OPTIMIZATION OF DRINKING WATER SUPPLY

PANGNIRTUNG, NUNAVUT

DESIGN DEVELOPMENT REPORT

GN-CGS PROJECT #08-2009

11 October 2013

Submitted to:	**GOVERNMENT OF NUNAVUT – COMMUNITY AND GOVERNMENT SERVICES**
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October 11, 2013

Government of Nunavut – Community and Government Services
2nd Floor, GNO 1045
P.O. Box 379
Pond Inlet, NU, X0A 0S0

ATTENTION: Jon Cooper

RE: DESIGN DEVELOPMENT REPORT – NEW WATER TRUCK FILLING STATION, PANGNIRTUNG, NUNAVUT (GN-CGS PROJECT #08-2009)

ARKTIS Solutions Inc. is pleased to provide the Government of Nunavut – Community and Government Services with the above mentioned report.

We trust that the information presented in this report satisfies the requirements of the project. Please do not hesitate to contact the undersigned if there are any questions or comments regarding this report.

Sincerely,
ARKTIS SOLUTIONS INC.

Matthew Hamp, P.Eng
VP Nunavut Affairs & Operations
ARKTIS SOLUTIONS INC.

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1.0 INTRODUCTION

1.1 Background

The Government of Nunavut Department of Community and Government Services (GN-CGS) retained Arktis Solutions Inc. (ARKTIS) to design and oversee the construction of a new water truck filling station in Pangnirtung, Nunavut, which is located at 66°09'00"N latitude and 65°40'34"W longitude on the coast of Pangnirtung Fjord within the Qikiqtaaluk Region of Nunavut, approximately 255 km north of Iqaluit (see **Figure 1**). The location of the proposed new facility is shown in **Figure 2** and **Figure 3**.

In June 2013, the GN-CGS revised their requirements for the facility; the current scope of work for the project is described in ARKTIS *Proposal for Consulting Services* dated 3 July 2013.

The design changes stipulated by the GN-CGS, in conjunction with the preliminary design work already completed by ARKTIS, obviated the need for another Schematic Design phase. This report therefore presents the results of the Design Development phase. As per the revised scope of work, this report contains the following:

- Methodology: a description of the design procedure;
- Analysis: a description of the engineering fundamentals relevant to the design; description of the design concept and how the system will function; discussion of the engineering parameters that were arrived at and how the design meets the requirements;
- Results: a description of the proposed design
- Conclusion: Summary of the results and conclusions; description of how the design meets the design goals; and
- Figures showing preliminary design drawings, and tables.

1.2 Design Requirements

On 10 June 2013 via email, and subsequently amended during a teleconference on 20 June 2013, the GN-CGS revised the design requirements for the new Water Truck Filling Station in Pangnirtung as follows:

1. Two intake pipes
2. Two truck fill arms
3. Chlorination calculations based on the CT approach, with the following stipulated values to be used in the calculations:
    a. CT Value = 12 mg·min/L
    b. Flow Rate = 1,000 L/min
    c. Contact time = 12 minutes
4. A contact pipe to achieve the required chlorine contact time

1.3 Service Conditions

1.3.1 Population

The population of Pangnirtung in 2013 is estimated to be 1,512 according to the Nunavut Bureau of Statistics. The estimated population of the community at the end of the 20 year design life of the proposed facility (from 2015 to 2035) is 1,996.

1.3.2 Water Consumption and Production Flow

Water Consumption Estimate

For estimating Community Water Use for Pangnirtung, population projections for the 20 year design life of the facility, from 2015 to 2035, were obtained from the Nunavut Bureau of Statistics.

For a total community population up to 2,000, the Total Community Water Use was estimated for each year of the facility design life using the following equation:

$$Volume\ (per\ capita) = Residential\ Water\ Use \times (1.0 + (0.00023 \times Population))$$ [1]

For trucked water and sewer service, Residential Water Use (RWU) is 90 L per capita per day (lpcd) as per the GNWT Department of Public Works and Services document titled *Water and Sewage Facilities Capital Program: Standards and Criteria*.

The estimated total annual community water consumption (demand) for the last year of the design life of the facility is 95,670 m^3. The results of predicted water usage for each year of the design life of the facility are presented in **Table 1**.

Production Flow Estimate

The GNWT Department of Public Works and Services *Water and Sewage Facilities Capital Program: Standards and Criteria* document also provides a method for determining the required production flow rate based on the predicted consumption rates for the community. For trucked systems a factor of 2.1 is applied to the design consumption rate to give the design production flow. This factor is made up of two components: (1) a maximum day demand factor of 1.5; and (2) a truck delivery factor of 7/5, based on water delivery five days per week.

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[1] GNWT Department of Public Works and Services. Water and Sewage Facilities Capital Program: Standards and Criteria, July, 1993.

The predicted production flow for the design horizon of the facility is 200,907 m^3 per annum (or 550,429 L/day), just over double the predicted demand of 95,670 m^3.

The results of estimated production flow for each year of the design life of the facility are also presented in **Table 1**.

1.3.3 Water Quality

The water dispensed by the new water truck filling station will meet the *Guidelines for Canadian Drinking Water Quality* (Health Canada, August 2012). The source water will be filtered to reduce turbidity to less than 0.1 NTU and will undergo chlorine disinfection prior to entering the delivery vehicles. The Nunavut Health regulations stipulate a minimum residual chlorine concentration of 0.2 mg/L.

1.3.4 Truck Fill Rate

A minimum truck filling rate of 1,000 L/min will be provided for both firefighting demand and regular consumption demand.

1.4 CT Concept Calculation Review

As noted above, the parameters for the determination of adequate treatment of drinking water according to the CT Concept described in Part 1 of the *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* (Government of Alberta, April 2012) have been stipulated by the GN-CGS. The values specified by the GN-CGS were reviewed and verified by ARKTIS in a separate document submitted 2 August 2013 (a copy of the Technical Memorandum covering the CT Concept Calculation Review is provided in **Appendix A**)

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2.0 METHODOLOGY

2.1 General Overview

As noted above, the GN-CGS has stipulated a baffling factor of 1.0 for the chlorine contact chamber required as part of the truck filling station design. A baffling factor of 1.0 assumes ideal plug flow conditions. In order to approach this condition, a contact chamber must have a very high length to width ratio, which is most easily achieved in a pipe. Consequently, the requirement for a baffling factor of 1.0 equates to a requirement for a contact pipe design. It is from this point, therefore, that the re-design of the water truck filling station began.

From the CT Concept calculations a contact vessel volume was derived. The maximum diameter of pipe possible with which the pipe would still exhibit plug flow behavior was determined, in order to allow for the shortest possible contact pipe. This would in turn allow for the minimization of the overall building footprint.

Once the pipe length and diameter were determined, the mechanical engineer worked with the structural engineer to develop a pipe layout and building floor plan that would allow the building size to be kept to a minimum.

From the final pipe layout arrived at, structural loads were determined in order to design the foundation and size the structural members. To facilitate uninterrupted truck filling at two truck fill arms, the CT pipe is sized to carry 15,000L of water. Based on the volume of water alone, the approximate weight of the CT pipe is 15,000 kg (147 kN) or 33,070 lbs. Given the magnitude of this weight, ARKTIS is proposing to locate the CT pipe on a solid slab on grade, rather than suspending the CT pipe from the roof of the steel structure and expecting the steel members to carry the load back down to the slab as larger concentrated loads. To facilitate the placement of the CT pipe on the slab on grade, ARKTIS is proposing an elevated “main floor” for the truck fill main operating area where the chlorination room will be located as well as the filters, electrical panels, and access to the intakes pipe ends and pumps. The back-up generator will be located in a separate room, directly on the slab on grade.

Based on ARKTIS previous design of a new Pangnirtung truck fill station that was not advanced to the tender phase, challenges in using conventional dimensional lumber framing were encountered due to significant wind loads (including other factors such as number of openings, height of building, etc.). As such, to begin the structural design for this revised new truck fill station, ARKTIS chose structural steel framing. Also as a result of the heavy wind loads a concrete slab on grade was selected to restrain the building from overturning. The perimeter of the slab on grade is thickened to support concentrated loads from the steel framing. Also, the slab was selected to serve as a base for the proposed 15,000L contact pipe.

The building envelope is proposed to be fully located on the outside of the structural members, which is the best configuration to allow for continuous air, thermal and vapour barriers without interruption from structural members. Exterior steel cladding, mineral fibre insulation and interior steel liner are proposed for the wall assembly and the roof assembly consists of exterior roof panels bearing on compression resistance rigid insulation, self-adhered air/vapour barrier on gypsum, all bearing on steel deck. These assemblies were selected since they best suit a structural steel industrial type building.

2.2 Mechanical and Electrical

The water delivery process of the truck fill station can be broken down to several building blocks that make up the complete system. These building blocks are:

- Pumping;
- Filtering;
- Chlorination;
- Water reservoir;
- Delivery system to trucks;
- Emergency power; and
- Controls and auxiliary equipment.

The design of each of these building blocks was derived from Government of Nunavut guidelines, applicable Codes and followed up by consultations with potential providers of specialized technologies. The final review and comments were provided by Government of Nunavut representatives.
See **Appendix B** for the full mechanical and electrical engineering sub-consultant Design Development report.

2.3 Structural

Structural design is completed by the structural design engineer using the National Building Code of Canada 2010, Part 4 – Structural Design, the National Building Code of Canada Structural Commentaries, climatic and seismic data specific to Pangnirtung, NU and limit states design to size the structural members and foundations considering both strength and serviceability. Methods of structural analysis used include hand calculations using formulas derived from accepted first principals to establish stresses on m embers (primarily for gravity loads such as the weight of the building and use and occupancy loads); also, more detailed finite element analysis is applied through the use of computer software to determine resulting stresses from both gravity and lateral loads (wind and seismic loads).

2.4 Building Envelope

Given that the truck fill building would require limited human use and r equirement for human comfort, thermal performance was selected based on a percentage of the recommended RSI values from the Government of Nunavut *Good Building Practices Guideline* (GN-GBPG) which are RSI 7.0 for roofs, RSI 4.9 for walls and RSI 7.0 for floors. Life cycle cost benefit analysis has not been performed. In keeping with recommendations from the GN-GBPG, materials were selected for their durability and ease of repair. For example, the sheet steel cladding selected is a durable construction material and exposed fastener type cladding will be used to allow for easier removal and replacement (if damaged) compared to hidden fastener systems. However since the roof is not likely to be damaged from everyday use of the building and area around the building, it is proposed that a standing seam metal roof (hidden fastener) be installed which is consistent with the recommendations from the GN-GBPG. Parts 5, Environmental Separations from the NBCC 2010, along with the recommendations within the GN-GBPG are considered in design of the building's envelope. Structural analysis using Part 4 of the NBCC 2010 will be used to determine required connection of building envelope components to the building structure during the detailed completion of contract drawings.

2.5 Civil

The civil engineering for the new facility is comprised of two parts: (1) the building site itself; and, (2) the truck turnaround area.

Major site grading will not be r equired for most of the new water truck filling station as the proposed location of the new facility is immediately east of, and adjacent to, the existing facility, where a granular base already exists. However, the granular base will need be expanded. Minor grading may be required to provide a level foundation surface.

The truck turnaround area will require expansion laterally to allow for the simultaneous filling of two vehicles side-by-side. The geometry required to accommodate this scenario was assessed and a ne w area will be designed, including a typical section for the turnaround pad. A terrain model will be developed using proprietary software to verify the site surface water drainage.

3.0 ANALYSIS

3.1 Water Treatment

As stipulated by the GN-CGS, the design of the disinfection system for the water truck filling station follows the CT Concept in order to demonstrate the level of treatment that will be achieved, using chlorine as the disinfection agent. The CT Concept stems from the observation that, in order to be effective as a disinfectant, chlorine must be given enough time to react with the microorganisms present in the water to be treated. The concept was developed with the assumption that most suppliers of potable water would need to inactivate cysts and oocycsts (i.e. Giardia) and viruses. The basic equation is:

CT = Concentration X Time

Where the concentration of residual chlorine is in mg/L and the time the water is in contact with the chlorine is in minutes. CT is also influenced by both the pH and the temperature of the source water.

The Government of Alberta *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* (April 2012) sets standards for the removal of both viruses and c ysts/oocycsts as percentages of the reduction of these organisms (e.g. 99.99% reduction is equivalent to 4-log reduction). The standard also provides a s eries of tables which relate temperature, pH, and r esidual chlorine concentration. The CT value and residual chlorine required to meet the removal standards is derived from the tables. The desired contact time can then be determined by varying the volume and type of the contact vessel.

For the Pangnirtung water truck filling station, these parameters (such as contact vessel volume and type) have been specified by the GN-CGS (for a more detailed description and discussion of the CT calculations see **Appendix A**).

3.2 Mechanical and Electrical

The mechanical and electrical engineering sub-consultant Design Development report in **Appendix B** provides the engineering analysis for these systems with respect to the design of the water truck filling station.

3.3 Structural

According to the National Building Code of Canada 2010 (NBCC 2010), design of structures must be completed using Part 4 – Structural Design. Within Part 4 of the NBCC 2010 loads for snow, wind and seismic can be determined through the use of climatic data for the 50 year return period. Appendix C of the NBCC 2010 provides climatic data for a s pecific city or town within each of the provinces and territories. However, there is no data provided for Pangnirtung, NU within the appendix. As such, and in conformance with the NBCC 2010, ARKTIS contacted the Atmospheric Environmental Service, Environment Canada (AES-EC) to obtain climatic data for Pangnirtung. To facilitate the AES-EC provision of climatic data, ARKTIS supplied the following coordinate and elevation data: 66°09’00” N, 65°40’33” W, 42 m above sea level which relates to the location of the existing truck fill station. The information requested pertained to the 1 in 50 year ground snow load (S_s), associated rain load (S_r), and the reference wind velocity (q). Refer to **Appendix C** for climatic data results.

To undertake seismic design, the spectral response acceleration values were obtained from the Geological Survey of Canada of Natural Resources Canada, specifically from the Natural Resources of Canada website, www.EarthquakesCanada.ca. Again, the coordinates 66°09’00” N, 65°40’33” W were used at the NRC website to generate the seismic data through interpolation between seven points within a 10km radius of the coordinates. The resulting information provides data for the following parameters: Sa(0.2), Sa(0.5), Sa(1.0), Sa(2.0) and PGA. These parameters represent NBC 2010 ground motions for 2% probability of exceedence in 50 years. Refer to **Appendix D** for seismic parameter results.

Within subsections of the NBCC 2010 Part 4, equations are provided to determine the snow, wind and seismic loads to be app lied to the building being designed. I n addition, the National Building Code Structural Commentary is used to determine distribution of snow and wind on the building surfaces. Also, within the NBCC 2010, Part 4, use and occupancy loads are determined for the building.

Limit states design is the method of analysis required by the NBCC 2010 and used by ARKTIS for design of the structure.

3.4 Building Code Analysis

Using Part 3 of the National Building Code of Canada, ARKTIS determined the building classification (major occupancy classification) and occupancy load for the new truck fill station. As well, based on the building classification the requirement for use of combustible or non-combustible construction is determined. Occupancy load determines the number and size of exits from the truck fill space.

3.5 Civil

A preliminary calculation indicates that the truck turnaround radius must be widened by approximately 3.0 metres. This would extend the turning area by approximately 71 m^2, not including the side slopes of the expanded area. The added area must be raised to meet the existing road surface and drainage maintained to the outside of the turning arc.

4.0 RESULTS (PROPOSED FACILITIES)

4.1 General

The following sections summarize the water supply system, water treatment system, building, and building services for the proposed water truck filling facility. **Figure 5** through **Figure 12** at the end of this report illustrate preliminary plans, elevations, and sections for the building.

4.2 Mechanical and Electrical Systems

The mechanical and electrical engineering sub-consultant Design Development report in **Appendix B** describes the proposed mechanical and electrical systems with respect to the design of the water truck filling station.

4.3 Building

4.3.1 General

The new water truck filling station will accommodate water filtration and disinfection equipment, and incorporates separate rooms for an emergency diesel generator and chemical handling/laboratory room. The building contains all service equipment necessary to operate the building and to draw water from the existing reservoir and deliver it to water trucks via two (2) parallel fill arms for simultaneous filling.

