To:	Greg Andrew, P.Eng	From:	Marcus Saari, P.Eng
Cc:	Chris Versteeg, AScT Andrew Katnick, P.Eng Craig Stenhouse, P.Eng Matt Tindall, P.Eng	Date:	May 5, 2021
Project Title:	Westshore Terminals LP – New Cargo Study	File No:	19-0925-10-DCR-006-R2
Re:	Potash Storage Building: High-Level Flood Evaluation		

As part of the New Cargo Study Project (the Project), the Potash Storage Building (PSB) is proposed to be constructed in Westshore Terminal's existing coal stockyard Line-D. The existing Line-D is bordered by asphalt-paved roads to the west, north, and east and a coal road along the south side, adjacent to a stacker-reclaimer (S/R) berm.

Figure 1 shows the existing site with the approximate location of the proposed PSB.

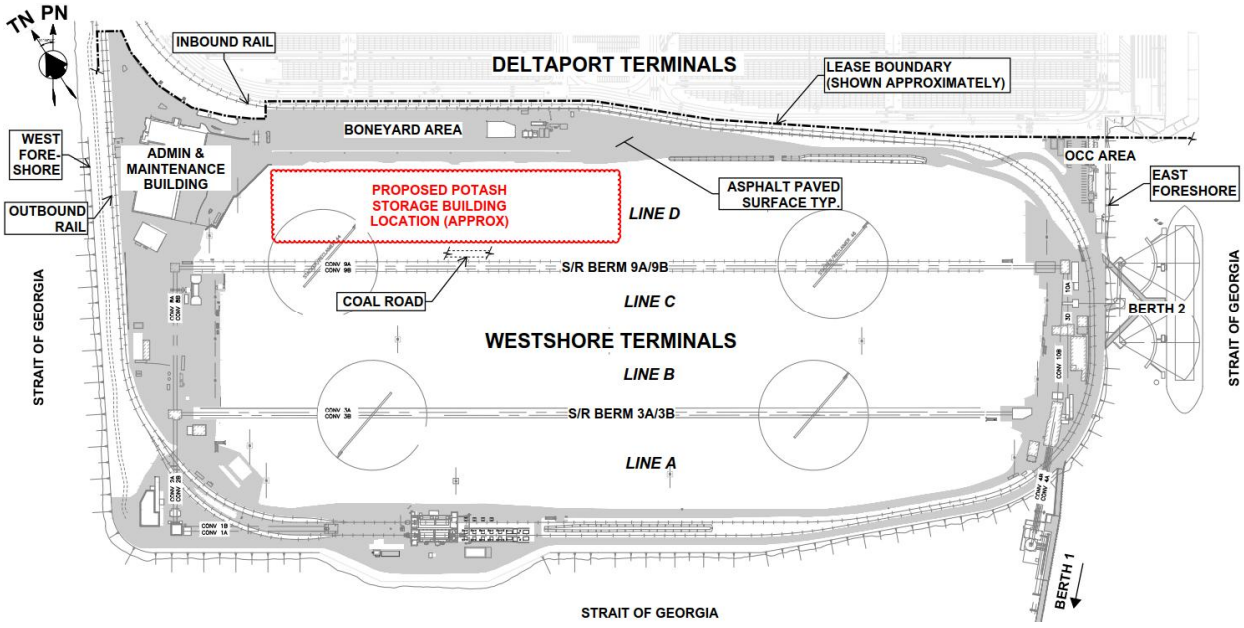


Figure 1: Existing Site Plan

As part of the Project, Line-D will be stripped of coal and raised using imported materials to set the PSB's top of foundation elevation higher than the surrounding area. The PSB's top of foundation elevation, which is equivalent to the interior floor elevation, is currently set at 24.75 ft Chart Hydrographic Datum (CHS). Note that this elevation is the "Long-Term Settlement Top-of-Concrete Elevation", which is the minimum allowable elevation of the Building over its lifetime. This is different than the "Post-Construction Top-of-Concrete Elevation", which is set at 26.75 ft. Refer to Binnie's Earthworks Material Handling Strategy memo "19-0925-10-DCR-007" for more information.

When selecting the design elevation of the PSB, a compromise is considered between the volume and cost associated with importing granular material versus the surrounding flood levels of the local drainage infrastructure at Westshore and Deltaport Container Terminal, the adjoining terminal to the

north. For discussion on the design elevation, refer to 19-0925-10-DCR-001; for information on the local drainage infrastructure refer to the drainage memo 19-0925-10-DCR-003.

The purpose of this memo is to review the proposed PSB siting and foundation elevation relative to the surrounding topography to better understand the risk of product loss during a flooding event. The following sections discuss the current site topography and flooding scenarios.

