A
CROSS SECTION A–A'
5' SIDEWALK
6' PARKING
6' BIKE LANE
22' ROADWAY
6' BIKE LANE
3' FLOW-THROUGH PLANTER
CITY OF MILWAUKIE
UNIVERSITY OF PORTLAND
5000 N WILLAMETTE BLVD.
PORTLAND, OREGON 97203
DESIGNERS: MASON JARVIS, ERIN MCCONVILLE, JOE TARABOCCHIA
ADVISORS: DR. WOLFAND, BETH BRITELL
INTERNATIONAL WAY
Street Improvements
R–1
FIGURE
R–1
FILE NO
21001

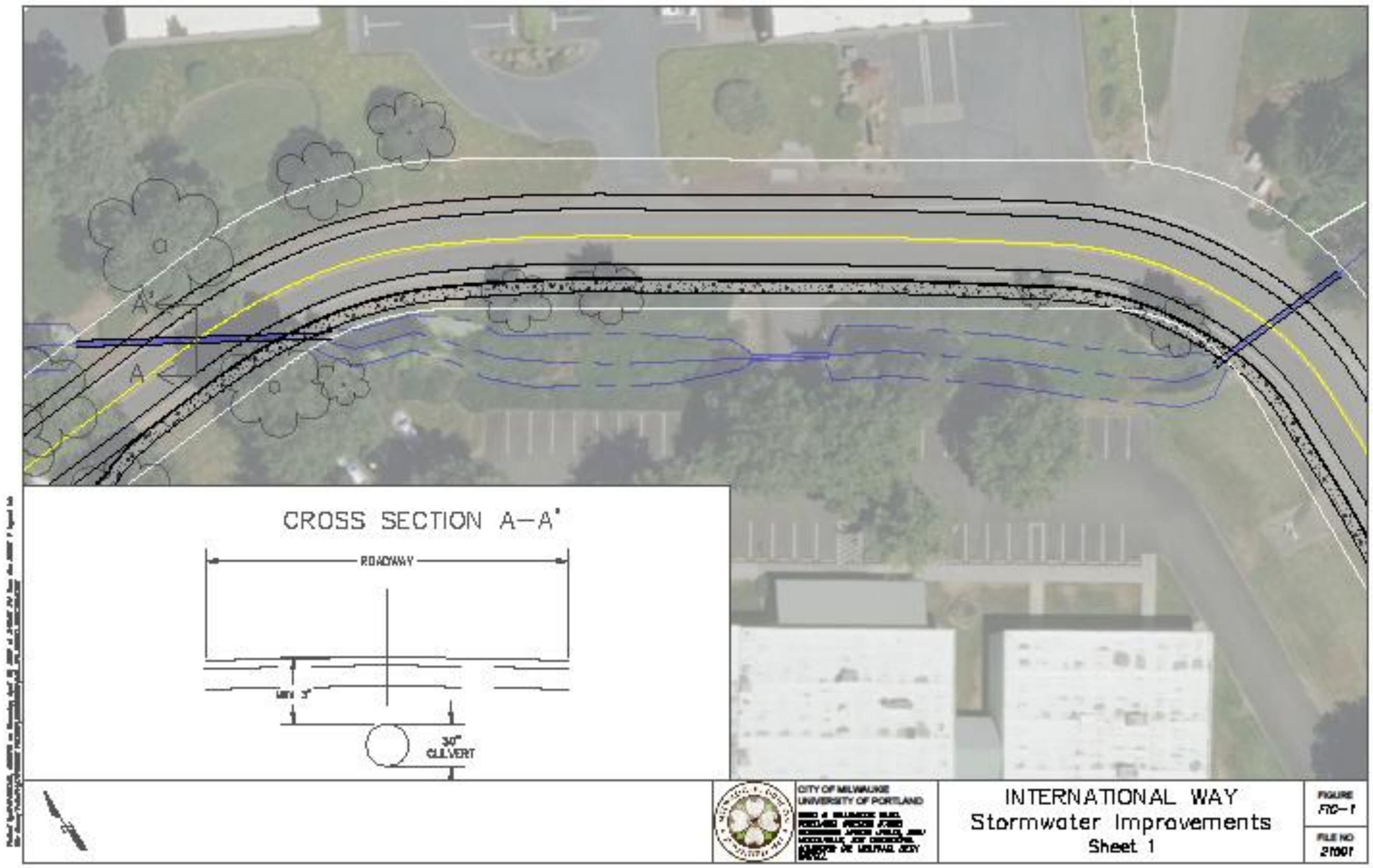
Drawings:


MATCHLINE 1
SEE SHEET 1
MATCHLINE 2
SEE SHEET 3
CITY OF MILWAUKIE
UNIVERSITY OF PORTLAND
5000 N WILLAMETTE BLVD.
PORTLAND, OREGON 97203
DESIGNERS: MASON JARVIS, ERIN MCCONVILLE, JOE TARABOCHIA
ADVISORS: DR. WOLFAND, BETH BRITELL
INTERNATIONAL WAY
Street Improvements
R-2
FIGURE
R-2
FILE NO
21001

Drawings:

MATCHLINE 3
SEE SHEET 4
MATCHLINE 2
SEE SHEET 2
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00
N
CITY OF MILWAUKIE
UNIVERSITY OF PORTLAND
5000 N WILLAMETTE BLVD.
PORTLAND, OREGON 97203
DESIGNERS: MASON JARVIS, ERIN MCCONVILLE, JOE TARABOCHIA
ADVISORS: DR. WOLFAND, BETH BRITELL
INTERNATIONAL WAY
Street Improvements
R-3
FIGURE
R-3
FILE NO
21001

Drawings:



CROSS SECTION A–A'
ROADWAY
30" CULVERT
A'
A
CITY OF MILWAUKIE
UNIVERSITY OF PORTLAND
INTERNATIONAL WAY
Stormwater Improvements
Sheet 1