PERSIGO WASTE WATER TREATMENT PLANT
Structural Condition Assessment

2145 River Road
Grand Junction, Colorado 81505

Final Report
January 21, 2020
WJE No. 2019.3776

Prepared for:
Ms. Kirsten Armbruster
Project Engineer
CGJ of Grand Junction, Public Works
333 West Avenue, Bldg C
Grand Junction, Colorado 81501

Prepared by:
Wiss, Janney, Elstner Associates, Inc.
3609 South Wadsworth Boulevard, Suite 400
Lakewood, Colorado 80235
303.914.4300 tel | 303.914.3000 fax

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Adrienne Larson, PE

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Terry McGovern, PE
Project Manager

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WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

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1. EXECUTIVE SUMMARY

Per your request, WJE has completed our structural condition assessment for select structures located at the Persigo Waste Water Treatment Plant (WWTP), located in Grand Junction, Colorado. Our condition assessment included a visual review of the readily accessible portions of the structural concrete elements (slabs and walls), visual review of isolated steel framing and piping elements, destructive and non-destructive testing, and a limited structural analysis. WJE also performed a Geotechnical Investigation of the site, and generally characterized the subsurface conditions (including the groundwater levels), provided preliminary recommendations for use in rehabilitation or improvement of the existing structures, and provided recommendations for future new construction at the WWTP. In this Structural Condition Assessment report, a summary of our field observations, structural analysis, and prioritized repair recommendations are presented, along with an Engineer's Opinion of Probable Costs for those repairs. To formulate a basis for development of our repairs, we have assumed a 30-year service life extension to the assessed structures.

The visually apparent distress to the roughly 35-year-old structures is minor, particularly given the exposure of the various structures to the process water. Distress primarily manifested itself as both interior and exterior longitudinal and transverse cracking (particularly aligning with areas of embedded reinforcing bars), evidence of through-wall moisture migration and efflorescence staining, and delaminations located primarily at the base of interior walls and adjacent to piping inlet lines. Atypical more severe distress included erosion of the surface paste at both the interior and exterior surfaces of the Primary Clarifier walls, concrete spalling at the soffit of the Aerobic Digester stairwells, and bowing of the exterior wall panels at the Anaerobic Digesters. We did not identify any current global structural concerns, and our analysis indicates that the reviewed structural elements are adequate for supporting both the original and updated soil loads.

Provided repair options are categorized into 'High', 'Medium', and 'Low' priorities based on structural deterioration, and include recommendations for concrete repairs, moisture protection considerations through coatings and sealants, as well as limited steel repairs. Further investigation, and repairs such as installation of coatings and concrete repairs at the Primary Clarifiers, and repairs including installation of supplemental connections at the Anaerobic Digester exterior walls, are the highest priority items at this time. For the purposes of this report, we have assumed that an additional 30 years of service for the various structures is the ultimate goal of the CGJ for the WWTP, and we have targeted repairs based on this timeframe using engineering judgement. However, supplemental detailed investigations and analysis of specific structures would ultimately allow for a more refined estimation of remaining service life for each, and would aid us in refining our recommendations for the CGJ to consider. Furthermore, additional variables such as operations impact, safety hazards, environmental impact, direct costs, indirect costs, future capacity need, and remaining service life expectations, would all aid the CGJ in development of a prioritization matrix for repairs at the facility.

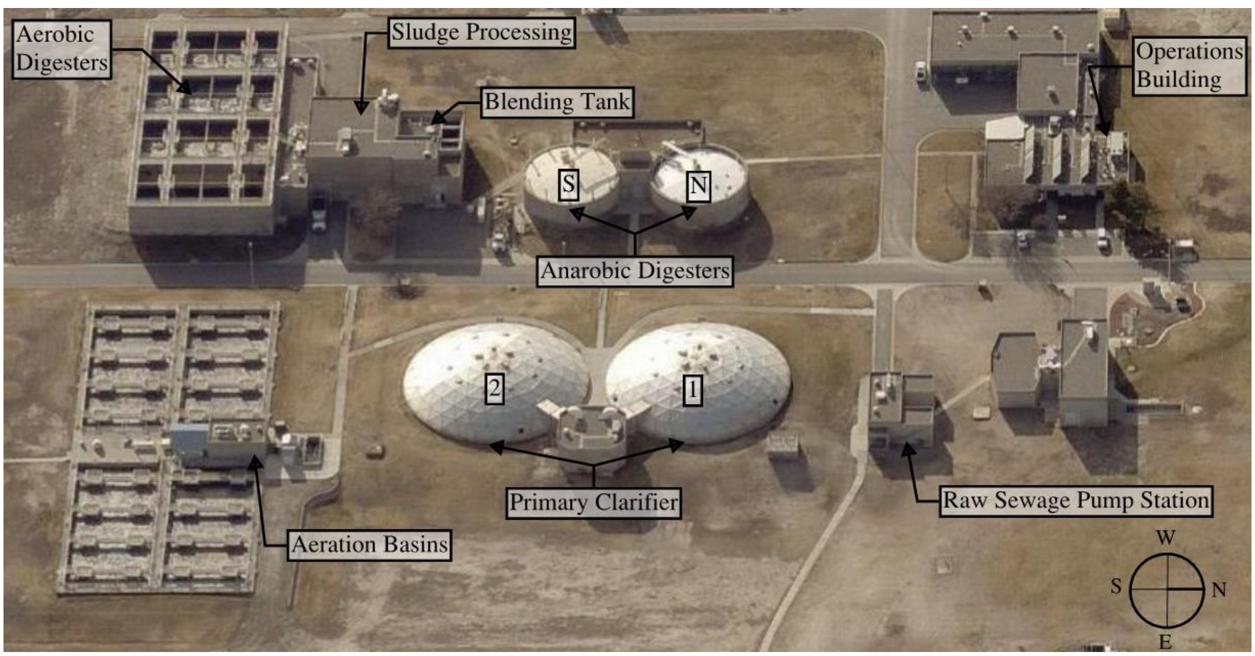
2. INTRODUCTION

At the request of the CGJ of Grand Junction (CGJ), Wiss, Janney, Elstner Associates, Inc. (WJE) has performed a structural assessment of select structures located at the Persigo Waste Water Treatment Plant (WWTP), located in Grand Junction, Colorado. Our assessment of these select structures included evaluating reinforced concrete slab and wall elements, isolated steel elements, and isolated piping elements. In addition, a parallel geotechnical investigation was performed by WJE, which is documented in a separate report dated October 22, 2019, and attached in Appendix A.

The scope of this assessment is as outlined in RFP-4653-19-DH, and the WJE proposal for the assessment dated June 21, 2019. The purpose of this study was to perform an engineering assessment to quantify the condition of the concrete and steel elements outlined in the RFP, prevent future propagation of any observed distress, and develop methods to repair or replace the structures as needed. Furthermore, the assessment was intended to provide recommendations to improve the stability of the structures and reduce long-term maintenance of the affected buildings to provide continued reliable operation of the WWTP.

This final report describes the work performed by WJE to date pertaining to the structural assessment, including our observations from the field investigation, a summary of the limited structural analysis that was performed, and provides conceptual prioritized repair recommendations and an associated Engineer's Opinion of Probable Costs for these repairs.

2.1. Background



The WWTP is jointly owned by the CGJ and Mesa County, and was constructed circa 1982. The treatment plant contains structures that house a multitude of processes, including step screens, grit removal, primary clarification, primary effluent flow equalization, secondary aeration, secondary clarification, and ultraviolent disinfection. While mechanical equipment has been maintained and replaced since the plant opened in 1984, it is our understanding that the structures have remained relatively unchanged with minimal repair or improvements made throughout their nearly 35 years of service. As indicated in the RFP, the structures included in the structural assessment were selected due to observations of deterioration by plant staff to concrete and/or steel elements, in addition to isolated erosion of pump piping elements. The RFP indicated that some of the deterioration appears to be the result of sulfate exposure, in addition to distress potentially caused by the reported high water table at the site. Structures and elements included in our structural assessment are outlined in Table 1, below.

Table 1. Assessment Summary

Structure	Concrete Structure	Steel Structure	Piping
Raw Sewage Pump Station	X		X
Primary Clarifier - North	X		
Primary Clarifier - South	X		
Aeration Basins	X		X
Aerobic Digester	X		
Sludge Pressing Unit	X	X	
Anaerobic Digester - North	X		
Anaerobic Digester - South	X	X	

2.2. Description of Structures

2.2.1. Raw Sewage Pump Station

The raw sewage pump station is generally rectangular in plan for its below-grade portion, and measures approximately 41 feet in the north-south direction, and 50 feet in the east-west direction. The structure contains one above-grade level, measuring approximately sixteen feet in height, and one below-grade level, measuring approximately twenty-three feet in height. The below-grade portion of the structure is split equally in the east-west direction by a concrete demising wall, such that the north portion of the structure houses inaccessible wet wells, and the south portion of the structure houses the pump room.

The structure consists of a conventionally reinforced 24-inch thick concrete slab foundation, with a 3-inch thick topping slab reinforced with WWR (welded wire reinforcing). The exterior face of the foundation slab is waterproofed with a continuous waterproofing that extends up the full height of the below-grade portion of the perimeter walls. The perimeter walls measure 14 inches thick and are conventionally reinforced with two mats of reinforcing. The above-grade exterior face of the perimeter walls comprises both smooth surfaced concrete, in addition to an upper band of ribbed concrete. A single stairwell at the east end of the structure provides access down to the pump room. The roof of the elevated structure is steel framed.

At the north portion of the basement level (pump room), a total of five inlet piping lines are present, which pull process water from the inaccessible wet wells. The inlet pipes reportedly have waterstops constructed at their perimeters, within the concrete demising wall. These inlet pipes are connected through various reducers, fittings and valves to the main outlet piping line, which discharges through the east perimeter wall. The piping lines are all mounted on concrete and steel framed pedestals and supports.

2.2.2. Primary Clarifiers

The two primary clarifiers are designated as north and south, and are identical in construction (opposite hand from each other). The circular structures measure approximately 118 feet at their outer diameter. The structures consist of a conventionally reinforced 8-inch thick concrete slab foundation, with a 2-inch thick grout layer, both of which have a 1:12 slope downwards towards the center of the clarifier. The perimeter walls consist of conventionally reinforced 10-inch thick concrete with two mats of reinforcing. The concrete structure extends approximately two feet above grade, and approximately nine feet below grade. A below-grade waterproofing system is not indicated on the original drawings. Along the interior face of the perimeter walls, a 2-foot wide effluent trough is present, with a conventionally reinforced 8-inch thick inner effluent launder wall and aluminum scum baffle and weir plate. The roof consists of an aluminum-framed dome cover, which is intermittently supported on the interior face of the perimeter wall at roughly 12-foot centers.

2.2.3. Aeration Basin

The aeration basin is rectangular in plan, and measures approximately 123 feet in the north-south direction, and 275 feet in the east-west direction. The aeration basin blower room is situated at the center of the structure (oriented in the north-south direction), and is approximately 30 feet in width. The basin walls extend approximately two feet above grade, and approximately nineteen feet below grade. To the east and west of the basin blower room, the structure is split equally in the east-west direction by interior basin baffle walls, such that four individual open-air basins are present. Elevated concrete catwalks with post-installed guardrails are present at-grade that provide pedestrian access above the basins below. A single-story basin control room is present at the north end of the structure, above the blower room.

The structure of the aeration basin consists of a conventionally reinforced 16-inch thick concrete slab foundation, with a 3-inch thick topping slab reinforced with WWR at the blower room. The slab thickens to 24-inches thick for approximately six feet in each direction below the 12-inch square interior columns. The exterior face of the foundation slab is waterproofed with a continuous waterproofing that extends up the full height of the below-grade portion of the perimeter walls. The perimeter walls primarily consist of conventionally reinforced 12-inch thick concrete with two mats of reinforcing, with intermediate thickened pilasters where the catwalk framing is present. A single stairwell at the north end of the structure provides access down to the blower room. The roof of the blower room consists of a conventionally reinforced 12-inck thick concrete slab, with multiple piping penetrations, and a single skylight.

Within the blower room, multiple piping lines are present, including the return and waste activated sludge lines. The lines are primarily situated at the south end of the blower room, with isolated elevated lines extending to the north end of the room. The piping lines are mounted on concrete framed pedestals and supports, in addition to pipe supports installed on the soffit above.

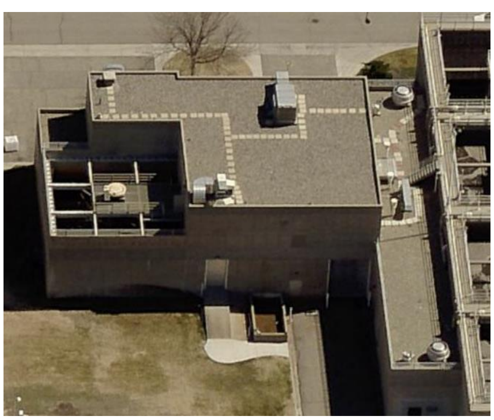
2.2.4. Aerobic Digester

The aerobic digester is rectangular in plan, and measures approximately 90 feet in the north-south direction, and 187 feet in the east-west direction. The basin walls extend approximately 24 feet above grade; no below grade rooms are present at this structure. The structure is split in the north-south direction by interior basin baffle walls, such that four individual open-air basins are present. Elevated concrete catwalks with guardrails are present at the upper level to provide pedestrian access above the basins below. The north wall of the aerobic digester directly abuts the south wall of the adjacent sludge processing unit.

The structure of the aerobic digester consists of a conventionally reinforced 8-inch thick concrete slab foundation. The perimeter walls primarily consist of conventionally reinforced 15-inch thick concrete with two mats of reinforcing, with intermediate thickened pilasters at mid points of the individual basins. The exterior face of the perimeter walls comprises both smooth surfaced concrete, in addition to intermittent bands of ribbed concrete. A single stairwell at the northeast end of the structure provides access to the roof of the adjoining sludge processing pump room roof, where an additional staircase is present that provides access from this roof to the catwalks above the digesters. There is no foundation waterproofing included in the design on this structure.

2.2.5. Sludge Processing Unit

The sludge processing unit is generally rectangular in plan, and measures approximately 120 feet in the north-south direction, and 66 feet in the east-west direction. The structure contains two above-grade floors, extending approximately thirty-five feet above grade; no below grade rooms are present at this structure. The south wall of the sludge processing unit directly abuts the north wall of the adjacent aerobic digesters. An open-air blending tank, measuring approximately 40-feet square, is present at the northwest corner of the structure.



The structure of the sludge processing unit primarily consists of a 6-inch thick concrete slab foundation reinforced with WWR, with a conventionally reinforced 8-inch thick concrete slab at the blending tank. The perimeter walls primarily consist of conventionally reinforced 14-inch thick concrete with two mats of reinforcing. The exterior face of the perimeter walls comprises both smooth surfaced concrete, in addition to intermittent bands of ribbed concrete. We understand that the roof of the blending tank originally consisted of a conventionally reinforced 8-inch thick slab/lid, which was replaced approximately twenty years ago with open air structural steel framing. At that time, the north and west exterior walls of the tank were reportedly lined with shotcrete.

2.2.6. Anaerobic Digesters

The two anaerobic digesters, designated north and south, are identical in construction (opposite hand from each other). The circular structures measure approximately 70 feet at their outer diameter. The structures extend approximately twenty feet above grade, and approximately ten feet below grade. The structures consist of a conventionally reinforced 12-inch thick concrete slab foundation within the digesters, with a conventionally reinforced 14-inch thick concrete slab and 3-inch thick topping within the pump room located between the two digesters.

