TECHNICAL MEMORANDUM

Client:	City of Cashmere		
Project:	Sherman Reservoir Assessment		
Project File:	CA 211.038.22	Project Manager:	Ryan Peterson, PE
Composed by:	Shannon Emerick, PE and Ryan Peterson, PE		
Reviewed by:	Jon Conner, PE, SE, and Randy Asplund, PE		
Subject:	Sherman Reservoir Assessment		
Date:	November 21, 2019		

Signed: 11/21/2019

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Background

The City of Cashmere's (City) Sherman Reservoir is a partially buried, circular, reinforced concrete reservoir with a hopper-style bottom, constructed in 1974, and designed by Lee Johnson Associates, Inc., of Everett, Washington. As-constructed drawing records indicate that the tank has an interior diameter of 106 feet with 8-inch thick and 15.5-foot-tall walls, with the top approximately 8 feet above grade and the remaining 7.5 feet of the exterior wall buried, supported underneath by a circular thickened footing foundation. The hopper-style floor is 6 inches thick and slopes are at 4 horizontal to 1 vertical from the base of the walls (15.5 feet below top of concrete wall) to a flat interior area roughly 58 feet in diameter and 21.5 feet below the top of concrete wall. The floor is thickened to ten inches at construction joints and to 18 inches in the 5-foot-square area under each roof support column.

Originally, the tank had an elastomer roof supported by wood and steel trusses, glulam beams, and steel pipe columns. The ends of two glulam beams were each set into recessed seats in the concrete wall. Submersible well-style pumps are installed on the reservoir floor, with guide wires anchored to eye bolts near the top of the concrete walls for removal (high on the north interior and south interior portions of the wall.)

Based on oral records, around the year 1990, leakage was detected at the reservoir. The tank was drained, and a buried joint on the inlet/outlet pipe in the center of the floor was found to have separated. The City removed an approximately 6-foot-square portion of the floor, repaired the fitting

joint, and replaced that segment of floor, including joint filler around its perimeter. No significant leakage from the underdrain system has been noted since. The underdrain observation manhole was checked in 2019, and no water was observed.

In March 2019, the central portion of the wood and steel roof collapsed, with the ends of several trusses falling from their supports to the tank floor. The roof membrane remained intact, and the reservoir was left in service through the summer while a repair plan was developed. At the time of RH2 Engineering, Inc.'s (RH2) November 6, 2019 observation, the wood roof members and steel columns had been completely removed in preparation for tank improvements.

It is the City's intent to add a new roof and supporting columns to the existing concrete structure, provided the existing concrete structure is in good condition. The purpose of this investigation is to visually assess the condition of the remaining concrete portions of the concrete reservoir and to recommend next steps. The new roof has been designed by Bethlehem Construction, Inc., (Bethlehem) of Cashmere, Washington, and their engineer, Mr. Matt Leslie, SE, of Leslie Engineering, LLC, (Leslie Engineering) and will be installed by Bethlehem.

Investigation

RH2 visited the site to assess the condition on November 6, 2019, with Mr. Bruce Germain, Mr. Jason Williams, and Mr. Jesus Espinoza from the City of Cashmere Public Works Department, and Mr. Steve Croci, the City of Cashmere Director of Operations. Air temperature was in the range of 40 degrees Fahrenheit, and the central portion of the floor was covered in approximately ½-inch of ice.

Steel Elements

Severe corrosion of the interior fixed ladder (**Photo 1**) and the bottom fitting of the overflow piping (**Photo 2**) was observed. The upper portion of the ladder may be retained as a handhold and the more corroded bottom section may be removed. A new full height ladder will be installed in a different location. During the site visit, City employees expressed the desire to avoid replacing the overflow piping, if possible. The eye bolts that suspend the pumps are above the normal water line and appeared to be free of significant corrosion, although limited access did not allow their close inspection.

