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ANCHOR QEA

Memorandum

September 29, 2021

To: City of Mequon

From: Anchor QEA

Re: City of Mequon Capital Improvement Plan Stormwater Study

Executive Summary

Anchor QEA (as FreshWater Engineering) completed a Capital Improvement Stormwater Study for the City of Mequon (City) in November 2020. The study focused on high water levels west of North Lake Shore Drive and included development of a stormwater model in *HydroCAD* to evaluate runoff. The project resulted in the recommendation of short-term mitigation measures including culvert modifications at the intersection of West Revere Road and North Prairie View Lane to increase discharge capacity. The culvert system was updated in the summer of 2021.

Following installation of the new culverts, rainfall amounts totaling between 2 and 3 inches fell on the site, leading to high water levels in ditches. The City received complaints from area residents indicating that water levels had increased as a result of the modifications. Anchor QEA visited the site in September 2021 and surveyed the construction to confirm the culverts were installed according to the provided plan set drawings.

The field team also surveyed water surface elevations (WSEs) in the ditches and compared them to model predictions and found that the system performed as expected. Modeled peak WSE was approximately 0.2 feet higher than the observed peak WSE. The increased flow capacity at the site was expected to prevent overtopping of the roadway during similar rainfall totals, and all reports indicate that water never reached the road surface during the storm event in question.

There is no indication that the system is performing more poorly than before the culvert modifications. Water levels in the ditch appear similar to those documented during a September 2020 visit by FreshWater staff. During the 2020 visit, water in the ditch was obscured by tall vegetation which was removed during construction. It is possible that this lack of vegetation has increased visibility and led to the perception that water levels are higher since the water is more visible. Over time, the vegetation can be allowed to regrow and will once again hide the ditches from view.

Introduction

Anchor QEA (as FreshWater Engineering) completed a Capital Improvement Plan Stormwater Study for the City of Mequon (City) in November 2020. The study focused on the area surrounding a wetland property owned by the Milwaukee Metropolitan Sewerage District (MMSD) west of North Lake Shore Drive. The work included development of a stormwater model in *HydroCAD* and a summary report of the findings, which was presented to the City upon completion of the work (FreshWater Engineering 2020).

In 2021, the City installed culverts under the intersection of West Revere Road and North Prairie View Lane in response to suggestions from the stormwater modeling efforts. Shortly after completion of the project, a precipitation event resulted in water accumulation in ditches along both roads and statements from residents indicating that flooding in the area was worse than it had been before culvert installation. Anchor QEA was contacted to evaluate the culvert installations and determine whether they performed as expected.

Data Review

Anchor QEA was contacted regarding flood concerns following a precipitation event on the weekend of August 28-29 in Mequon. According to the National Weather Service (NWS), the event produced between 2 and 3 inches of rainfall in the 24-hour period ending at 8:00AM CDT on August 29 (NOAA 2021a). This places the precipitation at approximately the 2-year, 24-hour rainfall event of 2.64 inches per NWS data (NOAA 2021b).

Anchor QEA understands that the high water levels were primarily a concern near the intersection of West Revere Road and North Prairie View Lane. Images of the ditches near the intersection were forwarded to the engineering team in an e-mail dated September 9, 2021 (Figure 1). The photographs show water below the road surface and contained to the ditches. Conversations included in the same e-mail chain indicated that water was confined to the ditches at all times and never crested the road.

Figure 1
Water Levels Shown in Photographs Following the August 28-29 Precipitation Event

Left to right: View looking east along northern edge of Revere Road; looking south along eastern edge of Prairie View Lane; looking east along southern edge of Revere Road
Source: E-mail from City of Mequon to Anchor QEA dated September 9, 2021