4.3.2 Site Location

The new truck fill station will be located along the north side of the existing access road, east of the existing truck fill station. Water trucks will travel along the existing access road as normal, turn around at the existing roundabout, and drive up to the new station, parking under an unoccupied fill arm. Trucks can park adjacent to one another for simultaneous filling. A preliminary site plan is shown on **Figure 4** at the end of this report.

4.3.3 Building Size

The exterior dimensions of the building are 7.9 m by 12.6 m.

4.3.4 Foundation

The foundation is proposed to be a 200mm thick concrete slab-on-grade with thickened perimeter (grade beams). The underside of the slab is insulated to protect the permafrost from the heated structure above. Insulation is to extend up the exterior face of the thickened slab.

4.3.5 Structural Systems

Floor

Within the generator room, the main floor of the 1-storey building consists of the finished concrete surface of the slab-on-grade. However, within the pump room the area of operation is raised above the concrete slab to allow for installation of the CT pipe. The raised floor is proposed to consist of a concrete infilled steel pan at the chlorination room to contain chlorine vapours; while the remainder of the raised for is proposed to be steel grating. This will allow heat to be shared between the crawl spaced below the raised floor and the remainder of the pump room space. An access hatch will be provided for routine maintenance of the CT pipe when required. Mechanical equipment such as the filters will be supported on checkered plate locally reinforced as necessary. The raised floor is supported be structural steel channels spanning the main structural steel beam at primary building frames.

Walls and Roof

The primary structure of the walls and roof is comprised of structural steel moment and braced frames that will resist both gravity and lateral loads. The secondary structure supports the exterior cladding and is framed using cold-formed steel girts and purlins connected to the structural frames of the building, adding to the overall structural capacity of the building system. A mono-sloped roof sheds rain, snow and ice to the rear of the building avoiding disruption of filling operations and preventing accidental injuries to workers.

4.3.6 Building Envelope

Walls

The wall envelope will consist of exterior sheet steel cladding over two layers of 75 mm mineral fibre insulation with interior sheet steel liner panels. All joints are sealed allowing the interior panels to serve as the envelope's air and vapour control membranes. The panels are connected on the exterior of the steel structural framing. Insulation is located on the outside of the vapour barrier and provides an RSI of 4.44.

Roof

The roof assembly will consist of standing seam roofing panels over two layers of 100mm rigid insulation with sufficient compressive resistance to transmit snow loads to the structural steel deck. Insulation is located on the top, exterior side of the air/vapour barrier and provides an RSI of 6.96. The air/vapour membrane within the roof assembly will consist of a self-adhered bitumous membrane applied over gypsum board covering the steel deck.

Floor Plan Layout

In order to minimize the area taken up by the chlorine contact pipe, the building has been divided into two levels and three rooms. The largest room is comprised of two parts, a lower crawlspace level (63.4 m^2) occupied by the 15,000 L serpentine chlorine contact pipe, and a pump room on the upper main level with a grated floor (48.8 m^2) occupied by the pumping and piping equipment. The other two rooms consist of a generator room (29.3 m^2) at the level of the main concrete floor, and a chlorination room (14.6 m^2) for chemical handling and storage built on top of the crawlspace.

The generator room is provided with its own exterior access and will house the generator only. The pump room is also provided with an exterior access and contains the pumps, filters, truck fill arm plumbing, and electrical and service equipment. The chlorination room is accessed via the pump room and contains the chlorine mixing equipment.

The generator room entrance can be accessed at ground level, while the pump room is accessed via a short stairway. The crawlspace will be accessed via a hatch within the main pump room grated floor. As well, knock-out walls in the wall assembly will be provided to allow for installation and removal of the CT pipe components as necessary.

The two fill arms protrude from the front elevation of the building and are supported by a structural steel frame perpendicular to the building.

The front elevation is protected from vehicular impact by a series of concrete filled steel bollards.

4.3.7 Building Code Analysis

As indicated above, NBCC 2010, Part 3, Table 3.1.2.1. was used to determine that the new truck fill building will be classified as a low-hazard industrial occupancy (Group F, Division 3). According to the NBCC 2010, Volume 1, Division A, Part 1, Section 1.4, "low hazard industrial occupancy means an industrial occupancy in which the combustible content is not more than 50 kg/m^2 or 1200MJ/m^2 of floor area". The same code section also indicates that an "industrial occupancy means the occupancy or use of a building or part thereof for the assembling, fabricating, manufacturing, processing, repairing or storing of goods and materials". The above definitions suit the intended use of the new truck fill station. Based on the occupancy type (industrial) and the use, ARKTIS used Table 3.1.17.1. to determine the occupant load for the new truck fill building. The most appropriate floor use for the truck fill building is the area per person of 9.30m2 which is for industrial uses, storage spaces. Based on the space within the operational area of the truck fill building (approximately 61.2 m^2), the occupant load is 7 people. According to

Sentence 3.2.2.85, and based on the area of the building, the components of the building can be heavy timber combustible or non-combustible construction. As such, the building materials are selected to be non-combustible. From a common sense approach, non combustible construction suits the building type and use.

4.4 Civil

The turnaround area will be expanded laterally by approximately 71 m^2, not including the area taken up by the side slopes. The side slopes of the expanded area will be 2:1 (H:V). Drainage will be maintained towards the outside of the turnaround area at approximately 2%. A terrain model must be performed to verify the site drainage.

A preliminary site plan is provided at the end of this report (see **Figure 4**).

5.0 CONCLUSION

This report presents the Design Development submission for the new Pangnirtung water truck filling station (GN-CGS Project 08-2009), in accordance with the revised scope of work described in ARKTIS *Proposal for Consulting Services* dated 3 July 2013. A design solution addressing the GN-CGS requirements of a chlorine contact pipe designed according to the CT Concept, and including two intake lines from the reservoir, and two water delivery arms, has been presented. Design parameters have been determined and design calculations completed, in coordination with all engineering disciplines involved. The design methodology has been explained, a design analysis presented, and the proposed facilities have been described.

6.0 LIMITATIONS OF LIABILITY

This report has been prepared for the exclusive use of the Government of Nunavut, Department of Community & Government Services for the specific application described in Section 1.0 of this report. It has been prepared for information purposes only. No other warranty is made, either expressed or implied. For further limitations, please refer to the General Conditions provided in **Appendix E**.

7.0 CLOSURE

We trust that this report meets your present requirements. Please contact the undersigned should there be any questions.

ARKTIS Solutions Inc.

ORIGINAL SIGNED BY

Matthew Hamp
Vice President – Nunavut Affairs & Operations

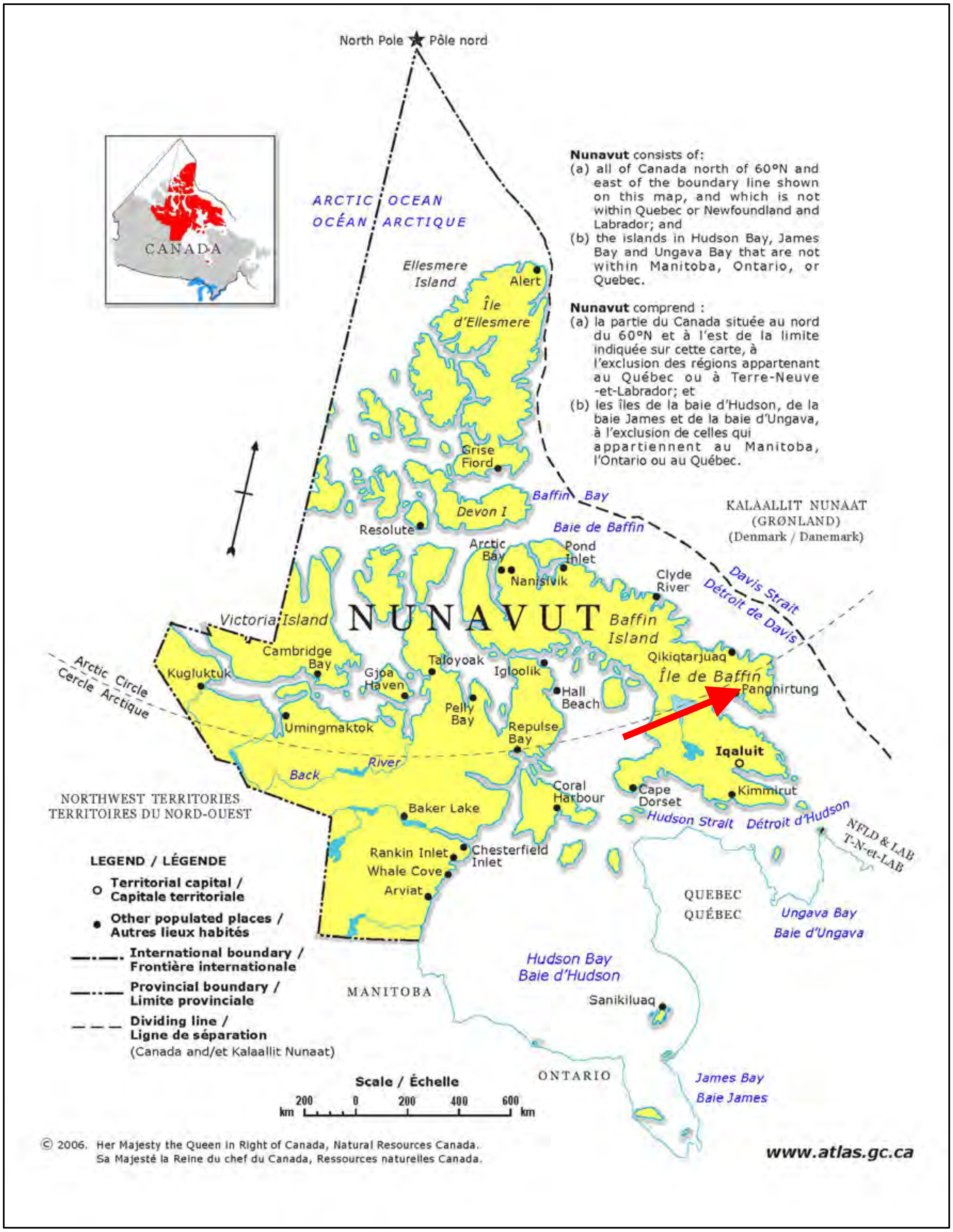

Figure 1 – Location of Pangnirtung, Nunavut

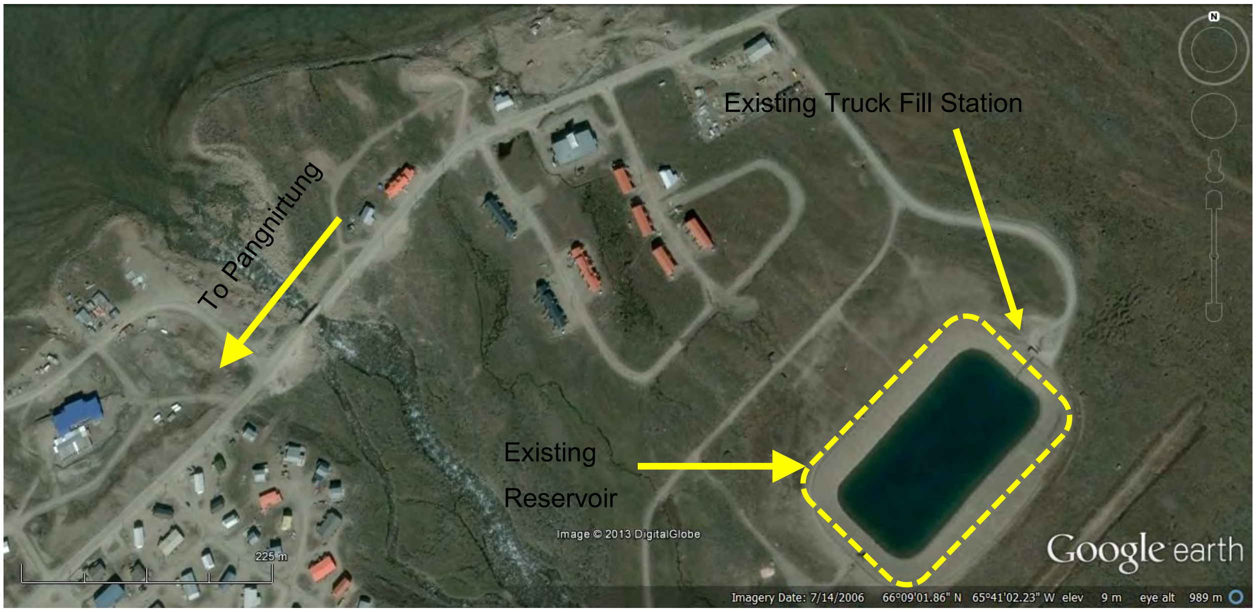

Figure 2 – Location of Existing Reservoir and Water Truck Filling Station

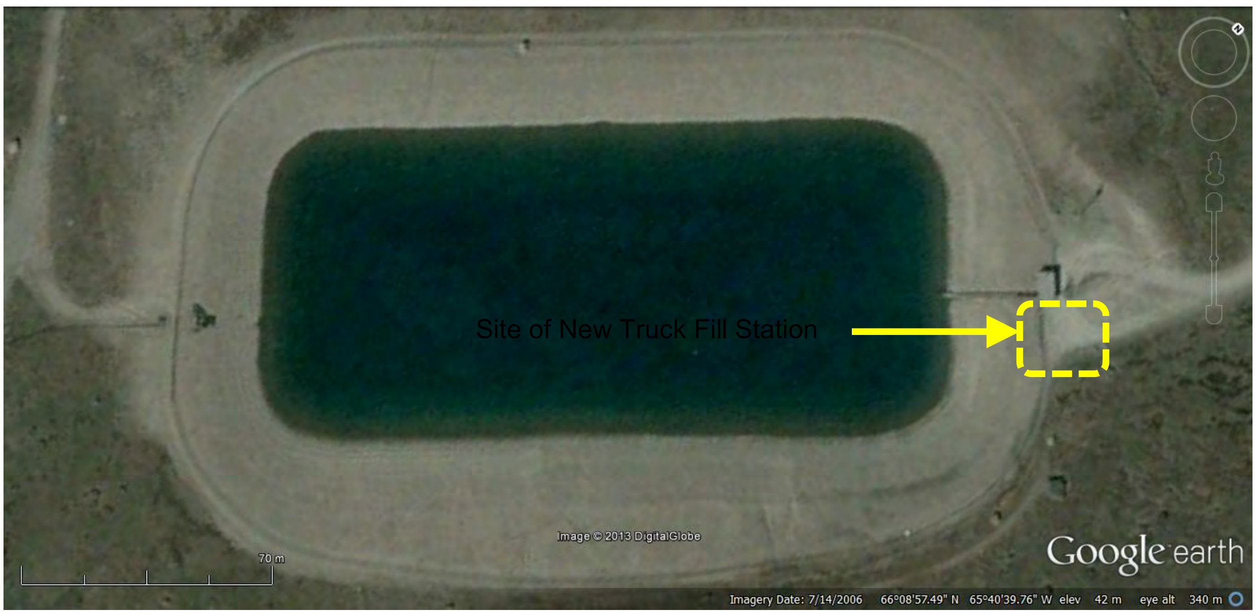

Figure 3 – Site Location for New Water Truck Filling Station

Table 1 – Projected Water Usage and Factored Demand

Facility Year	Calendar Year	Estimated Population[A]	Growth Rate	Water Use	Projected Water Use[B]	Factored Daily Demand[C]
			(%)	(lpcd)	(L/day)	(L/day)
0	2015	1,550	1.40%	122.09	189,232	397,387
1	2016	1,571	1.44%	122.52	192,478	404,205
2	2017	1,592	1.48%	122.95	195,743	411,061
3	2018	1,613	1.46%	123.39	199,027	417,956
4	2019	1,634	1.38%	123.82	202,328	424,889
5	2020	1,654	1.36%	124.24	205,489	431,528
6	2021	1,675	1.51%	124.67	208,826	438,536
7	2022	1,695	1.55%	125.09	212,022	445,245
8	2023	1,716	1.52%	125.52	215,394	452,328
9	2024	1,737	1.45%	125.96	218,785	459,449
10	2025	1,760	1.48%	126.43	222,520	467,293
11	2026	1,783	1.40%	126.91	226,277	475,182
12	2027	1,805	1.39%	127.36	229,891	482,771
13	2028	1,828	1.47%	127.84	233,691	490,751
14	2029	1,851	1.50%	128.32	237,512	498,776
15	2030	1,875	1.57%	128.81	241,523	507,199
16	2031	1,898	1.50%	129.29	245,390	515,319
17	2032	1,922	1.48%	129.79	249,448	523,840
18	2033	1,946	1.50%	130.28	253,529	532,411
19	2034	1,971	1.48%	130.80	257,806	541,393
20	2035	1,996	1.50%	131.32	262,109	550,429

Notes:

[A] Population data projections were provided by Nunavut Bureau of Statistics

[B] Total Water Use = Residential Water Use × (1.0 + (0.00023 × Population)) as recommended in

GNWT Water and Sewage Facilities Capital Program: Standards and Criteria, July 1993.