1 TOPOGRAPHIC DATA

Topographic survey data was collected between May 2020 and March 2021. The data collected is tied into the existing site project coordinate system using the horizontal and vertical survey control established earlier in this project and includes pickup of rail tracks, buildings and other structures, roads and overpasses, ditches, curb and gutter, S/R berms, walls, and general ground shots to establish an existing grade surface. For more information on the survey control and topographic studies refer to memorandum 19-0925-10-DCR-002.

2 TOPOGRAPHIC DATA EVAULATION FOR FLOOD ANALYSIS

The topographic data used for the flood analysis only focused on the northern region of the site around the new PSB. More specifically, from south-to-north: S/R Berm 9A/9B to the northern fence line boundary between Deltaport and Westshore; and from west-to-east: outbound rail tracks west of the Administration and Maintenance Building to the eastern foreshore bank adjacent to Berth 2.

The mid and southern areas of the site are excluded from the study since those areas generally have similar site topography to the northern area where the analysis is being focused and will not contribute to flooding around the PSB.

Using the survey data collected and design elevations determined during the Stage 2 Study, an existing and proposed ground surface was developed on the north end of the site in Autodesk's Civil 3D. Once established, flood levels were analyzed against the existing and proposed surface grades and PSB foundation elevation to determine the flood paths.

3 FLOODING SCENARIOS

The flood scenarios evaluated for the study included flooding caused by tidal water and storm water. For tidal water, various tide levels, projected sea level increases, storm surges, and wave effects were reviewed. For storm water, a worst-case situation was reviewed wherein extended loss of power at the site occurs during a storm event.

Water ingress to the PSB from underground utility failures, such as a water main burst, were not considered since this type of infrastructure is located outside the building footprint and at a lower elevation than the building foundation.

Water ingress from mechanical piping features is also not considered to be a high risk, as pavement will be graded to direct leakage away from the PSB. For example, the PSB's maintenance bay will have gravity drains that lead out of the building and into a sump; the sump will have emergency overflow drains that lead into nearby stormwater ditching. As for existing coal dust suppression systems, all Yard Sprays (medium-flow water cannons) that are within range of the PSB will be removed. Pole Sprays and Tower Sprays (light-flow misting poles, 70 ft and 130 ft in height respectively) will be

removed in the PSB area, though errant spray from remaining poles around site may still reach the Building in high-wind scenarios. However, the spray from these features is similar in intensity to rain and is not expected to have adverse effects when encountering the Building.

3.1 TIDAL WATER FLOODING

Tide elevations for the Project are in feet and referenced to Tide and Chart datum. All elevations are relative to this datum elevation 0.0 ft (0.0m) chart which is equal to elevation -9.76 ft (-2.975m) geodetic. The reference benchmark used onsite is the deep-seated monument 81H T001 in UTM NAD83. Tide levels are as follows:

Table 1: Roberts Bank 2021 Tidal Levels

TIDAL STATE	TIDAL ELEVATION
Extreme High Water Level (Estimated)	17.70 ft (5.4m)
Higher-High Water Level (Large Tide)	15.83 ft (4.82m)
Higher-High Water Level (Mean Tide)	13.50 ft (4.1m)
Mean Water Level (MWL)	9.84 ft (3.0m)
Lower-Low Water Level (Mean Tide)	3.61 ft (1.1m)
Lower-Low Water Level (Large Tide)	-0.33 ft (-0.1m)
Extreme Low Water Level (Estimated)	-1.31 ft (-0.4m)

The data in Table 1 is obtained from Government of Canada's Annual Survey.

The BC Ministry of Environment (MoE) recommend a minimum freeboard of 1.96 ft (0.6m) in their "Guidelines for Management of Coastal Flood Hazard Land Use (2011)". To ensure this minimum freeboard will not be exceeded over the lifetime of the Project, the following scenarios are compared against the PSB elevation of 24.75 ft (7.54 m):

- Higher-High Water in current day
- Higher-High Water with projected sea-level rise (SLR) by 2100
- Extreme High Water with projected SLR by 2100
- Extreme High Water with projected SLR by 2100 and wave-runup

3.1.1 HHWL

Roberts Bank's HHWL is estimated at 15.83 ft (4.82 m) as per Table 1. The PSB foundation has 8.92 ft (2.72 m) of freeboard above the HHWL tide level, which is considered acceptable.

3.1.2 HHWL + SLR

If we consider sea-level rise (SLR), according to the Government of Canada's "Canada's Changing Climate Report (2019)", the projected SLR in the Vancouver, BC is approximately 1.64 ft to 2.46 ft (0.50 to 0.75 m) by the year 2100. Using the upper range, the building foundation will have 6.46 ft (1.97 m) of freeboard above the HHWL + SLR, which is considered acceptable.