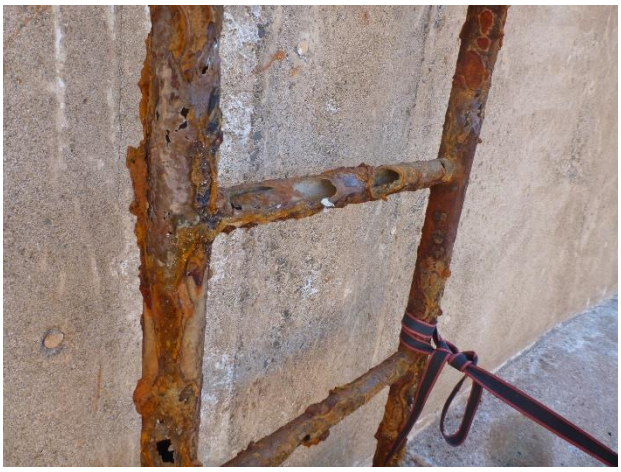

Photo 1: Existing Ladder

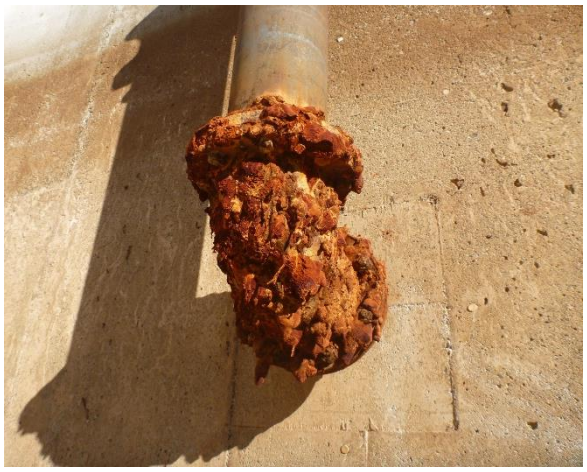

Photo 2: Existing Overflow Piping

Concrete

No obvious signs of concrete deterioration were observed at the wall interior face or the exterior face. No significant cracks in the walls were noted. Some areas of rock pockets were observed at the interior face of the wall, but do not appear to be actively leaking or a significant structural concern.

Rust-colored sediment, likely from the corroding steel distribution mains, covered much of the interior face of the floor (**Photo 3**) and walls, particularly in the range of the normal operating level of the tank (**Photo 4**) and at surface irregularities in the wall and floor. This made it difficult to identify areas of possible concrete spalling and rebar corrosion. High on the northeast interior face of the wall (also **Photo 4**), near the overflow pipe, a roughly 2-foot-long area has the characteristic appearance of concrete spalling and rebar corrosion, although this is well above the water level.

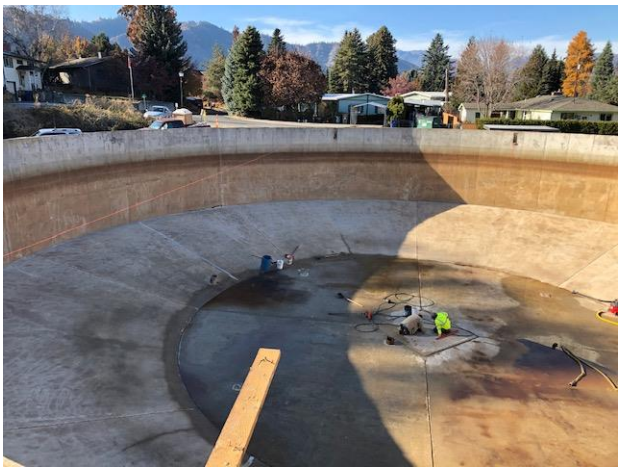

Photo 3: Rust Sediment at Tank Floor

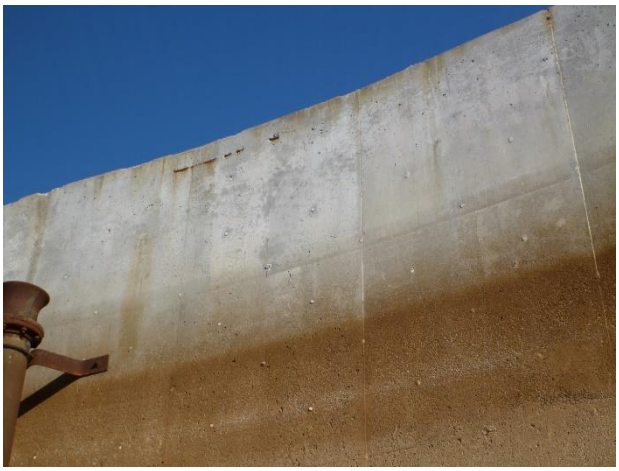

Photo 4: Rebar Corrosion at Top of Wall

At the southwest portion of the wall and floor intersection there is a roughly 12-foot-long region of potential rebar corrosion (**Photo 5**). At that location, it was not possible to discern whether the rust sediment was a result of rust sediment being drawn through the concrete from interior to exterior (due to hydrostatic loads and concrete porosity), or the result of rebar corrosion and associated concrete spalling inside the wall. Using the tip of a screwdriver, one spot in this region (**Photo 6**) was abraded, and despite abrading off approximately ½-inch of rusty concrete, no clean concrete or clean bar was reached. Numerous discolored points on the floor and several other points on the wall could also be signs of rebar corrosion, although none appeared significant.

