

December 15, 2023
Revised March 6, 2024

0837-103

Via email: IBenoit@rdn.bc.ca

Regional District of Nanaimo
6300 Hammond Bay Road
Nanaimo, BC
V9T 6N2

Attn: Ian Benoit, P.Eng. - Project Engineer, Capital Project Delivery

**Re: Greater Nanaimo Pollution Control Centre – Primary Sedimentation and Grit Tanks
Concrete Tank Relining – Materials and Structural Engineering Services**

Dear Ian:

As requested, we are pleased to provide the following report for materials and structural engineering recommendations for the surface remediation work for the concrete tanks at the GNPCC in Nanaimo, BC.

We trust this information is sufficient. Please call with any questions.

Yours truly,

HEROLD ENGINEERING LIMITED



Craig Appelman, P.Eng
Associate, Materials Engineer



Tyler Boyer, P.Eng.
Structural Engineer

Enclosure

Concrete Tank Relining – Materials and Structural Engineering Services

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1 Introduction

The Greater Nanaimo Pollution Control Centre (GNPCC) features three primary sedimentation tanks and three grit tanks. The tanks are constructed of cast-in-place concrete and are reportedly partially lined with a membrane.

The membrane and concrete surface of the tanks have reportedly experienced deterioration and require remediation including membrane replacement and potential concrete repairs. Herold Engineering Limited (HEL) has prepared the attached materials and structural recommendations for the anticipated remediation work for planning purposes.

The reference drawings and reports provided by the client show representative examples of the observed deterioration and provide additional information on the condition of the existing concrete such as depth of cover on the reinforcing and anticipated removal depths of affected concrete.

It is noted that some areas have experienced more extensive deterioration than others and a combination of repair materials and methods may need to be used throughout the tanks to properly address the various scenarios. HEL has evaluated the potential extent of deterioration and the potential loading scenarios and has prepared a summary table with ranking criteria to compare repair solutions relative to the encountered condition.

The analysis includes evaluating the loading scenarios for the potential reduction in effective wall thickness during remediation and we have considered the effect of the current, anticipated material loss and temporary removal of material from the tank walls. The proposed solutions include wall thickness removal limits and potential shoring requirements.

2 Background

The tanks are located at the GNPCC wastewater treatment facility on Hammond Bay Road in Nanaimo, BC. The total plan area of the tanks is approximately 1,850m² (20,000 ft²) and the walls are approximately 305mm (12") thick and maximum 4.6m (15') high. The sedimentation tanks are uncovered, and the grit tanks are covered. It is understood that the concrete tanks were built in the early 1970's, with an addition of a third grit tank in the late 1980's.

It was reported by SRM Projects in an assessment report dated November 16, 2022, that the existing membrane and the concrete surface of the tanks have deteriorated and require remediation. The replacement of the membrane is by others and is not in HEL's scope of work.

An evaluation report by Metro Testing + Engineering Ltd (Metro Testing) dated October 16, 2023 provides a recent assessment of the condition of the concrete tank walls and floors and provides test results to be considered in the analysis of the tank walls such as the anticipated depth to sound concrete and the compressive strength of the concrete.

3 References

The following documents were referenced during the review.

3.1 Reference Project Documentation

- AECOM – Civil Record Drawings – December 3, 2013.
- Dayton & Knight Consulting Engineers – Structural Drawings – Grit and Sedimentation Tanks – September 1, 1973.
- Dayton & Knight Consulting Engineers – Structural Drawings Phase 2– Grit Tank No. 3 – July 4, 1989.
- SRM Projects Summary Report dated November 16, 2022 (GNPCC No. 3 Grit Tank Inspection Report – *For Record RDN Ref: Project WW-0038 / Equip: T-113, SRM Ref: P0041*).
- SRM Projects Summary Report dated November 16, 2022 GNPCC No. 3 Primary Sedimentation Tank Inspection Report – *For Record RDN Ref: Project WW-0038 / Equip: T-213, SRM Ref: P0041*.
- WSP – Concrete Core Compressive Strength Test Reports dated March 31, 2023
- Metro Testing + Engineering Ltd Evaluation Report dated October 16, 2023 (GNPCC – Grit and Primary Sedimentation Tanks Refit - Evaluation of Concrete in Grit and Sed Tanks 1 to 3, Revision 01).

3.2 Reference Standards

- CSA A23.1:19 – Concrete Materials and Methods of Concrete Construction
- CSA A23.2:19 – Test Methods and Standard Practices for Concrete
- CSA A23.3:19 – Design of Concrete Structures
- ACI 506R – Guide to Shotcrete

4 Limitations

Herold Engineering Ltd (HEL) does not take responsibility for the existing conditions of the tanks or any related structures or equipment. These conditions include, but are not limited to, the condition and structural integrity of the existing concrete tanks. The Regional District of Nanaimo shall immediately notify HEL and SRM Projects of any unforeseen damage and/or deficiencies with the existing structure or field condition as encountered during the project.