Field Investigation

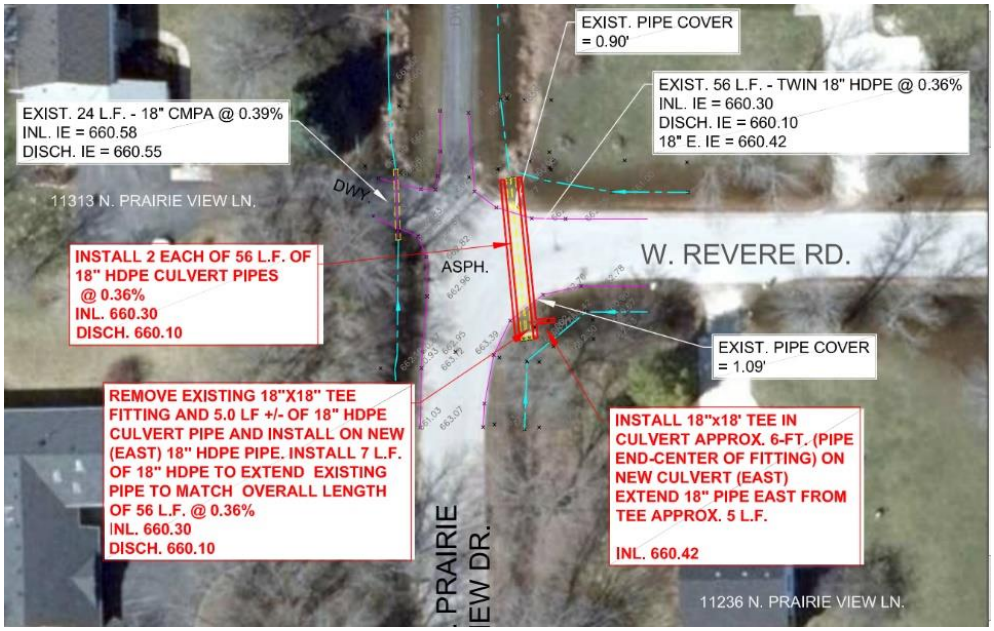
Anchor QEA staff returned to the site on September 21, 2021 to evaluate field conditions. Water surface elevations (WSEs) measured in the ditches were approximately 660.7 ft above the North American Vertical Datum of 1988 (NAVD88). Depths were approximately 0.6 ft near the culverts at the upstream (south) side of Revere Road and 1.3 ft at the downstream (north) side of Revere Road.

The field team also investigated the culverts at the intersection. The culverts consist of four pipes running parallel to Prairie View Drive and under Revere Road. There is also one culvert draining the south side of Revere Road that connects to the eastern culvert and flows under Revere Road to the north as shown in construction plans prepared by the City (Figure 3 and Figure 4). Each culvert was measured to be an 18-inch diameter corrugated plastic pipe (CPP).

Figure 2
Photographs of North Prairie View Lane and West Revere Road in Mequon, Wisconsin Taken on September 21, 2021 by Anchor QEA

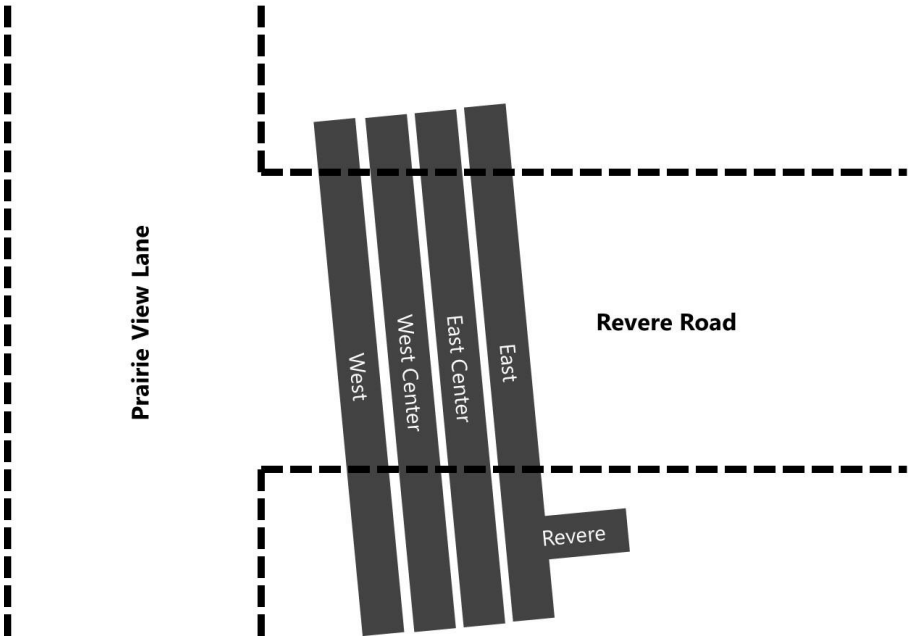
Clockwise from top left: View looking north from intersection along eastern edge of Prairie View Lane; looking east along south side of Revere Road; looking east along north side of Revere Road; looking northeast toward intersection from Prairie View Lane