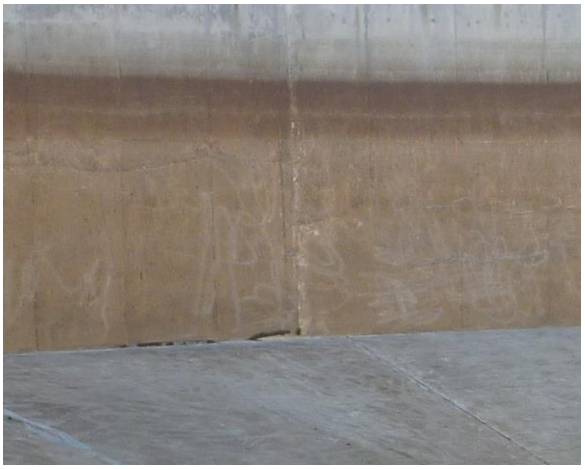

Photo 5: Area of Potential Rebar Corrosion

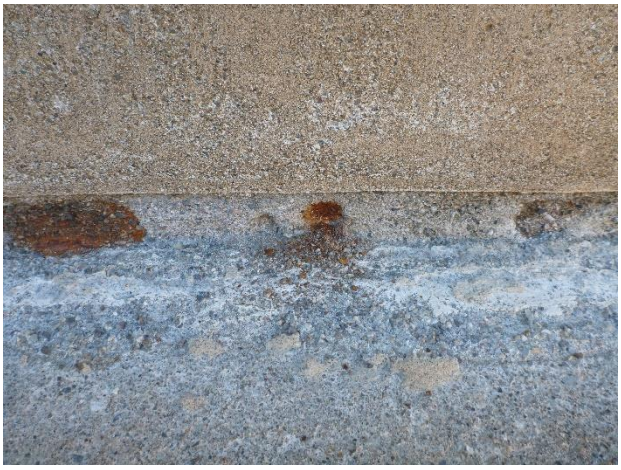

Photo 6: Potential Rebar Corrosion

At the top surface of the walls, the existing anchor bolts have been removed to within a fraction of an inch above the concrete surface. All other roof elements have been removed as well. At four locations high on the interior face of wall, the previous recessed glulam beam seats are exposed.

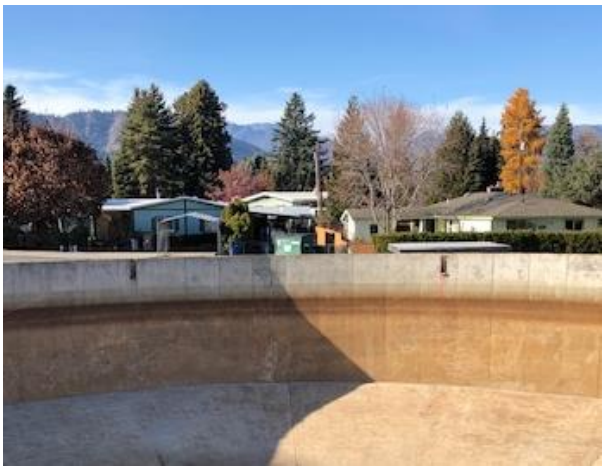

Photo 7: Existing Beam Seats

Photo 8: Existing Wall Exterior

The exterior paint is badly weathered including peeling, blistering, and staining (**Photo 8**) although this is considered a cosmetic rather than structural issue.

To check concrete strength, physical core samples were taken for testing. Construction Special Investigation (CSI) in Wenatchee took two 3.7-inch diameter floor cores on November 13, 2019 and tested them for compressive strength with results of 5,933 pounds per square inch (psi) and 8,457 psi (test results are included as **Appendix A**). The test results indicate that the concrete should be more than sufficient to support the new roof.