The recommendations contained herein do not purport to address any of the potential safety hazards associated with the completion of this work. It is the responsibility of the contractor to establish appropriate health and safety practices for the scope of work.

5 Materials Recommendations

5.1 Background – Materials

The recommended concrete repair solutions will vary depending on the amount of concrete that is ultimately removed from the surface of the tanks during membrane removal and repair work which, in turn, depends on the condition of the in-situ materials. The anticipated depth of removal of unsound concrete and resultant amount of exposed reinforcing discussed below will aid in decision-making for the repair solutions. However, due to typical fluctuations in field conditions, the actual extent of work on a per-location basis will only be determined once repair work begins.

Based on test results in the Metro Testing report, the anticipated depth of removal of unsound concrete may be as high as 40mm. The approximate value of 40mm includes the potential effect of additional scaling during removal of the physically deteriorated concrete. In some locations, particularly where the concrete was originally coated, the depth of removal may be less (approximately 25mm total) where the extent of deterioration may be less severe.

Based on the existing structural drawings for the tanks, the design concrete cover for the reinforcing steel was to be 50mm. A limited reinforcing cover survey performed by Metro Testing indicates that the cover was observed to be greater than 40mm in most surveyed locations with many locations showing 50mm – 60mm of cover. Some specific exceptions include 35mm or greater at the west wall of Grit Tank #1 and approximately 30mm at the columns in Sedimentation Tank #1 (Metro Testing). Although the cover survey was limited in scope, the results generally corroborate the information reported on the structural drawings, and it appears that the typical value for concrete cover can reasonably be assumed to be 50mm in most areas.

5.2 Recommendations for Repair Materials and Methods

The optimal outcome is that the membrane and any unsound concrete can be removed without exposing the reinforcing steel. If the condition of the concrete results in the removal of the entire concrete cover, and therefore the reinforcing is exposed, the required repair procedures will be more extensive.

Based on the field investigation results from Metro Testing, it appears that many locations are currently in adequate condition to allow the repair work to take place without exposing reinforcing steel.

For example, assuming that the typical cover on the reinforcing steel is 50mm and the maximum expected depth of removal of unsound concrete is 40mm or less, the reinforcing will not be exposed, and the recommended repair solution will be relatively straightforward, such as trowel-applied mortar repair, as described below.

If the depth of unsound concrete is greater than the concrete cover and the existing reinforcing steel becomes exposed, it will be necessary to chip out additional potentially sound concrete around the exposed reinforcing in order to properly re-encapsulate the reinforcing steel. As described below, a repair method using shotcrete is recommended for this scenario.

The potential repair solutions are divided into three categories as summarized below:

- Trowel-Applied: Mortar repair mix is applied by hand to repair the surface of the tank. It is noted that based on the results of the Metro Testing + Engineering Ltd Evaluation Report, this will likely be the primary repair method.
 - For locations where the depth of removal of unsound concrete does not expose reinforcing steel (generally assumed to be between 25mm and 40mm), repair mortar shall be used.
 - Remove unsound/deteriorated concrete material.
 - Prepare the bond surface with appropriate means, such as sand-blasting and/or hydro-demolition, and in conformance with the repair mortar manufacturer's recommendations.

- Repair mortar shall be a polymer modified repair mortar suitable for vertical applications.
 - Place a scrub coat of the repair mortar onto the prepared concrete surface. Press mortar firmly into the pores of the existing concrete.
 - Apply lifts of the repair mortar as per the manufacturer's recommendations.
 - Finish the surface of the repair mortar to match the adjacent concrete surface.
- Shotcrete: Shotcrete mix is spray-applied (or "shot") to build-up a new concrete surface.
 - For locations where depth of removal of unsound concrete exposes the reinforcing steel or the repair depth is greater than 50 mm:
 - Remove unsound/deteriorated concrete material.
 - Fully expose any partially exposed reinforcing steel by chipping potentially sound existing concrete away from bar for 25mm.
 - Prepare the bond surface with appropriate means, such as sand-blasting and/or hydro-demolition, and in conformance with the repair mortar manufacturer's recommendations.
 - Repair concrete shall be a ready-mix supplied wet-mix shotcrete in conformance with the recommendations of ACI 506R.
- Form and Pour: Conventional concrete formwork is built inside the tank and new concrete is poured over the existing surface.
 - For locations where depth of removal of unsound concrete exposes the reinforcing steel or repair depth is greater than 50 mm:
 - Remove unsound/deteriorated concrete material.
 - Fully expose any partially exposed reinforcing steel by chipping potentially sound existing concrete away from bar for 25mm.
 - Prepare the bond surface with appropriate means, such as sand-blasting and/or hydro-demolition, and in conformance with the repair mortar manufacturer's recommendations.
 - Repair concrete shall be a ready-mix supplied self-consolidating concrete (SCC).