The digester perimeter walls consist of conventionally reinforced 18-inch thick concrete with two mats of reinforcing, with a 2-inch wide insulation joint, and 4-inch thick by 10-feet wide conventionally reinforced exterior panels, which were designed to be anchored to the structural concrete wall behind. Between the panels is a vertical sealant joint, and the center of the panels have vertical architectural reveals mimicking the sealant joint. We understand that one of these exterior panels had to be re-attached to the building after separations between the two wall systems were discovered. A concrete coping cap is present at the skyward face of the exterior composite wall system.

The roofs are of two different vintages, with the south digester roof (included with our assessment) constructed of radial space trusses welded together from mild steel. The steel lid comprises the horizontal walking surface above the trusses, in addition to an approximately 6-foot deep "rim skirt" at the perimeter of the lid, which extends down into the digesters. The lid bears on concrete corbels within the digester for support.

2.3. Concrete Distress Terminology and Discussion

Please refer to Appendix B for a general background of pertinent terms associated with distress to concrete structures, as it pertains to our observations at the WWTP. In addition, general descriptions and discussion of common distress mechanisms for the reviewed elements as a part of this assessment is provided.

3. DOCUMENT REVIEW

As a part of our scope of services, WJE has reviewed several documents provided to us by the CGJ related to the as-built condition of the various structures at the WWTP. A brief summary of pertinent documents, and associated sheet numbers for each structure, is provided below.

1. Original Architectural and Structural drawings prepared by Henningson, Durham & Richardson Engineers, and dated November 1980.
   a. *General Structural Notes*
      (1) Sheet IV-39
   b. *Raw Sewage Pump Room*
      (1) Sheets III-9 through III-10, Sheets IV-9 through 11, Sheets V-4 through V-6
   c. *Primary Clarifiers*
      (1) Sheets IV-12 through 13, Sheets V-7 through V-8
   d. *Aeration Basin*
      (1) Sheet III-12, Sheets IV-15 through 17, Sheets V-12 through V-15
   e. *Aerobic Digester*
      (1) Sheets III-28 through III-29, Sheets IV-35 through 37
   f. *Sludge Processing Unit*
      (1) Sheets III-20 through III-25, Sheets IV-30 through 34
   g. *Anaerobic Digester*
      (1) Sheets III-16 through III-19, Sheets IV-25 through 29

2. Original Equipment and Erection drawings prepared by Atara, Incorporated, and revised August 1982.
   a. *Anaerobic Digester*
      (1) Sheets 2706-01-82, 2706-04-82, and 2706-20-82.

4. FIELD INVESTIGATION

Representatives from WJE visited the WWTP during the week of September 23, 2019, to perform our structural assessment. Structures inspected, and the assessment methods used, are listed below in Table 2.

Table 2. Scope of Structural Assessment

Structure	Assessment Methods						
	Visual	Sounding	Cover Depth	Corrosion Potential	Corrosion Rate	Inspection Cores	Ultrasonic Steel Thickness
Raw Sewage Pump Station	X	X	X	X		X	X
Primary Clarifier - North	X	X					
Primary Clarifier - South	X	X					
Aeration Basins	X	X	X				X
Aerobic Digester	X	X	X	X	X	X	
Sludge Pressing Unit	X	X					X
Anaerobic Digester - North	X	X	X				
Anaerobic Digester - South	X	X	X				X

4.1. Assessment Methods

Please reference Appendix C for methods and procedures used as part of our assessment, in addition to Appendix D for a copy of our field sheets for each structure.

4.2. Assessment Findings

4.2.1. Typical Interior Conditions at All Structures

- A textured coating, consisting of multiple layers, and measuring approximately 1/8-inch in total thickness, is installed at a majority of the interior wall surfaces (Figure 1).
- Cracks measuring approximately 5 to 20 mils in width were present along the interior walls (Figure 2 Figure 3).
- Locations of delaminated coating and surficial concrete deterioration were present surrounding the perimeters of the inlet piping, where present (Figure 4).

4.2.2. Typical Exterior Conditions at All Structures

- Distress to the exterior walls typically included map patterned cracking (Figure 5 and Figure 6), and both longitudinal and transverse cracking, measuring between 5 and 30 mils in width.
- Longitudinal and transverse cracking primarily aligned with locations of embedded reinforcing bars (Figure 7).
- Isolated areas of corrosion staining likely due to ferrous-containing aggregate (Figure 8), such as pyrite or magnetite, which are both naturally occurring minerals, were also observed.
- A parge or “rubbed” finish coat was present on the exterior of a majority of the structures, and was delaminated or spalled at numerous areas (Figure 9).
- Surface staining was observed at the base of structures that directly abutted landscaping (Figure 10).

4.2.3. Raw Sewage Pump Station

This section includes the results of the visual and sounding assessment, non-destructive evaluation, and inspection openings at the Raw Sewage Pump Station. The primarily focus at this structure was on the pump room slab (Figure 11) and accessible portions of the interior and exterior walls.

4.2.3.1. Visual and Sounding Observations

4.2.3.1.1. Interior Conditions

- In numerous locations, where the wall coating was removed as part of our half-cell potential (HCP) testing, additional cracks that were not visible in the coating were observed in the underlying concrete wall (Figure 12).
- Isolated locations of surficial concrete deterioration and efflorescence deposits were observed at the base of the walls (Figure 13).
- Exposed concrete portions at the base of the south elevation wall were observed to be wet on the surface following removal of the coating.
- Efflorescence and mineral deposits were observed beneath the inlet piping elements (Figure 14).
- The topping slab exhibited multiple randomly distributed cracks, ranging between 25 to 45 mils in width (Figure 15).
- Overall, approximately 35 percent of the topping slab was identified as delaminated, with delaminations located primarily adjacent to the pipe support pedestals, and the central trench drain (Figure 16 and Figure 17).

4.2.3.2. Non-Destructive Evaluation

4.2.3.2.1. Corrosion Potentials (Half-Cell)

Corrosion potentials were measured at select accessible portions of both the north and south walls within the pump room. At the south elevation, potentials were measured at an area that encompassed an observed location of distress at the wall coating (Figure 18). At the north elevation, potentials were measured between the two west-most inlet piping lines, and at areas of noted coating delaminations and efflorescence staining (Figure 19). At both locations, similar corrosion potential gradients were observed between the upper and lower portions of the measurements, with the corrosion potential increasing towards the bottom of the wall (Figure 20). The contour plot showing higher potentials also generally followed the profile of the adjacent inlet piping elements at the north wall (Figure 21). While the visible concrete surface distress appeared to be minimal, and generally correlated with the results from the half-cell testing, the values obtained over the area surveyed indicate a moderate and increasing probability of active corrosion, particularly near the base of the walls.

4.2.3.2.2. Cover and Bar Spacing (GPR)

A total of four GPR scans were performed on the interior walls. In general, the spacing of the scanned interior mat of reinforcing steel either conformed to, or was more tightly spaced, than the information indicated on the original construction documents. The pump room exterior foundation wall walls are reinforced with vertical bars at 6 inches on-center, with a 2-inch cover, and horizontal bars at 10 inches on-center.

4.2.3.3. Inspection Openings

Two inspection openings (cores) were performed at the topping slab of the pump room, in an effort to understand if the observed topside cracking propagated into the structural slab below. Both cores were performed centered on locations of existing cracks (Figure 22). The topping slab measured on average 3-1/4 inches thick, and the cracking was not present in the structural slab below (Figure 23). At one of the openings, WWR was observed, situated approximately 1/4-inch from the bottom of the topping slab (Figure 24).

4.2.4. Primary Clarifiers

This section includes the results of the assessment at the two Primary Clarifiers. Prior to our interior observations, the water line was lowered approximately two feet, such that the inner face of the effluent trough and scum baffle were exposed in Clarifier #1 (Figure 25). The interior clarifier walls were observed from the central catwalk. An up-close evaluation and sounding at the interior face of the clarifier walls was not performed due to fluid levels within the clarifiers.

4.2.4.1. Visual and Sounding Observations

4.2.4.1.1. Interior Conditions

- Moisture staining was present on the surface at the interior face of the exterior wall and aligned with attachment locations for the domed roof framing (Figure 26).
- Isolated areas of paste erosion, some of which was severe particularly at the base of the effluent trough, and within the sludge and scum pits, were present (Figure 27 and Figure 28).

4.2.4.1.2. Exterior Conditions

- The roof framing is attached at roughly 12-foot centers, and is secured in a manner that away from the attachment locations, the roof partially “floats” above the skyward facing surface of the perimeter walls. As such, an approximately 1-inch wide gap is present between a majority of the roof underside and the concrete walls (Figure 29). The connection hardware for these attachment nodes was not able to be readily observed during our assessment.
- Isolated locations of exposed and corroded reinforcing bars were present (Figure 30).
- Localized areas of paste erosion, aligned with attachment locations for the domed roof framing, were present (Figure 31). Approximately 38 of the 68 attachment locations (includes both clarifiers) exhibited this paste erosion.

4.2.4.2. Non-Destructive Evaluation

4.2.4.2.1. Cover and Bar Spacing (GPR)

A total of two GPR scans were performed on the exterior walls. In general, the spacing of the scanned exterior mat of reinforcing steel conformed to the information indicated on the original construction documents. The top-most exposed portions of the exterior walls are reinforced with vertical bars at 18 inches on-center, and horizontal bars at 4 inches on-center. The vertical and horizontal crack locations generally align with embedded reinforcing steel.

4.2.5. Aeration Basin

This section includes the results of the assessment at the Aeration Basin, primarily focused on the blower room (Figure 32) and the at-grade concrete catwalk railing supports (Figure 33). All interior observations were made from the blower room.

4.2.5.1. Visual and Sounding Observations

4.2.5.1.1. Interior Conditions

- Staining and evidence of previous leakage was present at the interior face of the elevated trough, located at the southeast and southwest portions of the blower room (Figure 34).
- Cracking was observed at the ceiling of the blower room, particularly at the skylight and pipe penetrations (Figure 35). Several of these cracks were also observed at the top surface from the catwalk

(Figure 36), indicating that they are full-thickness. Some of these cracks measured approximately 1/16-inch wide.

- The topping slab exhibited multiple cracks, ranging from 15 to 50 mils in width (Figure 37).
- WJE's sounding survey was limited to the south portion of the blower room, as conditions were generally similar throughout the entire slab. Overall, approximately 80 percent of the sounded portion of the topping slab was identified as delaminated, with isolated locations of sound topping at the perimeter walls.
- Staining and evidence of ponding water at floor drains was observed (Figure 38).

4.2.5.1.2. Exterior Conditions

- Localized incipient spalled concrete was present at approximately six percent of the catwalk guardrail post embeds (Figure 39). Sealant had been installed at several of these incipient spalls, some of which had adjacent spalls (Figure 40).
- Incipient spalls or delaminations were present at the perimeter of the catwalk, some of which had sealant installed at associated cracking (Figure 41).

4.2.5.2. Non-Destructive Evaluation

4.2.5.2.1. Cover and Bar Spacing (GPR)

A total of two GPR scans were performed on the demising wall between the blower room and the east-most aeration basins. In general, the spacing of the scanned interior mat of reinforcing steel conformed to the information indicated on the original construction documents. The wall is reinforced with vertical bars at 8 inches on-center, with 3-1/2-inches of cover, and horizontal bars at 14 inches on-center.

4.2.6. Aerobic Digester

This section includes the results of the visual and sounding assessment, non-destructive evaluation, and inspection openings at the Aerobic Digester (Figure 42). The digester is partially connected to the Sludge Processing Unit at the north elevation. Two concrete stairs are present on the exterior at the north elevation, providing access to both the roof of the Sludge Processing building, and the elevated catwalks above the digesters (Figure 43 and Figure 44).

4.2.6.1. Visual and Sounding Observations

4.2.6.1.1. Interior Conditions

- Existing crack repair attempts, which appeared to have involved either routing and sealing, or installation of an epoxy adhesive, were observed within the digester basins (Figure 45).

4.2.6.1.2. Exterior Conditions

- Evidence of moisture intrusion at multiple cracks and reveal joints was observed, in addition to organic growth and actively leaking cracks (Figure 46 through Figure 48).
- Spalling, delaminations, and corrosion of embedded reinforcing was present at the soffit of the ground level stairwell (Figure 49 and Figure 50), in addition to less severe spalling observed at the soffit of the stairwell leading from the roof of the sludge processing building to the aerobic digester (Figure 51).
    - At the ground level stairwell, the concrete cover over the reinforcing bars measured approximately 3/4-inch.
- Corrosion was present on the bearing plates at the stairwell from the sludge processing building roof to the aerobic digester catwalks (Figure 52).
- The sealant joint between the north digester wall and the adjacent sludge processing building wall was worn and had failed along its height (Figure 53).

- The sealant joint between the ground level stairwell and the north digester wall was no longer in contact with the face of the stair risers (Figure 54). A translation based on the sealant joint indicates that the digester has moved down and to the east.

4.2.6.2. Non-Destructive Evaluation

4.2.6.2.1. Corrosion Potentials (Half-Cells)

Corrosion potentials were measured at select accessible portions of both the north and east elevation walls. At the north elevation, potentials were measured at both the underside of the lower stairwell (Figure 55), and at an adjacent area on the main digester wall exhibiting efflorescence and previous moisture staining (Figure 56). At the east elevation wall, potentials were measured at an area exhibiting several cracks, included efflorescence staining (Figure 57).

At the lower stairwell soffit, the values obtained indicate isolated areas of elevated corrosion activity, towards the perimeter and bottom of the stairs. However, near the center of the stairs, a low probability of corrosion potential was recorded. At the north elevation wall, only a low probability of corrosion potential was recorded, despite the adjacent efflorescence and evidence of previous moisture intrusion at adjacent cracks. At the east elevation wall, the values obtained over the area surveyed indicate a high and increasing probability of active corrosion, particularly at the adjacent joint and cracking observed with moisture staining and efflorescence.

4.2.6.2.2. Corrosion Rate

Corrosion rate potentials were measured at the north elevation wall, corresponding to where the HCP measurement were also obtained. Overall, the corrosion rate was identified as passive or low, and was predominantly less than 10µm per year, with slightly elevated levels across the crack with observed efflorescence. This indicates a low to moderate rate of corrosion of the reinforcing steel.

4.2.6.2.3. Cover and Bar Spacing (GPR)

A total of four GPR scans were performed on the north and east digester walls. In general, the spacing of the scanned exterior mat of reinforcing steel conformed to the information indicated on the original construction documents, and the observed cracking aligned with the reinforcing. The wall is reinforced with vertical bars at 12 to 14 inches on-center, with a cover ranging between 2 to 3-1/2 inches, and horizontal bars at 12 to 14 inches on-center.

4.2.6.3. Inspection Openings

Two partial-depth inspection opening cores were performed at the east elevation wall; one at an intersection of existing cracks (Figure 58), and one at a location of an embedded reinforcing bar. The purpose of these openings was both to evaluate the propagation of the surface cracking through the thickness of the wall, as well as to observe the condition of the reinforcing steel at a location where elevated HCP readings were obtained. The core to review crack depth was centered on an existing crack located away from underlying reinforcing bars. This core identified that the cracks extend the full length of the approximately 6-inch long core (Figure 59). The second core was located at a reinforcing bar and revealed a horizontal reinforcing bar in good clean condition, with very little to no surface corrosion present (Figure 60).

4.2.7. Sludge Processing Unit

This section includes the results of our assessment at the Sludge Processing Unit, which was focused on the exterior walls (Figure 61), and the steel framing at the blending tank (Figure 62). We understand that the blending tank previously had a conventionally-reinforced concrete slab serving as a lid or roof, which was removed and replaced approximately 20 years ago with the current open-air steel framing elements. The lid framing was observed from the central steel-framed catwalk. Reportedly, a shotcrete liner wall was also installed on the interior of the north and west walls of the blending tank when the concrete lid was removed. An up-close evaluation of the framing connections and shotcrete liner was not performed due to access restrictions.