[C] Factored demand = Projected Use X 2.1 (Max day demand factor 1.5 X truck delivery factor 7/5)

Residential Water Use is 90 lpcd.

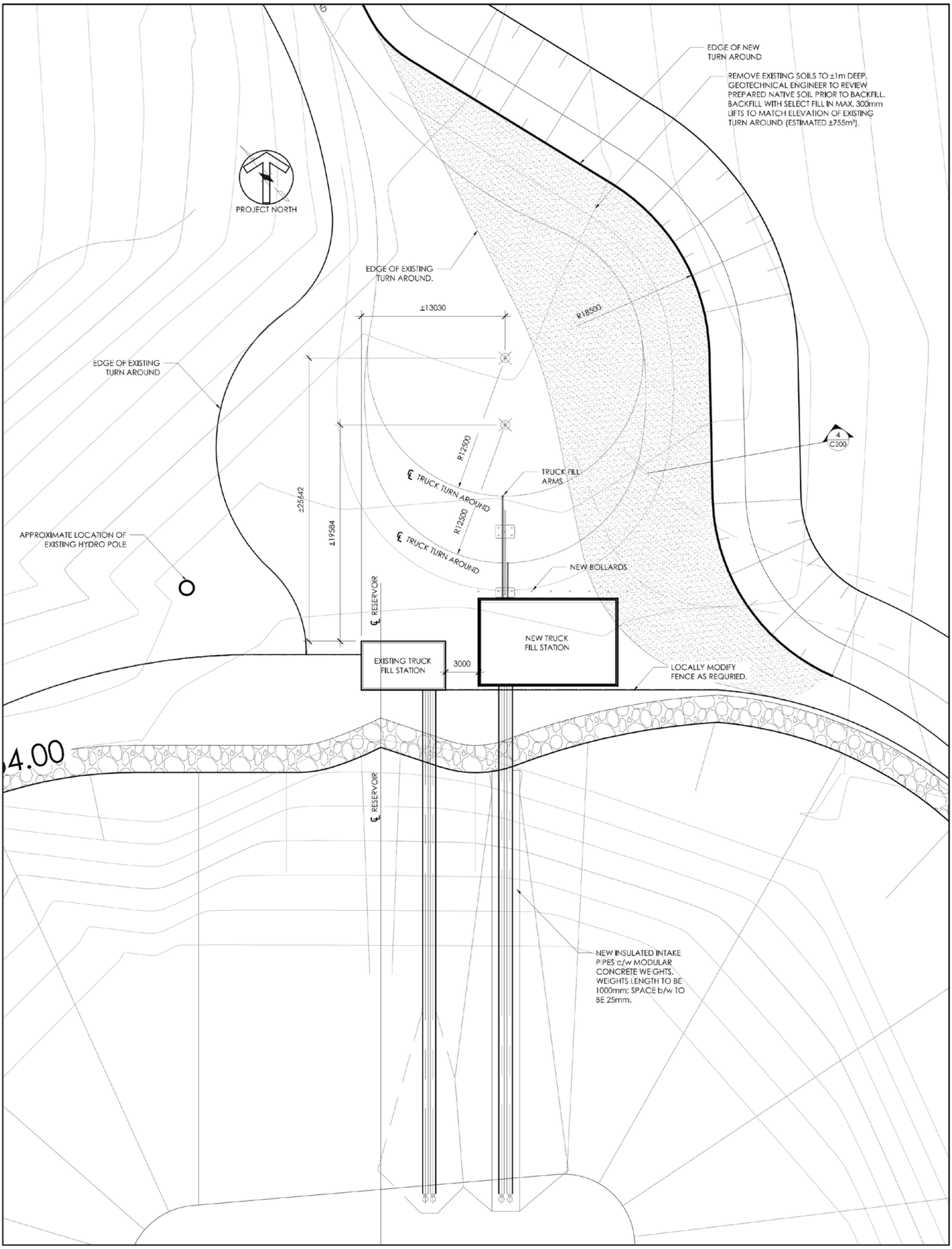

Figure 4 – Site Plan

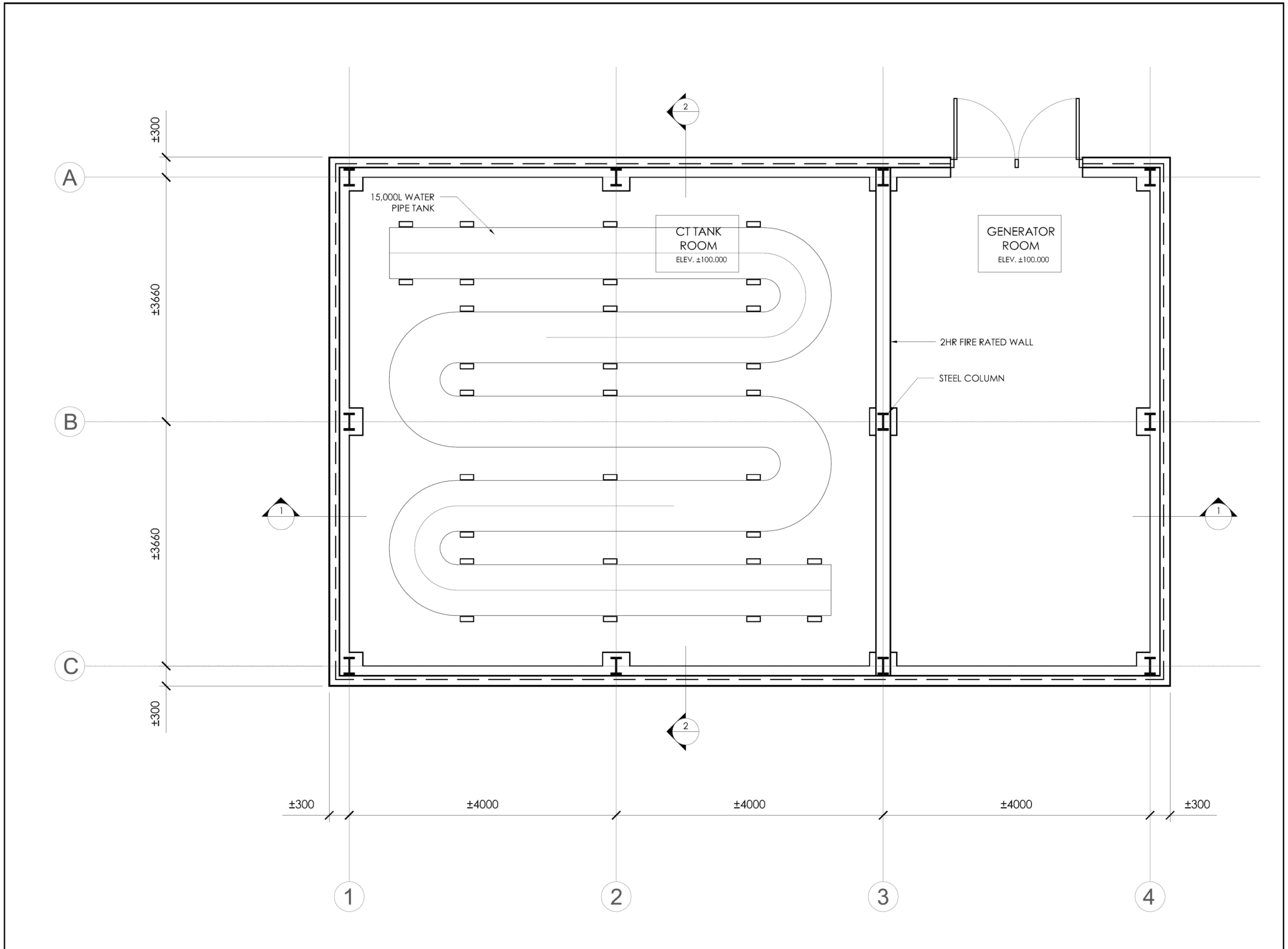

Figure 5 – Lower Level Floor Plan

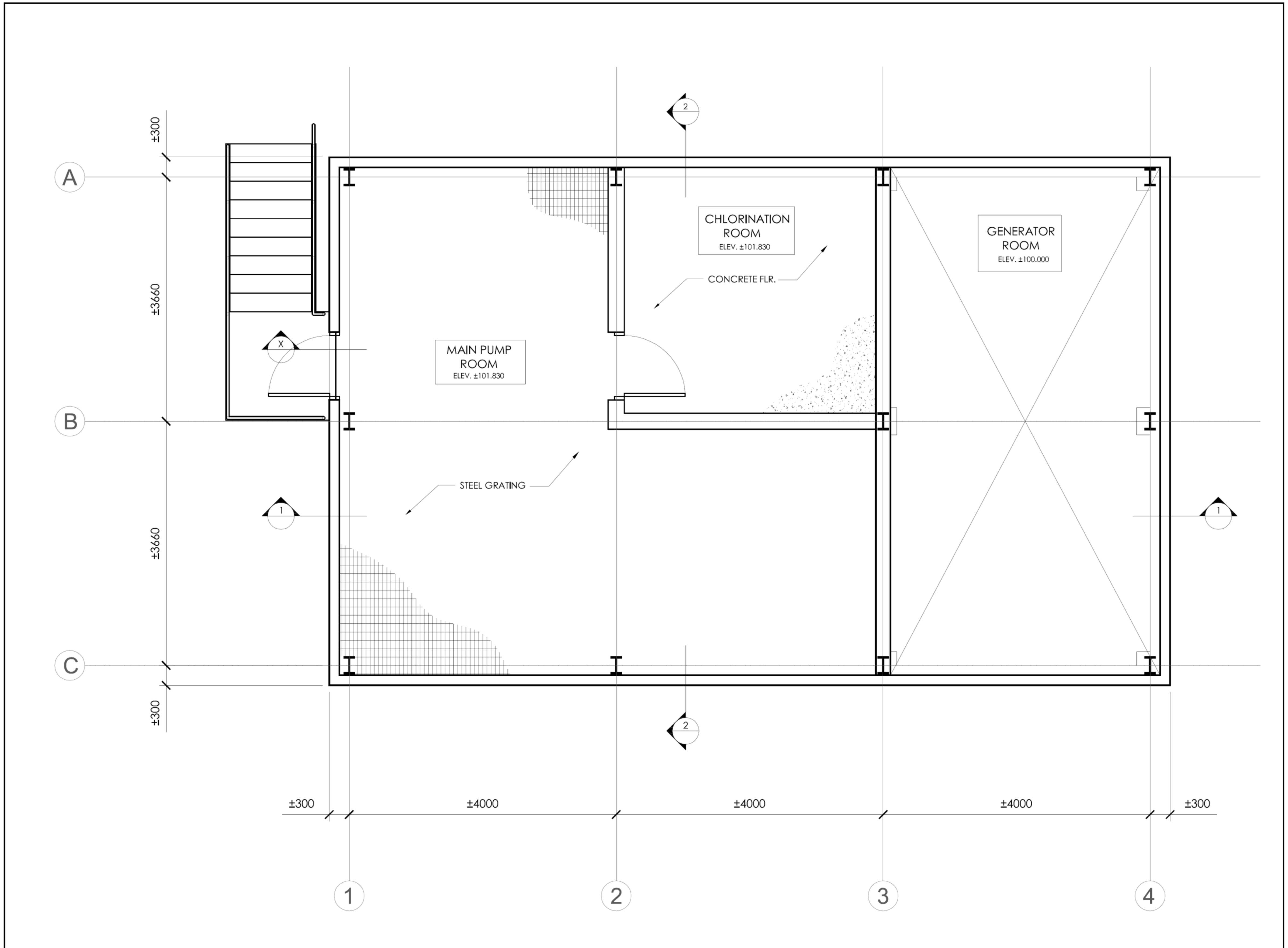

Figure 6 – Upper Level Floor Plan

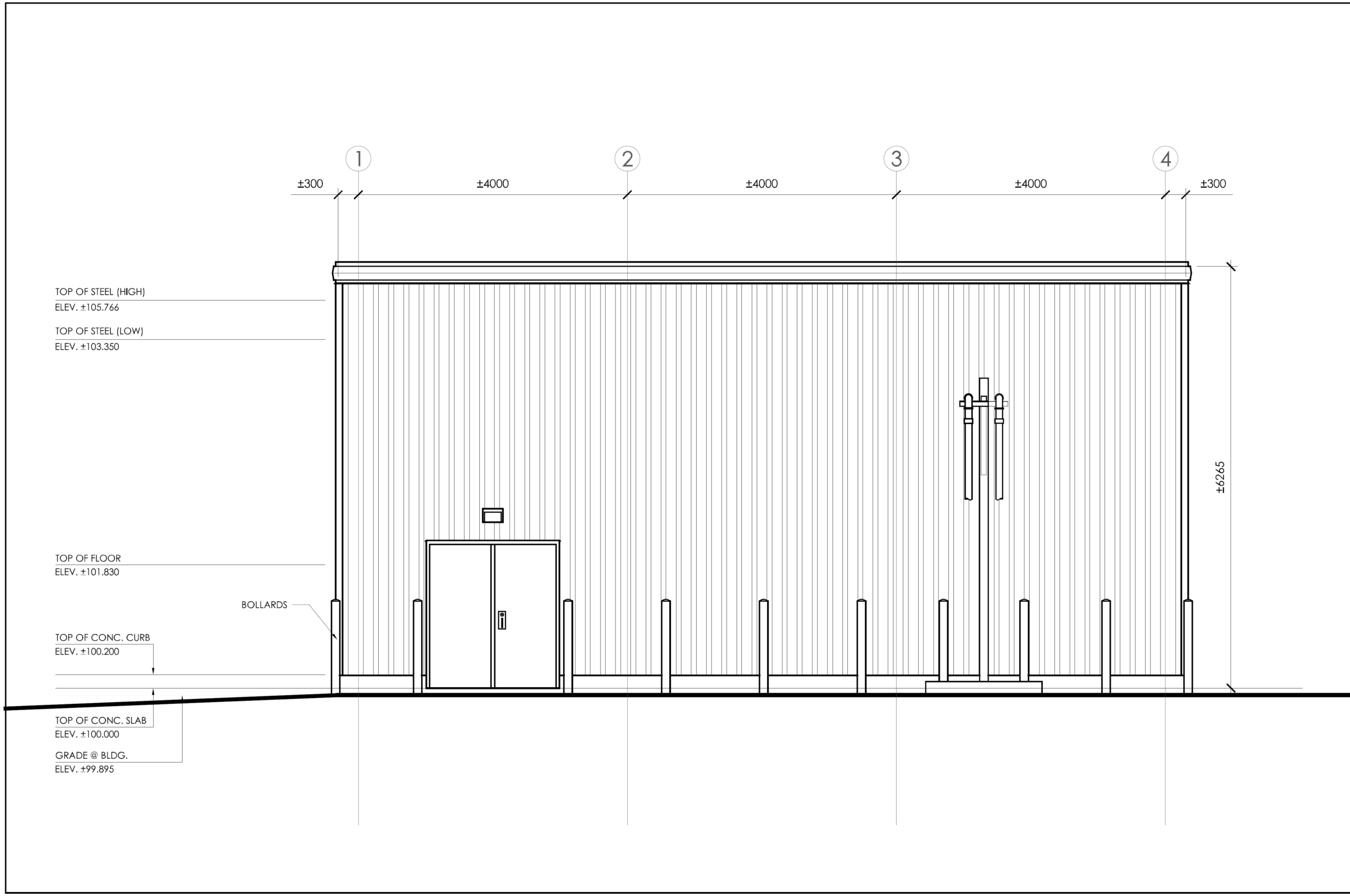

Figure 7 – North Elevation (Front)