Removing the first core sample showed a mix of aggregate and fines directly below the floor slab, with the material nearly impervious to drainage. After drilling the second core sample, the core dropped approximately ½-inch, and standing water on the floor drained quickly into the hole. The core was removed, and the hole inspected. Clean round aggregate with no fines was seen below the slab, with a ½-inch to 1-inch gap between the slab and the aggregate. Due to this unexpected soil condition, CSI was requested to return on November 14, 2019, to obtain cores at each corner of the proposed

column support footings to inspect soil conditions. On November 15, 2019, Mr. Ryan Peterson, PE of RH2 and Mr. Kevin Tooley of Bethlehem observed the completed 3.7-inch diameter holes, which were completed in areas with floor thicknesses ranging from 6 to 11 inches. Of the 16 cores, only 3 (which included the prior core) implied a ½ to 1-inch void under the slab at those locations. At the time of writing this technical memorandum, Bethlehem is developing options to address the possible voids.

The existing joint material/sealant at joints in the floor were observed to be well-adhered to the concrete and did not appear to be degrading. Previously installed sealant over floor cracks (**Photo 9**) appeared to be in good condition and showed no sign of dampness or leaking. However, several un-sealed cracks (**Photo 10**) were observed in the floor slab. The cracks appeared mostly filled with silt and may not leak significantly, although no leak testing of the reservoir has been performed to verify the possibility.

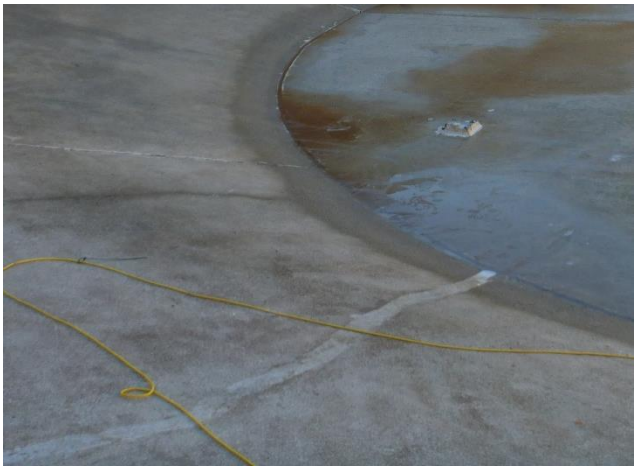

Photo 9: Previously-Sealed Floor Crack

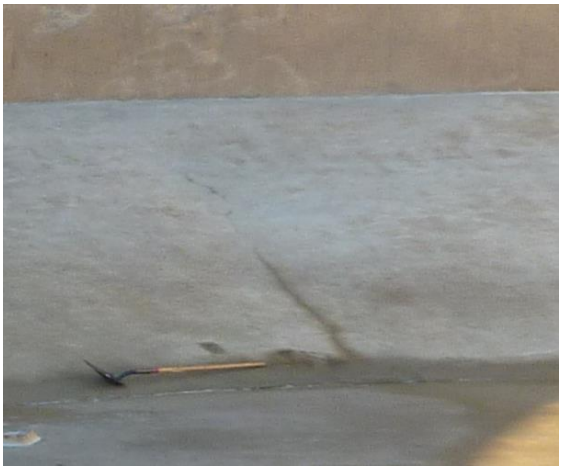

Photo 10: Actively Leaking Floor Crack

Proposed Roof Improvements

The proposed reservoir roof has been designed by Bethlehem and Leslie Engineering. The proposed reservoir roof improvements include a pre-cast concrete roof composed of pre-cast concrete columns and cast-in-place column bases at the same locations as the previous steel columns, pre-cast concrete beams installed at the previous beam locations, and pre-cast hollow-core roof panels. Seats for the proposed beams will be sawcut into the top of the wall and the areas surrounding the beam seats will be patched. At the tank interior, the beams will be supported by the pre-cast concrete columns. The pre-cast hollow-core concrete slab panels will span between the wall and beams.

Conclusions and Recommendations

The concrete walls and floor of the Sherman Reservoir are generally in good condition and are expected to be serviceable for many years if spot locations of rebar corrosion are effectively halted. The expected additional life of the reservoir can be assumed to be at least 30 years, and possibly 50 years, if recommended rebar protection repairs are completed.