3.1.3 Extreme HWL + SLR

Extreme cases, or Extreme High-Water Level, occurs during Higher High-Water (Mean Tide) in combination with storm surges. Storm surges occur from atmospheric low-pressure systems and strong winds blowing onshore during a large storm. Storm surges can raise the tide surface by heights of up to 4.2ft (1.28m) as per Table 1. Considering an Extreme High-Water Level + SLR, the assumed maximum sea-level for the Project is 20.16 ft (6.14 m). This results in a PSB freeboard of 4.59 ft (1.40 m), which is considered acceptable.

3.1.4 Extreme HWL + SLR + Wave Effect

The consideration of wave effects include wave set-up and wave run-up, each of which are depicted below:

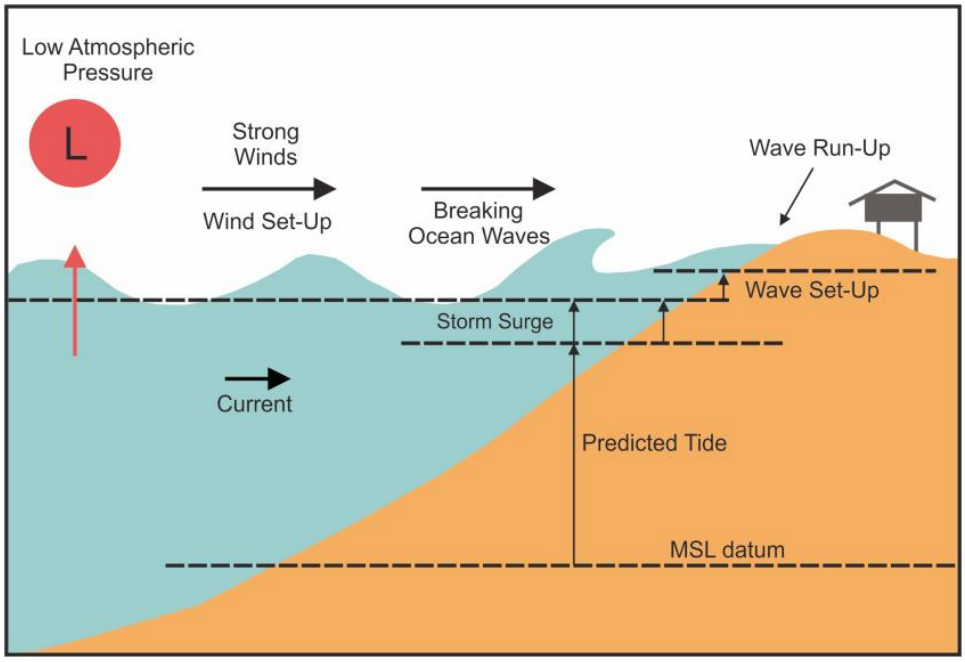


Figure 2: Wave Set-Up and Wave Run-Up

The Port of Vancouver (formerly Vancouver Port Authority) performed a geomorphology study for the Roberts Bank Container Expansion in 2004. A section of this study highlights the wave climate at Roberts Bank, which including the significant wave height (the mean height of the highest 1/3 of waves in a given sea state) under various wind conditions. A southeast wind, which is the most predominant wind direction, was found to generate the largest waves at Roberts Bank. Figure 3 provides the significant wave heights (H_s) during a 30 kt/hr (56 km/hr) SE wind, as provided in the Port of Vancouver's study.

