Memorandum

To:	Uki Dele, PE and John Featherstone, PE – City of Shoreline
From:	Gwyn Perry, EIT Tyson Hounsel, PE
Copies:	File
Date:	September 19, 2018
Subject:	Task 16 WO16516 – Solution Concept Development for Flooding at NE 175th Street and 10th Ave NE
Project No.:	32713.B16

Otak prepared a previous memo to the City, (Modeling Tech Memo, 2/15/2018), documenting an assessment of the nature of flooding that occurs near the intersection of NE 175th Street and 10th Avenue NE in the City of Shoreline (City), WA. The flooding complaint(s) are documented in the Cityworks database as work order #16516. The previous memo suggested potential solution concepts that could be considered with further engineering to alleviate flooding. The City is preparing for a NE 175th overlay project to be constructed in 2019 and would like to know if flood reduction improvements near the intersection should be included in the project to avoid disturbance of the new 175th St. pavement overlay in the future. This technical memorandum documents feasibility assessment of concepts for minor improvements near the intersection only that could reduce flooding.

In addition to the field assessment and modeling work summarized in the previous memo, Otak has since reviewed the following information provided by the City:

- Topographic basemap (electronic) that was prepared in 2014 by SvR Design Company, through their on-call with the City, as part of the alternatives analysis phase of the 10th Avenue Drainage Improvements project
- Design information for the installation of pipes and valves intending to result in a flow split at the intersection of NE 175th St and 10th Ave NE, dated 2004. The documents include spreadsheet results that indicate the design invert elevations of the pipes to the north and south along 10th Ave NE, the valve opening heights for the two pipes, and the calculated flow split resulting from this design at the 25-yr peak flow event. An email exchange from previous City staff was also included, indicating that flooding was still expected to occur with the flow split, and recommending options for future improvements to keep flooding within the roadway.

Review of City Flow Split Design Information

According to the information provided, it appears that the flow splitting pipe configuration at the intersection of NE 175th and 10th Ave. NE was designed by the City in 2004. As designed, the flow split creates a backwater effect from the partially closed valve to the north, to divert flow to the higher invert pipe to the south, during a peak flow event.

The design and modeling results as described in the 2004 documents were compared to the 2014 survey data, and the PCSWMM modeling results prepared by Otak based on the 2014 survey data. As

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described in the previous memo, Otak developed hydrologic data in WWHM as inputs to the PCSWMM model. The delineated basins shown in the 2004 City documents closely match those delineated by Otak. However, the peak flows do not match, which is likely due to a difference in landcover classification, and modeling assumptions and techniques. The Otak hydrologic inputs do not include any dampening effects from existing upstream detention, as including such would require a more detailed modeling effort that is beyond the current scope of work. The 2004 City documents do not provide the calculations or assumptions for the hydrologic inputs, so Otak did not attempt to recreate these results. To compare the hydraulic results from the two studies, the 25-yr peak (10.8 cfs) from the 2004 City document is compared to the 2-yr peak (11.45 cfs) from the 2018 Otak modeling memo. As shown in the table below, the flow split intended by the 2004 design does not occur in the model that is based on as-built conditions.

Table 1. Comparison of 2004 and 2018 Modeling Efforts

Flood Event	Flow Rate (cfs)	Flow to the South (cfs)	Flow to the North (cfs)
2004 Memo 25-yr	10.8	3.04	8.00
2018 Memo 2-yr	11.45	0	10.07

The as-built (surveyed in 2014) flow split pipe inverts roughly match the 2004 design information except that the difference in the pipes inverts to the north and south is slightly less in the as-built condition. The 2004 design intended the high flow diversion pipe invert to the south to be 3.46 ft higher than the pipe invert to the north, and the 2014 survey reports a difference of 3.4 ft between the two inverts. Per the 2014 survey, the north and south pipe valves are 6.5 inches and 6.6 inches closed respectively, which roughly matches the 6-inch closures recommended by the 2004 design. It is not clear when the valves and high flow overflow pipe to the south were installed or if adjustments were made during construction.