Steel Elements

RH2 recommends that, in addition to the ladder already slated for replacement, the overflow piping be replaced or cleaned and painted to reduce rust sediment in the water, thereby improving the ability to inspect for rebar corrosion.

Concrete Elements

At all spots of rust-colored debris, which could indicate rebar corrosion, RH2 recommends that the area be ground back to clean concrete and/or steel to confirm whether the rust-colored debris is the result of rebar corrosion. If it is discovered that rebar corrosion is the source of the debris, it is recommended that the bars be ground clean to a distance of 6 inches minimum beyond any sign of corrosion and then patched/sealed to discontinue the corrosion that, left unchecked, will continue along affected bars and potentially affect other bars that come in contact with the affected bars. If rebar corrosion is not discovered to be the source of the sediment, the area may be patched or sealed without further exploration.

Paint blistering and other staining at the wall exterior is considered a cosmetic issue rather than a structural issue and the City may choose to blast or otherwise abrade the stains and remove blistering paint. If stains are difficult to remove, darker gray or tan concrete stain could be applied to the exterior to mask discoloration. Because concrete is porous, painting typically does not last as long as on other common construction materials, and repainting every 10 to 20 years should be anticipated.

The floor cores should have a 1-inch layer of bentonite installed no less than 2 inches above and no more than 5 inches below the floor surface before filling with grout. Alternately, the cores can be filled with a crystalline patch such as Xypex Patch-n-Plug.

To prevent leakage, it is recommended that the cracks in the floor be sealed. Various methods are possible, listed as follows in order of effectiveness and difficulty. Any caulking or epoxy products must have National Sanitation Foundation (NSF) 61 certification.

1. Cover joint with membrane elastomer strip, epoxied at the edges. This provides a flexible repair that is not affected by minor concrete movement. Suggested product: Sika Combiflex SG system.
2. Route out the crack and fill with epoxy, crystalline grout, or caulk. Any of the products may work since the cracks do not appear to be moving, although epoxy can translate a moving crack through it. Suggested products: Xypex Patch-n-Plug, Euclid Tammsflex NS.
3. Clean the surface and apply a coat of epoxy, crystalline patch, or flexible patch, similar to what is seen on existing previously repaired cracks in the reservoir. This system is the most susceptible to damage from cracks that are still moving. Suggested product: Euclid Hey'Di SB/K-11 system.

Since the cracks do not appear to have a structural impact, but may still move slightly, especially when the reservoir is refilled, RH2 recommends either the first or second method.

Appendices

Appendix A – Floor Core Test Results

Appendix A
Floor Core Test Results

CSI:Construction Special Inspection

Materials Testing & Special Inspection

1250 N. Wenatchee Ave. Ste H135

Wenatchee, Wa 98801

(509)664-4843

CONCRETE CYLINDER REPORT ASTM C-39-05 & C-617

CLIENT	RH2 Engineering	LAB NO.:	**7230**
PROJECT NO:	19-229	TESTED BY:	D. Nyland
PROJECT:	Sherman Reservoir Coring	CAST BY:	D. Nyland
SUPPLIER:	N/A	MIX TEMP, ASTM C-1064:	N/A FIELD TEMP. MIN.
CONTRACTOR:	Bethlehem Construction	AIR TEMP:	N/A FIELD TEMP. MAX.

CYL. NO.	DATE CAST	DATE TESTED	AGE IN DAYS	CYLINDER WT. LBS.	CYL. HT."	CYL. DIA."	SURFACE AREA SQ.IN.	UNIT WT. PCF	APPLIED LOAD	COMPRESSIVE STRENGTH (PSI)	REQD. STRENGTH	BREAK DESC.
1 East	N/A	11/13/2019	N/A	6.57	6.96	3.66	10.52	155.0	88970	**8457**		3
2 West	N/A	11/13/2019	N/A	6.18	6.56	3.67	10.58	153.9	62760	**5933**		3

CYLINDER DATA

SLUMP, ASTM C-143: N/A

UNIT WT, ASTM C-138:

PCT. AIR, ASTM C-231: N/A

CEMENT: N/A

W/C RATIO:

ADDITIVES:

GENERAL INFORMATION

LOCATION: Reservoir Base Slab

Note: All sample material will be discarded after 30 days of receipt unless otherwise notified.

Reviewed By: J. Hills