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MEMORANDUM

TO: Jerry Plein

FROM: Mike Hemstad, PE, John Friel, PE, and Caleb Weber

DATE: October 4, 2023

RE: WWTF Trickling Filter Concrete Dome Cover Condition
SEH No. RWING 174561 14.00

PURPOSE

In 2022, SEH prepared a Feasibility Study for the City of Red Wing assessing whether the existing WWTF site could be used for an upgraded WWTF capable of meeting a total nitrogen limit through biological nutrient removal. The Feasibility Study included a high-level condition assessment of the WWTF, including the trickling filters which were identified as an area of concern.

A second review was performed to determine if the trickling filter concrete domes require rehabilitation in the immediate future, or if the domes are in satisfactory condition to last until the next major upgrade project anticipated in the next 10 years.

SEH performed a follow up structural inspection in June 2023. This memo summarizes the findings of the inspection and provides recommendations to extend the service life of the concrete domes.

CONDITION ASSESSMENT

Originally constructed in 1961, the trickling filter concrete domes were designed for the concrete to always be in compression as it transfers load to the ring walls. Concrete is strong in compression so there are not significant amounts of reinforcing steel required to handle the loading on the dome. The trickling filter dome is 4” thick at the thinnest area near the top and 10” thick at the bottom near the wall connection. 4x4/4x4 welded wire mesh reinforcement is the primary reinforcement throughout the cover.

Corrosive moisture and gas as well as freeze/thaw cycles, typical of normal trickling filter operations, have caused the inside surface of the concrete dome to deteriorate over time. The welded wire mesh reinforcement and other rebar is corroded and exposed over most of the inside surface, as seen in the attached photos. As the steel rusts, it expands causing concrete to spall off. For freeze/thaw, moisture and vapor soaks into the inside face of the dome during warm temperatures, but then experiences freezing temperatures from the exterior during winter which causes freezing and concrete spalling.

The dome appears to have been poured from the bottom to the top in multiple lifts of concrete pours. Construction joints and/or cold joints were created when fresh concrete cured next to concrete that had already begun to cure. The cold joints allow more moisture ingress and more freeze/thaw cycles to the concrete. ‘Latitude’ lines of deterioration can be seen on the inside of the cover at the cold joints. The holes in the dome are also located at cold joints.

As the rebar continues to corrode and the concrete experiences more freeze/thaw cycles, more concrete will spall. This deterioration will occur in an exponential fashion. Based on the existing condition, SEH believes the cover has approximately 2 to 3 years of useful life without any intervention.

The concrete walls have also experienced surface deterioration in the wet and corrosive environment. However, the amount of deterioration is not as significant compared to the dome and no rebar is showing. Therefore, the walls are not an area of concern for the immediate future.

RECOMMENDATIONS

The life of the concrete domes may be extended by reducing the loss of rebar and concrete through the addition of structural patching of the concrete and then applying a protective coating to the inside face. Additionally, an outer layer or coating may be needed to reduce moisture from traveling from the exterior (outside) of the cover through the concrete adding pressure to the interface between the interior side of the cover and the coating. Further review is needed during preliminary design.

The recommended repair procedure would include:

1. Take one trickling filter offline at a time.
2. Prep and protect media and trickling filter distribution mechanism.
3. Pressure wash and/or abrasive blast the inside surface of the concrete
4. Patch all holes and significant spalls with concrete or grout mix.
5. Coat the entire inside surface of the concrete dome.
    a. It is not recommended to do spot coating because leaving exposed edges of coating allow moisture to travel behind the coating and cause failure of the coating.
6. Based on further review and if deemed necessary apply exterior moisture sealer or coating to prevent moisture from traveling through cover and impacting new interior coating.

The specific coating recommendation would be either a 100% solids epoxy like Sherwin Williams Duraplate 6000 or a 100% solids polyurethane like Sherwin Williams Polycote 115. There are pros and cons to epoxies and polyurethanes, but both would be capable of resisting corrosion and moisture for this application. The coating is estimated to extend the life of the dome 10 to 20 years.