In conclusion, the existing flow split does not appear to be functioning as intended, and the partially closed north valve may be worsening the flooding issue on private property upstream. Additionally, the 2004 documents include an email by previous City staff that indicates that flooding was expected to occur even with the intended flow split. Based on the email communication, limiting the flooding to the roadway was a goal and suggestions were made for other future improvements such as detention storage to further alleviate the roadway flooding. The following section describes four options for minor improvements near the intersection to achieve a greater flow split and reduce flooding.

Solution Concept Feasibility Assessment

The following are summaries of the solution options considered and feasibility findings.

1. This option proposes to divert additional flow south into the 10th Ave. conveyance system by lowering the existing pipe (SP 8660) to engage flow split diversion at a lower stage. The current invert elevation of SP 8660 is 410.20, per the 2014 survey data. This solution proposes to replace SP-8660 with 18” pipe at the same slope of 0.13%, lowering the invert by 0.3’, to 409.9’. This alteration would match the outlet invert of SP-8660 to the inlet invert of SP-8682. Lowering the inlet of SP 8660 any further would require replacing additional downstream pipe along 10th Ave NE.

This solution would increase the flow split to the south. However, the increased flow split would be minimal, therefore this is not recommended as a stand-alone solution.

2. This option proposes to decrease the backwater at the flooding location, by adjusting the slopes of the existing pipe (SP 8465) network going north, which has a lower inlet elevation (IE = 406.8). However, according to the downstream survey information provided, the existing slope on the northern pipe system is 0.17%. We feel it would be infeasible to reduce the slope further for any segments of this pipe system. One further consideration was raising the inlet to the north line to more evenly split the flow between north and south. This may worsen the flooding at the low spot due to backwater effects to the east. This appears to be the intent of setting the existing valve on the north line, but the backwater and flow split do not appear to operate as designed. Modifying the pipe network further to the north is not recommended.

3. This option proposes to decrease the backwater at the flooding location, by adjusting the storm sewer valves. The two viable solutions involving operational changes are opening the flow split valve to the north (Option 3A) and altering the valve to the pond (Option 3B).

The modeling results shown in Table 2 below suggest that opening the flow split valve to the north may partially relieve the backwater effect at the flooding location, by increasing the peak flow routed downstream to the north. It is unknown whether the conveyance to the north has capacity to handle increased flows, even with recent LID retrofit improvements along 10th Ave NE. A downstream analysis including modeling of the downstream system is recommended if this solution is selected. Additionally, if this solution were implemented, monitoring of the system after construction would be recommended so the City could make adjustments if downstream conditions are worsened.

Table 2. Option 3A Hydraulic Modeling Results

Flood Recur. Interval	Flow Rate	Flood Duration		Flow to South		Flow to North	
(years)	(cfs)	(hr)		(cfs)		(cfs)	
		Current Setting	North Valve Fully Open	Current Setting	North Valve Fully Open	Current Setting	North Valve Fully Open
2	11.45	0.53	0.17	0.79	0	7.65	10.41
25	20.02	3.41	2.09	1.03	0.02	7.72	10.6

Under Option 3B, there is potential to improve utilization of the existing pond storage by increasing the size of the valve and outlet pipe to the pond, allowing the pond to fill faster. Using the pond to reduce flooding in the current configuration can only be achieved by manually opening the valve during peak flows. This would draw down the flood level until the pond is filled, but would not prevent flooding. As described in the previous 2018 memo, this is likely not an effective way to eliminate flooding, as the flood events are flashy and flooding occurs faster than the pond can fill, and the existing pond does not have capacity to contain the modeled flood volumes. Therefore, this solution is not recommended as a stand-alone solution. Other options discussed at the end of this memo describe additional potential improvements to the existing pond that could be implemented in the future, but that would be outside of the current NE 175th St. overlay project area.

4. This option proposes to divert high flows into the NE 10th Ave conveyance system to the south, by constructing an overflow diversion swale near the flooding location, as well as implementing the alterations to SP8660 described under Option 1 (see Figures 1 through 4). This would allow flow splitting to engage at a higher elevation and closer to the flood issue location than the current south diversion pipe within the manhole at the intersection. The hydraulic modeling results, shown in Table 3 below, indicate that the proposed overflow diversion swale would result in an estimated flow split similar to the 2004 design split shown in Table 1.