Refer to Table 1 for a summary of the repair materials and methods for planning purposes.

5.3 Materials Testing

The structural analysis of the concrete walls assumes a compressive strength value of 36 MPa. The assumed strength is based on core samples extracted from site including test results provided by SRM Projects in March 2023 as well as test results from Metro Testing provided in October 2023. Refer to Appendix A and Appendix B.

6 Structural Recommendations

6.1 Background - Structural

The remediation work at the surface of the tanks is expected to include the removal of the membrane and a variable amount of concrete, which in turn will reduce the thickness of the existing concrete walls. In order to perform the repair work, it is assumed that one or more tanks will be drained, while adjacent

tanks remain operational, causing one-sided loading on the walls in question. According to the structural drawings, the existing walls are 305mm (12") thick and a maximum 4.6m (15') high. As shown on the Dayton & Knight drawing set, labelled 69-7-2, the following elevations were noted:

- **Grit Tank:** Section 1 on Sheet M21
The top of the concrete grit tanks is EL. 90'-0" and the maximum and minimum wastewater elevations are EL. 88'-11" and EL. 88'-4" respectively. The lowest location of the grit tank is calculated as EL. 76'-2".
- **Sedimentation Tank:** Section 1 on Sheet M24
The top of the concrete sedimentation tanks is EL. 90'-0" and the maximum and minimum wastewater elevations are EL. 87'-6 ¾" and EL. 87'-3" respectively. The lowest location of the sedimentation tank is calculated as EL. 75'-0".

The compressive strength used in the analysis of the existing concrete walls is 36 MPa, as noted in Section 5.3 above.

6.2 Structural Implications of Wastewater Level and Change in Wall Thickness

The removal of concrete from the tank surface will result in a reduction in the cross-sectional area of existing structural elements, such as tank walls, which in turn will reduce the capacity of these elements. Furthermore, the tank walls are expected to experience one-sided lateral pressure during repair work due to a filled tank on one side and a drained tank on the other side. The residual capacity of the grit and sedimentation tank walls has been analyzed for a range of minimum wall thicknesses and wastewater elevations in the adjacent tanks.

The RDN completed field measurements of the wastewater elevations in the grit and sedimentation tanks on January 25, 2024, to confirm the minimum elevations noted on the reference drawings. Since these measurements were recorded during winter, it is understood that these water elevation values correspond to a larger-than-expected, operational, wastewater elevation when the remediation will occur – anticipated to be during the summer months. The following are the maximum wastewater elevations measured by the RDN:

- **Grit Tank:** Wastewater depth of 12'-2.7", which corresponds to **EL. 88'-4.7"**.
- **Sedimentation Tank:** Wastewater depth of 12'-5.1", which corresponds to **EL. 87'-5.1"**.

The analysis considers the combined effect of reduction in wall thickness along with the maximum expected, operational, wastewater levels for the potential loading scenario described below. **It is recommended that these depths/elevations be periodically measured during remediation work to ensure they are not exceeded.**

6.2.1 Grit Tank Removal Limit Recommendations

The potential wastewater levels in adjacent tanks used in the structural analysis are based on the maximum measured operating elevations noted above. Note that the grit tanks and sedimentation tanks each have their respective maximum measured wastewater elevations. Refer to the reference

structural drawings and Section 6.2 – *Structural Implications of Wastewater Level and Change in Wall Thickness*.

It is assumed that the grit tanks are operated at or below the **measured** wastewater depth of 12'-2.7" from the lowest location in the grit tank, which corresponds to an elevation of EL. 88'-4.7". It is noted that this wastewater elevation is lower than the maximum wastewater level elevation noted on the original facility structural design of 88'-11". The wastewater elevation of 88'-4.7" has been assumed based on field measurements and flow volume recommendations provided by the RDN. **It is recommended that these depths/elevations be periodically measured during remediation work to ensure they are not exceeded.** If the operating wastewater elevation exceeds these conditions during the remediation, contact the undersigned for further review and/or shoring design.