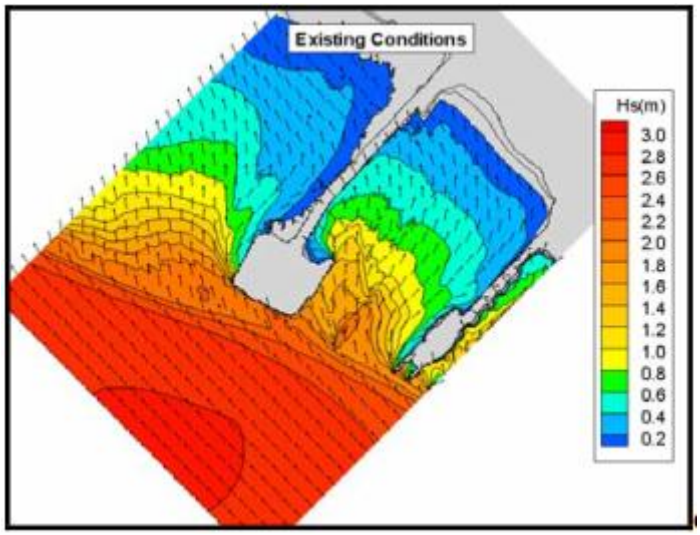


Figure 3: Significant Wave Heights at Roberts Bank

Figure 3's significant wave heights are provided in meters and are based on the full amplitude of the wave (bottom of trough to top of crest). The tide level selected during the modelling is Mean Water Level (MWL), though it is expected that wave heights do not change considerably at Westshore's foreshores when comparing the same conditions with different tide levels. A 30 kt/hr wind in the SE direction and its resulting waves (as shown) is considered to have an exceedance rate of 0.312%. Note, A 30 kt/hr wind in any direction is considered to have an exceedance rate of 0.659%.

As seen in Figure 3, significant wave heights offshore can reach up to 9.84 ft (3.0 m) but reduce in height as they get closer to shore due to dissipating processes. Wave heights are reduced to 5.91 ft (1.8 m) along Westshore's east and south foreshore, which approximately equate to a wave crest of 2.95 ft (0.9 m) above mean sea-level. Superimposing this wave to the Extreme HWL + SLR, the wave crest reaches an elevation of 23.11 ft (7.04 m).

This wave height is then compared against the armoured foreshore construction and height and the horizontal distance between the PSB and the foreshores:

- the eastern foreshore top-of-bank typically ranges in elevation from +/- 24.0 ft to 26.5 ft. This would require a wave run-up of 3.84 ft to 6.34 ft (from mean sea-level) to crest over the bank.
- the foreshore is armoured with riprap, which allows for energy dissipation.
- The Potash Storage Building is 1770 ft and 680 ft from the eastern and western foreshore respectively as seen in Figure 4 (snapshot taken from attached drawings – blue indicates an elevation less than 24.0 ft)

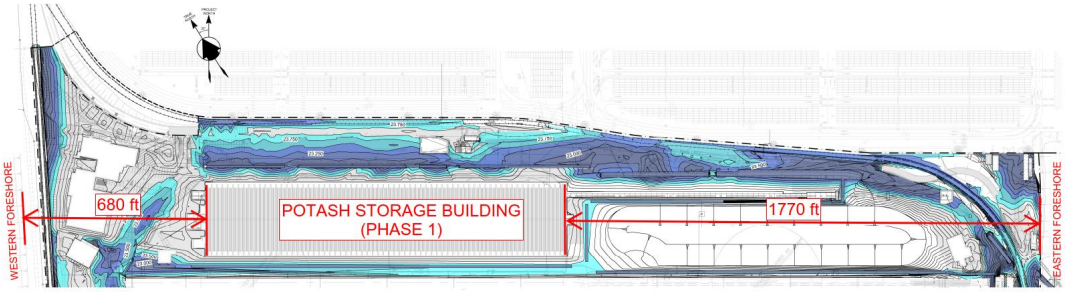


Figure 4: Potash Storage Building Distance from Foreshores

Based on these considerations, it can be reasoned that a wave under the given conditions has a negligible risk of reaching the PSB. To evaluate an approximate freeboard with respect to wave effects, an in-depth analysis of the wave set-up, wave run-up and the interaction with the armoured foreshore is required. However, due to the armoured bank height, energy dissipation of the bank, and the distances between the Building and the foreshores, wave effects are not considered to pose a practical risk and, therefore, further analysis is not recommended.

3.2 STORM WATER FLOODING

For stormwater flooding, a catastrophic event was considered where Roberts Bank has an indefinite power failure and Westshore's backup power fails; consequently, any drainage collection and pumping systems onsite would be inoperable. Should a scenario like this occur during a continuous storm rainfall event, the site would flood.

With the scenario described (an infinite amount of rainfall and no ability to convey the water around and off site) we determined that flooding would occur in the following sequence:

1. Storm water will drain to the ditches and swales where it will rise and eventually flood onto the surrounding roads and other paved surfaces.

2. Flood water will reach the inbound rail, which will begin to act as a dam along the north and west sides of site. The west side of site is dammed by the outbound rail embankment.

3. Flood water will first breach over the inbound rail at el. 23.99 ft.

4. Once the rail is breached, flood water will flow west and egress to Deltaport through the fence line (near Reservoir 5) at el. 23.27 ft. Flood water will flow east and egress to Deltaport at a second point through the fence line near the OCC at el. 22.42 ft.

   At this stage, the flood path would also continue towards the foreshore at the east side of the site and egress into the ocean. The lowest top-of-bank elevation surveyed was at 22.43 ft.

