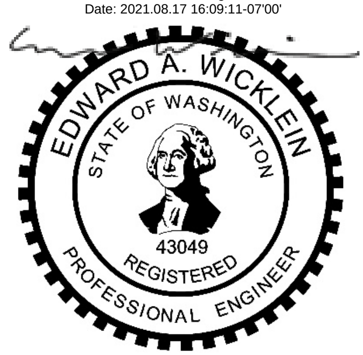
City of Tacoma
D-to-M Streets Track & Signal Project Surface Water
Hydraulic Analysis

Executive Summary
STORMWATER CONCEPTUAL DESIGN REPORT (FULL BUILDOUT)

FINAL | August 2021

Digitally signed by Edward A. Wicklein
Contact Info: Carollo Engineers, Inc.
Date: 2021.08.17 16:09:11-07'00'



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EXECUTIVE SUMMARY

ES.1 Introduction

In 2012, Sound Transit (ST) completed the D-to-M Streets Track & Signal Project (Project), an expansion effort of a regional rail line in Western Washington that reconstructed a 19-acre portion of the City of Tacoma (City) from South "D" Street to South "M" Street, installed new rail bed, and regraded an existing rail bed. The Project relocated over 4,000 linear feet of the City's stormwater drainage pipes, replacing piping in the area with new assets ranging from 12 to 72 inches in diameter. This system drains to the Thea Floss Waterway via two 96-inch outfalls, Outfalls A and B, approximately 2,000 feet northeast of the Project Area. Figure 1 locates the Project Area and Thea Foss Waterway.

Figure 1 Project Location Map

The Project's rail line alignment crossed numerous City roadways, including Pacific Avenue near its intersection with South 26th Street. To accommodate this crossing, the Project constructed a rail line bridge and also lowered the elevation of this intersection's grade surface to allow for adequate vehicle clearance; as a result, reconstructed storm drain manholes (MHs) and catch basin (CB) rims were installed up to 18 feet below their pre-construction elevations. Following construction, MHs within this area have excessively surcharged and flooded the lowered roadway during large storm events, particularly at the intersection of Pacific Avenue and South 26th Street where flooding has been documented to depths of approximately 10 feet.

This persistent flooding indicates that the relocated and reconstructed stormwater system does not meet the City's trunk conveyance design criteria, as detailed in their *2008 Surface Water Management Manual* (TSWMM).

The City contracted Carollo Engineers, Inc. (Carollo) to conduct uniform flow and backwater analyses of the Project Area piping based on TSWMM design standards, which revealed that the relocated and reconstructed stormwater system is more likely to flood under a 25-year storm and even more severely under a 100-year event.

This technical memorandum develops a stormwater conveyance design that meets TSWMM design standards for the system in the Project Area. The process to develop the conceptual design was completed through the following tasks:

- Reviews the design standards to which the Project had been held and the system's current ability to meet them.
- Summarizes the evaluation and modeling efforts that were employed to screen preferred alternatives for piping construction and improvement in the Project area.
- Identifies the most viable piping improvement alternative, which would have been the City's preferred method for design and construction, along with its estimated costs.

ES.2 Design Criteria and Current Status

Because it was located within the Thea Foss Waterway basin (Basin), the Project was required to meet the following four trunk conveyance design criteria as delineated in the City's TSWMM:

1. All pipe systems greater than or equal to 24 inches in diameter and all public pipe systems shall be designed to convey the 24-hour peak flow rate of a 25-year design storm event without surcharging (i.e., the water depth in the pipe must not exceed 90 percent of the pipe diameter) during uniform flow analysis.
2. Under a 25-year design storm event, there shall be a minimum of 0.5 feet of freeboard between the water surface and the top of any MH or CB with backwater analysis.
3. Under a 100-year design storm event, the pipe conveyance system may be overtopped. However, the additional flow shall not extend beyond half the width of the traveled way's outside lane and shall not exceed 4 inches in depth at its deepest point.
4. All conveyance systems shall be designed for fully developed conditions, which shall be derived from the percentages of proposed and existing impervious areas within the Project site.