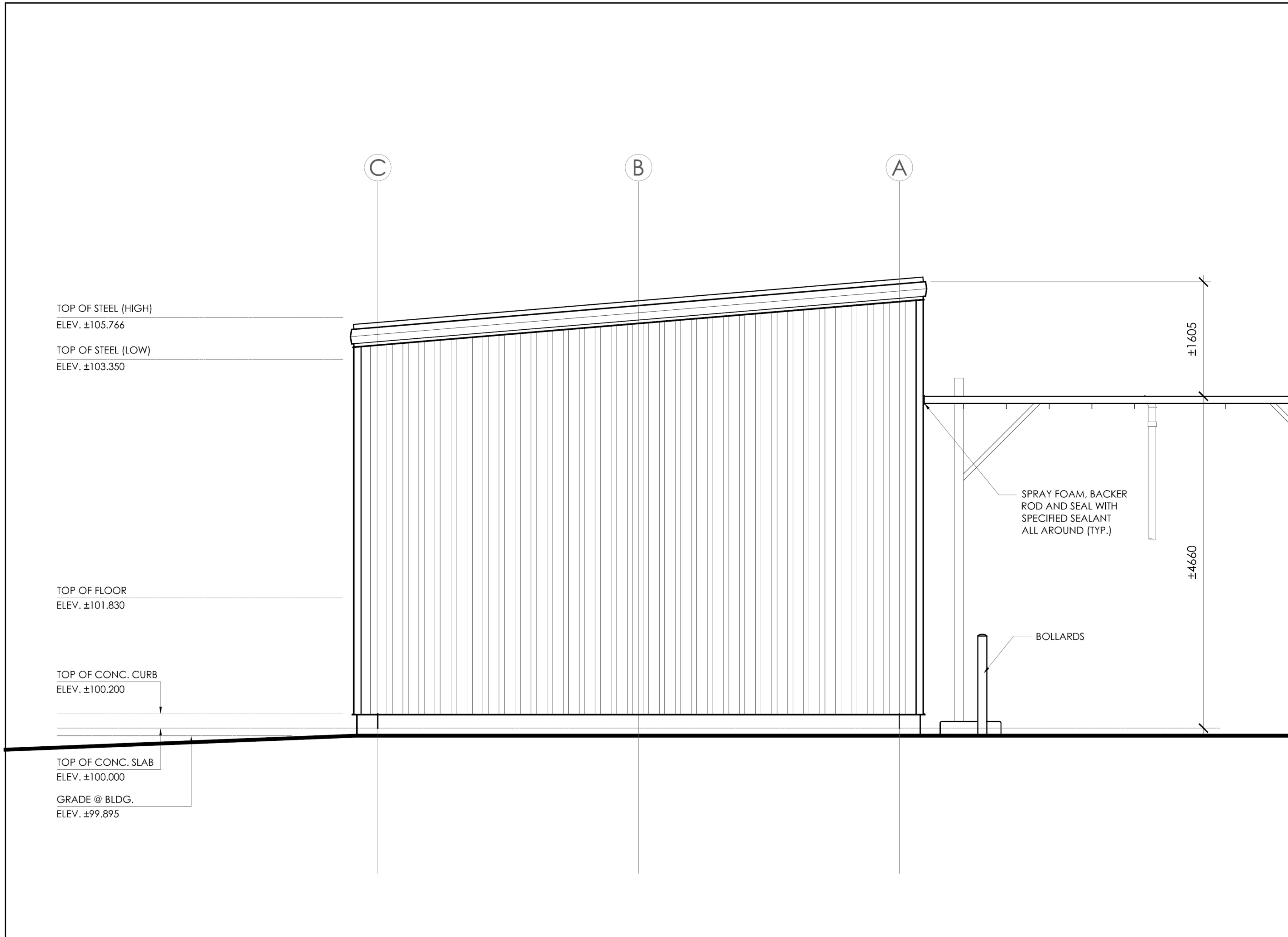

Figure 8 – East Elevation (Side)

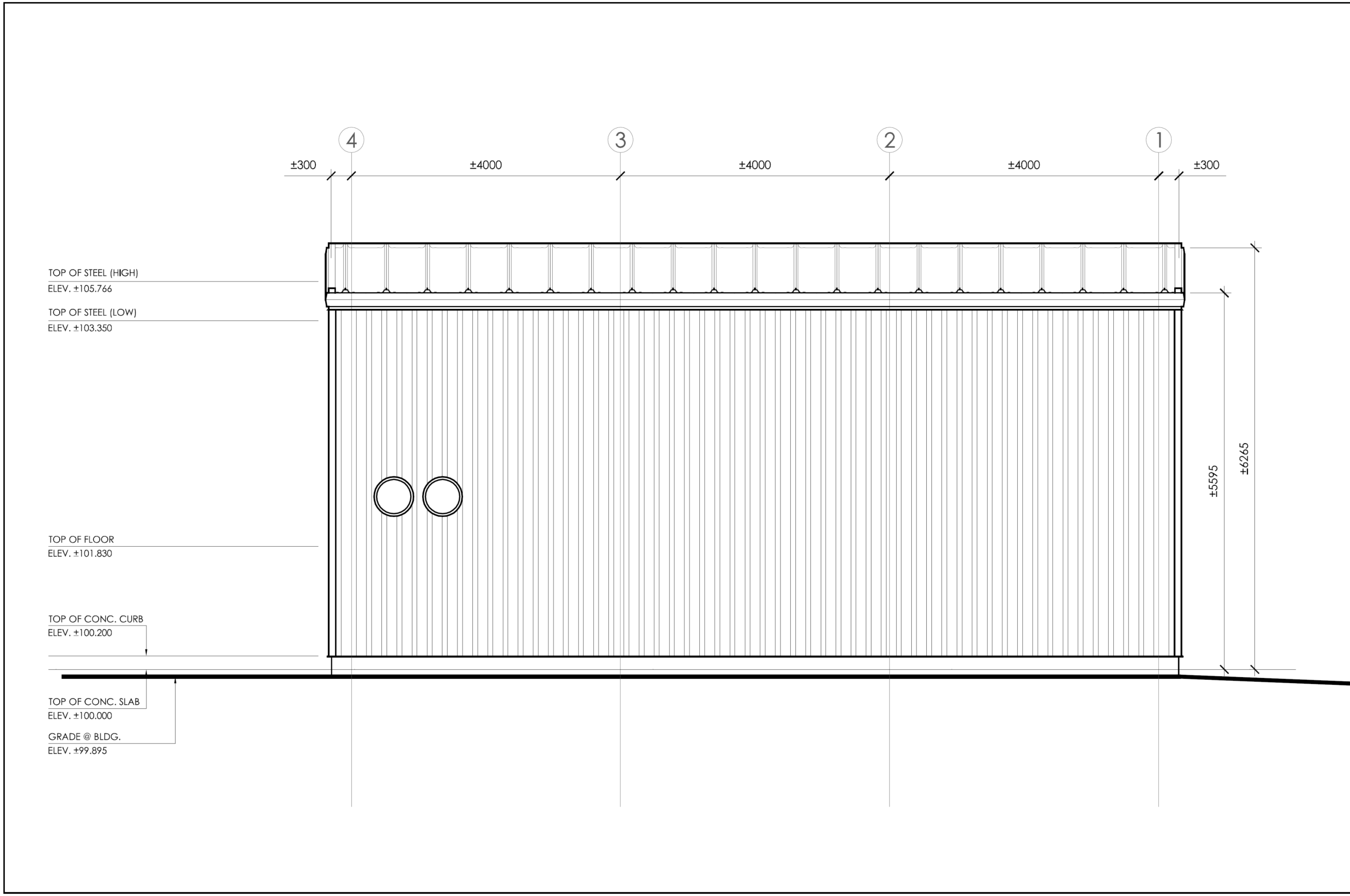

Figure 9 – South Elevation (Rear)

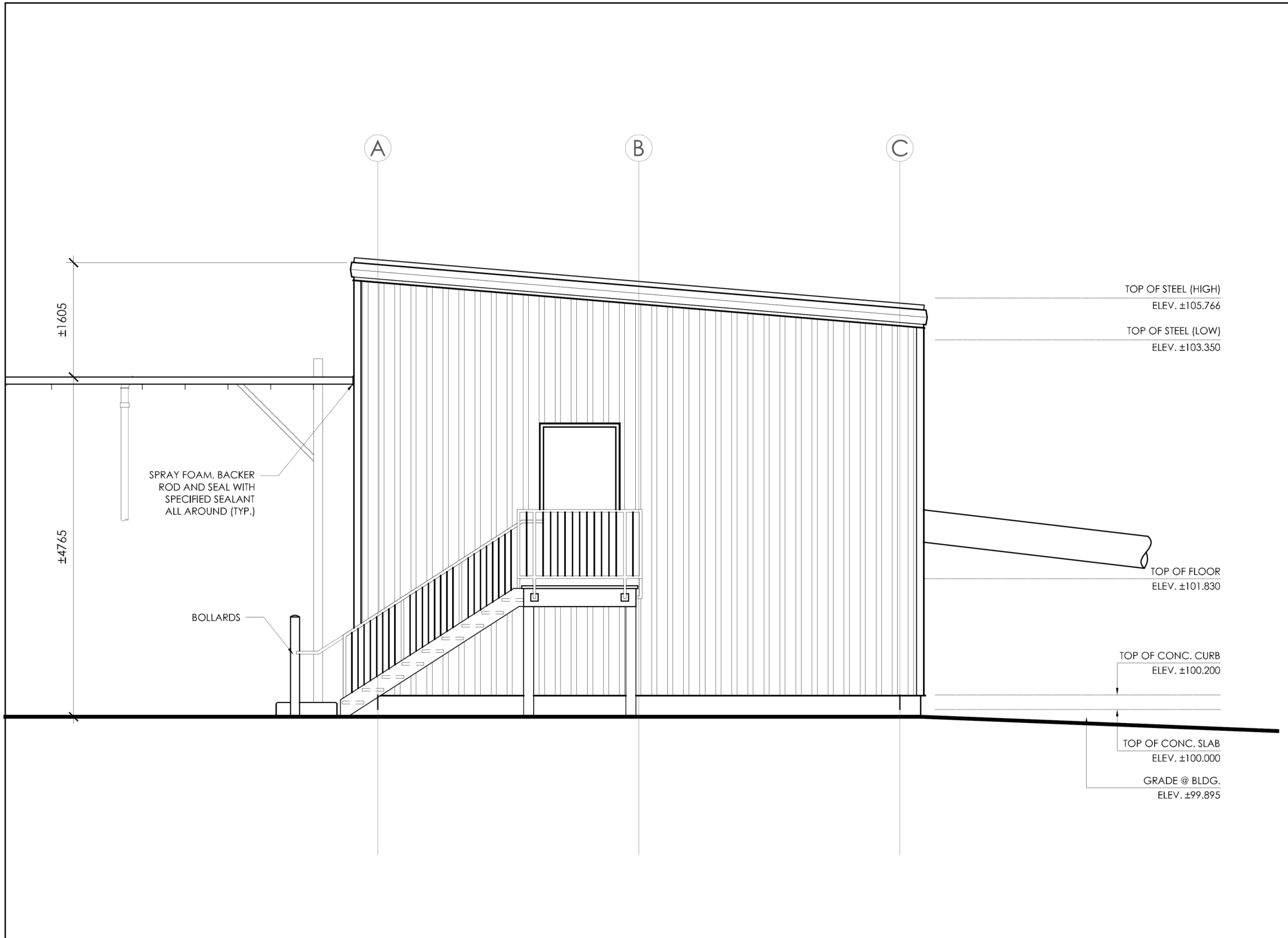

Figure 10 – West Elevation (Side)