It was discovered that once flooding reached equilibrium across Roberts Bank, the entire peninsula would flood and drain into the ocean prior to reaching the PSB foundation. The equilibrium condition is shown in the attached sketches (88305-D0006-SK0030 to -SK0032).

4 CONCLUSION

The Potash Storage Building (PSB) top of foundation is set at 24.75 ft (24'-9").

Our desktop study of the tide levels at Roberts Bank determined a maximum mean elevation of approximately 20.16 ft, which considers an extreme high-water level combined with forecasted sea level rise by the year 2100. This allows the PSB 4.59 ft of freeboard, which is above the Ministry of Environment's recommended minimum freeboard of 1.96 ft. Wave effects are not included in this freeboard calculation; however, due to the armoured foreshore heights and horizontal distances from the PSB, wave effects are not considered a practical risk.

Should a storm flood event occur with an infinite storm duration at the same time as a power outage, the flood waters would reach an approximate elevation of 23.99 ft prior to overflowing into Deltaport to the north and over the foreshore to the east.

With respect to the tidal and storm flooding scenarios considered, the Building elevation of 24.75 ft is considered the minimum allowable post-settlement top-of-concrete elevation. Refer to memo 19-0925-10-DCR-007 for further discussion on the foundation elevation.

5 CLOSURE

We trust that the information contained within this memorandum satisfies your requirements. Should you require any additional information or have any questions regarding this memo, please do not hesitate to contact the undersigned.

Sincerely,

R.F. BINNIE & ASSOCIATES

Prepared By:	Reviewed By:
Marcus Saari, P.Eng	Chris Versteeg, AScT
Project Engineer	Senior Project Manager

Attachments:

- Drawings
  - 88305-D0006-SK0030
  - 88305-D0006-SK0031
  - 88305-D0006-SK0032

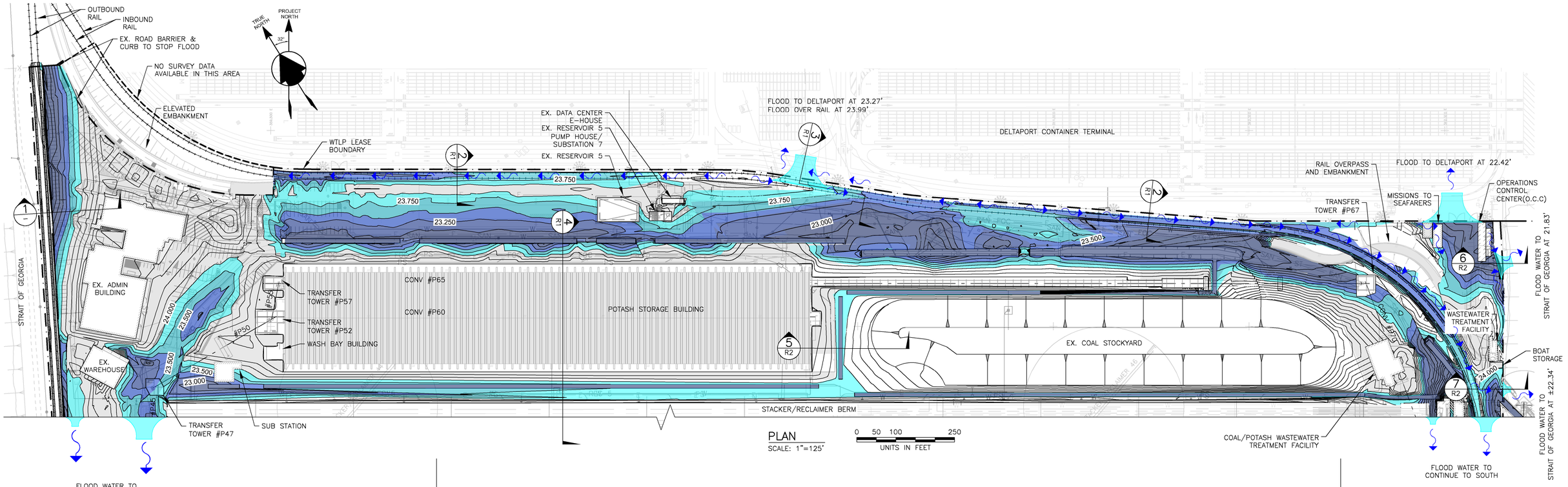
REFERENCES

Ausenco Sandwell. 2011. *"Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use".* In Guidelines for Management of Coastal Flood Hazard Land Use. Rev 0. Written for the BC Ministry of Environment.