The following are recommendations for wall removal limits in the concrete removal and remediation work of the grit tanks without shoring:

- Wastewater elevation on one side of the grit tank wall is **limited to a maximum specified wastewater elevation of 12'-2.7" from the lowest location in the grit tank, or EL. 88'-4.7"** as noted above. The locations of the critical sections have been outlined in Appendix A.
- Use of the walkways is not permitted directly above, and within 1m of the outer extents, of the concrete removal sections during the removal and repair procedure. This recommendation is to not induce unaccounted loads into the wall and wall's base.
- In the upper portion of the wall, above 405mm (16") from where the base of the wall meets the tanks bottom slab, or the bottom of the wall measurement line outlined in Appendix A, surface material removal is limited to under 50mm (2"), with a resultant wall thickness of minimum 250mm (10"), without shoring required.
- In the lower 405mm (16") portion of the wall, measured up from the base of the wall, or the bottom of the wall measurement line outlined in Appendix A, surface material removal is limited to 32mm (1 - 1/4") without localized shoring or a phased-remediation approach required.

Note that the repair work and the shoring involve specific sequencing and logistical considerations that shall be addressed in the detailed repair design (separate scope of work). The shoring design will likely include one design for general wall shoring and a separate design for localized shoring at the bottom section of the walls if required.

6.2.2 Sedimentation Tank Removal Limit Recommendations

The potential wastewater levels in adjacent tanks used in the structural analysis are based on the maximum measured operating elevations noted above. Note that the grit tanks and sedimentation tanks each have their respective maximum measured wastewater elevations. Refer to the reference structural drawings and Section 6.2 – *Structural Implications of Wastewater Level and Change in Wall Thickness*.

It is assumed that the sedimentation tanks are operated at or below a wastewater depth of 12'-7" from the lowest location in the sedimentation tank, which corresponds to an elevation of EL. 87'-7". **It is recommended that these depths/elevations be periodically measured during remediation work to ensure they are not exceeded.** If the operating wastewater elevation exceeds these conditions during the remediation, contact the undersigned for further review and/or shoring design.

The following are recommendations for wall removal limits in the concrete removal and remediation work of the sedimentation tanks without shoring:

- Wastewater elevation on one side of the sedimentation tank wall is **limited to a maximum specified wastewater elevation of 12'-7" from the lowest location in the sedimentation tank or EL. 87'-7"** as noted above. The locations of the critical sections have been outlined in Appendix A.
- Use of the walkways is not permitted directly above, and within 1m of the outer extents, of the concrete removal sections during the removal and repair procedure. This recommendation is to not induce unaccounted loads into the wall and wall's base.
- In the upper portion of the wall, above 405mm (16") from where the base of the wall meets the tanks bottom slab, or the bottom of the wall measurement line outlined in Appendix A, surface material removal is limited to under 50mm (2"), with a resultant wall thickness of minimum 250mm (10"), without shoring required.
- In the lower 405mm (16") portion of the wall, measured up from the base of the wall, or the bottom of the wall measurement line outlined in Appendix A, surface material removal is limited to 32mm (1 - 1/4") without localized shoring or a phased-remediation approach required.

Note that the repair work and the shoring involve specific sequencing and logistical considerations that shall be addressed in the detailed repair design (separate scope of work). The shoring design will likely include one design for general wall shoring and a separate design for localized shoring at the bottom section of the walls if required.

6.2.3 Conceptual Shoring Detail

A conceptual shoring detail is shown for reference in Figure 1 below, however, the shoring design and final shoring details are a separate scope of work. Note that not all components, such as columns or other structural elements, are not shown in the conceptual detail for clarity.