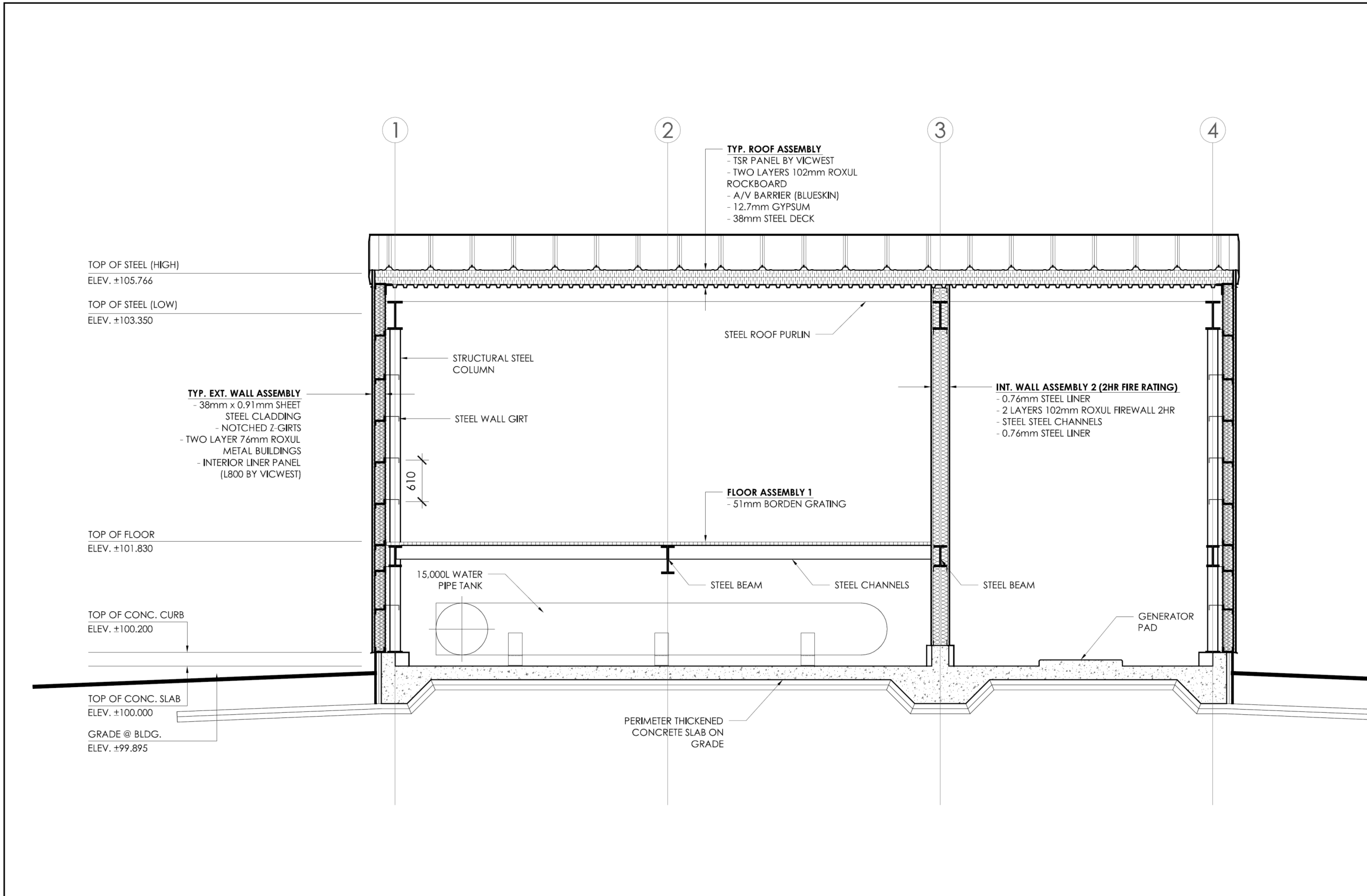

Figure 11 – Building Section 1

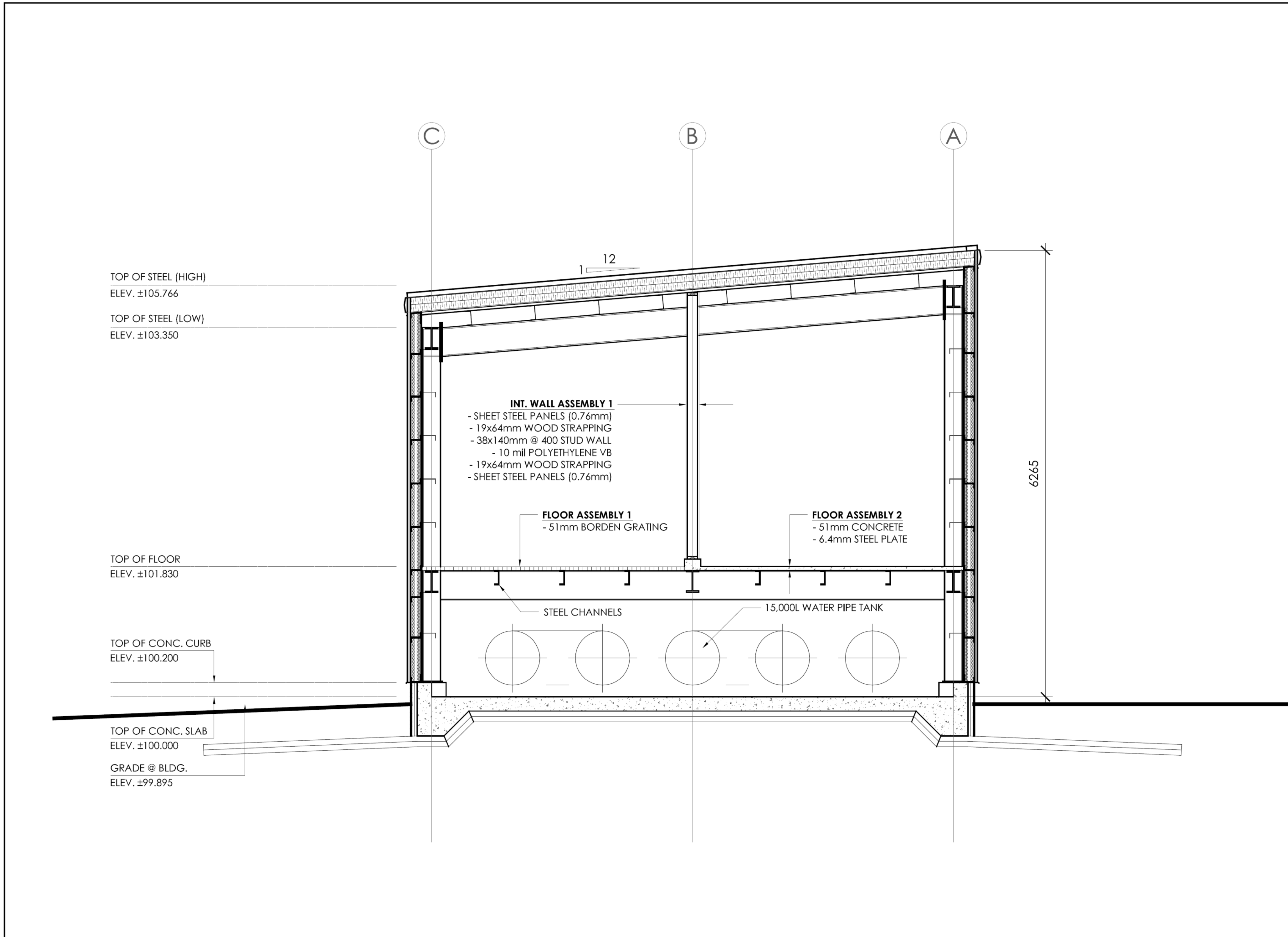

Figure 12 – Building Section 2

APPENDIX A – CT CONCEPT CALCULATION REVIEW

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TECHNICAL MEMORANDUM	
File:	004-GNCGS – Pangnirtung Water Reservoir
To:	Government of Nunavut – Department of Community and Government Services (GN-CGS)
Attention:	Mr. Jon Cooper, Project Officer
Subject:	GN-CGS Project #08-2009 – CT Concept Calculation Review
Author:	Mr. Matthew Hamp
Page Total:	7
Date:	2 August 2013

1.0 Introduction

As directed by the Government of Nunavut – Department of Community and Government Services (GN-CGS), the disinfection system for the proposed new water truck filling station in Pangnirtung is to be designed according to the CT Concept[1] using the following design parameters:

i. CT Value = 12 mg·min/L
ii. Baffling Factor, T_{10}/T = 1.0
iii. Flow Rate = 1,000 L/min
iv. Contact time = 12 minutes

In accordance with the 3 July 2013 ARKTIS *Scope of Professional Services*, the CT Concept calculations were to be completed in order to confirm the GN-CGS stipulated parameters and assumptions and to identify any discrepancies or issues of concern. This technical memorandum presents the results of this exercise.

2.0 Methodology

2.1 Overview/Summary

The methodology followed for determining the total log reduction of viruses and cysts/oocysts by filtration and disinfection, and for determining the size of the chlorine contact chamber required to achieve these disinfection rates, is that presented in Part 1 of the *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* (Government of Alberta, April 2012).

[1] *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* (Government of Alberta, April 2012)

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This document prescribes performance standards for the treatment of potable water from a surface water source, as follows:

i. All waterworks systems shall be provided with filtration and disinfection;
ii. For new systems, filtration and disinfection together shall achieve a minimum of 3-log reduction of Giardia and Cryptosporidium, and 4-log reduction of viruses, until a source water assessment is completed[2] (note: if a source water assessment is not completed, the system must achieve 5.5-log reduction of Giardia and Cryptosporidium, and 4-log reduction of viruses);
iii. For a system equipped with membrane filtration (the most likely scenario in the case of the Pangnirtung Water Truck Filling Station), the treated water turbidity levels from individual filter trains shall be less than or equal to 0.1 NTU at all times, and particle counts (particles greater than 2 μm) from individual filter trains shall not exceed an absolute value of 20 particles/mL[3];
iv. Disinfection shall be sufficient to:
    - inactivate the pathogens not removed by clarification and filtration, and achieve the level of cysts / oocysts reduction as stipulated in Table 1.1 (of the standard);
    - inactivate viruses and achieve the level of virus reduction as stipulated in Sections 1.2.1 (of the standard); and
    - maintain a minimum total chlorine residual of 0.2 mg/L in the water distribution system.

The standard also specifies the use of the CT disinfection concept to demonstrate satisfactory treatment of potable water.

The standard allows for potable water treatment credits to be applied to the calculation of treatment effectiveness for filtration and disinfection provided the treatment methods can be shown to meet certain prescribed limits. The credits would normally be granted by the Government of Alberta Ministry of Environment and Sustainable Resource Development and would therefore be applicable to projects in Alberta only. In the case of Nunavut, since there is no government body mandated to issue these credits and the Alberta standard has not been officially adopted by The Government of Nunavut, a case for applying log reduction credits for filtration is presented herein.

[2] As stipulated in the standard, systems serving a population of less than 10,000 shall first monitor raw water for *E.coli* at least every two weeks for a period of one year. Per the standard, no cysts and oocysts monitoring is required if the source reservoir has an average *E.coli* concentration of less than 10/100 mL, based on all of the samples in the one year period. Should the raw water sample results exceed this standard, monitoring for cysts and oocysts is required at least four times per year for a period of two years.

[3] Based on continuous monitoring at a minimum of five minute intervals

2.2 Reduction of Cysts and Oocysts

For the reduction of cysts and oocysts, Giardia and C ryptosporidium are identified in the standard as the organisms of concern to be addressed during treatment. For membrane filtration systems, credits would only be applied based on product specific challenge testing and verified by direct integrity testing of the membrane, as described in the latest edition of the USEPA Membrane Filtration Guidance Manual. Membrane cartridge filters, such as Harmsco LT2 Pleated Cartridges, are independently certified by NSF International (an independent, not-for-profit organization that provides product certification for products related to public health and the environment) to provide 3.6-log reduction of cyst-sized particles. Since the Alberta standard stipulates a minimum of 3-log reduction of cysts/oocysts, the use of this type of independently certified membrane filter is sufficient to provide the required reduction for these organisms.

2.3 Reduction of Viruses

For the reduction of viruses, some form of disinfection is required. Options for disinfection include chlorination (free chlorine), ultraviolet (UV) light, chlorine dioxide, and ozone. In addition to the inactivation of viruses, the disinfection system must provide a residual chlorine concentration in the treated water, according to both the Alberta standard and the Nunavut Public Health Regulations.

Chlorination meets the requirements of both disinfection and maintaining a residual chlorine concentration in the treated water, while at the same time greatly simplifying the treatment system by accomplishing these two requirements with one sub-system (i.e. chlorination). All other options require multiple systems to achieve the same goals.

The Alberta standard stipulates the use of the CT concept to calculate the contact time necessary to provide a 4-log inactivation of viruses. The following section sub-section details the CT concept calculations.

2.3.1 CT Concept Calculations

According the Alberta standard "the CT concept uses the combination of disinfectant residual concentration (mg/L) and the effective disinfection contact time (in minutes) at maximum hourly flows to measure effective pathogen reduction." The basic equation is:

$$CT = \text{Concentration} \times \text{Time}$$

Where, the concentration of residual chlorine is in mg/L and the time the water is in contact with the chlorine is in minutes.

This equation can be modified to calculate the actual $CT_{achieved}$ as follows:

$$CT_{achieved} = \text{Concentration X Time X } T_{10}/T_{MIN}$$

Where, T_{10}/T_{MIN} is the baffling factor, which is the ratio of the time it takes 10% of a unit of water to move through a contact vessel and the minimum time it takes for the entire unit of water to pass through the same contact vessel. The baffling factor is an i ndication of the mixing efficiency of a given contact vessel.

T_{MIN} can also be expressed as follows:

$$T_{MIN} = \frac{\text{minimum volume of water in the contact vessel (L)}}{\text{maximum flow rate (L/min)}}$$

The GN-CGS has stipulated that the CT calculations for the disinfection system must use the following values:

i. CT Value = 12 mg·min/L
ii. Baffling Factor, T_{10}/T = 1.0
iii. Flow Rate = 1,000 L/min
iv. Contact time = 12 minutes

Note: a Baffling Factor of 1.0 assumes a perfect baffling condition (i.e. ideal plug flow), which entails a very high length to width ratio, perforated inlet and outlet, and intra-vessel baffles. This condition can be represented by a water pipeline with no mixing and no short-circuiting, wherein a unit of water moves through the vessel from the inlet to the outlet across the entire cross-section of the vessel for the entire length of the vessel.

The following calculations are presented to verify that these values can indeed be us ed to demonstrate effective disinfection treatment to the virus and cyst/oocyst reduction levels stipulated by the standard.

What we know (in addition to the above-noted GN-CGS stipulated values):

i. The water temperature most likely to be en countered throughout the course an operational year is 0.5°C or less. Given that there are insufficient water temperature records available and given the arctic climate in which the facility will operate, it must be assumed that for most of any given operational year, the source water will be near freezing. The effectiveness of chlorine as a d isinfection agent in water is directly proportional to the temperature of the water, and therefore this is a conservative assumption;

ii. The pH of the source water will be within the range of 6.5 to 7.0[4]; and
iii. The minimum chlorine residual is 0.2 mg/L prescribed by both the Nunavut Public Health regulations and the Alberta standard.

Calculation of $CT_{required}$

Since the membrane filter provides the necessary 3-log reduction of cysts/oocysts, no additional chlorination is required to inactivate these organisms.

Thus, the $CT_{required}$ for virus inactivation can be determined from tables provided in Appendix 1-B of the Alberta standard. For a water temperature of 0.5°C and a pH range of 6 to 9, the $CT_{required}$ for 4-log inactivation of viruses is 12 mg·min/L.

Calculation of Chlorine Residual

The residual chlorine (at the outlet of the contact vessel) can be calculated from the CT formula, by entering known and given values for CT and contact time (T_{MIN}). For a CT of 12 mg·min/L and a contact time of 12 minutes, the residual chlorine concentration is 1.0 mg/L. Therefore, the chlorine dosage rate ultimately selected for the treatment system must be sufficient to result in a residual chlorine concentration of 1.0 mg/L (note: the minimum chlorine residual stipulated in both the Alberta standard and the Nunavut Public Health Regulations is 0.2 mg/L).

Given the input parameters for the CT calculation that have been specified by the GN-CGS, the residual chlorine of 1.0 mg/L is the only possible value for this parameter, and therefore is also indirectly specified by the GN-CGS.

Calculation of Required Contact Vessel Volume

The volume of the contact chamber required can be calculated from the relationship between contact time (T_{MIN}), maximum flow rate, and minimum volume of contact vessel. Using the calculated value for T_{MIN} and the required maximum flow rate stipulated by the GN-CGS, gives a contact chamber volume of 12,000 L or 12 m^3.

[4] As part of the *Comprehensive Performance Evaluation* of the existing water truck filling station completed by ARKTIS in July 2009, two source water samples were procured and analysed for a suite of chemical parameters and pH. The pH for these source water samples was 6.63 and 6.61. These results are sufficient to use for this exercise, however, source water characterization should be completed to confirm that the pH of the source water is consistently within this range.

3.0 Results

The CT calculations were completed using the following GN-CGS stipulated parameters:

i. CT Value = 12 mg·min/L
ii. Baffling Factor, T_{10}/T = 1.0
iii. Flow Rate = 1,000 L/min
iv. Contact time = 12 minutes

The calculated results are as follows:

i. Residual Chlorine Concentration = 1.0 mg/L
ii. Volume of Contact Vessel = 12,000 L

4.0 Discussion

The values stipulated by the GN-CGS to be used in the CT calculations, and hence, the design of the water treatment system for the water truck filling station, have been verified, giving reasonable results for residual chlorine concentration and contact vessel volume.

The contact vessel volume of 12,000 L may, however, present a problem in design given the length of pipe that will be necessary to approach ideal plug flow conditions (i.e. a Baffling Factor of 1.0). For example, a pipe of 1 metre diameter will result in a length of over 15 metres to provide the required 12,000 L capacity. Additionally, as two truck filling arms are required, capable of filling two water trucks *simultaneously*, two such contact vessels will be required. The building that will be necessary to house these contact vessels and associated equipment will have to be quite large and able to withstand the increased loads of at least 30 metres of 1 metre diameter pipe in addition to the other systems required for the facility.

Further, the Baffling Factor of 1.0 represents ideal plug flow (i.e. perfect mixing in the radial direction across a pipe, or 100% mixing efficiency, along a straight pipe with no bends). In practice, this is not possible, as real-world pipe flow does not behave ideally (e.g. there is always some turbulence and friction along the walls of the pipe), particularly in a pipe that will necessarily have multiple bends along its length in order to fit it into a limited space. Some level of hydraulic analysis would be necessary to determine whether a Baffling Factor of 1.0 is appropriate for the pipe system to be designed, which could likely result in an increase in the volume required for the contact vessel.

5.0 Recommendations

As an alternative to the contact pipe, ARKTIS recommends a baffled tank system as presented in our March 15th 2011 Briefing Note. The advantage of the baffled tank system is that a number of pre-engineered tank designs are available (typically with Baffling Factors of 0.7) and can be used in the design to reduce the overall complexity of the system and simplify its construction. At present, there are no known pre-engineered contact pipes currently manufactured. Use of a contact pipe in the facility would thus require the design and construction of a prototype system to satisfy the requirement of a Baffling Factor of 1.0.

Although a Baffling Factor of 0.7 for a pre-engineered tank would result in a larger volume requirement and a s lightly longer contact time (or slightly higher chlorine residual), it is the opinion of ARKTIS that the overall volume of building space taken up by a tank system would likely be very similar to that taken up by a pipe system, particularly when the non-ideal configuration of the pipe is taken into account (which may likely result in an adjustment to the Baffling Factor and hence increase to contact vessel volume anyway). The reason for this is that in order for the pipe system to fit inside a reasonably-sized building, multiple turns and bends would be required, which would necessarily result in an increase in overall volume of building space taken up by the piping. In short, the size of the building required for either system would likely be very similar; however, the complexity of design and difficulty of construction would be reduced with the tank system.