Figure 3
Plan Drawing Prepared by City of Mequon for Culvert Installation



Source: E-mail from City of Mequon to Anchor QEA

Figure 4
Schematic Layout and Naming Conventions for Culverts at Prairie View Lane and Revere Road Intersection



Installed culvert elevations at the site were surveyed using real-time kinematic GPS (RTK-GPS) equipment to compare with stormwater model elevations. Invert (lowest point in the culvert pipe) elevations, pipe lengths, and slopes for the culverts are shown in Table 1.

Table 1
Culvert Invert Elevations, Lengths, and Slopes as Measured by Anchor QEA

	West Culvert	West Center Culvert	East Center Culvert	East Culvert	Revere Road Culvert*
Upstream Invert Elevation (ft NAVD88)	660.1	660.2	660.1	660.1	660.1
Downstream Invert Elevation (ft NAVD88)	659.9**	660.0	660.0	659.9	N/A
Pipe Length (ft)	55.9	56.1	56.0	55.8	N/A
Slope (% Grade)	0.32	0.45	0.21	0.23	N/A

Notes: *Revere Road culvert joins to the east culvert under the ground surface and does not have its own outlet.
**West culvert outlet invert was not accessible due to sedimentation; elevation was determined by subtracting culvert diameter (18 inches) from top elevation (661.4 ft NAVD88)

Comparisons to Plan Drawings

Anchor QEA reviewed the plans provided by the City and compared them to the installed conditions (Table 2). The as-built inlet elevations are approximately 0.2 ft lower than drawn. Outlet inverts were installed approximately 0.1 ft lower than drawn.

Table 2
Comparison of As-Built Dimensions to Plans and Model

	Inlet Invert Elevation (ft NAVD88)	Outlet Invert Elevation (ft NAVD88)	Length (ft)	Grade (%)
As-Built*	660.12	659.95	56.0	0.30
Plan Drawings	660.30	660.10	56.0	0.36
Model	660.13	659.93	55.0	0.36

Notes: *As-Built information is an average of the four culverts parallel to Prairie View Lane.

Comparisons to Model

Built Dimensions

The model was initially prepared with a 36-inch diameter corrugated metal pipe (CMP) culvert. The City of Mequon asked Anchor QEA in July 2021 whether replacement with four 18-inch diameter culverts would provide similar results in terms of peak WSE during precipitation events. After evaluating the proposed changes, Anchor QEA found that the four smaller culverts would provide similar performance to the original 36-inch diameter CMP. The comparisons summarized hereafter are for the four 18-inch diameter CPP culverts.

Initial assessments involved installed elevations, lengths, and slopes. As shown in Table 2, the as-built design was more similar to the modeled elevations than the plan drawings, though stalled pipe slopes were shallower than those modeled.

Flow Performance

Shortly after completion of the installation, a precipitation event occurred in the project area. Mequon received between 2 and 3 inches of rainfall, leading to increased WSEs in the ditches near the culverts. Anchor QEA understands that the road was not submerged by runoff flows during this event and that the water was confined to the ditches near the site.

Vegetation establishment at the project site indicates where water levels were at the peak. Where grass was drowned due to prolonged submersion, staff measured elevations and found a WSE of approximately 661.5 ft NAVD88. Given that peak elevations are typically slightly higher than that level, peak WSE was estimated as 662 ft NAVD88. This is consistent with reports that water was contained in the ditches and the fact that the road surface is approximately 663.1 ft NAVD88.