4.2.7.1. Visual and Sounding Observations

4.2.7.1.1. Blending Tank Interior Conditions

- The mild steel framing at the north and west walls of the roof of the blending tank were mechanically attached to the perimeter concrete walls with stainless steel through-bolts and mild steel plate washers (Figure 63).
- The mild steel framing members were coated and exhibited surface corrosion (Figure 64).
- The ends of the reinforcing bars for the removed slab lid are exposed at the perimeter walls, and exhibit surface corrosion at each bar (Figure 65).
- The mild steel members in contact with the stainless steel through-bolts were corroding, such as the plate washers on the exterior (Figure 66 and Figure 67), and the members on the interior (Figure 68).
- Corrosion was most commonly present at the bolted connections between steel wide flange beams and channel members (Figure 69).

4.2.7.1.2. Blending Tank Exterior Conditions

- Evidence of previous water infiltration was present at several locations, most notably efflorescence and staining at the wall panel reveal joints at the base of the walls (Figure 70 and Figure 71).

4.2.7.2. Non-Destructive Evaluation

4.2.7.2.1. Cover and Bar Spacing (GPR)

GPR scans were performed on the north elevation exterior wall at the blending tank. In general, the spacing of the reinforcing steel either conformed to, or were more tightly spaced, than the spacing shown on the original construction documents. The location of the observed cracking in this area was not well correlated with the reinforcing.

4.2.7.2.2. Ultrasonic Steel Thickness

A total of sixteen ultrasonic thickness measurements were made on the various mild steel framing components. For each framing component type, the variance in measured thicknesses between similar components was less than 0.042 inches.

4.2.7.2.3. Ultrasonic Coating Thickness

A total of twenty ultrasonic thickness measurements were made on the coating on the mild steel framing. The total coating thicknesses measured were highly variable, with a low of 0.35 mils, and a high of 9.1 mils. Corrosion of the mild steel framing was typically noted at areas of thin coating thickness, approximately less than 1.5 mils (Figure 72), and was not noted at areas of thicker coating.

4.2.8. Anaerobic Digester

The concrete walls of the two Anaerobic Digesters are connected by the Anaerobic Digester Building in the center (Figure 73). An overall view of the south digester is presented in Figure 74. Within the Anaerobic Digester Building, the exterior face of the structural concrete wall is exposed, as no panels are present. Although these portions are technically ‘exterior’ concrete (i.e. are not the interior face of the concrete exposed to the process water), for purposes of our assessment, observations made within the Digester Building are considered as ‘interior’.

4.2.8.1. Visual and Sounding Observations

4.2.8.1.1. Interior Conditions

- Horizontal cracking was present at each digester, with cracking of the north digester much more prevalent than the south.
- The coating appeared to have been repaired at the location of a crack at one location on the south digester wall (Figure 75).
- No moisture or corrosion staining was observed at any of the cracks at the interior digester walls.

4.2.8.1.2. Exterior Conditions

Exterior concrete distress was similar at both digesters.

- Portions of the north digester walls were covered in plant growth and were not able to be readily observed (Figure 76).
- Twelve of the twenty-nine observable panels were observed to be bowing outwards near their centers (Figure 77).
- One panel was displaced approximately 1-inch from the top coping piece (Figure 78).
- Transverse (horizontal) cracks were noted on several panels, near the center of their height, some of which had efflorescence staining (Figure 79). This transverse cracking was most common at bowed panels.
- Spalled areas of concrete and distress were observed at the upper and lower corners of several panels (Figure 80 and Figure 81).
- Supplemental bolts were observed at the base of one panel at the south digester (Figure 82). This correlated to the panel which had reportedly been re-attached.
- The concrete coping cap at the top of the digester walls exhibited a 50-mil wide crack, extending longitudinally approximately 65 feet, at the top surface (Figure 83). The crack was primarily located along the portion of the digester that abutted the central digester building.
- Transverse cracking was observed at the cap piece at roughly 2-feet on-center (Figure 84).
- The vertical sealant joint between panels had failed in both adhesion and cohesion in several locations (Figure 85).

4.2.8.2. Non-Destructive Evaluation

4.2.8.2.1. Cover and Bar Spacing (GPR)

GPR scans were performed on the exterior wall panels and the interior digester wall from within the building. The spacing of the wall panel reinforcing steel appears to have been switched from that shown on the original construction documents. The vertical steel was measured at 6 to 10-inches, yet was specified at 18-inches; the horizontal steel was measured at roughly 16-inch spacing, and 11-inch spacing was specified on the drawings. Clear cover was measured at 1 1/4-inches to the vertical reinforcing. Horizontal reinforcing aligned across panels.

The reinforcing of the structural wall, as observed from the interior of the digester building, generally conformed to the original construction drawings. Horizontal reinforcing was measured at 4 to 6-inches on-center, and vertical reinforcing was measured at 16 to 21-inches and was specified as 18-inches on-center.

4.2.8.3. Steel Lid

The coating at the top and sides of the lid at the south digester was evaluated using several non-destructive and semi-destructive techniques, discussed below. The off-white or cream-colored coating on the top of the lid (Figure 86), and the black coating on the sides of the lid (Figure 87) appear to be different coating systems, with much different thicknesses.

4.2.8.3.1. Typical Coating Observations

Each of the coatings exhibited similar visual distress, including chalking, corrosion at isolated locations (likely due to impact damage), and flaking of the coating.

4.2.8.3.2. Ultrasonic Steel Lid Thickness

Thickness measurements on the top surface of the tank lid were taken at random locations, and indicated an average lid thickness of 0.269 inches, from 35 readings. Corrosion of the steel lid was observed at seven of the measured locations, with an associated average lid thickness of 0.190 inches.

4.2.8.3.3. Ultrasonic Coating Thickness

Coating thickness measurements on the top surface of the tank lid were taken at random locations, and indicated an average coating thickness of 13.2 mils, from 10 readings. However, at one of these locations, it was noted that at least one layer of coating had peeled or flaked away (Figure 88), resulting in an individual measurement of only 7.6 mils.

Coating thickness of the sides of the tank lid ranged between 21.2 mils and 50.5 mils, with an average of 41.9 mils from four readings. There were not distinguishing visual differences between the high and low readings.

4.2.8.3.4. Tooke Gauge Observations

A Tooke Gauge was also used to physically measure the thickness of the coating on the top of the tank lid. A Tooke Gauge uses a steel blade to score through the coating down to the steel substrate, and the blade used to score the coating is angled such that the resulting coating left in place is sloped back and away to allow measurement with an optical field microscope. One score location was performed, and three measurements were taken resulting in an average total thickness of 15.3 mils, which correlates well to the non-destructive measurements. No discernable difference was noted between coating layers, as they were all generally of the same color.

4.2.8.3.5. Adhesion Testing

Adhesion testing was performed at three locations. The results of the three tests were 4A, 5A and 5A, indicating generally good adhesion of the coating. The 4A test result had some trace peeling or removal along their incisions and at their intersection (Figure 89). However, this peeling did not extend through all coating layers, just the top, which is consistent with the peeling or flaking of the coating observed at some locations.

4.2.9. Steel Piping

4.2.9.1. Visual Observations

4.2.9.1.1. Raw Sewage Pump Room

Six steel intake pipes protrude from the north demising wall (from the wet well) into cast valves. One valve is capped, as per plan, and five continue through sewage pumps. The steel outlet lines gradually increase in size up to a final pipe diameter of 36 inches. The outlet pipe runs parallel to the north wall. The pumps and intake valves are supported directly on the concrete bases, and piping is supported by welded supports bearing on the concrete foundation slab. The vertical pipe supports appear to be in good condition. The horizontal supports between the outlet line and the north wall also appear to be in good condition. All connection flanges appear to be solidly fastened, with flange faces evidently parallel to each other. The piping and the connections have all been coated.

4.2.9.1.2. Aeration Basin Blower Room

Various diameter steel pipes are present, connecting the Clarifiers to the Aeration Basins. The pipes run through six return sludge pumps. All connection flanges appear to be solidly fastened parallel to each other. The piping and the connections have all been coated.

4.2.9.2. Non-Destructive Evaluation

WJE performed spot thickness verification on several piping components, by randomly selecting locations on the steel pipe and fittings to identify the range of section loss in those elements, with results tabulated below. Each standard straight pipe section was measured at a minimum of three locations (not in the same clock or axial positions). Each tee fitting was measured at a minimum of four locations (upper section, lower section, opposite side of perpendicular pipe, and near tee weld). Each elbow (typically welded section) was measured in at least five locations (upper and lower mid-lines, intrados, extrados, and near at least one circumferential weld). The formed elbows at the Aeration Basin pumps were measured in eight locations (same as above and additional measurements for each weld seam). Pipe reducers were typically measured in three locations (near each flange), and mid span (not in same clock position). Pipe reducers at each pump valve were measured at additional locations focused mainly around the lower flange (previous reducer rupture). Additional measurements were taken at and around previous repairs.

The results of the non-destructive testing are summarized in Table 3 (Raw Sewage Pump Room), Table 4 (Raw Sewage Pump Room Repair) and Table 5 (Aeration Basin) below.

Table 3. Summary of Ultrasonic Thickness Measurements in Raw Sewage Steel Pipe

Pipe Description	Portion of Pipe	Number of Measurements	Average (in.)	Maximum (in.)	Minimum (in.)	Standard Deviation (in.)
Rolled and Welded Straight	Mid-Section	82	0.319	0.439	0.212	0.038
	Flange/Weld	12	0.331	0.456	0.241	0.063
Fabricated Tee Joint	Opposite of Perpendicular Tee	8	0.366	0.312	0.474	0.063
Reducers	Small Diameter End	18	0.330	0.473	0.275	0.052
	Mid-Section	12	0.324	0.226	0.514	0.082
	Large Diameter End	52	0.314	0.466	0.125*	0.065
Welded Elbow	Outside Radius	12	0.326	0.380	0.227	0.046
	Inside Radius	10	0.328	0.405	0.170*	0.067
	Upper and Lower Section	10	0.329	0.246	0.382	0.052

*Dimension taken at previous repair location

Table 4. Summary of Ultrasonic Thickness Measurements in Raw Sewage Steel Pipe Repair

Location	Approx. Patch Size LxW (in.) (Thickness, in.)	Number of Measurements	Minimum (in.)	Maximum (in.)	Average (in.)
Main Outlet Patch Near Pump 1	3x6 (.263)	20	0.174	0.289	0.234
Main Outlet Patch Near Pump 5	24x36 (.247)	16	0.240	0.317	0.275

Table 5. Summary of Ultrasonic Thickness Measurements in Aeration Basin Steel Pipe

Pipe Description	Portion of Pipe	Number of Measurements	Average (in.)	Maximum (in.)	Minimum (in.)	Standard Deviation (in.)
Typical Rolled and Welded Pipe	Mid-Section	80	0.299	0.403	0.168	0.038
	Flange/Weld	48	0.311	0.485	0.236	0.055
Rolled and Welded Tee Joint	Opposite Perpendicular Tee	8	0.283	0.306	0.262	0.016
Rolled and Welded Reducer/Expander	Small Diameter End	50	0.475	0.648	0.251	0.109
	Mid-Section	38	0.562	0.663	0.286	0.081
	Large Diameter End	6	0.391	0.470	0.274	0.085
Welded Section Elbow	Outside Radius	28	0.300	0.727	0.260	0.085
	Inside Radius	22	0.279	0.304	0.243	0.016
	Section	16	0.275	0.306	0.257	0.013
Formed Elbow	Outside Radius	18	0.415	0.449	0.284	0.035
	Inside Radius	4	0.426	0.447	0.400	0.021
	Section	10	0.411	0.467	0.304	0.043

5. STRUCTURAL ANALYSIS

As a part of our scope of services, we proposed to perform a structural analysis on select elements based on observations made during our field work, and as a result of the findings from the Geotechnical Investigation. Model geometry was based primarily on details obtained from the original structural drawings, as well as as-built information obtained via our GPR scans. Material properties and member capacities were based solely on information from the original drawings, as no materials testing was performed by WJE.

Based on the items discussed above, we determined that an analysis of the following elements was warranted:

- Raw Sewage Pump Station South Foundation Wall: This structure is the deepest of any on site, and varying extents of cracking were observed.
- Raw Sewage Pump Station Foundation Level Structural Slab: This structure is the deepest of any on site, and therefore the uplift loading due to the water table on the structural slab is the most significant. In addition, the geometry of this slab is similar to that of other structures, making it a good representative slab to review.
- Anaerobic Digester Exterior Concrete Wall Panels: The observed conditions call into question the lateral support of the panels, and therefore the stability of the panels was reviewed for potential stabilization.

5.1. Foundation Elements

Based on the concerns raised in the RFP, and during our conversations with the CGJ during the project, review of select foundation elements for updated geotechnical parameters was performed. Table 6 provides a comparison of equivalent fluid pressures used as loading of these elements. It appears that the values used during original design were considered more in the range of active soil loads. However, given the stiffness of the elements under consideration, conventional current practice would be to use at rest soil pressures, which require that the elements resist higher equivalent fluid pressures due to their relative stiffness.

Table 6. Comparison of Equivalent Fluid Unit Pressures on Foundation Wall Elements (PCF)

Source	Condition	Above Groundwater Level	Below Groundwater Level
Original Construction (Drawing IV-39)	Not Specified	35	85
WJE Geotechnical Investigation Recommendations	Active	37	80
	At Rest	57	91

There is a perceived increase in loading based on the recommendations of the current geotechnical report, and analysis of the elements to resist soil in the at rest condition. However, based on our observations, there is no substantial structural damage to any of the structures. As such, there is no requirement that the existing structures meet current building code requirements for new construction, including the updated soil loading values. Therefore, our analysis considered the elements for both the original construction soil loading requirements, as well as the current WJE Geotechnical Investigation values for at rest conditions.

5.1.1. Raw Sewage Pump Station South Foundation Wall

Structural modeling of the foundation walls for the Raw Sewage Pump Station was performed using the SAP2000 finite element analysis program, as well as tabular finite element analysis for tanks from the Portland Cement Association Rectangular Concrete Tank design aid[1]. Analysis geometry was based primarily on details obtained from the original structural drawings, as well as as-built information of reinforcing confirmed via our GPR scans. Material properties and member capacities were based solely on information from the original drawings, as no materials testing was performed by WJE. Our analysis focused on the bending capacity of the walls, which we deemed to be the critical performance element. A copy of our calculations for the south foundation wall can be found in Appendix E.

Based on our review we have determined that the wall is adequate to resist the originally specified soil loads and therefore does not require strengthening. Our review of the walls for the updated soil loads required that we refine our analysis, but we ultimately identified that the wall has adequate capacity to resist even the updated soil loading. However, we did identify an overstress of three percent for resistance in bending at the center of the wall in the vertical direction. This marginal overstress does not exceed the acceptable threshold of five percent commonly used by engineers for existing structures, consistent with the provisions of the International Existing Building Code. In addition, the wall is an indeterminate structural system that has the ability to re-distribute these stresses to one of the other three critical bending support conditions (i.e. there is redundancy through strength of adjacent elements). This calculated overstress may account for some of the observed horizontal cracking, as in order to re-distribute these stresses, some deformation and cracking must occur. In addition, when deformation occurs the loading of the structure shifts from an at rest soil condition, to an active soil condition, thus further reducing the forces that the wall required to resist.