Further, there is a limit to the diameter that the pipe system can have, above which it would no longer exhibit plug flow behaviour (a precondition for a Baffling Factor of 1.0). The larger the diameter of piping, the shorter the length of piping required; however, the larger the diameter, the less likely the piping will exhibit plug flow behaviour, negating any advantage of such a system.

6.0 Closing

Should you have any questions whatsoever about its contents, please feel free to contact the author at 867.899.6060 and/or hamp@arktissolutions.com.

APPENDIX B – MECHANICAL AND ELECTRICAL ENGINEERING DESIGN DEVELOPMENT REPORT

CHIARELLI ENGINEERING MANAGEMENT LIMITED

ɜEMENT LTD.

Drinking Water Truck Fill Station & Infrastructure
Pangnirtung, NU
Design Development Report

Prepared for: ARKTIS Solutions, Inc.

Project No.: 13-072
Updated October 10, 2013

Chiarelli Engineering Management Ltd.
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1 Executive Summary

The objectives of this Design Development phase are to follow-up on our previous report that assessed three different chlorination tank options for a new truck fill station. The new truck fill station is to be designed and constructed next to the existing truck fill station at the current drinking water reservoir in Pangnirtung, Nunavut. The schematic options previously considered included provisions for tanks as follows:

- Option 1: a single large exterior (insulated) tank.
- Option 2: a single mixing tank (baffled mixing).
- Option 3: two retention tanks

Each of these options was looked at in detail and Option 3 was recommended as it satisfies all objectives, including: projected growth and increased water delivery capacity. It also provided isolated storage for chemicals, proper water chlorination, and allowed incorporating additional water storage in future.

The Government of Nunavut rejected the proposed option in favor of a fourth option which is essentially a variation of option 1 and 2. The result is a serpentine piping approach that will contain approximately 15,000 litres of chlorinated water. The advantage of this approach is that it will reduce the actual contact time of the chlorine by some eight to ten minutes.

The new option will replace the present truck fill station that is at the end of its operational life and in addition increase its limited delivery capacity. This study does not discuss the interconnection of the future water reservoir with the pumping station forecasted for the hamlet within the next 5 to 10 years. However, the system is designed such that it would accommodate connection of additional pumps serving the future reservoir.

Concurrently with the development of this project, ARKTIS was also retained by the GN-CGS to complete the design of the water truck filling station in Igloolik, a community of similar population size, projected water demand, and with water also drawn from a reservoir. In June 2013 the GN-CGS requested that ARKTIS revise our existing scope of services for both Pangnirtung and Igloolik projects to account for changes in the design requirements for both of the proposed Water Truck Filling Stations. Consequently, the design analysis and proposals for both truck fill stations are identical as they reflect the results of previous design iterations and concepts.

It is recommended to carry out the work in 2014 construction season. The project period is estimated to take about 4 months. Cost estimation of this option is not in the scope of this report.

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2 Introduction to New Design

2.1 Background

The existing water reservoir and associated truck fill station construction commenced in 1985 and was completed in 1987. The facility was built and operates on now outdated technology. The facility has not been modernized since its construction. Maintaining the facility is becoming increasingly difficult due to its age and availability of replacement parts.

The existing truck fill station chlorination technology reflects the technology used 25 years ago and by todays standards it is outdated and should be brought to present day standards.

In addition, the population increase has increased demands on water consumption which cannot be met by the present single filling arm and its water delivery capacity.

Based on the above the Government of Nunavut opted to replace the existing facility with a new truck fill station.

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ARKTIS Solutions Inc, the firm responsible for the design and implementation of the new truck fill station has retained Chiarelli Engineering Management Ltd. to design the mechanical and electrical system requirements for the drinking water supply operation and to address the above design issues.

2.2 Objectives

The objectives of the Design Development phase portion of this project are to:

- Understand the present day operation, capacity of the water delivery system, health concerns, safety and operational requirements and predicted growth.
- Propose a design, develop and implement a quality drinking water delivery system that will stand the test of time, and based on the design parameters stipulated by the GN-CGS (i.e. serpentine contact vessel).

2.3 Information Assessed

Previous reports and studies as well as some original design documentation were provided.

Interviews were conducted with the municipality officials and maintenance personnel who relayed operational concerns and provided historical perspectives of issues with running the water delivery in the town of Pangnirtung, NU.

Feedback on the previous report by the Government of Nunavut that provided guidelines for the desired truck fill station schematic and setup.

Also, manufacturers of the relevant equipment (pumps, chlorination and control systems, piping, etc.) were contacted for information on availability of replacement parts and new systems.

2.4 Scope of Design Development Phase

This phase is primarily concerned with the truck filling station and its associated equipment. It does not address concerns with operation of trucks or expansion of the water storage. It is the intent of this phase to present an agreed upon design concept, develop and implement design strategies that the Government of Nunavut can move forward with and provide the Hamlet of Pangnirtung with a reliable, safe potable drinking water truck fill station.

2.5 Limitations

Reviewed material, furnished by others, is expected to be free of any deficiencies or inaccuracies.

Comments and conclusions within this report represent our opinion, which has been based on our analysis and our past experience.

In issuing this phase, Chiarelli Engineering Management Ltd, does not assume any of the duties or liabilities of the designers, builders, owner or property managers of this operation. Persons who use or rely on the contents of this report do so with the understanding as to the limitations of the documents examined. Such persons understand that Chiarelli Engineering Management Ltd cannot be held liable for the damages they may suffer in respect to the design construction, purchase, ownership, use or operation of the water delivery facilities.

2.6 Methodology

The water delivery process of the truck fill station can be broken down to several building blocks that make up the complete system. These building blocks are:

- Pumping,
- Filtering,
- Chlorination,
- Water reservoir,
- Delivery system to trucks,
- Emergency power, and
- Controls and auxiliary equipment.

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The design of each of these building blocks was derived from Government of Nunavut guidelines, applicable Codes and followed up by consultations with potential providers of specialized technologies. The final review and comments were provided by Government of Nunavut representatives.

3 Analysis and Discussion of the Existing Truck Fill Station

3.1 Truck Fill Station

The present truck filling station operates with equipment installed over 25 years ago. Maintaining this equipment is becoming increasingly difficult as replacement parts are increasingly difficult to get.

In addition, some equipment, such as the chlorination system, is out of date by today's standards and will have to be replaced to meet relevant health and safety standards and Codes.

The truck fill facility, and all equipment in it, has reached its useful life expectancy. A major breakdown of any of its key components is unavoidable. A breakdown of this nature will leave the community without drinking water for an extended period of time which renders this community in a high risk management situation.

Immediate (as soon as practicable) action needs to be taken to ensure that all broken or non-functioning equipment be repaired or replaced to address this situation while planning for a major renovation or replacement of the whole truck fill station in 2014 construction season.

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3.1.1 Maintenance of Existing Equipment

Most of the automation built into the operation has deteriorated to the point that is working only partially, or not working at all. As a consequence some features of the production are running in manual mode and thus leaving the operation vulnerable to human error.

Features that are compromised:

- Operating the redundant pumps:
  It is unclear whether pump #1 is operational, and if it is, to what extent.
  Consequence: Running the operation on a single pump provides no backup in case pump #2 fails.

- Automatic Transfer Switch:
  The automatic transfer feature was removed. During an AC power outage, the backup generator must be turned on manually.
  Consequence: There is no heating without AC power and equipment and pipes can freeze.

- Pump Control and Alarm Panel:
  The control panel has some indicator lights, including their sockets that are burned out.
  Consequence: unable to see any alarm condition (e.g. high/low diesel room temperature). In combination with faulty alarm annunciation, the alarm condition stays unnoticed. This may have serious consequences.

- Heat Tracing Control Panel:
  The control panel has some indicator lights burned out.
  Consequence: unable to see any alarm condition (e.g. faulty heat tracing cable). In combination with faulty alarm annunciation, the alarm condition stays unnoticed. This may have serious consequences.

- Diesel Generator:
  Replacement generator is already available but not installed.
  Consequence: decreased reliability of the aging generator.

- Gaps in metal cladding:
  To improve thermal efficiency, gaps around the roof and pipes must be sealed.
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  Consequence: unnecessary thermal losses and exposure to potential equipment and pipe freezing.

- Heating system:
  The ceiling mounted heater in the pump room is not controlled by a thermostat. The generator room is heated by a plug-in temporary heater.
  Consequence: Unnecessary heating expenses for the continuously running heater and vulnerability of heating in the generator room.

- Rusty electrical distribution equipment:
  Due to its installation in the chlorination room, the electrical panels and other equipment are exposed to corrosive vapors.
  Consequence: accelerated aging of electrical distribution equipment.

- Miscellaneous equipment:
  Including flow and level meters, battery chargers, fire extinguishers, etc. This equipment should be tested and/or calibrated regularly.
  Consequence: inability to notice failed or improperly working devices.

Features that are not working:

- Emergency lighting:
  Not working, must be replaced
  Consequence: no lighting in the building during power failure.

- Remote alarm system:
  The Motorola radio and alarm encoder is not operational. The remote alarming needs to be replaced.
  Consequence: an alarm condition occurring at the truck fill station will stay unnoticed until the next visit by personnel. This may have serious consequences.

Other issues:

The building of the truck fill station will need some renovation and maintenance to fix the consequences of years of neglect, wear and tear. This includes fixing the door lock and latches, broken lights of the filler spout, caulking gaps around the roof and pipes, etc.

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Perceptively, the layout of the truck fill station is not well suitable for expansion and modification of the facility. It does not provide separation of incompatible operational environments, such as separation of chlorination (generating corrosive vapors) from electrical equipment (sensitive to such vapors). The building is undersized to accept equipment that would be necessary to install to provide increased pumping capacity or to accommodate the pumps of the future water reservoir.

3.1.2 Chlorination

The chlorination process used in the truck fill station does not comply with today standards for safe drinking water:

- There is only one dosing pump with no backup if it fails.

- Mixing and transferring the liquid chlorine mixture is susceptible to leaks and spills.

- It is difficult to monitor proper mixing dosage.

Also, the chemical used for chlorination may not be the best chemical to be applied for chlorination of the drinking water systems. This process should be in a self-contained room to prevent corrosive action as well as provide adequate and proper ventilation.

3.1.3 Truck Filling Capacity

The capacity of the truck filling station is limited by the size of the pump (~1000 L/min.) combined with the single filling spout. During peak demand hours there could be multiple trucks lined up at the station to be filled.

As of our last review of the Hamlet truck filling operations in 2012, the hamlet of Pangnirtung has 5 water delivery trucks: 2 trucks of 13,600 L capacity and 3 trucks of 6,500 L capacity. It takes approx. 15 minutes to fill a larger truck.

The activation time for chlorine according to the relevant public water supply regulation, is 20 minutes.

Occasionally, non-chlorinated water is required for skating rinks and other non-drinking applications. This worsens the vulnerability to errors by operators as pipes and trucks must be subsequently flushed.

In summary, the present truck filling station has limits to increase delivery of water and has no facility to separate delivery of non-chlorinated water from drinking water.

3.1.4 Features for Future Expansion

The present reservoir will reach its limits within 5 to 10 years. Studies that looked at ways to add more holding capacity suggested building a second reservoir adjacent to the existing one. It would be highly desirable to maintain only one truck fill station to serve both reservoirs after the construction of the second reservoir.

The size of the present truck fill station building does not permit that possibility.

3.1.5 Location of the Truck Fill Station

It was brought to our attention by the Senior Administrative Officer that maintaining the road up to the present truck fill station location is difficult in bad weather. The last section of the road is steep and exposed to high winds.

If the truck fill station could be located at the bottom of the reservoir dam, it would be much easier to drive there in addition to the savings on time and fuel that is spent on climbing to the top of the dam.

3.2 Other observations noted but not covered by this report

The water reservoir is an integral part of the water delivery operation. Although not part of this report, there are two points that need to be highlighted:

1. The present size of the reservoir will reach its capacity within 5 to 10 years. Expanding the capacity may not be an immediate concern, but it deserves to be included in budget planning for the near future.

2. The present reservoir will require maintenance, however, this is not tied into the refurbishment or rebuild of the truck fill station. The areas that will need attention are:

   - Draining and cleaning the reservoir of the accumulated debris.

   - Repairing the eroded slopes, the liner and draining equipment.

   - Fixing the protective berm, ditches and chain link fence around the reservoir.

4 Design Analysis

4.1 Functional Requirements

Functional requirements of water delivery operation can be summarized into the following points:

- Provide safe quality potable drinking water.
- Provide increased delivery capacities and quantities of drinking water.
- Be safe working environment for the personnel and equipment.

4.2 Functional Blocks of the New Truck Fill Station

In order to house pumping and water delivery equipment and supporting infrastructure the overall footprint for the building is estimated at 1100 square feet. The architectural and structural design of the new pumping building is not in the scope of this report.

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4.2.1 Pumping

The current proposed design will have redundant pumps that will pump the water out of the reservoir and into the serpentine piping arrangement through filters and chlorination process.

Each pump (WP-1 and WP-2) will have the required capacity of delivering 1000L/m specified for filling of delivery trucks. The two pumps are sequenced in operation but can run simultaneously when filling two water bowsers at the same time.

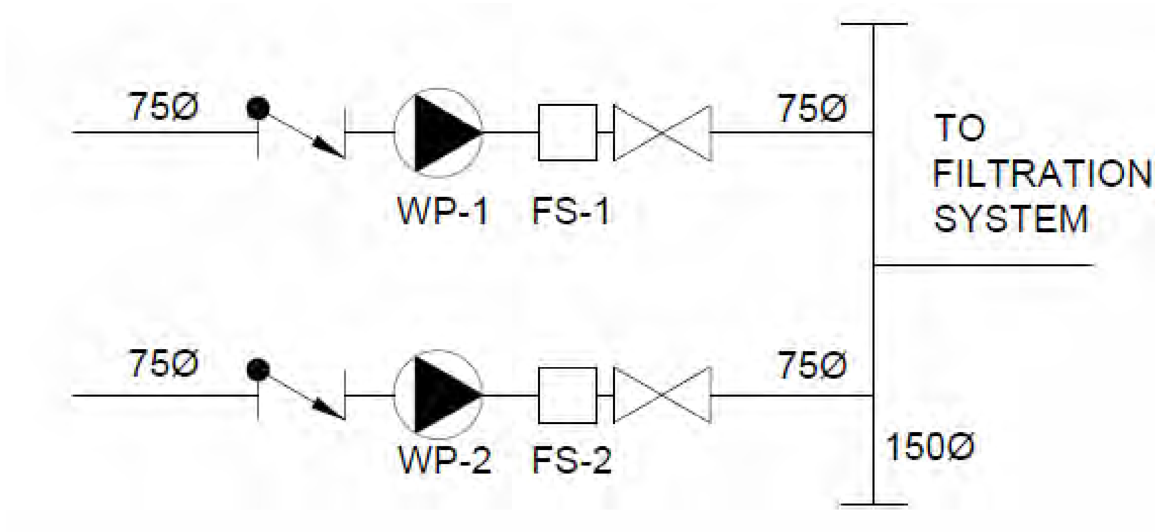

Figure 1: Pumping Arrangement

Note that during original design stage the GN-CGS specifically rejected the idea of a third intake line and pump and as a result, there is no full redundancy in the system. Therefore, the recommendation is to store a third pump set on site in case one of the two pumps fails.

In case one of the two working pumps fail, only one pump will run whether one or two truck fill stations are initiated while the failed pump is being replaced with the spare set. In this arrangement the impact of a pump failure is minimized.

4.2.2 Filtering

The truck fill station will include filtration equipment through 20 micron, 5 micron and 1 micron filter cartridges capable of filtering water delivered by both pumps simultaneously (2000L/m).

Each filter will be monitored by a differential pressure gauge that indicates that the filter cartridge is clogged and will need to be cleaned.