The recorded rainfall was approximately a 2-year recurrence event (i.e., it has approximately a 50% chance of occurring in any given year). Modeled peak WSE for the 2-year event was approximately 0.9 ft below the road surface elevation, which is consistent with the reported peak WSE at the site (Table 3). Given the known site topography, modeled scenarios, and field measurements, the culvert installation passed runoff flow as expected.

Table 3
Comparison of Approximate Measured and Modeled Peak WSE to Road Surface Elevation

	Peak WSE (ft NAVD88)
Estimated High Water	662
Modeled High Water 1 x 36" Culvert	662.6
Modeled High Water 4 x 18" Culverts	662.2

Notes: Estimated High Water is based on approximate elevation of water surfaces from field evaluations

Discussion of Findings

Based on field measurements and reported model outputs, Anchor QEA found that the culvert installation functioned as expected. Peak flows were contained entirely in the ditches and there are no indications that there was overtopping of the roads at the site. Peak WSE is similar to expected peak WSE as stated in the November 2020 FreshWater Engineering report.

The FreshWater Engineering report (2020) indicates that the "modeled culverts are still overwhelmed during larger events, but are capable of conveying smaller flows without spilling onto the roadway." Based on field conditions, written statements, and the photographs provided by residents, this is what occurred during the approximate 2-year event of late August 2021.

Appearance

The e-mail chain provided by the City included statements that floodwaters were worse than they had ever been before. There is no reason to believe that this is in fact the case. Water flows to the lowest point in a system, which means that runoff is moving north at this location. There is no indication that this site is experiencing significant backflow, nor is there a mechanism by which that would be likely to occur. Increasing the conveyance under the road will not increase WSE upstream of the culvert.

It is possible that the water levels *appear* worse following culvert installation regardless of actual WSE. During the September 1, 2020 site visit by FreshWater Engineering, the ditches in question contained a significant volume of water. One major difference between the ditch conditions at that time and the current conditions is a noticeable lack of vegetation following construction. Because the vegetation was largely overgrown in and around the ditches, it obscured the view of any water in them (Figure 5). Another difference is that near the culverts, the ditches have been widened. Now that the vegetation is gone and the ditches are wider, the water in them is far more visible, which likely makes it appear more significant than before culvert installation. However, there is no reasonable mechanism by which the culverts have caused higher water levels.

Figure 5
Photographs Taken by FreshWater Engineering During September 1, 2020 Site Visit

Images show the ability of vegetation to hide water present at the site during the September 2020 site visit performed by FreshWater Engineering. Compare these images to Figure 2.
Clockwise from top left: View looking southeast from the intersection of Prairie View Lane and Revere Road; looking north from the intersection along the eastern edge of Prairie View Lane; looking south toward the intersection along the eastern edge of Prairie View Lane

Further Mitigation

The purpose of the Capital Improvement Plan (CIP) evaluation was to assess potential options for reducing peak WSE at several locations within Mequon. The result of the project was a series of recommendations, one of which was implemented and has performed as expected. The goal was not to eliminate water in the ditches in the project area during periods between storm events.

With the site located in close proximity to a wetland, there is ample evidence that the water table is close to the surface, which slows drainage times for water to soak into the ground. If the goal moving forward is to lower sustained water surface elevations in the area, a more complex system will be required.

One option would be to drain the downstream wetlands to lower the local water table. As stated in the FreshWater Engineering report, this would require intensive permitting efforts, and it is highly likely that permits would be denied by the Wisconsin Department of Natural Resources. In addition, draining the wetland would have an overall negative impact on the environment because it would eliminate the numerous benefits that wetlands provide and potentially create a downstream flooding issue.

References

FreshWater Engineering. *City of Mequon Drainage Capital Improvement Stormwater Study: Prairie View Lane and Lakeshore Drive*. FreshWater Engineering, November 2020.

National Oceanic and Atmospheric Administration (NOAA). 2021a. "HYD Analysis Images." *National Weather Service – HYD Analysis Images*, NOAA National Weather Service, 2021, https://www.weather.gov/mkx/hydanalysis.

NOAA. 2021b. "Precipitation Frequency Data Server." *Precipitation Frequency Map: Contiguous US*, NOAA National Weather Service, 2021, https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=wi