Table 3. Option 4 Modeling Hydraulic Results

Flood Recur. Interval	Flow Rate	Flood Duration	Flow to South	Flow to North
(years)	(cfs)	(hr)	(cfs)	(cfs)
2	11.45	0.28	2.02	7.9
25	20.02	2.45	2.28	7.95

This solution does not eliminate flooding under the modeled flow rates. However, the resulting flood duration and flood volume, are lower under Option 4 than under existing conditions. As this solution would result in increased flows to the south conveyance system, a downstream analysis and modeling of the downstream system are recommended if this solution is selected. Additionally, if this solution were implemented, monitoring of the system after construction would be recommended so the City could make adjustments if downstream conditions are worsened.

VALVE ON NORTH SIDE CB- 4096

CB- 4096
RIM = 413.95
IE IN = 406.6 (18" S)
IE OUT = 405.7 (18" N)

CB- 4096

SP-2622
18" CMP

CB- 7705
RIM = 413.78
IE IN = 407.1 (E)
IE IN = 407.1 (W)
IE OUT = 406.8 (N)
IE OUT = 409.9 (SW) NEW

CB-4823
RIM = 411.24
IE IN = 408.8 (N)
IE IN = 407.8 (E) ASSUMED, NOT SURVEYED
IE OUT = 407.7 (W)
IE OUT = 408.7 (S) NEW

CB- 8175

SP-6088
18" CMP

SP-8465
18" CPP
@0.17%

NE 175TH ST

NE SERPENTINE PL

CB- 10550

SP-8459
12" CMP

CB-12546
RIM = 411.88
IE IN = 409.0 (N)
IE OUT = 408.7 (S)
IE OUT = 408.5 (W)

NEW 12" CULVERT INLET
IE = 409.92

SP-6089
12" CONC

CB- 8176

SP-8463
18" CPP

10TH AVE NE

CB- 7705

SP-8461
18" CPP @0.88%

CB- 4823

SP-8460
18" CPP

CB- 12546

SP-8607
18" CPP

SP- 1930
12" CMP

CB- 8622

CB- 4095

SP- 8664
12" CMP

CB- 8622

SP- 8464
12" CMP

NEW SWALE 125 LF @ 0.5%

NEW 18" CPE
15 LF
@ 0.5%

REPLACE
75LF
18" CPE
@0.13%

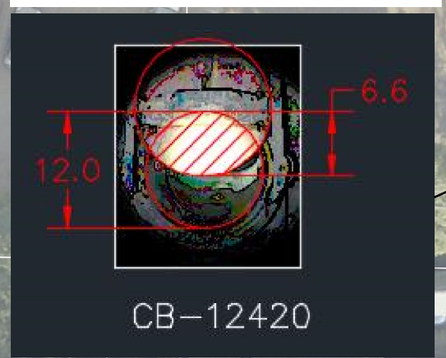
EXIST. DRIVEWAY CREST
APPROX ELEV = 412

SP-8884
24" CMP

1017 NE
175TH ST

Private Infiltration System

VALVE ON SOUTH SIDE CB- 12420



CB- 12420

CB-12420
RIM = 414.59
IE IN = 409.8 (NE) NEW
IE OUT = 409.8 (S)

NEW OVERFLOW OUTFALL STRUCTURE
RIM = 411.74
IE IN = 408.7 (N)

Valve Box

SP-8682
18" CMP
@0.3%

EXISTING 4" PIPE
INLET TO POND

PD- 15

Detention Pond

POND LOCATED ON
PRIVATELY OWNED
(CONDO) PROPERTY

Pictometry International Corp. 2015

Legend

- Flow Split
- Gate Valve
- Existing Catch Basin
- Existing Storm Pipe
- Street
- Tax Parcel

Document Path: K:\project\32700\32713.B16\CADD\GIS\MXDs\Figure3_Network.mxd

FIGURE 1 - OPTION 4
Task 16, WO #16516, Flooding at NE 175th Street and 10th Ave NE