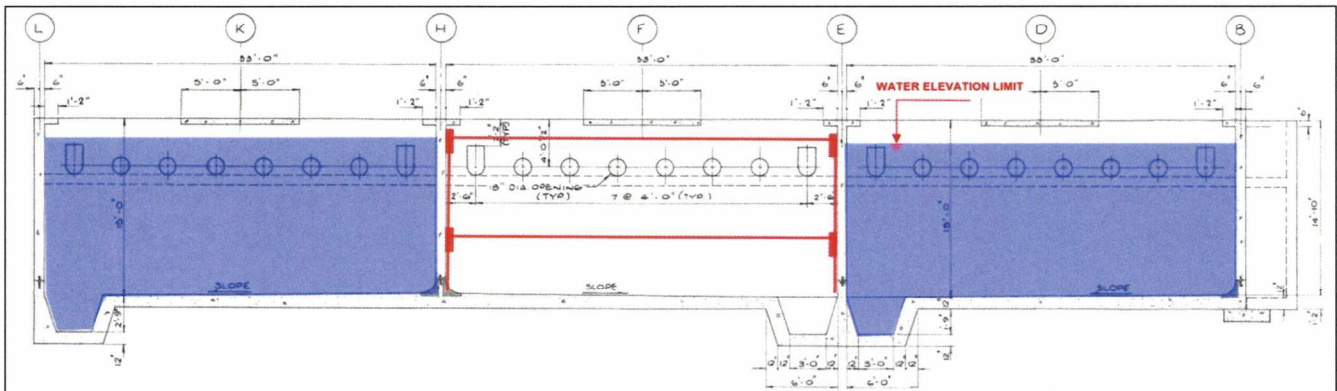


Figure 1 - Conceptual Shoring Detail - For Reference Only

7 Recommendations for Concrete Removal Limits

The concrete cover on the reinforcing steel is assumed to be 50mm as shown in Figure 2 below. If the repair work exposes reinforcing steel, the steel must then be fully exposed on all sides in order to accomplish proper re-encapsulation. Therefore, once any reinforcing steel is exposed, further concrete removal is required as shown in Figure 3.

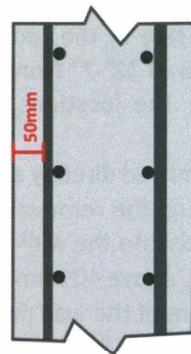


Figure 2 - Conceptual View of Concrete Cover and Reinforcing Steel

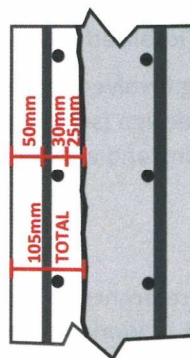


Figure 3 - Conceptual View of Surface Concrete Removal

Based on the structural drawings, the dimension for the cover plus the diameter of the reinforcing in both directions is assumed to total 80mm as shown in Figure 3 above. The repair procedure for exposed reinforcing requires an additional 25mm clear space behind the reinforcing for proper re-encapsulation of the steel therefore the total amount of surface concrete removed would be approximately 105mm. Therefore, once reinforcing is exposed at the anticipated 50mm depth – shoring will automatically be required.

During the review of the reference drawing Sheet S51, Section 12, it was noted that between Grit Tank 2 and 3, along Gridline (GL) G/J, and along the exterior part of Grit Tank 3, along GL L, there is a much smaller cover shown. The cover is anticipated to be approximately 38 mm (1-1/2") , for the reinforcement cover for these walls, determined from the proportioning on the drawings compared to other sections. Therefore, there is a possibility that the reinforcement may be exposed around the 32mm concrete removal depth in these locations.

The shoring design is a separate scope of work, however, it is noted for planning purposes that the configuration and the logistics of the shoring will need to be coordinated with the repair work and the depth of concrete removal. The shoring solution shall include sequencing and other logistical considerations as it is anticipated that the shoring supports will conflict with the repair work areas.

8 Summary of Repair Materials and Installation Methods

The following table summarizes the repair materials and installation methods.

Table 1 – Recommendations for Repair Materials and Installation Methods

<u>Amount of Surface Concrete Removed</u>	<u>Repair Material</u>	<u>Method of Repair</u>	<u>Notes</u>	<u>Rank</u>
Less than 50mm	Mortar	Trowel-Applied	Simplified repair method. Recommended if steel is not exposed.	1
Greater than 50mm	Shotcrete	Sprayed	Recommended repair method for exposed reinforcing.	2
Greater than 50mm	Ready-Mix	Form and-Pour	Less efficient repair method for this application. Not recommended.	3
Note: Refer to Section 6 for information on removal limits for shoring requirements.				

9 Discussion

As expected with older concrete in an exposure condition, such as the GNPCC tanks, the degree of deterioration will likely not be fully known until work begins and will likely be inconsistent from wall-to-wall or area-to-area. A better understanding of the concrete condition has been provided by the Metro Testing + Engineering Ltd Evaluation Report. Regardless, it is expected that there will be a variation in the concrete condition and a differential amount of surface depth removal throughout the tanks. This may mean that the repair method and the shoring requirements will be a combination of those noted in Section 6 and listed in Table 1 above.

It is recommended that the condition on site be reviewed by HEL as membrane removal work occurs so that the repair can be tailored to be as economical and efficient as possible. **It is also recommended that the depths/elevations be periodically measured during remediation work to ensure they are not exceeded.**

10 Future Scope of Work

Shoring design is a separate scope of work. Note that the shoring plan shall include a review the contractor's plan regarding the sequencing of tank draining, amount of concrete removal, and shoring installation. Specific attention would be required for the localized shoring at the bottom portion of the wall, if required.

11 Closing

Herold Engineering Limited appreciates the opportunity to assist you with these recommendations and we are available to provide any further assistance. Please call with any questions.