Carollo conducted a conveyance capacity evaluation of the constructed stormwater system through the Project Area to determine if the constructed stormwater system meets the TSWMM's requirements. This evaluation found the constructed system did not meet the requirements, with the following results:

- Some pipes within the system exceed the depth-to-diameter ratio (d/D) of 0.9 (i.e., 90 percent of the pipe diameter), thus breaching the TSWMM's design criterion.
- The system does not meet the TSWMM-established hydraulic grade lines (HGLs) for neither the 25-year nor 100-year design event. In other words, the water surface level can overtop the reconstructed MH rims during a 25-year storm and more severely during a 100-year storm, increasing the potential for surface flooding.

A preferred piping configuration alternative was developed and evaluated in the following section that meets the design criteria. It was selected according to its ability to accommodate peak flows under a 25-year or 100-year storm, without concerns for excessive surcharging and flooding in the Project area.

ES.3 Piping Conceptual Design Analysis

Five conceptual piping options were developed for the Project Area that included combinations of current and larger-diameter piping, using revised slopes, as well as box culverts and parallel piping. These alternatives were screened with the TSWMM's design criteria for trunk conveyance, which were simplified from the four trunk conveyance design criteria to the following pass/fail conditions for this analysis:

- **Condition 1**: d/D < 0.9 during 25-year event uniform flow analysis.
- **Condition 2**: HGL 0.5 feet or greater below rim elevations for 25-year backwater.
- **Condition 3**: HGL 4 inches above rim may be considered during 100-year backwater.

To streamline analysis efforts and accurately compare alternatives, Carollo conducted a fixed flow analysis under which the 25-year storm event's peak flow into the Project Area was set at 650 cubic feet per second (cfs) and the 100-year storm event's peak flow was set at 800 cfs based on an upstream basin flow calculation. These flows were assumed to enter the Project Area at its upstream limits and include the calculated inflows along the reach, which contribute up to 13 cfs during a 25-year event and 19 cfs during a 100-year event, or 2 percent of the total peak flow for both scenarios.

Using StormShed 3G, an industry-accepted single event modeling software, Carollo completed both uniform flow and backwater analyses to understand the adequacy of each alternative and its ability to comply with the TSWMM's design requirements. The uniform flow analysis determined pipe capacities within the Project area while the backwater analysis modeled 25-year and 100-year peak flows to confirm acceptable HGLs.

ES.4 Preferred Alternative: Parallel Piping

Of the five conceptual piping options that were evaluated, only one alternative was determined to meet all three pass/fail conditions in the Project area. Therefore, the recommended conceptual design through the Project Area that would meet TSWMM requirements is using the existing Project Area pipes and adding new pipes in parallel to convey flows that exceed the project pipes' capacities. This alternative would have also installed six new 96-inch MHs adjacent to existing MHs.

Figure 2 shows the parallel pipeline alternative. Under this preferred alternative, the parallel pipes would have been sized at 72 inches in diameter and extended approximately 1,100 feet through the Project Area to accommodate all conditions under 25-year and 100-year flows. Modeling results show that, under a 25-year storm, the HGL would be at or below MH and CB rims, and, under a 100-year storm, the HGL would be slightly above the rim at MHs 1 and 3. While the overtopping expected at MH 3 meets Condition 3, the overtopping at MH 1 may have slightly exceeded the 4-inch depth requirement. However, this was deemed acceptable at the conceptual stage, given the uncertainty associated with new MHs' rim elevations and the existing roadway slope in the area.

As illustrated in Figure 2, the parallel pipeline would have been installed to approximately match the grade of the project storm pipeline with large vaults at the upstream and downstream ends of the new pipeline's alignment to split and then combine flow, respectively. In general, the pipeline would be located within grassy areas but crossed an active railroad track and several City roadways. Installing the parallel pipe now would require extensive construction within the Project Area that was recently rebuilt. In Figure 2, all utilities not prefaced with proposed are existing.

A cost opinion was prepared for the preferred alternative assuming reinforced concrete pipes (RCP). As shown in Table 1, installing a new parallel pipeline was estimated to cost $9,700,000, of which $6,700,000 would have been expended on construction.

Table 1 Parallel Pipeline Project Cost Opinion

Cost Type	Upper Range (+50%, 2019 $)	Upper Range (+50%, 2020 $)
Construction Cost	$6,700,000	$7,100,000
Project Cost	$9,700,000	$10,300,000

Note: The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers has no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

This cost opinion follows the Association for the Advancement of Cost Engineering's (AACE) Class 4 designation, which, per *Recommended Practice 18R-97 Cost Estimate Classification System for the Process Industries* (1998), has an expected level of accuracy of -30 percent to +50 percent of the cost presented. To reflect the system's needs as it currently exists, estimations are in 2019 dollars, consistent with the Seattle Engineering News-Record (ENR) value of 12112. Depending on the cost of labor, materials, and equipment and the final design, these costs would have been subject to change. Table 1 also presents costs in 2020 dollars. 2020 dollars were calculated by extrapolating from 2019 dollars using the 2020 ENR index value of 12840.