5.1.2. Raw Sewage Pump Station Foundation Level Structural Slab

Based on the concerns raised in the RFP regarding cracking in the foundation level slabs of this and other structures, a review of the structural slab capacity to resist upward fluid pressures was deemed appropriate. The only applied uplift load to the slab is due to the anticipated ground water static head pressure, which was taken as 17.5-feet for this structure based on the findings of the WJE Geotechnical Investigation. Geometry, reinforcing information, and material properties were based on details and information provided on the original structural drawings. Rather than modeling the slab using a finite element program such as SAP2000, we explicitly used the tabular finite element analysis for tanks produced by the Portland Cement Association to determine applicable bending moments of the two-way slab system. A copy of our calculations for the structural slab can be found in Appendix E. The results of our analysis indicate that, even when using conservative assumptions, the slab has adequate capacity to resist the applicable groundwater upward loading. As such, this loading is not likely contributing to the observed distress in the topping slab.

5.1.3. Anaerobic Digester Exterior Concrete Wall Elements

As further discussed below, our observations indicated that the specified ties between the main interior structural wall and the exterior wall panel elements may not have been installed as designed. As such, without further investigation, it is warranted to determine if the exterior panel walls are capable of supporting the code prescribed loads, assuming a connection is only provided at the top and bottom of the walls, which should be confirmed through investigative openings.

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[1] *Rectangular Concrete Tanks*, Revised Fifth Edition, Portland Cement Association, 1998

The primary external force that the wall panels need to resist is wind loading, both in the positive direction (pushing against the wall), and in particular the negative direction (pulling the wall outward). As the panels are not considered part of the main wind-force resisting system, components and cladding loading was considered for these elements based on ASCE 7-16, as Mesa County has adopted the IBC 2018 edition. Element geometry was based primarily on details obtained from the original structural drawings, as well as as-built information obtained during our site visit through measurement of panel width and our GPR scans of reinforcing location and depth. Material properties and member capacities were based solely on information from the original drawings, as no materials testing was performed by WJE. Our analysis focused on the bending capacity of the exterior wall panels, which we deemed to be the critical performance element based on our observations of bowing panels and cracking. A copy of our calculations for the exterior wall panels can be found in Appendix E.

The analysis for wind loading indicates that the panels have sufficient bending capacity to resist these forces. However, we observed several panels which were bowed outwards. As such, the walls are now also tasked with resisting an additional bending moment due to this eccentricity. Even with this eccentricity, the wall panels have sufficient bending capacity to resist the current code prescribed loads assuming that the reinforcing geometry for all panels is similar to that of the single reviewed panel. Furthermore, the maximum calculated bending stresses are not predicted to exceed the cracking stresses for the concrete, and therefore the observed horizontal cracking is not likely solely due to bending stresses; however, it may be due to a combination of bending stresses and shrinkage.

6. DISCUSSION

The following provides a discussion on the various types and levels of distress observed throughout the surveyed structures. As indicated in our Condition Assessment Memorandum, dated October 23, 2019, various degrees of additional sample extraction, inspection openings, and laboratory testing would be beneficial at each structure in order to better understand the nature of the observed distress and the underlying mechanisms. Please refer to our Condition Assessment Memorandum for further information about recommended additional testing, provided as Appendix F.

6.1. Typical Interior Conditions

At the interior portions of the concrete structures that were readily observable (i.e. did not hold process water), a textured coating of varying thickness was present. We understand that the interior walls are frequently coated with a thin layer of paint as a part of routine maintenance, but the initial coating was reportedly installed shortly after construction. Therefore, it does not appear that the coating was installed as a means by which to conceal unsightly cracking that developed over time. Furthermore, traditional interior coatings of this nature would likely not hide or bridge actively moving or widening cracks, indicating that the coating was likely installed after most of the underlying cracks had propagated. Based on our structural analysis of the wall and slab loading scenario at the Raw Sewage Pump Station, these cracks do not appear to be indicative of a concerning overloading of the structure and are likely attributable to early-age restrained volume change (shrinkage and/or thermal). However, the cause and extent of the cracking is not fully defined as no concrete samples were taken, and therefore no laboratory review was performed to fully characterize the potential distress mechanisms.

The original drawings indicate that a majority of the structures contain a waterproofing membrane beneath the foundation slabs and on the backside of the foundation walls. However, it is not uncommon for breaches in these types of systems to occur at changes in plane (i.e. outside corners) or at penetrations (i.e. piping), and for additional moisture to collect at the base of foundation walls. Any damaged areas or breaches in the waterproofing membrane would allow water to enter the wall system and collect at the base of the walls, which is likely the cause of the increase of observed coating delaminations at the base of the interior foundation walls with respect to the field of the foundation walls. This is consistent with the increasingly negative HCP survey results near the base of the wall in the Raw Sewage Pump Station, as more moisture will yield more negative HCP values.

6.2. Typical Exterior Conditions

In general, the transverse and longitudinal cracking appeared to align with locations of embedded reinforcing bars. At these locations the cross section of the concrete is reduced and therefore is more prone to crack propagation due to restrained shrinkage. At the inspection opening (core hole) above a crack at the Aerobic Digester wall, the crack propagated at least 6 inches through the thickness of the exterior wall (the full-depth of our core) and traced around aggregate particles rather than through them. This crack propagation indicates that the crack likely developed early in the age of the concrete, prior to the concrete reaching sufficient strength to bond to aggregate and therefore propagate through aggregate. Cracking such as this may be expected given the potential size of the concrete placements required and the thickness of the elements. When large, relatively thick, concrete placements are made, a significant amount of heat can be generated early on, which can increase the potential for early-age cracking of the concrete. Similarly, the observed map patterned cracking may be caused by shrinkage or loss of moisture near the surface of the concrete following placement, or may also be attributable to a chemical reaction between the concrete material constituents. If there is a material issue which is the cause of the cracking, it may continue to propagate over time. To further define the cause of the cracking, core samples would need to be reviewed in the laboratory. Our assumption with the information at this time is that the distress is not due to material constituents and therefore is not expected to worsen.

Our HCP testing at the Aerobic Digester indicated an elevated probability of corrosion at the east elevation wall, yet an inspection opening (core) at one of these areas revealed clean non-corroded reinforcing steel, indicating that the HCP readings are likely being skewed by deposits and moisture present at the observed cracking. Therefore, it does not appear that the cracking is due to stresses innate to corrosion of the internal reinforcing bars.

The observed parge coat was likely installed after the forms were removed, in an effort to achieve the as-specified hand-rubbed aesthetic finish. While its deterioration does not pose a structural concern, the loosely adhered coating may have a propensity for collecting and holding an increased level of moisture against the surface of the wall, thus trapping moisture which may lead to isolated and accelerated locations of concrete deterioration, prior to the coating flaking off. In addition, while not likely its intended purpose, such a coating may also have a beneficial effect in reducing the carbonation rate of the concrete, and therefore slowing the rate of deterioration due to corrosion of embedded reinforcing steel.

Surface corrosion staining of ferrous-containing aggregates, such as pyrite or magnetite, is solely of the aggregate particles themselves, and is not indicative of corrosion of the embedded reinforcing steel. The dark staining of lower portions of the walls adjacent to landscaped areas (approximately lowest four feet) appears to be due to irrigation with process water as the staining strongly aligns with a pattern that would be created by adjacent sprinklers. While it is unclear if this process water is attributing to some of the noted cracking and distress at these locations, the discoloration highlights any cracking present at the base of the wall.

6.3. Raw Sewage Pump Station

Concrete distress at the pump room topping slab is likely due to a combination of misplaced WWR that is not effective at helping to reduce topside shrinkage cracking, coupled with a lack of large coarse aggregate, indicating that the topping had an increased potential for shrinkage. This cracking provides an avenue for moisture to penetrate the topping, and possibly contributes to the observed delaminations. While the cracking may not currently pose a serviceability issue, the existing cracks will only continue to ravel and widen over time, and may eventually lead to spalls and trip hazards throughout the slab. Widespread spalling may potentially create an instability of isolated pipe support framing elements, some of which appear to bear directly onto this topping.

The observed delaminations and efflorescence staining at the base of the walls indicates that some moisture is likely penetrating through the wall and leading to the noted concrete and coating distress. This condition was observed in isolated locations, where the concrete wall was noted to be wet on the surface following removal of the coating. Similarly, the HCP testing we performed at two interior wall locations indicated some potential for corrosion of the internal reinforcing steel, with corrosion potentials greatest towards the bottom of the walls and adjacent to inlet piping locations, where an increased moisture content is expected.

We understand that the seals to the inlet piping have been problematic over time, and at some locations appear to be continually contributing to moisture infiltration. Furthermore, where process water is allowed to contaminate the concrete, there is the potential for increased concrete deterioration due to sulfate attack.

6.4. Primary Clarifiers

The observed erosion at the clarifier walls was concentrated at areas where moisture condensate is likely to accumulate or fluctuate, namely at roof attachment nodes, as well as at the splash zone at the interior of the tanks. It may also be present at lower levels on the tank interior which were not observed during our study due to the water line at the time. As the domed roof is situated approximately 1 inch above the surface of the concrete walls, moisture condensate that collects on the attachment nodes is provided a direct avenue to migrate to the exterior face of the walls. The as-built attachment of the domed roof was not able to be observed, and therefore corrosion of any attachment hardware or connectors was unable to be identified. We understand that elevated levels of hydrogen sulfide are present within the process water, as is expected within wastewater operations, and this is likely the root cause of the paste erosion distress through sulfate attack. However, core extraction and laboratory analysis was not performed as part of our condition assessment, therefore the general extent and depth of the erosion, or the propagation of potentially deleterious ions (chlorides or sulfates) into the concrete, is not known at this time.

Additional isolated locations of exposed corroded reinforcing and support chairs were also observed; however, these areas were few, and are not likely indicative of a more global corrosion of the embedded reinforcing bars, but rather simply isolated locations of reduced cover.

6.5. Aeration Basin

The distress to the aeration basin blower room slab was similar to that observed at the Raw Sewage Pump Station. GPR scans performed on the floor slab were able to clearly detect the interface between the topping and structural slab, confirming the delamination. While a cursory review did not detect any clogged drains, it is possible that the sloping of the topping is not appropriate to provide drainage, and the observed standing water may be migrating through the topping cracks and contributing to the overall topping delaminations at this structure.

Cracks on the underside of the elevated troughs and ceiling soffit of the blower room exhibited staining on the interior of the structure at several locations; however, additional distress in the form of spalls or delaminations were not observed. The staining is indicative that the cracks are allowing moisture to penetrate from the exterior into the space, and the cracking should be addressed so that moisture propagation through the slab can be reduced.

Distress at the guardrail post connections does not present an imminent instability issue, given the connection of the vertical and horizontal members, as well as the shape in plan of the guardrails. Our observations indicate that the guardrail posts were installed by coring into the concrete substrate to create an oversized hole, then installing the aluminum posts into a grout placed in the cored hole. In our experience, the observed distress is frequently associated with post embeds that are installed into an expansive grout, typically containing gypsum. As this grout cures and is exposed to external moisture, the material begins to expand, imparting a lateral pressure onto the face of the adjacent concrete substrate, causing the parent concrete to crack and eventually spall away. In multiple locations, sealant had been installed at cracks around the guardrail post bases, likely in an effort to reduce moisture exposure. Additional locations of distress may continue to manifest over time as more moisture migrates into the crack. This distress could be the result of the increased moisture exposed to the expansive material, ice jacking due to water freezing and expanding inside the crack, and corrosion of embedded reinforcing as the cracking provides an avenue for moisture and other contaminates to more readily reach the level of the reinforcing.

6.6. Aerobic Digester

Deterioration of longitudinal reinforcing bars and spalling of concrete was observed to be isolated to the soffits of the exterior stairs. This distress is likely attributable to moisture accumulating on the top surfaces of the stair (potentially containing additional chlorides from applied de-icing chemicals), which runs down and around onto the soffit where it later evaporates and deposits efflorescence and chlorides. The exposure to moisture and chlorides have resulted in corrosion of embedded reinforcing and the observed distress. The condition was likely worse at these locations due to a shallower cover than that of the adjacent walls. The extent of the current deterioration is not cause for concern regarding the ability of the stairs to support the code prescribed loads. At the roof level stairwell, corrosion product was also present on the bearing plates and angles at the upper stair supports. No observable section loss or indication of a reduction in strength was observed at these elements. Finally, the sealant joint between the stairs and the north elevation face of the Aerobic Digester was observed to have failed along its height. The consistent directionality in the offset of the sealant indicates that the digester has moved down and to the east since the installation of the joint. Associated distress to the stair structure as a result of this translation was not observed.

Organic growth and actively leaking cracks were unique to the Aerobic Digester, and were observed throughout the exterior elevations. Although previous crack repair attempts were observed at the interior of the digester basins, these repairs do not appear to have successfully mitigated the through-wall moisture ingress through the existing cracks. While the exploratory opening at this structure revealed relatively clean embedded reinforcing (described in Section 6.2 above), this continued migration of moisture through the concrete structure may lead to future concrete distress due to corrosion. Further investigation through laboratory sample review can help to define the risk of corrosion.

6.7. Sludge Processing Unit

The primary cause of distress to the open-air framing connections appears to be due to galvanic corrosion. This form of sacrificial corrosion was observed on the steel plate washers at the exterior walls, and to a lesser extent on the framing members at the perimeter walls. At this time it is unknown if the connection bolts are experiencing any levels of section loss, which could cause a structural instability were they to fail. Furthermore, while our review of the framing was limited to a visual survey of accessible elements from the central catwalk, there were no readily identified areas of through-member section loss, or areas that exhibited severe corrosion. Corrosion on the exposed bars serving as the reinforcement for the previously removed concrete lid was minor, and should be expected of uncoated reinforcing bars exposed to the elements.

Through-wall moisture migration in the form of efflorescence was also present, particularly at the base of the wall at reveal joints. This continued migration of moisture through the concrete structure may lead to future concrete distress due to corrosion.

6.8. Anaerobic Digester

The construction of the exterior panel walls appears to deviate from the details on the original construction drawings, and it is unclear how these panels are attached back to the main structure. The original drawings indicate that the exterior panels were to be attached via 1/4-inch diameter hooked ties, spaced at 24-inches on center in both directions (Figure 90). These ties would have provided continuous attachment throughout the panel back to the structural wall. Given the observed bowing, panel and coping cap cracking, torn sealant joints, and spalling at the top and bottom of panel corners revealing what appears to be connection steel, it is not clear if any of the original specified ties or anchors are present in the wall, or if the wall was constructed as detailed or as separate panels. Cursory GPR scans along the panels were unable to locate reinforcing other than the specified mat of reinforcing bars. As such, the assumption in our analysis was that the ties were not present. Given that the relatively tall panels (approximately 19 feet tall) appear to only be attached at the top and bottom, coupled with the potential lack of continuous support provided by the specified ties, a potential instability of the exterior panels exists due to the distressed connections top and bottom.

Observed longitudinal cracking on the concrete coping cap appears to align with the interface between the surface panels and the structural wall. The transverse cracking may be due to restraint against movement, as the original drawings indicate that the cap was cast after the walls were detailed, and potentially had been constructed for some time. As these cracks are on an unprotected and skyward facing surface, moisture intrusion through these cracks that can reach the structural walls and insulation cavity below may result in premature failure of the existing attachment anchors, or of any new supplemental repair ties that are installed.

The source behind the variance in crack appearance at the interior digester walls is not known for certain; however, it may be related to the sequencing of the digester construction, with respect to initial coating application. If the digesters were constructed one at a time (reasonably assuming several weeks between completion of the two digesters), and then were coated at the same time, the initial digester would have had the time to develop more early-age cracking prior to installation of the coating, which were then covered. However, the second digester would have been developing its early-age shrinkage cracks once the coating was already installed, and would have caused these cracks to telegraph through the relatively thin coating.

The observed steel coating systems at the south digester lid appear to be performing well at this time. The isolated areas of corrosion appear related to areas of localized coating damage, and are not a significant structural concern. As with all coating systems, additional deterioration will manifest over time, and periodic maintenance and eventual replacement will be warranted.