The challenges with coating the concrete include: the strength of the existing concrete needs to be sufficient to allow coating to adhere; the existing concrete surface will need to be resurfaced to an almost smooth condition (significant amount of priming coating required); abrasive blasting is required and the blast dust needs to be contained and collected without entering the filter media; controlling moisture and temperature conditions of the concrete are critical during the application; and access to the inside dome surface over the filter media.

SEH still recommends structural patching and coating instead of completely replacing the cover because of the higher cost of a new aluminum or FRP cover, which likely cannot be reused as part of the forecasted plant-wide upgrade project.

SEH recommends considering correspondence and inviting a coating contractor, a coating vendor (Sherwin Williams, Tnemec, etc), and/or SEH coating specialists to visit the trickling filter to further scope out the coating for the dome.

OPINION OF COST

The repair work is assumed to be bid as one project for both existing concrete covers to be repaired with structural patching and coating as discussed above. The interior surface area of each cover is approximately 7,500 square feet. The repair work would involve protective provisions for the media and existing trickling filter distributor arms and mechanism. Work may be able to be done in the summer, one TF at a time, with an estimated construction project time of 7 to 9 months based on good weather conditions and added coordination and sequencing by the general contractor, otherwise construction may need to be done over 2 summers. The opinion of probable construction cost at this high level is $1.3 to $1.4 million for both of the concrete covers bid as a single project.

CONCLUSION

The trickling filter domes have been in service for over 60 years and are reaching the end of their useful life. The remaining useful life is estimated at 2 to 3 years, so a concrete structural patching and coating repair is recommended to extend the useful life another 10 to 20 years. The opinion of probable construction cost at this high level is $1.3 to $1.4 million for both of the concrete covers bid as a single project.

Photo Attachment

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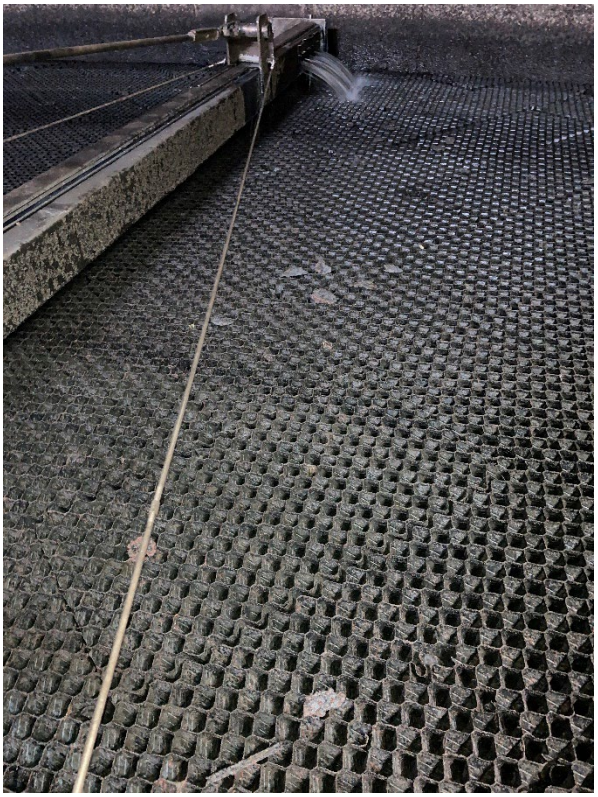
Welded mesh rebar has lost concrete cover. Two holes in the concrete cover can be seen with light coming through between the two light fixtures.

Trickling filter walls have experienced surface deterioration but are in better condition than the dome.



(Left) Small chunks of concrete from the dome have fallen onto the tricking filter media. (Right) Welded mesh and #4 ring rebar has lost concrete cover.

The exterior face of the concrete domes are in relatively good condition for 60 years of service life. #4 radial rebar have lost cover and are exposed.

The exterior trickling filter walls have experienced less surface deterioration.