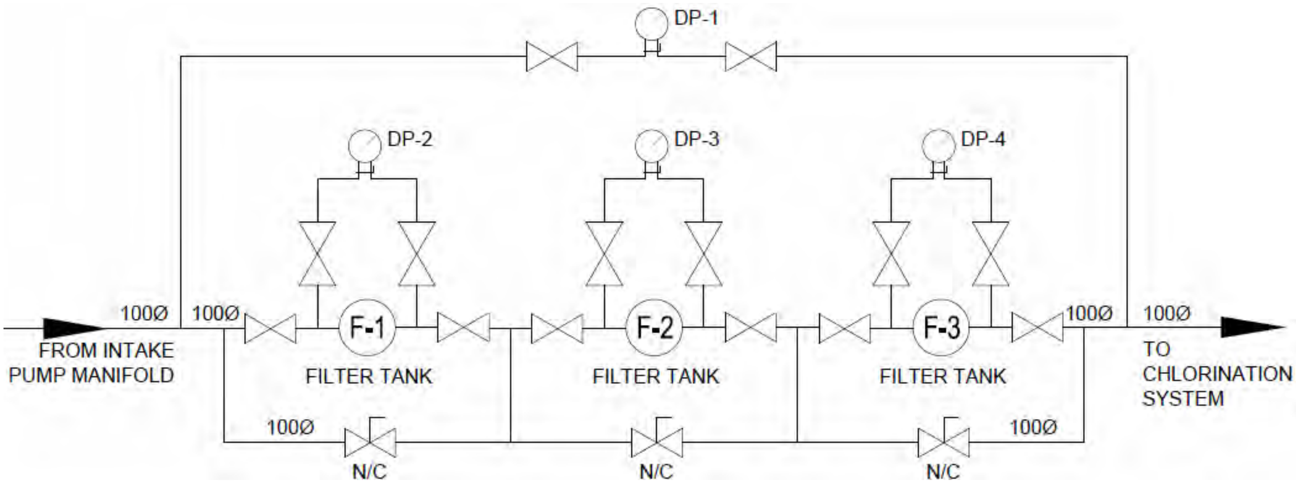

Figure 2: Arrangement of Filters

4.2.3 Chlorination

The chlorination will be provided through dosing pumps, and redundancy is planned. The legislation requires a minimum 0.2 mg/L of chlorine residual reading. The chlorination process described below shall provide flexibility to set the residual chlorine in a wide range. The pre-mixed chlorine will be injected into the main fill pipe feeding water into the serpentine pipe. The minimum chlorine contact time due to application of the serpentine pipe is reduced to 12 minutes.

The second, identical chlorination system (post-chlorination) will be located between the output of the serpentine tank and the truck fill stations checking and adjusting the chlorination level just before the water is delivered to the distribution trucks.

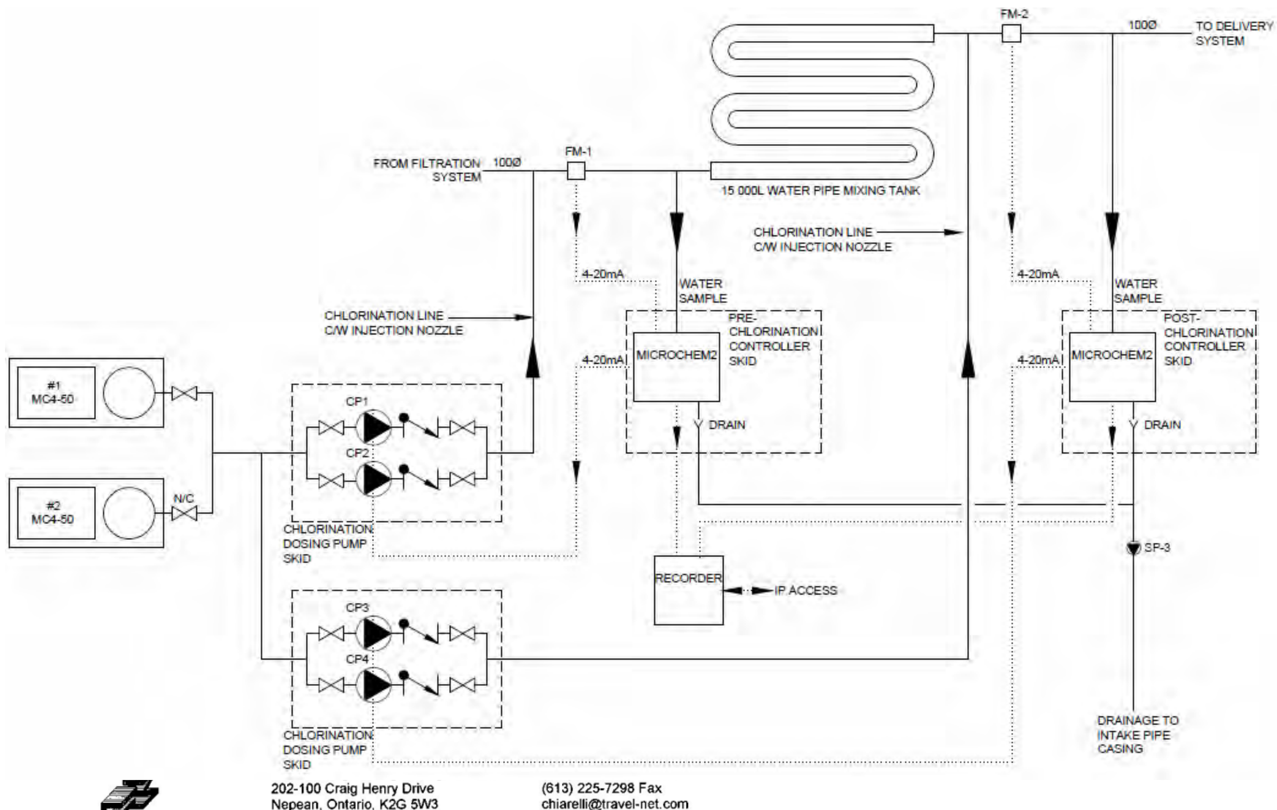

Figure 3: The Chlorination Loop

The Microchem2 is the controlling unit for the chlorination process. Since the water flow in the main 100 mm water pipe can vary depending whether 1 or 2 pumps are running, the condition of the filters and the water level in the lagoon, the flow is precisely measured by the flow meter (FM-1). The controller sends a 4-20 mA signal to the chlorination dosing pump (CP-1 or CP-2) that is proportional to the water flow measured by FM-1. Water is tested continually by chlorination and pH/temperature probes connected to Microchem2 which will adjust the amount of chlorine solution pumped by CP-1 or CP-2 to ensure the required level of chlorination.

Figure 4: Microchem2 Skid with Probed

The information gathered by Microchem2 (water delivery, chlorination, temperature and pH) will be stored in the data recorder and the data will be accessible through a USB port or remotely through an IP address.

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Nepean, Ont

Figure 5: Nanodac Data Recorder

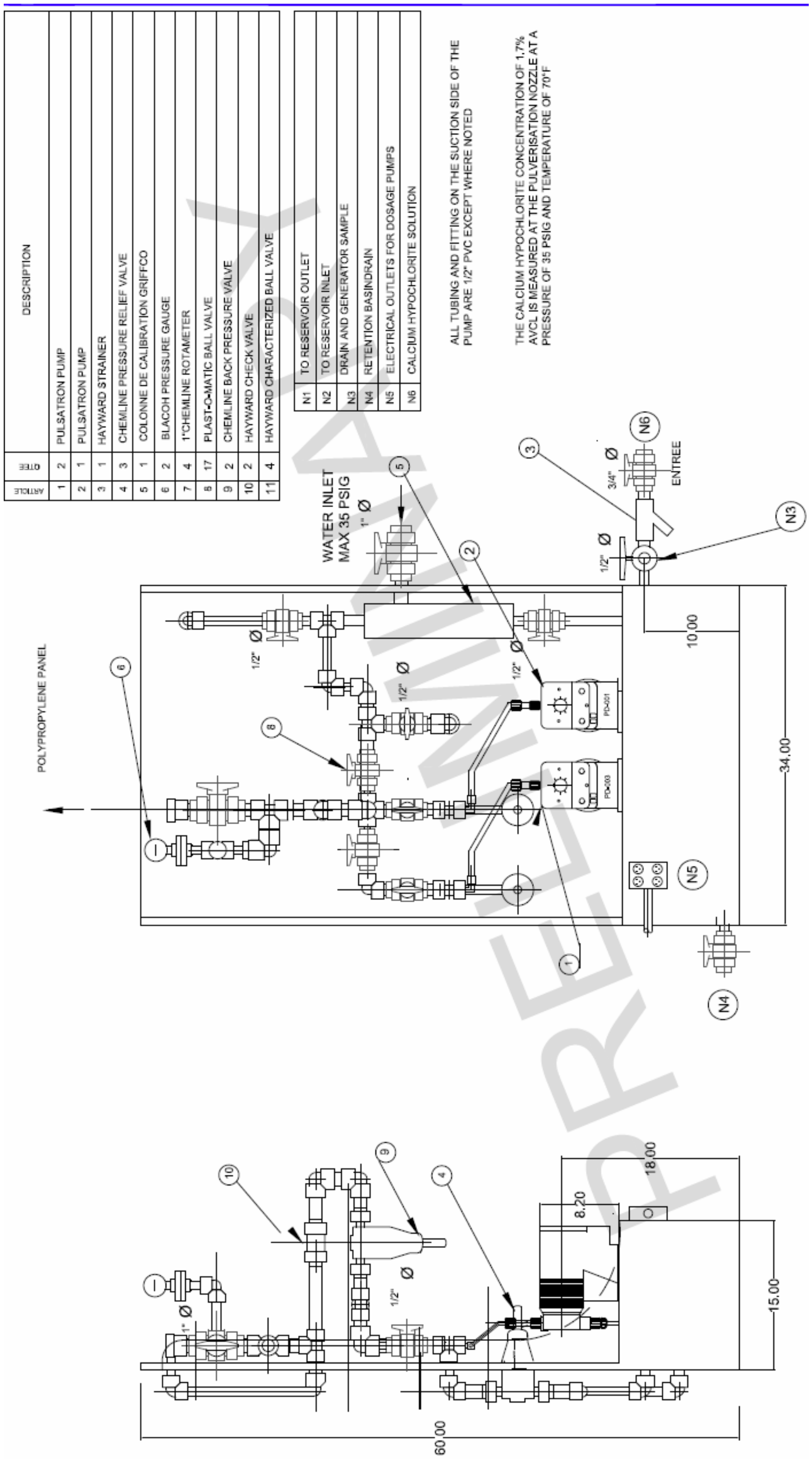

Figure 6: Dosing Pump Skid

Only one of the two dosing pumps will be "ON". The second pump is a backup in case that the active pump failed. This has to be switched manually. The dosing pump skid also contains calibration and cleaning accessories.

The chlorine solution for the dosing pumps will be prepared by an automated "MC4-50" feeding system. Here again, the second system is a backup in case the active one fails. It is recommended to keep the backup system dry & clean and only activate it if required.

Note that a redundant pair of these feeding systems can serve both the pre and post-chlorination systems.

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Nepean, Ontario, I

Figure 7: "MC4-50" Feeding System

4.2.4 Water Reservoir

After rigorous discussions and analysis of reports and various options, this design focuses on the use of a serpentine type of piping arrangement that will be housed in a substructure of the new truck fill station. The serpentine piping will contain approx. 15,000 litres of potable drinking water that will be pre-chlorinated prior to transferring to the delivery trucks. The capacity of the stored water will meet the requirement to supply potable drinking water simultaneously to at least two medium sized water bowser vehicles or a single 13,000 litres water bowser vehicle that serve the current community.

The design centres around a single serpentine pipe of 30” in diameter. The crawl space will allow for access to the piping system. The serpentine pipe itself will be mounted on a concrete pad and will be supported on a cradle type support system. The actual description and characteristics of the construction of the truck fill station was designed by Arktis Solutions Inc. and can be found in their report.

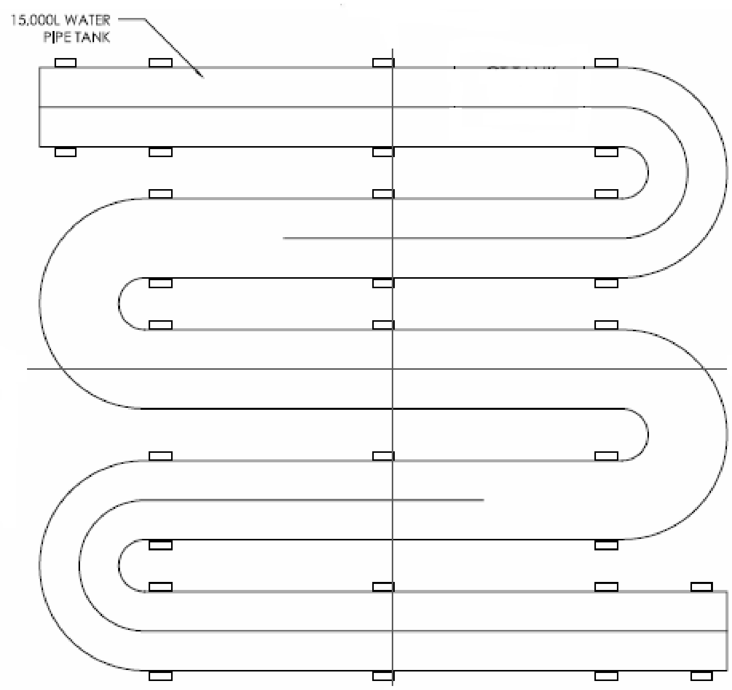

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Figure 8: 15,000 Litre Serpentine Pipe Water Tank

4.2.5 Delivery System to Trucks

The delivery system to trucks will have the ability to fill two water bowser vehicles simultaneously. In order to accomplish the simultaneous filling of trucks, the station will require two dedicated transfer arms, one for each bowser fill station.

When filling of a delivery truck is initiated, the normally closed (N/C) motorized valves of the relevant filling arm will open while the draining valve will close and one of the two pumps will start to pump water. The function of the draining valve is to drain the water from the filling pipe exposed to outside temperatures. The outdoor portion of the filling arm will be insulated to prevent formation of ice inside the pipe.

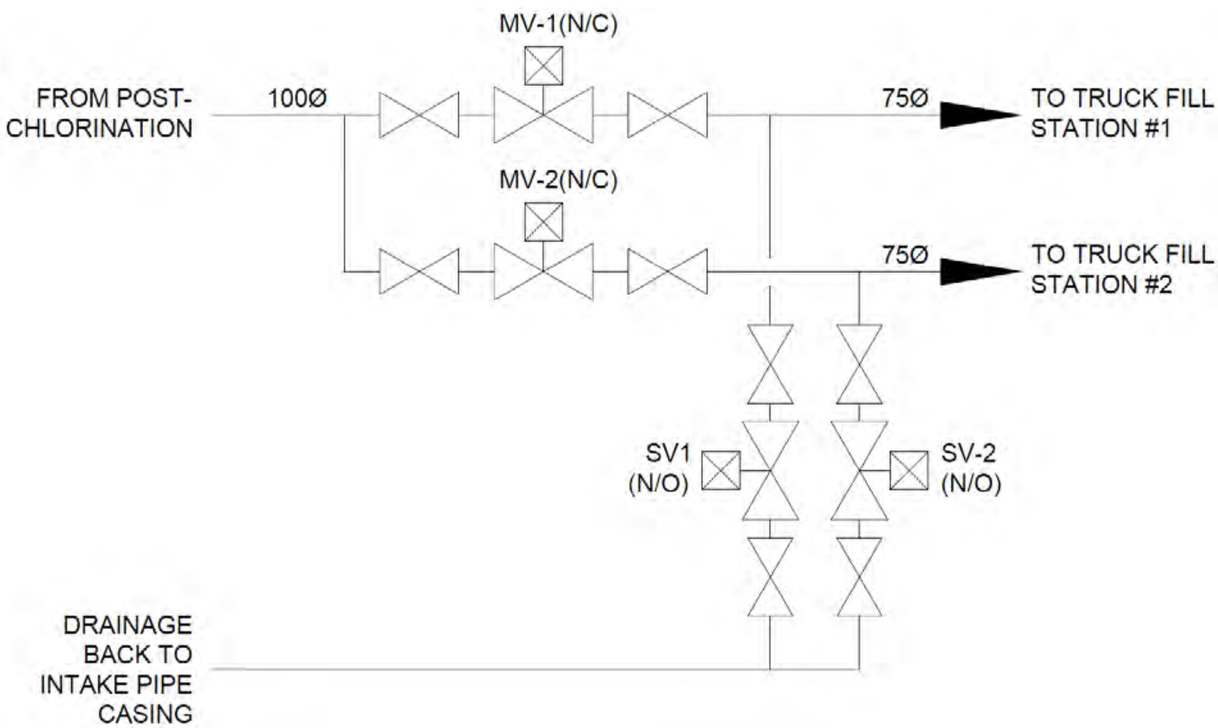

Figure 9: Schematic of the Delivery System

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chiarelli@travel-net.com

4.2.6 Power and Emergency Power

Electrical service: The present truck fill station is fed from three (3) single phase, pole mounted transformers, 25 kVA each. These transformers will have to be replaced due to the condition (age and corrosion). The load summary calculation established the load demand for the new truck fill station at 79.3 kVA. Therefore the new transformers will have to be upgraded to 37.5 kVA each.