6.9. Steel Piping

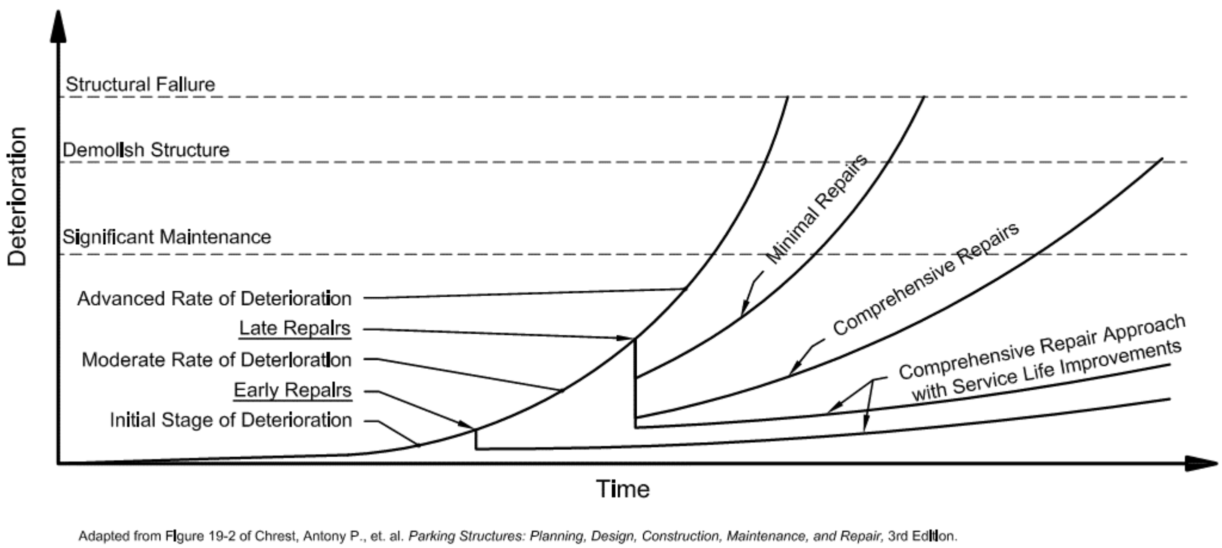
The piping inspections performed provided good coverage for uniform corrosion loss (i.e. oxygenated water corroding carbon steel). The readings show some degree of thinning, but no readings indicated imminent failure due to corrosion and wall loss. Additionally, the plates installed to cover prior leaks were not located exclusively at or near weld seams, suggesting that the corrosion mechanism is not strongly electrolytic.

Based on our observations and measurements, and the service conditions expected, the most likely cause of the previous leaks is a broad category of ‘under-deposit’ corrosion, which can be the result of Sulfur-Reducing Bacteria (SRB’s) or simply solids adhering to the wall of the piping and locally changing the corrosion behavior of the steel. The observations made to date provide a reasonable basis to conclude that the piping is generally Fit For Service, but that future leaks can (and will) appear with little warning. In contrast, demonstrating that *all* corrosion spots, similar to those which have likely caused past leaks, have been identified would require a very thorough inspection. This inspection would require approximately one measurement per 0.25 square inch (0.5-inch grid) to find and quantify each corrosion location. This could be done manually, or with Automated Ultrasonic Testing (AUT) in the ‘C-Scan’ mode. In order to protect against all future leaks, the C-Scans would likely need to be repeated on an annual or bi-annual basis as sludge deposits can form anywhere in the piping system, and progress rapidly. Based on the limited level of risk, and the extraordinary cost of full-coverage UT thickness scanning, it is not likely cost effective to take that approach over a repair as-needed approach.

7. SERVICE LIFE DISCUSSION

Service life is a term that often means different things to different entities. As such, a common understanding or definition of service life expectations of the existing structures must initially be defined based on their unique requirements. For example, criteria may be based purely on a structural basis (i.e. ensuring that the capacity of a given structure does not fall below required load demands), or it may be based on performance concerns that would affect day-to-day operations (i.e. a maximum quantity of concrete spalls falling into the process water that would ultimately result in a shut down or excessive maintenance; or concrete spalls falling and damaging equipment or injuring personnel). Similarly, for WJE to identify appropriate repair approaches that provide the performance to meet the remaining service life expectations for the facility, we first need to define what that remaining life is, whether it be another 5 to 10 years of overall service life, or 30 years. The duration expectations can have a significant impact on the applicable recommendations for repair scope and timing. For the purposes of this report, we have assumed that an additional 30 years of service for the various structures is the ultimate goal of the CGJ for the WWTP.

While our visual survey provides an indication of the current distress, and non-destructive measures give some indication as to the potential for future deterioration, these methods alone cannot provide information needed to refine recommendations, such as the material properties of the concrete, or the mechanism of the observed distress and potential latent distress not readily detectable. This additional information would be obtained from a more detailed assessment and supplemental laboratory study. Once this information is gathered, we can refine our estimation of where the structures lie on their deterioration curve. Furthermore, this additional information also allows us to work with the CGJ to determine when it is most appropriate to undertake a repair project, and the ultimate scope of that project. As can be seen in the deterioration plot shown below, different timing and extents of work can help to slow the rate of deterioration, and therefore extend the remaining service life.



Deterioration vs. Time Curve

8. REPAIR RECOMMENDATIONS

Based on the information contained within the initial RFP, as well as our follow-up conversations with the CGJ, we understand that the CGJ desires prioritization for addressing the existing distress by having them generally categorized into 'High', 'Medium', and 'Low' priorities. However, in order to most effectively characterize the priority of repairs, a methodology should be established for refining these priorities. The CGJ should consider numerous variables when determining these repair priorities, including structural deterioration, operations impact, safety hazards, environmental impact, direct costs, indirect costs, future capacity needs, remaining service life expectations, and others. Many of these factors are outside of the scope of our structural assessment, for which our main focus was structural deterioration. As such, our prioritizations should be used by the CGJ to aid in the development of a larger and more comprehensive prioritization matrix for repairs at the facility.

The remedial repairs recommended by WJE have been categorized in terms of priority for each individual structure, given the extent of structural deterioration observed during our visual assessment, and our experience with similar structures. As the visible distress during our assessment was limited, internal distress mechanisms which were not visually discernable cannot be accurately accounted for at this time, and warrant further investigation. Therefore, the discussion and prioritization of remedial options offered in this report are based on our experience with similar projects, our current understanding of the underlying distress mechanisms that have manifested thus far, and assumed understanding of the expected remaining service life for the WWTP. In many instances there are alternate approaches which could be considered, but we have selected the one that best suits our understanding of the goals of this project. Please refer to Appendix G for conceptual design repairs, as discussed in further detail below.

8.1. Concrete Repairs

8.1.1. Typical Concrete Repairs

The areas of noted concrete distress at all vertical and soffit surfaces (spalling, delamination, etc.) should be repaired, including at the two Aerobic Digester stairwells. From a structural standpoint, repairs to the delaminated topping at the Raw Sewage Pump Station or Aeration Basin Blower Room are not necessary. However, the noted deterioration will only continue to progress, and consideration should be given to replacing the toppings prior to a more global deterioration that may lead to instability of the piping supports and/or hazards caused by spalled concrete and an uneven walking surface.

For areas that were not able to be visually surveyed (i.e. the interior surfaces of the various digesters and basins), the quantity of concrete distress is unknown. Based on the overall limited distress that was observed throughout the structures, we have assumed that distress at the interior surfaces is similar and limited. Quantities for repair have been assumed as 1% of the total surface area for these un-surveyed areas, and are quantified only for the basis for inclusion with a potentially installed coating system.

The concrete repairs can be designed and installed to have a service life similar to that of the remaining adjacent concrete. While the concrete repairs themselves should not require any ongoing maintenance, if no action is taken to help extend the service life of the adjacent parent concrete elements, through installation of coatings or other preventative measures, additional concrete areas requiring repair will manifest throughout the structure's extended service life, which will likely become more frequent and widespread as time progresses. However, the extent and timing of this additional adjacent distress is uncertain as it requires additional knowledge as to the root cause (i.e. is the current distress global due to increased contamination of chlorides or other elements, or is the distress local due to imperfections such as low cover or deteriorated waterstops at piping elements, etc.)

8.1.2. Atypical Concrete Repairs

8.1.2.1. Aeration Basin Guardrail Post Spalls

Work to repair the spalled areas at the guardrail posts generally aligns with the typical concrete repairs described above. The service life of these repairs should be expected to be on the order of 10 to 15 years, and given the likelihood of additional distress to develop at other non-repaired posts on a regular basis, this work should be anticipated to require repeating once every couple years.

8.1.2.2. Anaerobic Digester

As the existing constructed conditions of the exterior panels are not yet fully understood, they should be further investigated through the creation of exploratory openings and review using an aerial lift, and the structural analysis can be refined at that time. If this additional work is not performed, or the refined analysis indicates potential issues, then the panels should have tiebacks, similar to those originally specified, installed throughout the panel in a grid pattern. These ties would resist any further bowing of the panels and thereby reduce the risk of a panel potentially becoming dislodged as has reportedly occurred in the past. These tiebacks could be post-installed using a supplemental anchor, and would be spaced at an appropriate spacing across the panels to provide the as-designed continuous attachment. WJE recommends including an allowance for an additional investigation into the construction and attachment of these outer panels as well as installation of the supplemental anchors.

There would not be any maintenance associated with the installation of supplemental ties, and their service life should be comparable to that of the concrete walls to which they are attached. However, the condition of the insulation between the inner wall and outer panels is not well understood, and if moisture is present at this level it could result in premature failure of the supplemental ties. During the additional investigation and exploratory openings, the condition of this insulation should be reviewed. In order to further protect any supplemental anchorage, as well as the as-built connections, a sheet metal flashing cap should be installed on the coping to limit the amount of water able to enter the wall cavity below.

8.2. Moisture Protection

8.2.1. Typical Interior Protection on Tanks

Efflorescence and evidence of long-term through-wall moisture migration was noted at a majority of the structures that contain process water, despite previous crack repair attempts that were likely performed in an effort to mitigate such moisture migration. As described in Appendix B, corrosion of embedded reinforcing relies on exposure to moisture and oxygen, and is accelerated in the presence of chlorides and carbonation. Our scope did not include performing a detailed review on any of the digester or basin interiors in order to understand the extent of distress that may be present at a result of exposure to the process water. Therefore, we recommend that at a minimum, and as an initial first step, an in-depth assessment be performed at the interior of each of the tanks, which will include removal of core samples and laboratory testing. Given our experience with similar projects, we would expect that installation of a protective coating may be recommended on the interior face (process water side) of the applicable water-containing structures, in order to reduce moisture and process chemicals from entering into the concrete that may accelerate future concrete distress. However, results from a more detailed investigation may find that an alternate more cost-effective solution may be more warranted for a given structure, such as if the deterioration is extremely localized (due to shallow cover over reinforcing bars), and a global coating system will not provide a significant benefit. In addition, this further study may help to determine if coating the entire interior surface is necessary, or possibly just specific areas in or adjacent to the splash zone.

Installation of any coating will require regular on-going maintenance to repair localized damage and account for wear and deterioration. If this regular maintenance is performed once every few years, a service life on the order of 10 to 20 years could be achieved prior to needing a complete removal and replacement of the coating. However, service life is ultimately dependent on the elected coating system, which can vary widely in initial cost, so the final selection of a coating system will need to take into account the desired service life for the structures as defined by the CGJ. Installation of any protection to the interior surface of the concrete structures will require that the selected structures be taken out of service for an extended period of time, not only to allow for the required preparation of the surface and potential associated concrete repairs, but also to allow for the required curing time of the system. Typical durations could be decreased to some extent, but this would require additional cost to accelerate the construction schedule. As such, in addition to a defined service life, the CGJ will also need to consider the cost benefit of placing various structures offline, and the ramifications to the process plant at a whole.

8.2.2. Atypical Protection on Tanks

8.2.2.1. Primary Clarifiers

Due to the extent of the observed paste erosion at the Primary Clarifiers, the clarifiers would benefit from installation of a coating system on the interior surface (process water side). Without additional laboratory testing, the required timeframe before a coating is warranted is unclear. If the paste erosion is allowed to continue for a prolonged period of time, and potentially worsens to a point where the interior layer of reinforcing begins to corrode and spalling occurs, additional conventional concrete repairs will be needed to restore the structural integrity of the walls prior to installation of a coating, which will increase the cost and duration of the overall repairs. Additional surface preparation may be required at the clarifiers prior to installation of a protective coating system. This preparation will likely include installation of a surface leveling compound or additional base layers of a coating system due to the existing roughened surface profile, and cleaning of the concrete surface to ensure that it is compatible with the selected coating or liner system. Prior to installing a coating, we recommend performing laboratory testing to confirm the depth of the affected concrete and ensure the reinforcement has not been affected.

Consideration should also be given to installing some sort of gasketed or barrier system between the domed roof structure and the top surface of the concrete wall, in an effort to prevent process water condensate from being able to reach and drip down the exterior face of the clarifier walls, further propagating the observed distress at the exterior concrete surfaces at the roof nodes. During installation of a gasketed system, the connections for the domed roof structure should also be inspected for the presence of corrosion or section loss, and replaced as necessary.

8.2.2.2. Sludge Processing Unit Blending Tank

The durability and quality of the supplemental shotcrete wall at the north and west interior walls of the blending tank should be further evaluated prior to installation of a suitable protection system. Specifically, it should be confirmed that this shotcrete wall provides a suitable substrate for a coating and is sound and mechanically attached to the structural wall behind. WJE recommends that an allowance for such an investigation be established prior to proceeding with a coating campaign.

8.2.3. Miscellaneous Sealant

Multiple full-thickness cracks were observed at the Aeration Basin catwalks located above the blower room, with evidence of moisture intrusion through some of the cracks. To mitigate further moisture intrusion through the slab, we recommend that these topside cracks be routed and sealed. Installation of any sealant will require routine maintenance and replacement, as these exposed sealants will deteriorate over time. A service life on the order of 5 to 10 years can be expected for these sealant joints.

8.3. Steel Repairs

8.3.1. Blending Tank Steel Framing Distress

Repairs to the steel framing will likely require that the blending tank be shut down, due to safety precautions of personnel performing repairs from the open-air framing above and the potential for debris entering the tank. Areas where existing corrosion is present should be addressed, and would generally consist of the following work:

- Remove all corrosion buildup from the steel framing members.
- Remove all existing coatings in the area to be addressed.
- Repair any areas of damaged steel or welds.
- Remove and inspect all attachment hardware for signs of section loss due to corrosion. Replace any damaged hardware, bolts, or steel plate washers.
- At areas where galvanic corrosion is suspected (i.e. the exterior steel plate washers and interior steel framing), replace the stainless steel through-bolts with mild steel bolts.
- Install a new protective coating.

8.3.2. Anaerobic Digester Steel Roof Lid Distress

Typical distress to the Anaerobic Digester steel lid included isolated locations of corrosion and flaking of the coating. It is recommended that the lid be cleaned, the surface prepared using power tools, and the existing system be over coated, with spot priming at areas of exposed steel substrate. We do not recommend complete removal of the coating system as the existing coating appears to be generally well bonded. Given the concerns over flammable gases contained by the tank, it is recommended that the tank be taken out of service prior to implementing these coating repairs.

Installation of any coating will require regular on-going maintenance to repair localized damage and account for wear. If this regular maintenance is performed once every few years, a service life on the order of 10 to 20 years could be achieved prior to a full re-coating.

8.3.3. Piping Distress

Concrete deterioration, efflorescence, and evidence of more progressed moisture ingress was observed at the various pipe inlet locations. WJE recommends that an allowance be established to investigate the construction of the seals at the inlet pipes, and at a minimum perform concrete and coating repairs at these locations.