Yours truly,

HEROLD ENGINEERING LIMITED

Prepared by:



Roxanne Duigou, EIT
Structural Engineer

Reviewed by:



Craig Appelman, P.Eng.
Materials Engineer PERMIT No. 1000201

Tyler Boyer, P.Eng.
Structural Engineer



Attachments:

Appendix A – Structural Drawing Markup for Reference Elevations and Critical Wall Locations

Appendix B – AECOM – Civil Record Drawings – December 3, 2013

Appendix C – Dayton & Knight Consulting Engineers – Structural Drawings – Grit and Sedimentation Tanks – September 1, 1973

Appendix D – Dayton & Knight Consulting Engineers – Structural Drawings Phase 2– Grit Tank No. 3 – July 4, 1989

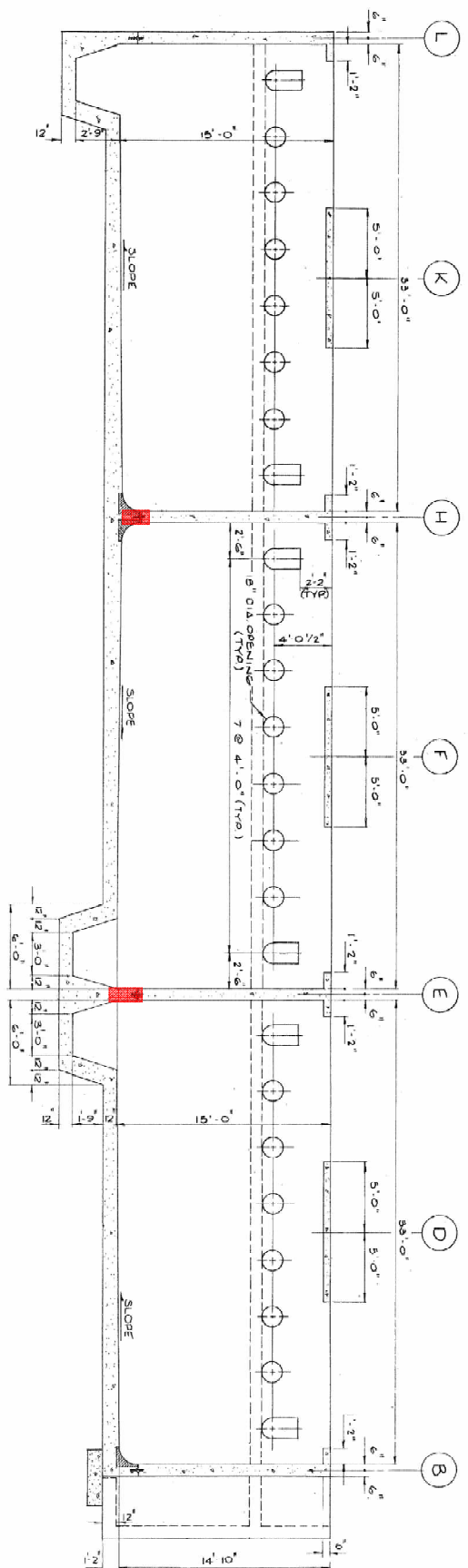
Appendix E – SRM Projects Summary Report dated November 16, 2022 (GNPCC No. 3 Grit Tank Inspection Report – For Record RDN Ref: Project WW-0038 / Equip: T-113, SRM Ref: P0041)

Appendix F – SRM Projects Summary Report dated November 16, 2022 GNPCC No. 3 Primary Sedimentation Tank Inspection Report – For Record RDN Ref: Project WW-0038 / Equip: T-213, SRM Ref: P0041

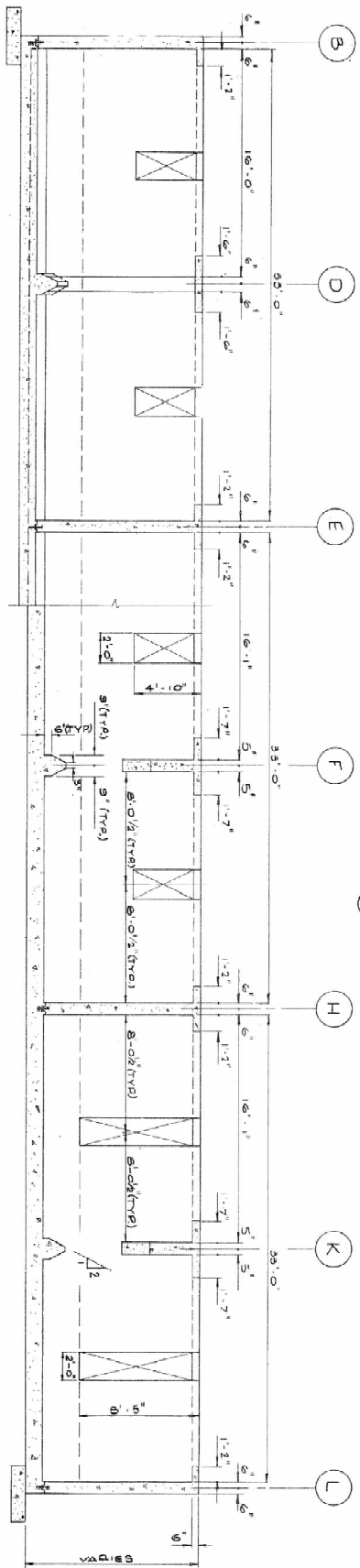
Appendix G – WSP – Concrete Core Compressive Strength Test Reports – March 31, 2023