Emergency generator: The backup generator will have to be proportional to the electrical service in size to fully maintain the operation in case of a power outage over an extended period. A matching standby diesel engine generator would be a 100 kWe air cooled diesel generator set.

4.2.7 Controls and Auxiliary Equipment

The truck fill station will contain several dedicated control panels to control and monitor the operation of the redundant pumps, the chlorination pumps, the backup generator, heat tracing cables and other relevant equipment. Alarm conditions will be fed into an alarm encoder and transmitted to the operations personnel of the Hamlet of Pangnirtung.

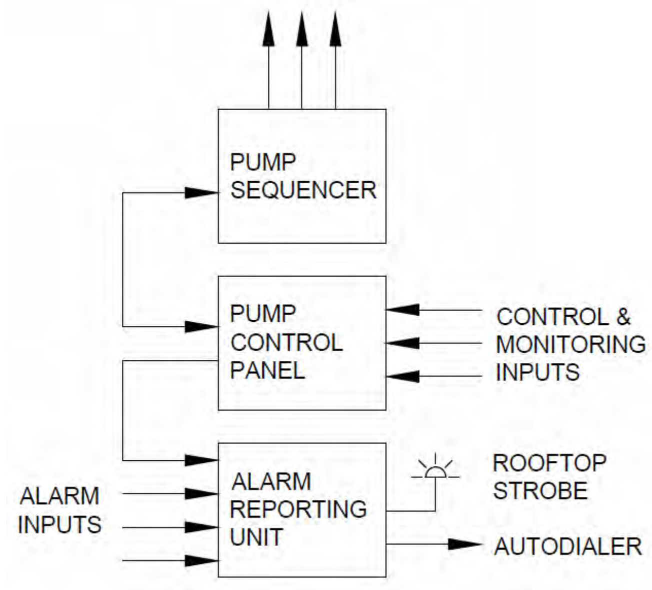

Figure 10: Pump Station Control and Monitoring Schematic

Pump Sequencer: its function is to cycle the 2 submersible pumps, so that each pump is exercised equally over time. In case of a pump failure (determined by the relevant flow switch (FS-1 or FS-2) the sequencing stops at the functioning pump and the sequencer initiate an alarm condition.

Pump Controller: its function is to tie ties together all other items required for the operation; fill station push buttons, controls of various valves, time delay relays, alarms and the emergency stop push button. Lights will indicate which filling station is being used and which pump is running. It will also indicate some of the alarm conditions and provides an emergency power off and reset functions.

The alarm reporting unit combines all alarm inputs. When any of the alarm conditions occurs, it turns on the strobe located outside on the truck fill station building and initiates the autodialer that will place a telephone call with a recorded message to sequence of phone numbers.

Some of the alarm levels will be settable:

- Low temperature alarm on the thermostat located in the main pumping room.

- Pressure drops across the water filters. This pressure switch will have two adjustable alarm settings: High (H) – when one truck is being filled (one pump is running) and High/High (H/H) – when two trucks are being filled (two pumps are running).
  The higher the allowed pressure drop across the filters, the longer it will take to fill the trucks, though the filters will need to be cleaned less frequently.

The truck fill station will also need a distribution of potable cold and hot water and a storage tank for waste water. The water storage tank will be monitored for low level when the water will need to be replenished. The waste water tank will be monitored for high level indicating that the tank needs to be emptied.

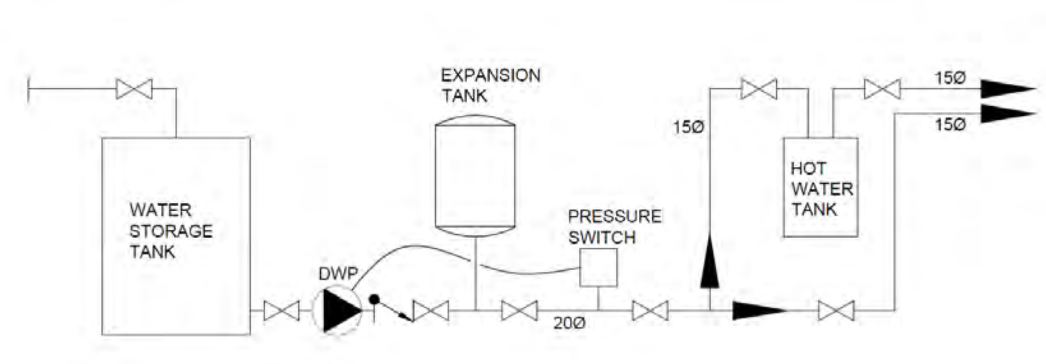

Figure 11: Domestic Cold and Hot Water Schematic

The building will be heated by oil-fired unit heaters while the ventilation of the facility will be through the installation of a Heat Recovery Ventilator (HRV).

5 Conclusion

5.1 Summary

Figure 12 below shows the overall schematic of the new proposed truck fill station comprised of the building blocks described above.

Each step of the water delivery process meets the requirements for quality, quantity, reliability, remote monitoring and historical data storage of crucial elements of the water delivery process with minimal human intervention or maintenance.

In addition, standardizing this design will make it easier to understand the process and operational requirement for the attending personnel as well as for the responsible government officials.

5.1.1 Advantages

- Meets the needs of the Hamlet and that of the Government of Nunavut
- Updates the water delivery to currents standards.
- Increases the water delivery capability to meet the needs of a growing population.

5.1.2 Disadvantages

- Costly endeavor for the Government of Nunavut.

5.1.3 Risk Analysis

- High risk – potential for breakdown of the existing truck fill station causing water delivery outages.
- High risk – for paying premium for fixing broken down equipment

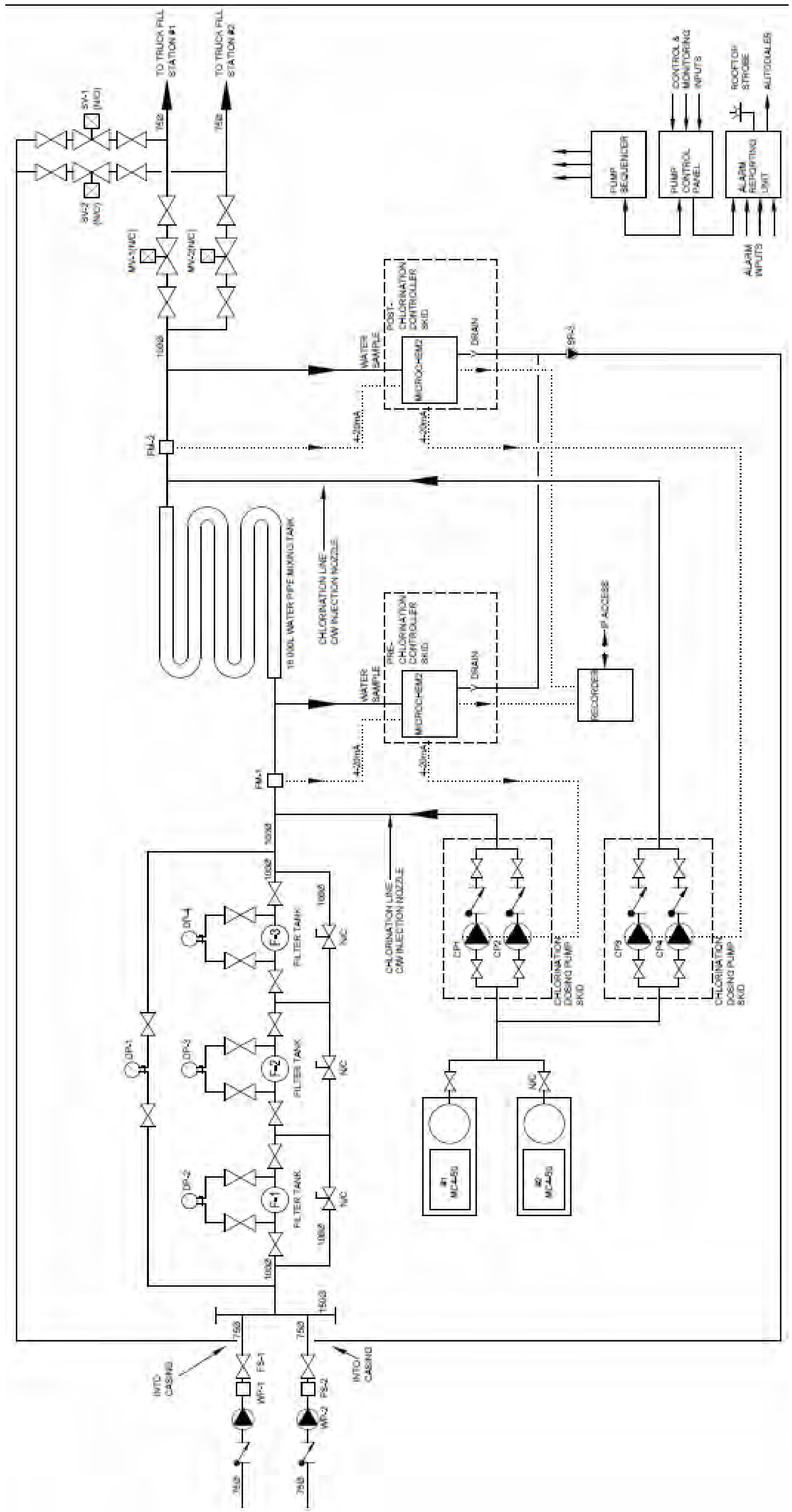

Figure 12: Overall Schematic of the Truck Fill Station

5.1.4 Schedule of Work

The construction of the new pumping facility should be scheduled during the summer construction period.

Description	Number of Weeks
Design	10 weeks
Tender and Award	3 weeks
Construction	10 weeks
Commissioning	1 week
TOTAL NUMBER OF WEEKS	**24 weeks**

5.2 Cost

Cost estimation of this option is not in the scope of this report. ARKTIS Solutions Inc. will retain cost consultants to provide cost estimates of the required classes.

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APPENDIX C – CLIMATIC DATA

Environment Canada | Environnement Canada

Reference Number
ArktisGregFairthorne20121220

Pangnirtung, NU

Latitude: 66 ° 9 ' 0 " **Longitude: 65 ° 40 ' 33 "** **Elevation (Metres): 42**

Design element	Design value
January 2.5% design dry bulb temperature °C	
January 1% design dry bulb temperature °C	
July 2.5% design dry bulb temperature °C	
July 2.5% design wet bulb temperature °C	
Annual total degree days below 18 °C	
Maximum 15 minute rainfall (mm)	
Maximum one day rainfall (50 years) (mm)	
Annual rainfall (mm)	
Annual total precipitation (mm)	
Moisture Index	
Driving Rain wind pressure 1/5 years (Pa)	
Ground snow load, snow component Ss (30 years) (kPa)	**3.5**
Ground snow load, rain component Sr (30 years) (kPa)	**0.2**
Ground snow load, snow component Ss (50 years) (kPa)	**3.9**
Ground snow load, rain component Sr (50 years) (kPa)	**0.2**
Hourly wind pressure 1/10 years (kPa)	**0.95**
Hourly wind pressure 1/30 years (kPa)	**1.14**
Hourly wind pressure 1/50 years (kPa)	**1.23**
Hourly wind pressure 1/100 years (kPa)	**1.36**

December 21, 2012

APPENDIX D – SEISMIC DATA

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: Greg Fairthorne, ARKTIS Solutions Inc. March 04, 2013

Site Coordinates: 66.15 North 65.6758 West

User File Reference: Pangnirtung

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**PGA (g)**
0.439	**0.217**	**0.097**	**0.031**	**0.240**

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.063	0.176	0.257
Sa(0.5)	0.035	0.093	0.138
Sa(1.0)	0.018	0.048	0.067
Sa(2.0)	0.006	0.015	0.022
PGA	0.026	0.077	0.132

References

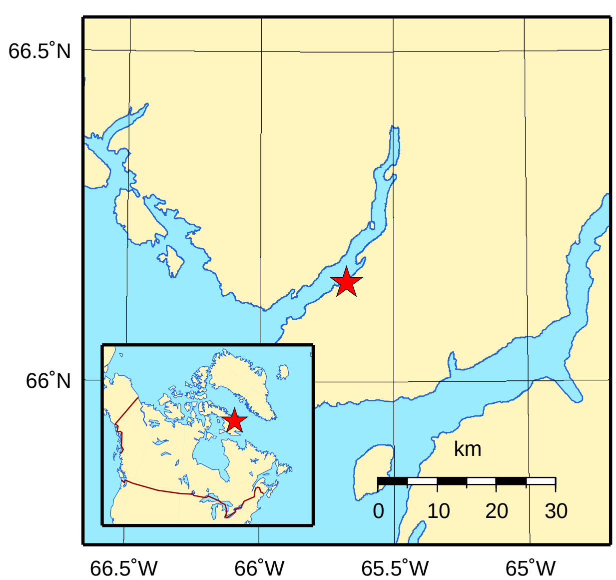
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



APPENDIX E – GENERAL TERMS AND CONDITIONS

This report incorporates and is subject to these "General Conditions"

USE OF REPORT

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of The Government of Nunavut, Department of Community & Government Services (herein after referred to as the "Client"). ARKTIS Solutions Inc. (herein after referred to as "ARKTIS") does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any third party unless otherwise authorized in writing by ARKTIS. Any unauthorized use of the report is at the sole risk of the user.

LIMITATIONS OF REPORT

This report is based solely on the conditions which existed on site at the time of ARKTIS' investigation. The Client, and any other parties using this report with the express written consent of the Client and ARKTIS, acknowledges that conditions affecting the assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive.

The Client, and any other party using this report with the express written consent of the Client and ARKTIS, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made.

The Client acknowledges that ARKTIS is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

During the performance of the work and the preparation of this report, ARKTIS may have relied on the information provided by persons other than the Client. While ARKTIS endeavors to verify the accuracy of such information when instructed to do so by the Client, ARKTIS accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

LIMITATIONS OF LIABILITY

The Client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of ARKTIS providing the services requested, the client agrees that ARKTIS' liability to the Client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:

a. With respect to any claims brought against ARKTIS by the Client arising out of the provisions or failure to provide services hereunder shall be limited to the amount of fees paid by the Client to ARKTIS under this Agreement, whether the action is based on breach of contract or tort;

b. With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the Client agrees to indemnify, defend and hold harmless ARKTIS from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor Client costs, arising or alleged to arise either in whole or part out of services provided by ARKTIS, whether the claim be brought against ARKTIS for breach of contract or tort.

STANDARD OF CARE

Services performed by ARKTIS for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and financial and physical constraints applicable to the services. Engineering judgment has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

Where ARKTIS submits both electronic file and hard copy versions of reports, drawings and other project related documents and deliverables (collectively termed instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by ARKTIS shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by ARKTIS shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of instruments of professional services shall not, under any circumstances, no matter who owns or uses them, be altered by any party except ARKTIS. The Client warrants that instruments of professional services will be used only and exactly as submitted by ARKTIS.