9. ENGINEERS OPINION OF PROBABLE COSTS

The costs provided in Appendix H are our opinions of order of magnitude costs based on the estimated quantities, which are based on extrapolations of our observations during our visit or assumed values where visual observations were not able to be made during our assessment (i.e. inside of the various process water-containing structures). Due to the often localized nature of concrete deterioration, and given the limited nature of the observed distress, the quantities listed should be considered in relative magnitude only (i.e. 100 square feet of repairs verses 1,000 square feet of repairs). Additionally, deterioration, and in particular, spalled and/or delaminated concrete areas, are prone to significant quantity increases due to the items discussed above. Actual costs may vary considerably depending on economic conditions, the actual repair design and specifications, final quantities for the work, and method for which the work is undertaken (i.e. during a shutdown of portions of the plant, or as a part of a project where the items are kept online). For these reasons, we suggest that any project include a contingency to help cover the costs associated with some of these conditions.

Costs associated with access and general conditions (permits, project management) have been provided based on the estimated construction costs and receipt of pricing from repair contractors for similar work in recent years. However, WJE has not estimated a reserve cost for future maintenance or repair. We recommend that once repair approaches and service lives are defined, a reserve fund estimate be developed. Furthermore, direct and indirect costs associated with specific recommendations were not considered by WJE in the prioritization, but may influence the CGJ's approach to implementing the recommendations. Due to the other variables necessary to consider as a part of any repair project, the presented costs should not be considered final budgeting numbers.

10. CLOSING

Overall, the structures and elements were in generally good condition considering their roughly 30 years of service. Several elements would benefit from typical repairs, maintenance, and installation of protective systems to address current distress and minimize future deterioration.

WJE's findings and recommendations are based on the observations and representative conditions at the time of our assessment as described herein, and our understanding of the CGJ's goals. Other conditions may exist, or develop over time, which were not found during our investigation. We recommend that regular inspections be performed, and recommendations updated accordingly. WJE reserves the right to modify our findings should additional information become available.

FIGURES

Figure 1. Typical coating installation at interior wall surfaces

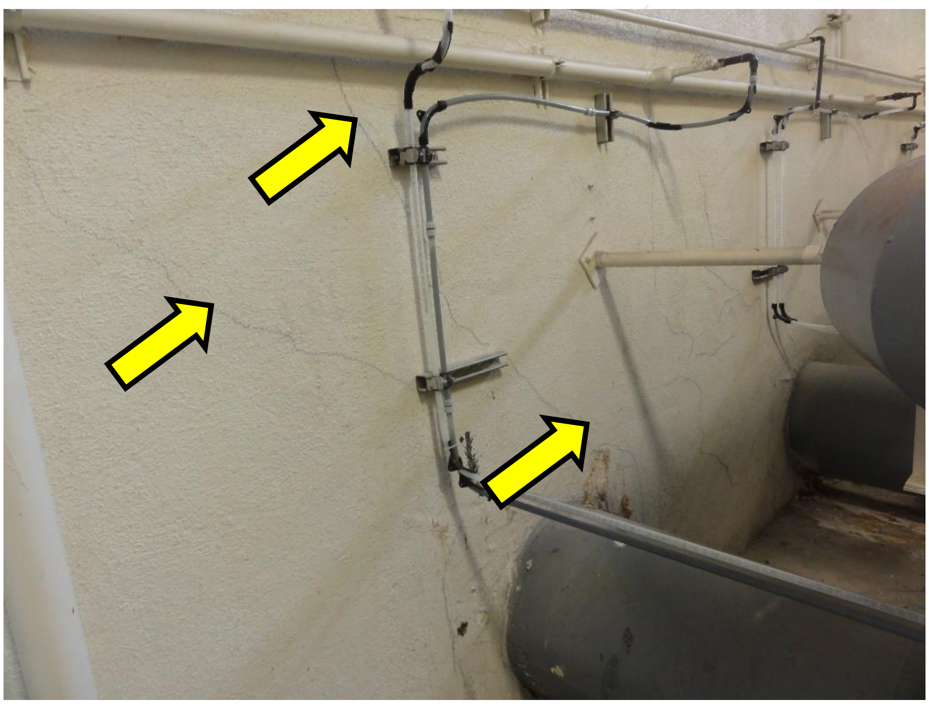


Figure 2. Noted cracks at the Raw Sewage Pump Station perimeter wall (demising wall between the pump room and the wet well), traced in blue

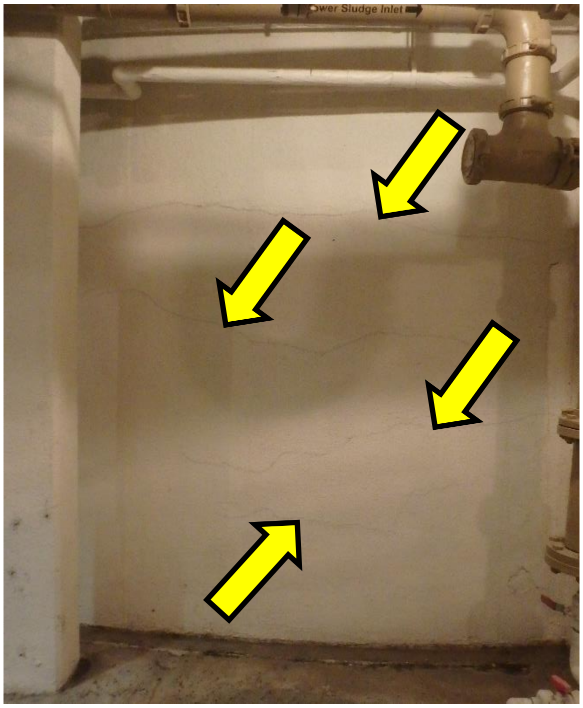


Figure 3. Noted cracks at the Anaerobic Digester interior wall, traced in blue

Figure 4. Sounded delaminated coating adjacent to inlet pipe

Figure 5. Map patterned cracking at exterior of Primary Clarifier walls

Figure 6. Map patterned cracking at lower half of Aerobic Digester perimeter walls

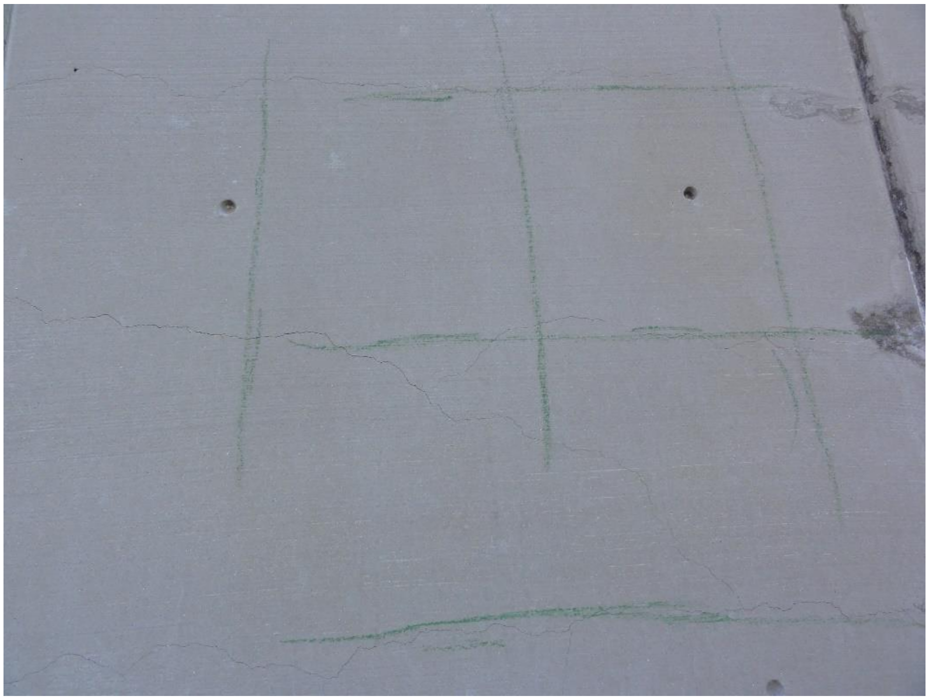


Figure 7. Typical longitudinal and transverse cracking, aligning with locations of embedded reinforcing (reinforcing traced in green)

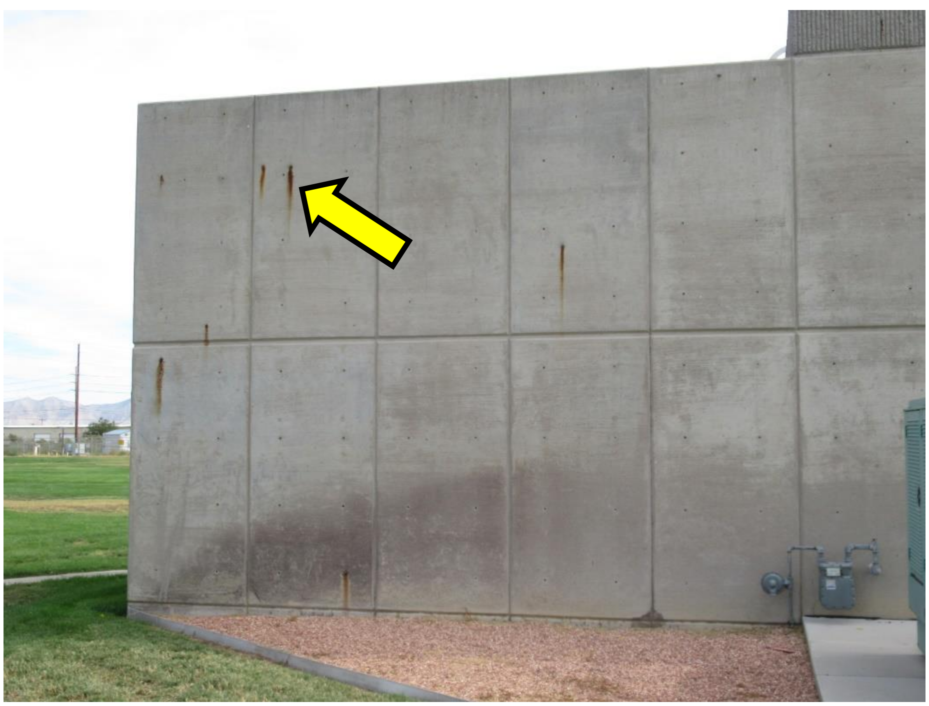


Figure 8. Typical and isolated corrosion staining at aggregate particles


Figure 9. Flaking of surface applied parge coat at Aerobic Digester perimeter wall


Figure 10. Typical surface staining at base of wall, adjacent to landscaping irrigation

Figure 11. Overall view of the pump slab room, as viewed from the ground floor slab

Figure 12. 15 mil crack observed in concrete substrate, that had not yet propagated through the wall coating

Figure 13. Coating delaminations at the base of the interior walls

Figure 14. Efflorescence and mineral deposits beneath inlet piping

Figure 15. Measurement of a crack at the topping slab of the pump room

Figure 16. Noted delamination, adjacent to a pipe support pedestal, highlighted in blue

Figure 17. Noted delamination, adjacent to the central trench drain, highlighted in blue

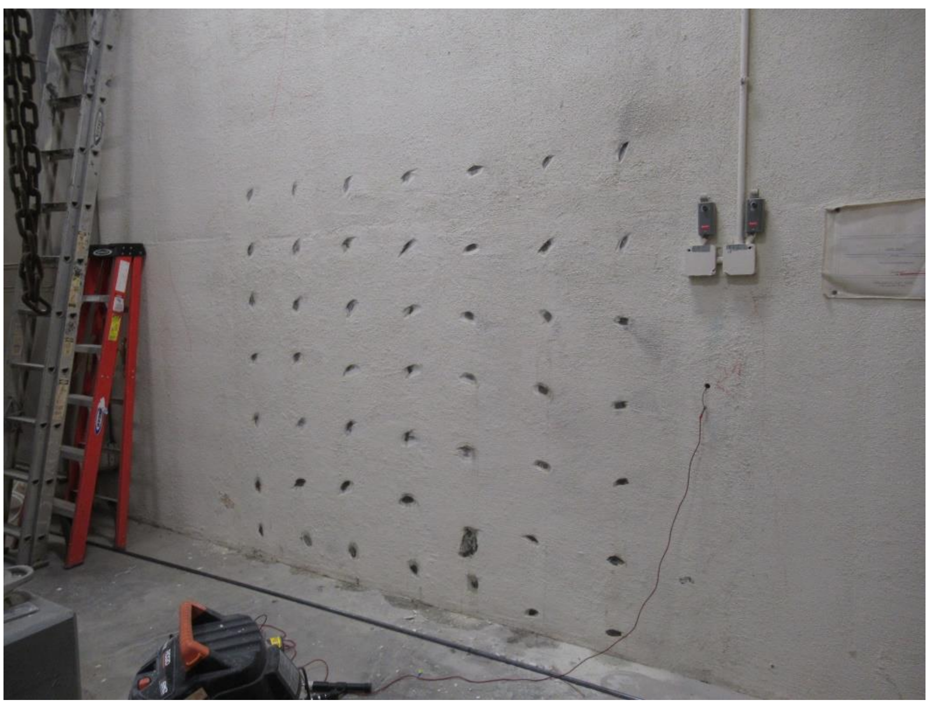


Figure 18. Overall view of HCP testing at south elevation wall

Figure 19. Overall view of HCP testing at north elevation wall

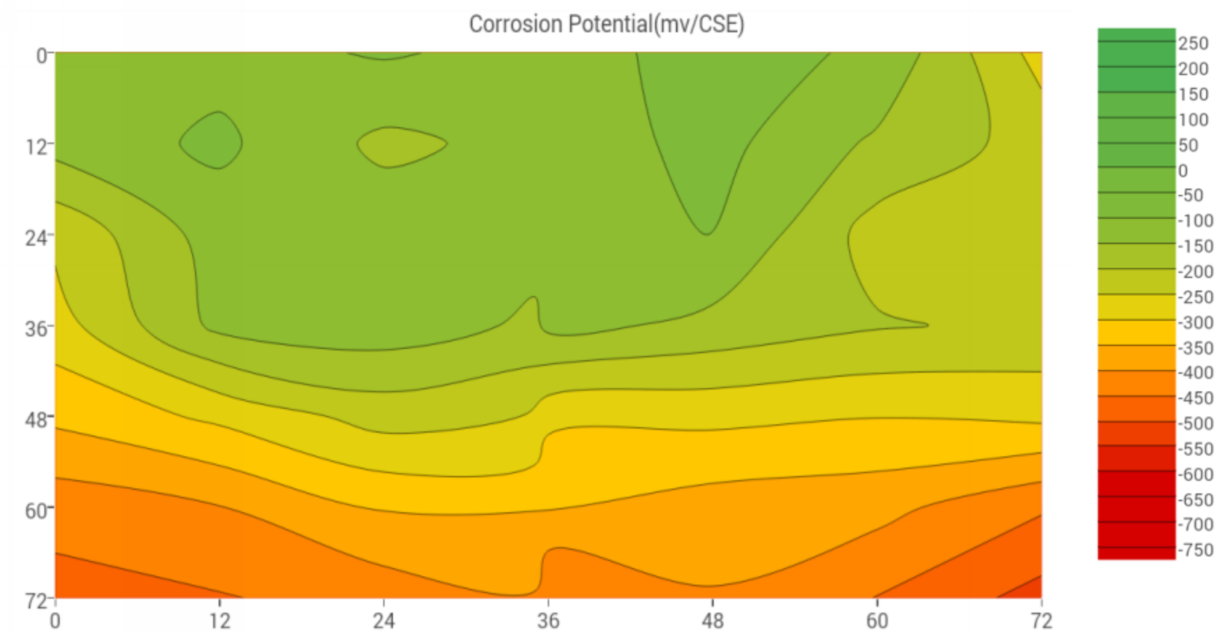


Figure 20. Half-cell potential data at the south elevation interior foundation wall (shown in Figure 18). The color scale is in mV and the reference electrode is a CSE