Appendix H – Metro Testing + Engineering – Concrete Evaluation Report - October 16, 2023

Appendix A



SECTION 2/3



SECTION 3/3

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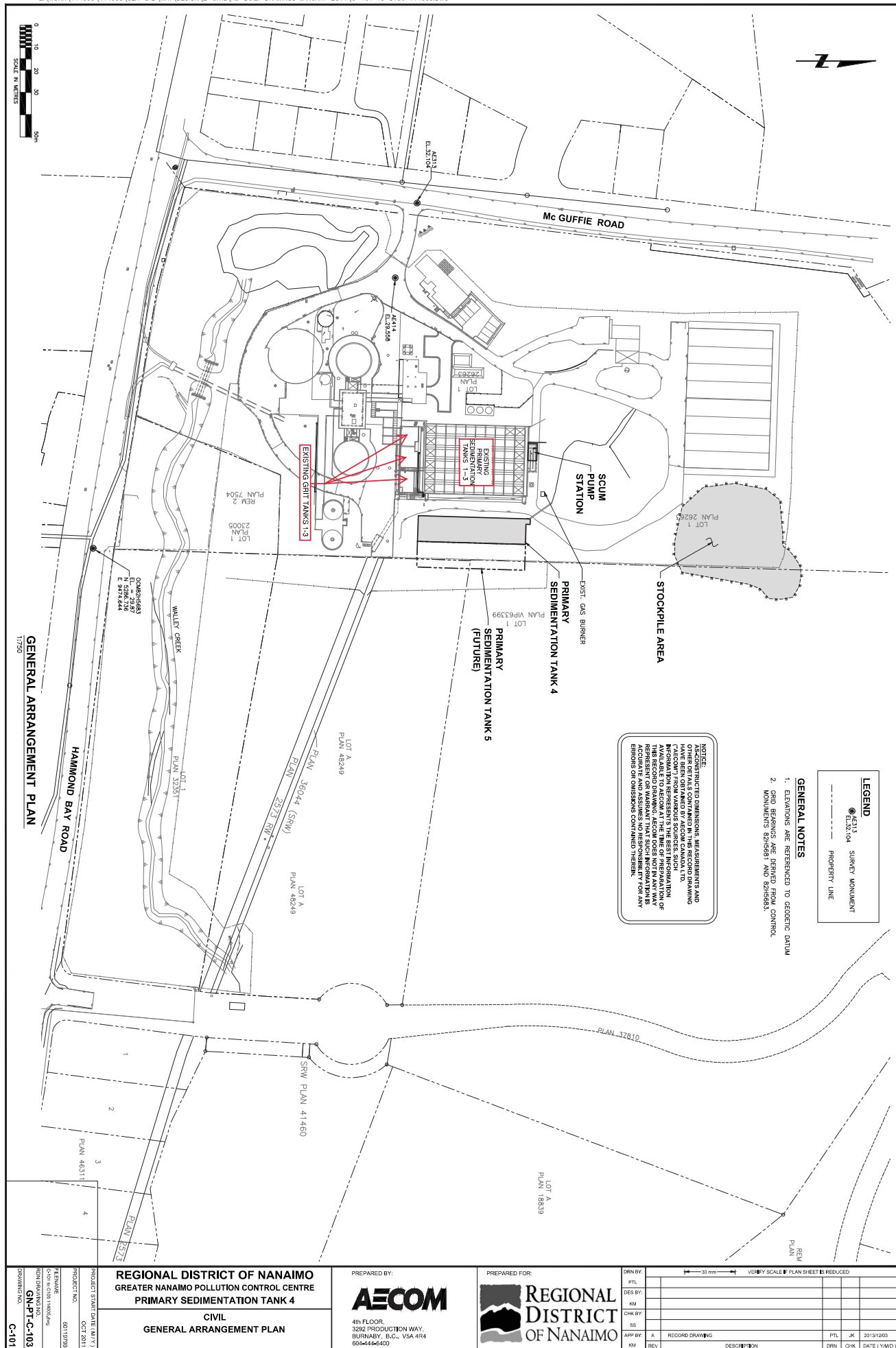