1 inch = 50 feet

50 25 0 50 Feet

Otak

CITY OF SHORELINE

FIGURE 2 - OPTION 4 LOOKING WEST

Google Maps 1001 NE 175th St

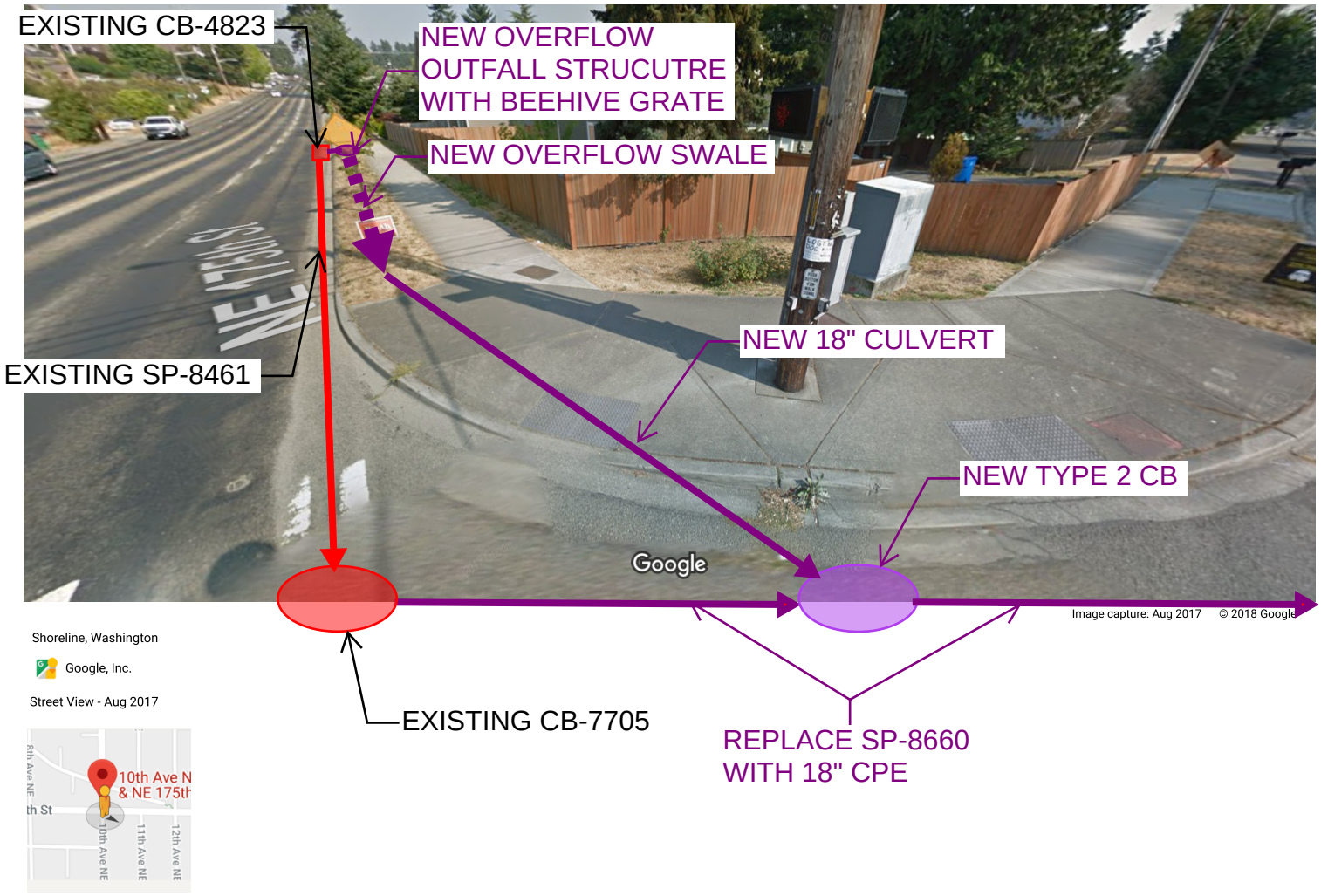


FIGURE 3 - OPTION 4 LOOKING EAST

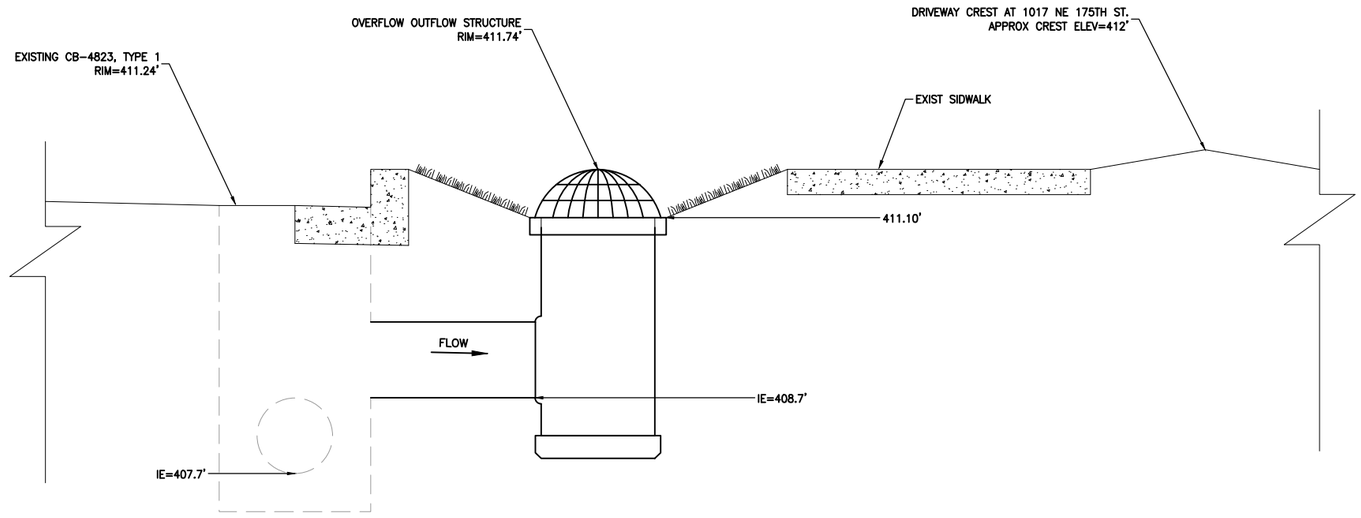


FIGURE 4 - OVERFLOW OUTFALL STRUCTURE SCHEMATIC DETAIL

Recommendations

To reduce flooding at the issue location, the most effective minor solutions that could be implemented as a part of the current NE 175th St overlay project are Options 3A, 4, or a combination of the two. As described above, Option 3A is to fully open the valve to the north, and Option 4 is to install an overflow swale diverting high flows to the south along 10th Ave. The hydraulic modeling results for a combination of Options 3A and 4 are shown in Table 4 below.

Table 4. Options 3A and 4 Combination Modeling Hydraulic Results

Flood Recur. Interval	Flow Rate	Flood Duration	Flow to South	Flow to North
(years)	(cfs)	(hr)	(cfs)	(cfs)
2	11.45	0	0.81	10.39
25	20.02	1.32	1.24	10.99

Other major flood reduction improvements could be considered for future implementation outside of the NE 175th overlay project area. These include solution options such as:

- Adding detention storage further upstream in the basin.
- Adding detention storage near the roadway flooding location by expanding the existing pond and optimizing the periods it is utilized. Any improvements to expand the pond storage should include assessment of the infiltration capacity and the addition of a pond outlet via a gravity pipe or a pump connected to the downstream conveyance system. A gravity outlet would allow for gravity pond inlet controls, such as an overflow weir, but due to flat grades, would require extensive downstream improvements to tie into the existing conveyance system at a lower elevation. If the pond does not have an outlet, pond inlet controls could also be automated and set to engage with certain pipe flow thresholds, so the City is not attempting to manually activate the pond storage during an estimated peak flow period. These are high-level concepts that can be discussed further with the City, if requested.
- Adding detention storage near the roadway flooding location by installing underground storage near the intersection – In an email included the 2004 City documents, it was suggested to consider working with the church at the southwest corner of the intersection to install underground detention within their parking lot area.

Otak recommends that a workshop be held with the City to review results and discuss next steps.