Blair J. W. Greenan et al. 2019. *"Chapter 7: Changes in Oceans Surrounding Canada"*. In Canada's Changing Climate Report. Written for the Government of Canada.

Government of Canada. 2021. "Canadian Tide and Currents Tables – Volumes 1-7". tides.gc.ca/eng/data

Northwest Hydraulic Consultants Ltd. / Triton Consultants Ltd. 2004. *"4.0 Wave Climate".* In Roberts Bank Container Expansion – Costal Geomorphology Study. Written for the Vancouver Port Authority.



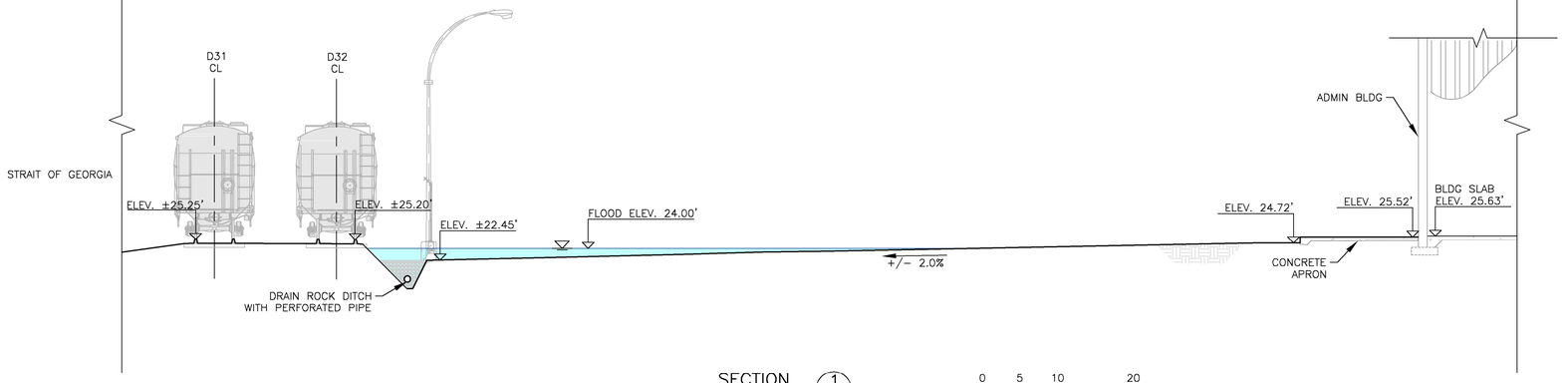
PLAN
SCALE: 1"=125'

0 50 100 250
UNITS IN FEET

ELEVATION TABLE			
NUMBER	MIN. ELEVATION (FT)	MAX. ELEVATION (FT)	COLOR
1	23.75	24.00	
2	23.50	23.75	
3	23.25	23.50	
4	23.00	23.25	
5	< 23.00		

NOTES:

1. ALL EXISTING INFORMATION ON INFRASTRUCTURE IS BASED ON BEST AVAILABLE RECORDS AND SHALL NOT BE CONSTRUED TO BE ACCURATE OR COMPLETE
2. ALL MEASUREMENTS ARE IN IMPERIAL UNITS U.N.O.
3. ALL ELEVATIONS ARE TO CANADIAN HYDROGRAPHIC (CHS) DATUM
4. THE FLOOD MODEL ASSUMES A CONDITION WHERE ROBERTS BANK HAS TOTAL LOSS OF POWER, INCLUDING MAINLAND AND BACKUP POWER SOURCES. AT THE FLOOD LEVELS SHOWN, THE STORM DURATION IS ASSUMED TO BE INFINITE
5. STORM WATER INFILTRATION INTO GROUND HAS NOT BEEN ACCOUNTED FOR
6. OCEAN HIGH-HIGH WATER LEVEL (HHWL) WAS ASSUMED TO BE 15'-10" (4.83M) AS OBTAINED FROM GOVERNMENT OF CANADA'S ANNUAL SURVEY
7. GRADING SHOWN IS A COMBINATION OF EXISTING AND PROPOSED GRADES
8. POTASH STORAGE BUILDING TOP-OF-CONCRETE ELEVATION SHOWN BASED ON "LONG-TERM SETTLEMENT T.O.C. ELEVATION": THE MINIMUM ALLOWABLE ELEVATION FOR THE FOUNDATION OVER THE LIFESPAN OF THE BUILDING. THIS IS RELATIVELY LOWER THAN THE "POST-CONSTRUCTION T.O.C. ELEVATION": THE ELEVATION OF THE FOUNDATION ON THE DAY OF POURING. REFER TO BINNIE MEMO 19-0925-10-DCR-007 FOR FURTHER INFORMATION.