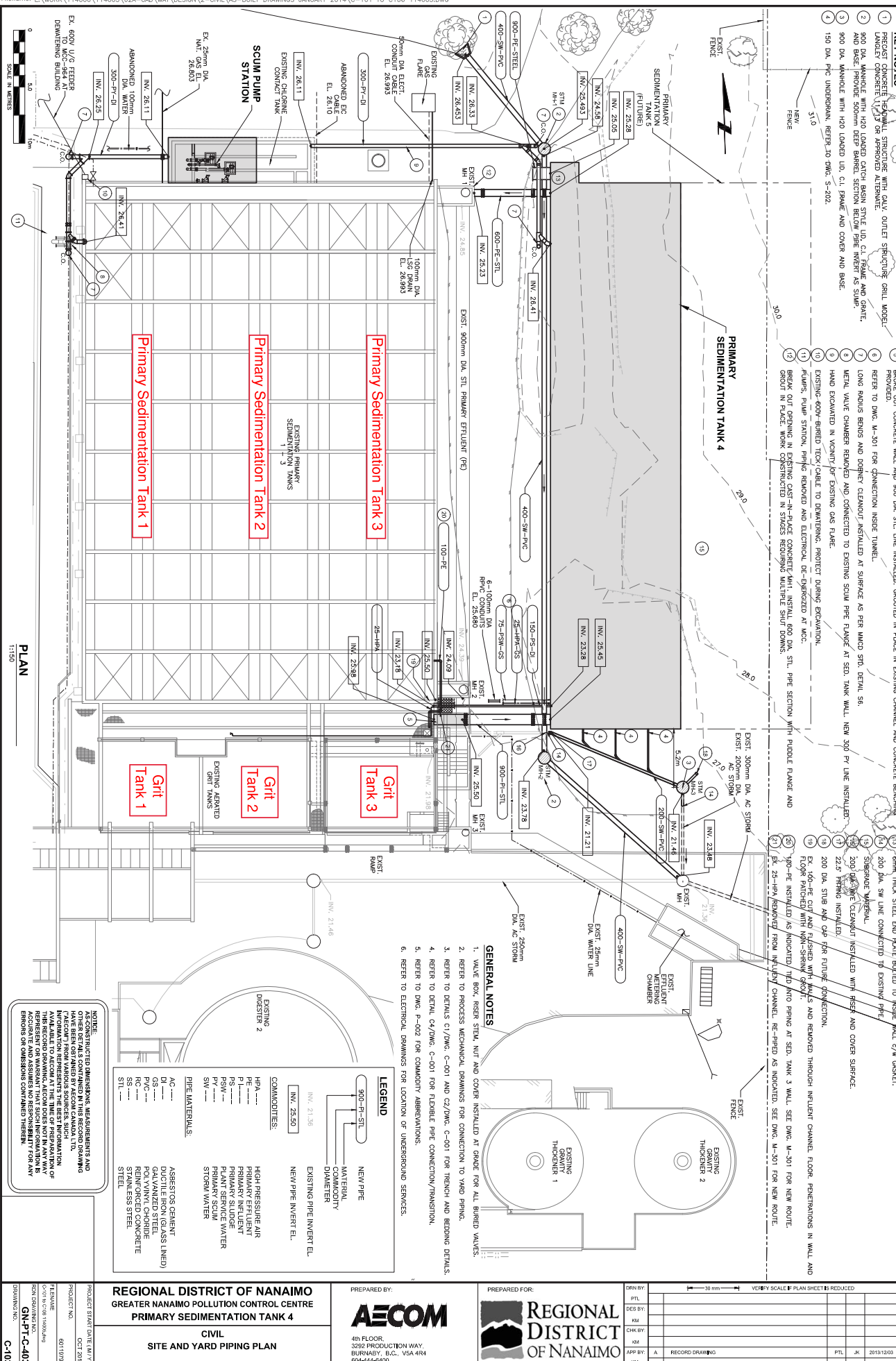
DAYTON & KNIGHT LTD.
CONSULTING ENGINEERS
3501 N. 1973

MAHARAJA REGIONAL WATER AUTHORITY
GREATER MAHARAJA WATER POLLUTION CONTROL CENTRE
5017 AND SEDIMENTATION TANKS - CURRENT OUTLINE

SCALE: 1/4" = 1'-0"
SHEET: 5/21 OF 28
THIS DRAWING REDUCED TO HALF SCALE

Appendix B





Appendix C