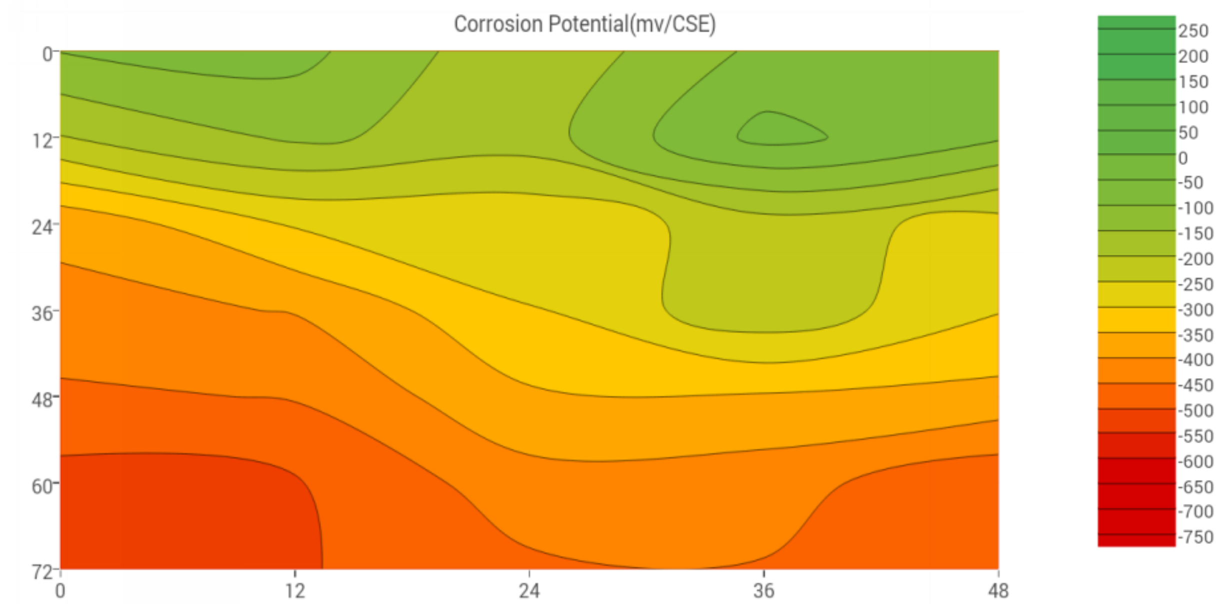


Figure 21. Half-cell potential data at the north elevation interior foundation wall (shown in Figure 19). The color scale is in mV and the reference electrode is a CSE

Figure 22. Core location through topping slab crack

Figure 23. Topside of structural slab present after removal of topping slab. Note that the topping slab crack does not continue into the structural slab below.

Figure 24. WWR observed near the bottom surface of the extracted core

Figure 25. Overall view of the interior of the primary clarifier

Figure 26. Moisture staining present beneath roof attachment locations


Figure 27. Paste erosion within the effluent trough

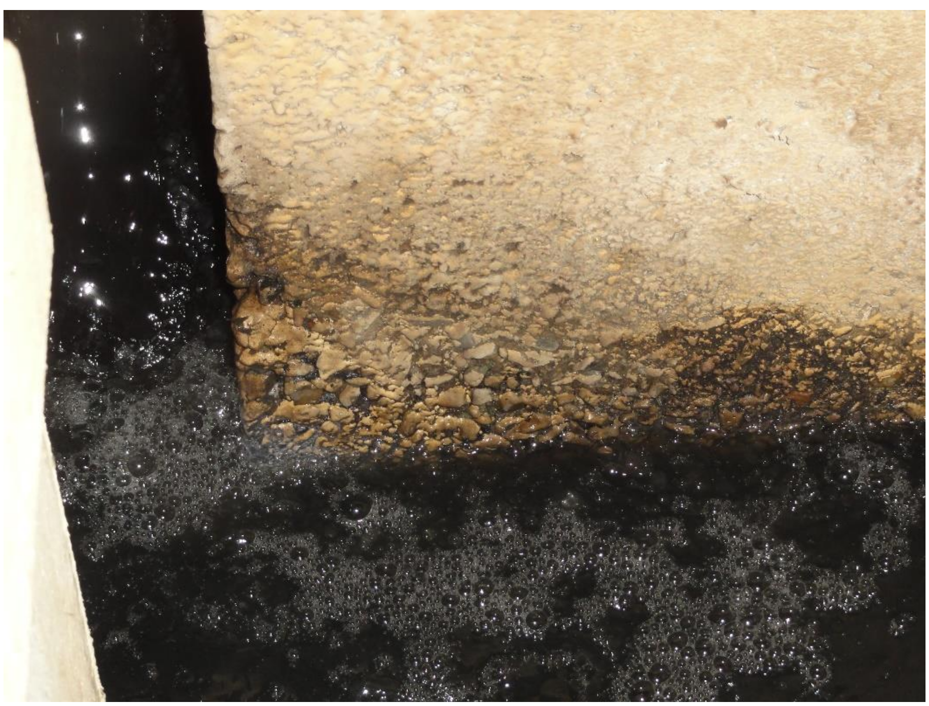


Figure 28. Paste erosion within the scum pit

Figure 29. Underside of roof attachment, with a 1-inch wide gap (arrow) between the roof framing and the top surface of the clarifier walls

Figure 30. Isolated exposed and corroded reinforcing bar

Figure 31. Paste erosion at exterior of clarifier walls

Figure 32. Overall view of the blower room, looking south

Figure 33. Overall view of the catwalks, looking north

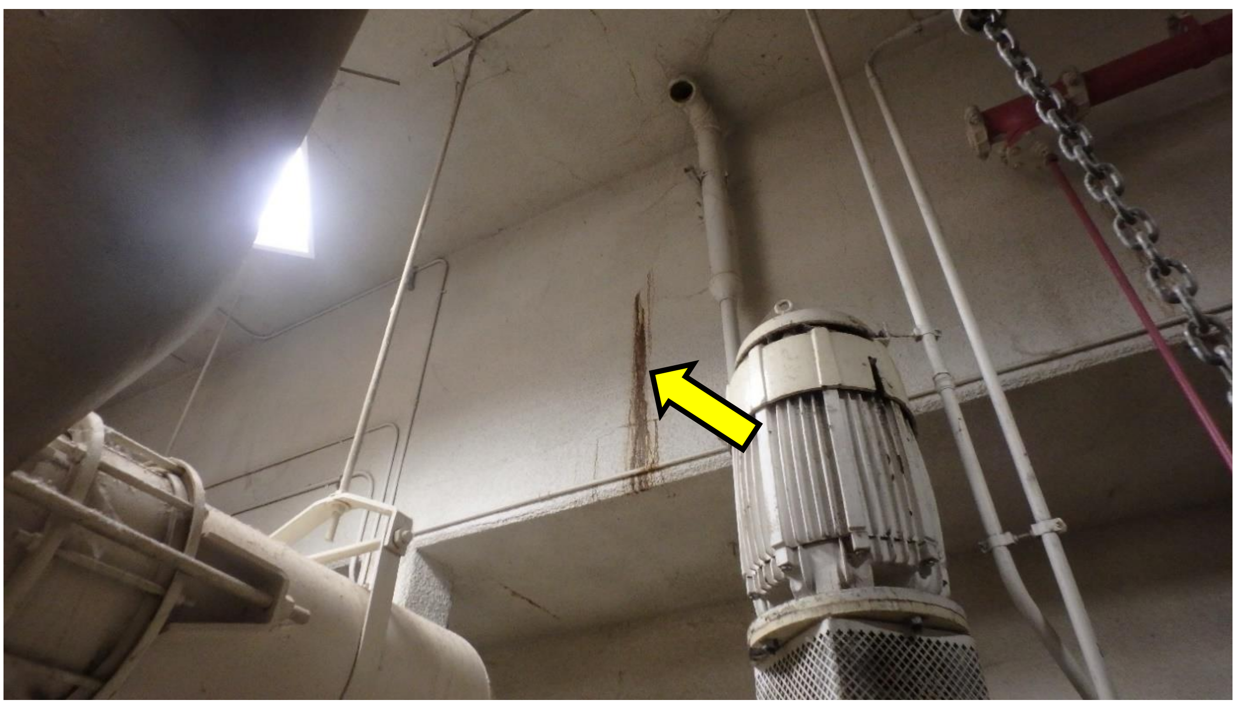


Figure 34. Staining at elevated trough

Figure 35. Re-entrant corner cracking at blower room skylight, as observed on the soffit of the ground floor slab

Figure 36. Re-entrant corner cracking at blower room skylight, as observed on the top surface of the ground floor slab

Figure 37. Typical topping slab cracking

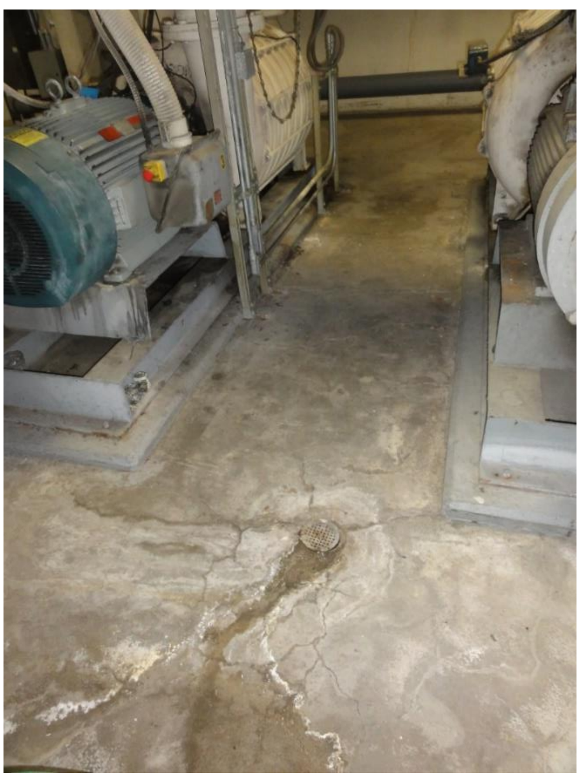


Figure 38. Evidence of ponding water at existing floor drain

Figure 39. Incipient spall at guardrail post embed

Figure 40. Previously installed sealant at incipient spall location


Figure 41. Previously installed sealant at incipient spall location


Figure 42. Overall view of the east elevation of the Aerobic Digester

Figure 43. Ground level stairs located at northeast corner of Aerobic Digester

Figure 44. Stairwell leading to Aerobic Digester catwalks

Figure 45. Previous crack repair attempt at the digester basin walls


Figure 46. Evidence of moisture intrusion and efflorescence staining at reveal joints

Figure 47. Evidence of moisture intrusion and potential organic growth staining at reveal joint

Figure 48. Actively leaking crack within reveal joint

Figure 49. Overall view of the soffit of the ground level stairwell, with noted cracking, spalls, and exposed corroded reinforcing

Figure 50. Up-close view of exposed corroded reinforcing at the soffit of the ground level stairs

Figure 51. Overall view of the soffit of the roof level stairwell, with noted cracking and spalls

Figure 52. Surface corrosion on the upper support bearing angles and plates for the roof level stairwell

Figure 53. Failed sealant joint between Aerobic Digester and Sludge Processing Unit

Figure 54. Sealant joint between the ground level stairs and the adjacent building face that had failed and was no longer in contact with both substrate surfaces

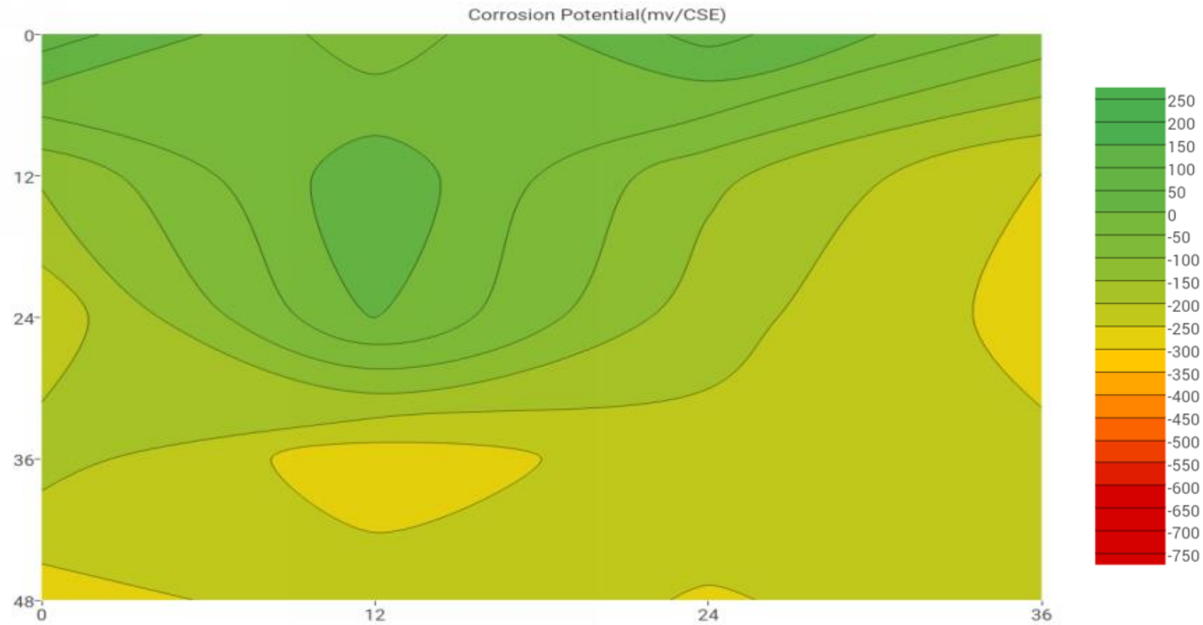


Figure 55. Half-cell potential data at the soffit of the aerobic digester stairwell (shown in Figure 49). The color scale is in mV and the reference electrode is a CSE

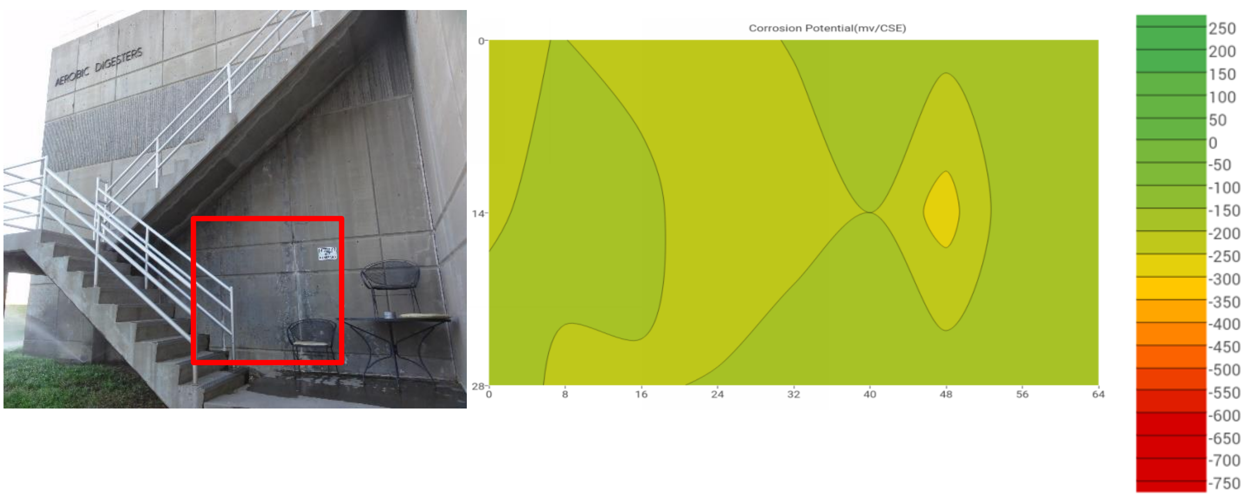


Figure 56. Half-cell potential data for the north wall of the aerobic digester. The color scale is in mV and the reference electrode is a CSE