SECTION 1
SCALE: 1"=10'

0 5 10 20
UNITS IN FEET

PRELIMINARY

Ref.	Document Number	Description
R2	88305-D0006-SK0032	
R1	88305-D0006-SK0031	

No	Date	Revision Description	Drawn	Drawing Check	Design	Design Check	Disc. Approval	Proj. Approval
P3	21/05/05	ISSUED FOR USE – NEW CARGO STUDY	DY	MS	MS	CV		
P2	21/03/12	ISSUED FOR REVIEW	DY	MS	MS	CV		
P1	21/03/05	ISSUED FOR REVIEW	DY	MS	MS	CV		

STAMP

Client: Westshore Terminals LP

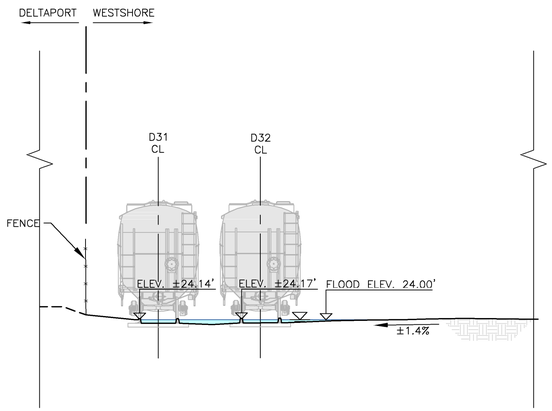
CONSULTANT
BINNIE
The people behind your infrastructure.
R.F. BINNIE & ASSOCIATES LTD.
300 - 4940 Canada Way,
Burnaby, BC V5G 4K6
TEL 604 420 1721
BINNIE.com

Proj Title: NEW CARGO STUDY

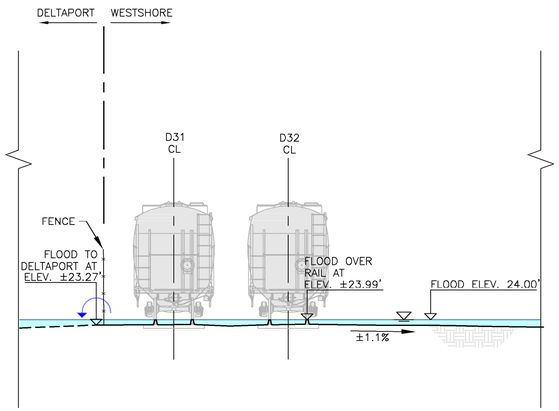
Dwg Title: GRADING AND PAVING HIGH-LEVEL FLOOD REVIEW STORAGE AREA SHT.1

Drawing Number: 88305-D0006-SK0030
Plot Scale: AS NOTED
Rev: P3

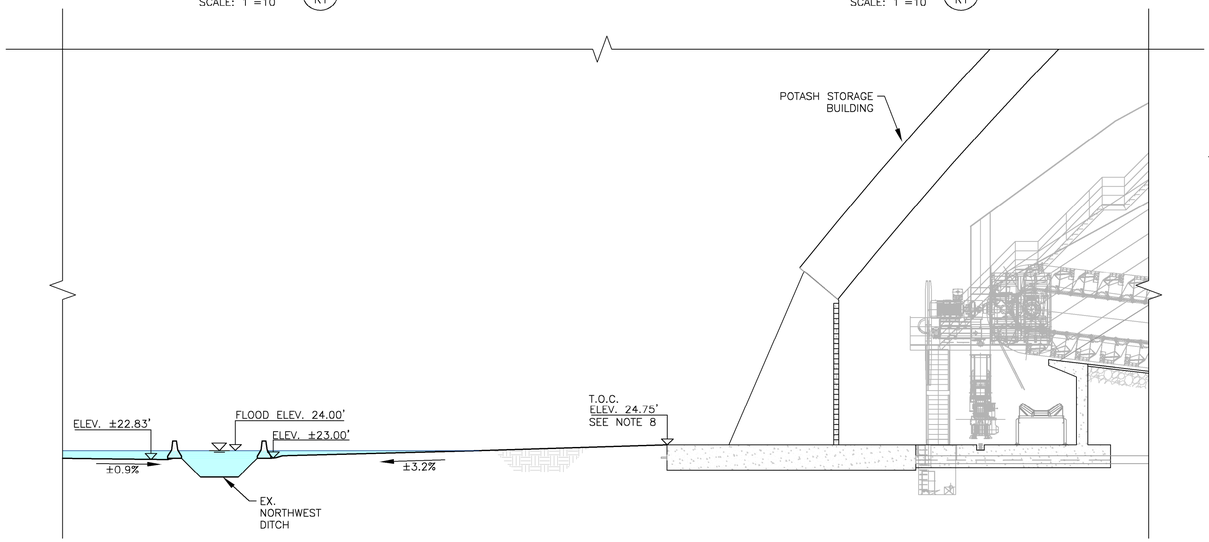
PLOTTED: 2021-05-05 10:52:34 AM FILE: P:\201919-092600 - CAD FILES\DWG\FINAL\88305-D0006-SK00.DWG LAYOUT: 100 USER: DYU