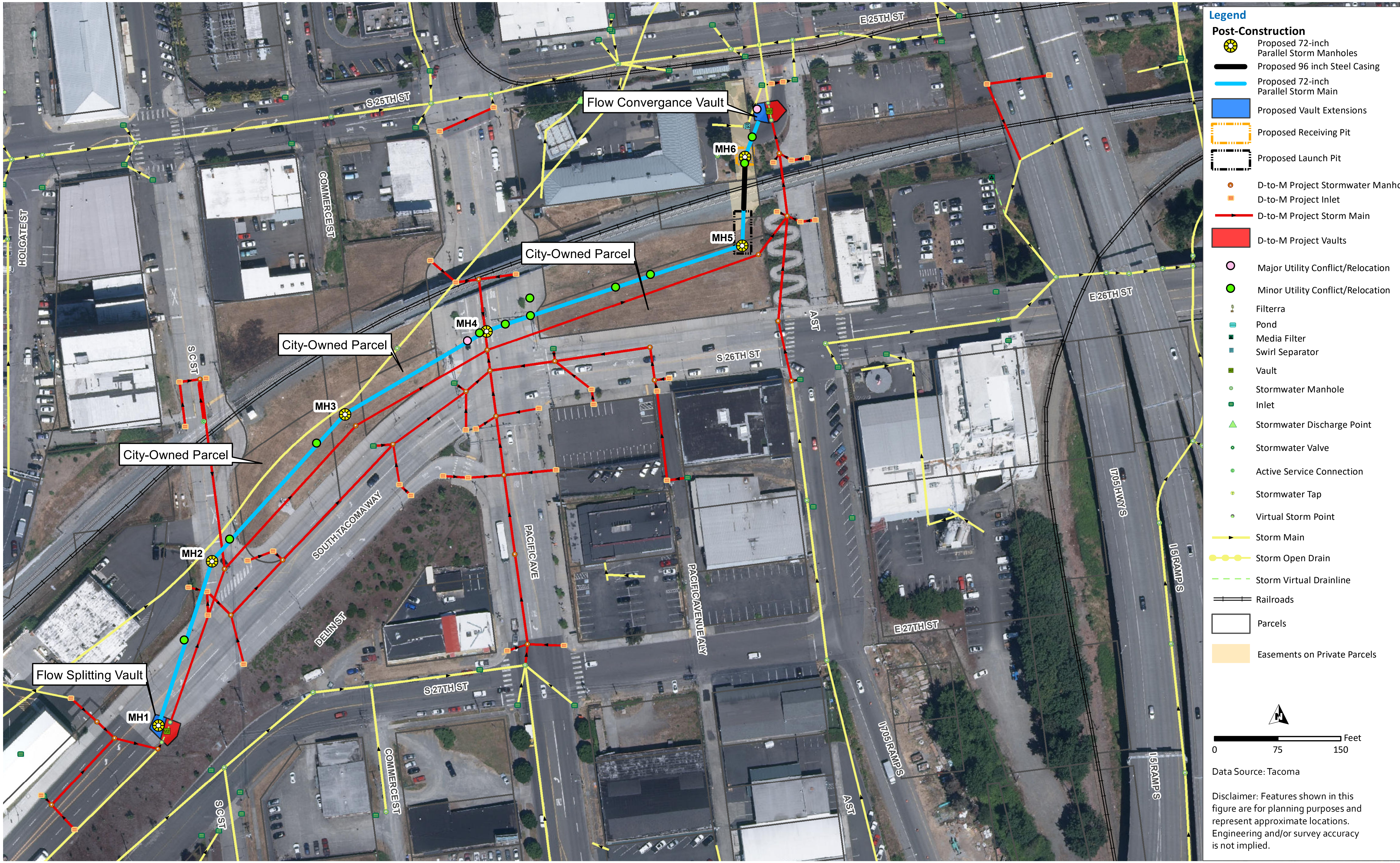

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Figure 2: Parallel Pipe Alternative