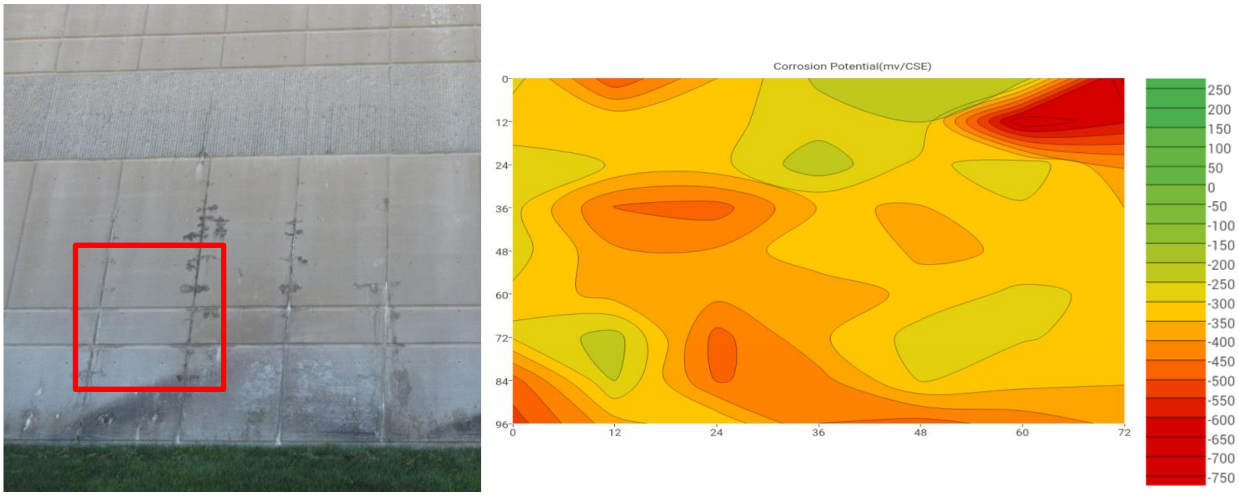


Figure 57. Half-cell potential data for the east wall of the aerobic digester. The color scale is in mV and the reference electrode is a CSE

Figure 58. Core sample location at east elevation wall, intersecting multiple surface cracks

Figure 59. Partial-depth core sample obtained from area documented in Figure 58

Figure 60. Exposed embedded reinforcing bar, with little to no surface corrosion present

Figure 61. Overall view of the northwest corner of the Sludge Processing Unit

Figure 62. Overall view of the open-air framing above the blending tank

Figure 63. Typical steel framing and attachment at north and west walls of blending tank

Figure 64. Surface corrosion on coated framing members

Figure 65. Surface corrosion on previously sawcut reinforcing, which was abandoned when concrete lid/roof was removed

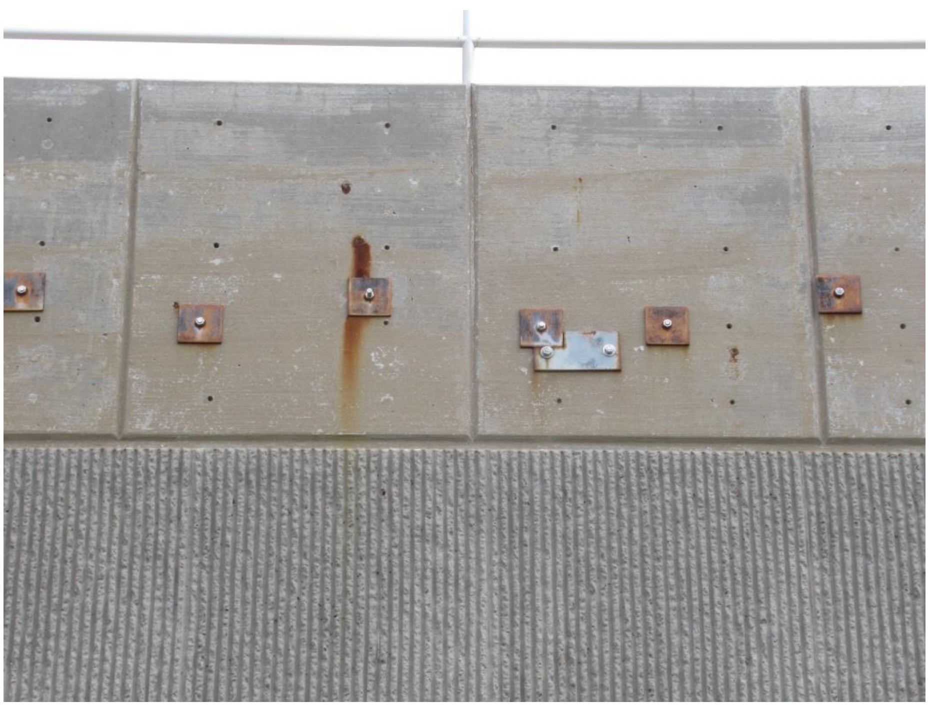


Figure 66. Corrosion of plate washers, as viewed from the exterior of the blending tank walls

Figure 67. Corrosion of plate washers adjacent to bolt attachments, as viewed from the exterior of the blending tank walls

Figure 68. Corrosion of plate washers adjacent to bolt attachments, as viewed from the interior of the blending tank walls

Figure 69. Corrosion on bolted connection for the interior framing support

Figure 70. Noted efflorescence and staining at northwest corner of blending tank

Figure 71. Noted efflorescence at panel reveal joint

Figure 72. Coating thickness correlated to corrosion distress, note black coating thickness measurements in mils

Figure 73. Overall view of the east elevation of the Anaerobic Digesters, with the Anaerobic Digester Building situated in the center

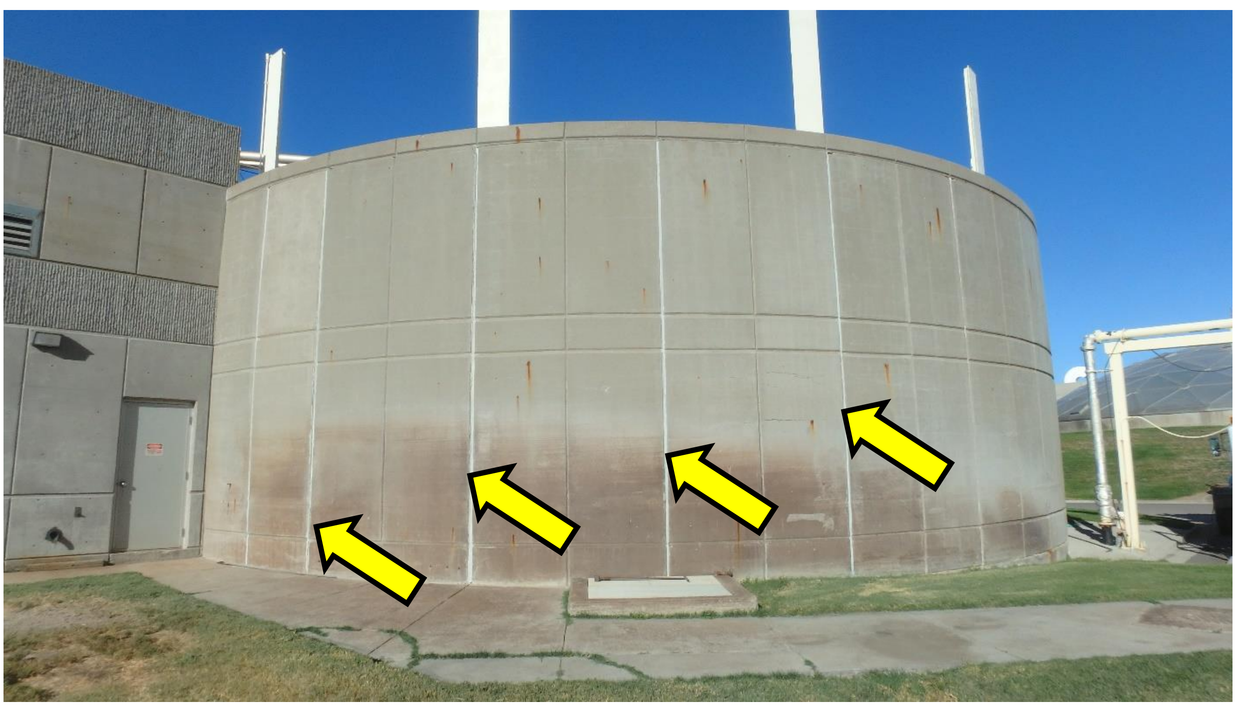


Figure 74. Overall view of the south digester, with exterior panels delineated by sealant joints (arrows)

Figure 75. Previous coating repair location at the south digester interior wall

Figure 76. Plant growth on north digester exterior

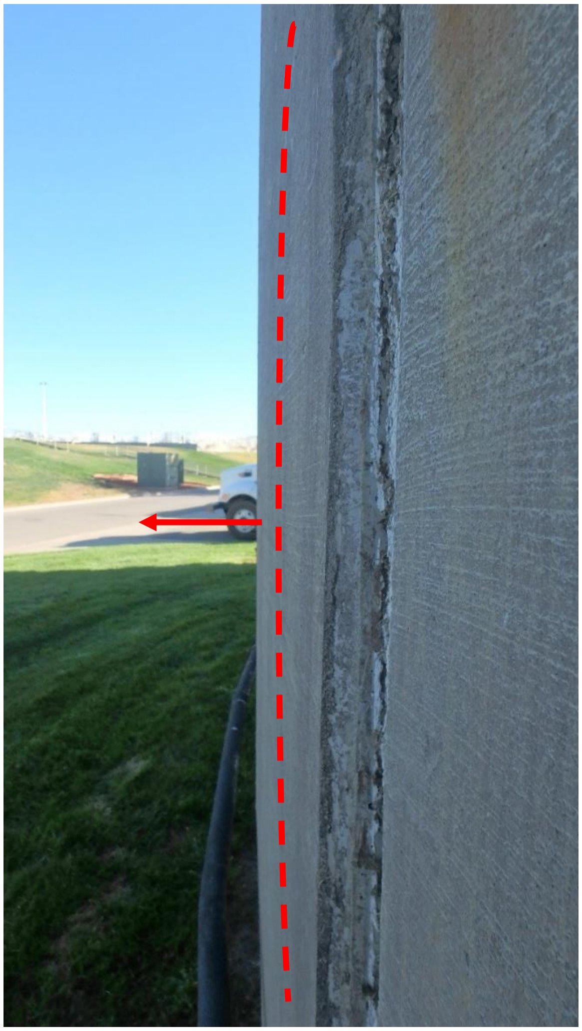


Figure 77. Outward bowing of panel in the background at a vertical sealant joint, with respect to the panel in the foreground. Arrow indicates direction of movement and dashed line indicates shape.

Figure 78. Panel top edge that had bowed approximately 1-inch outboard from concrete coping cap

Figure 79. Transverse cracking observed on multiple panels

Figure 80. Spalled concrete at upper corner of exterior panel

Figure 81. Spalled concrete at lower corner of exterior panel

Figure 82. Supplemental attachment bolts at one panel at the south digester

Figure 83. Longitudinal crack at the centerline of the concrete coping cap

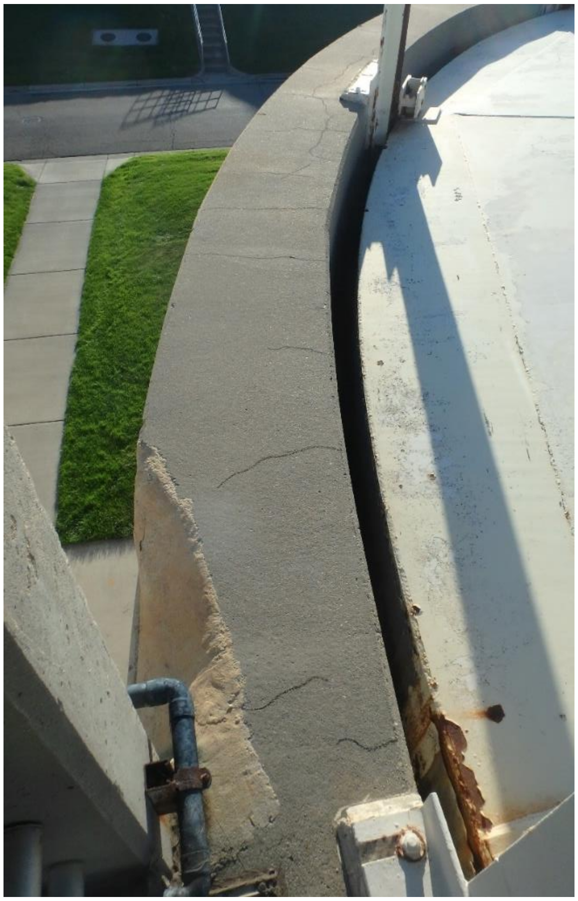


Figure 84. Transverse cracking at the concrete coping cap


Figure 85. Sealant joint that had failed in both adhesion and cohesion


Figure 86. Overall view of the coating on the top surface of the south digester lid

Figure 87. Overall view of the coating on the vertical surface "rim skirt" of the south digester lid

Figure 88. Peeling and flaking coating at south digester lid

Figure 89. Overall view of "X" tape cut at lid coating

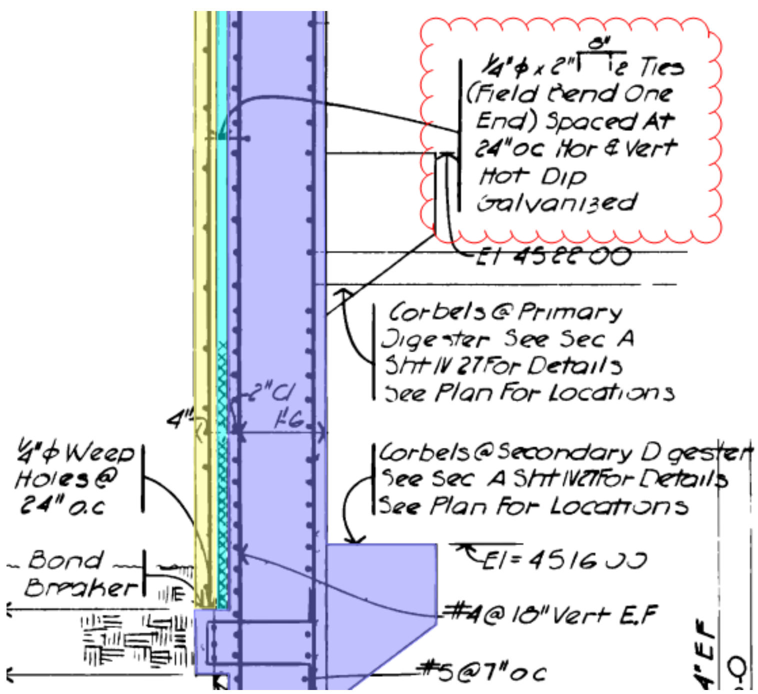


Figure 90. Detail A/IV-28, reproduced from original construction drawings. The exterior panels are shown in yellow, the interstitial insulation in blue, and the structural concrete framing in purple