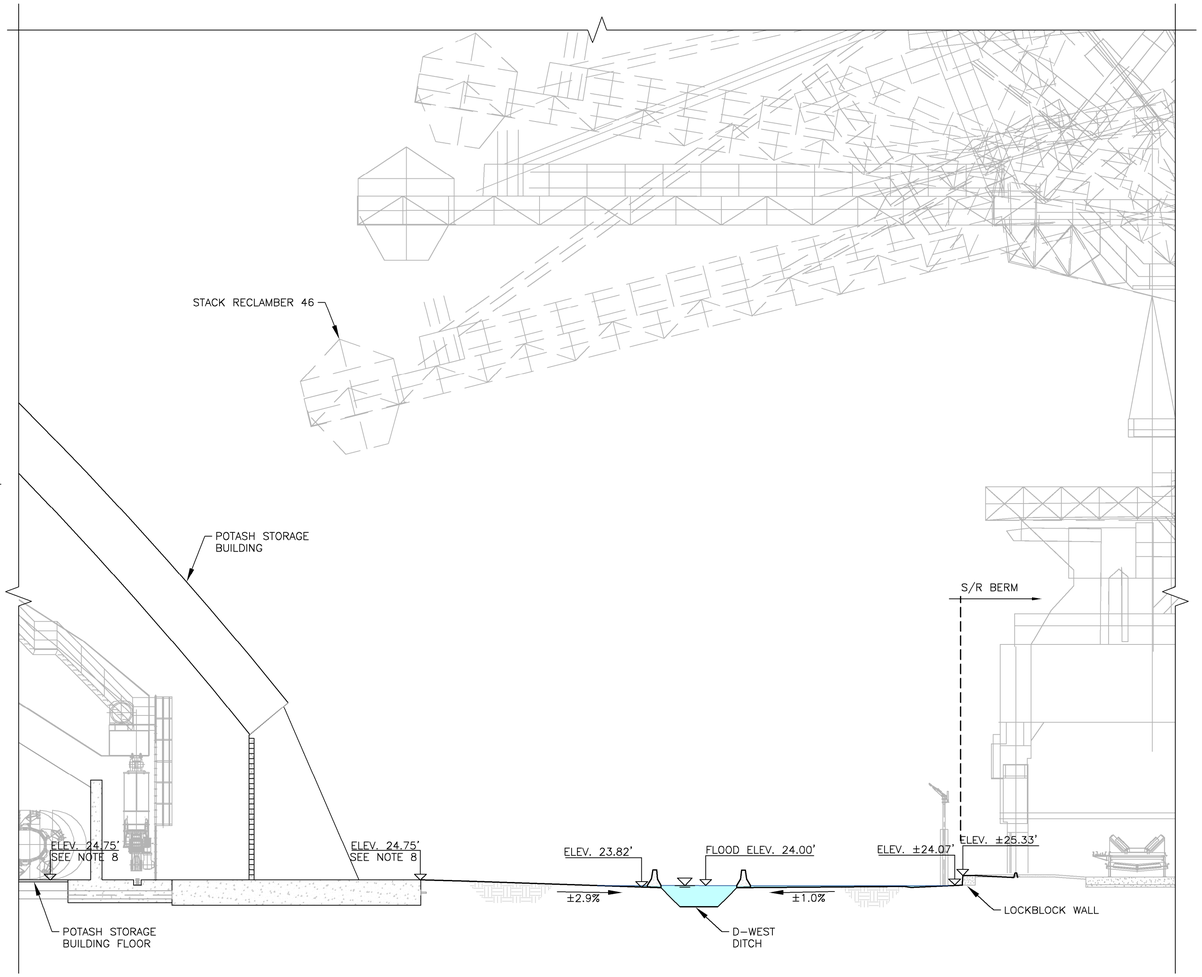


SECTION 2 R1
SCALE: 1"=10'



SECTION 3 R1
SCALE: 1"=10'





SECTION 4 R1
SCALE: 1"=10'

0 5 10 20
UNITS IN FEET

NOTES:

1. ALL EXISTING INFORMATION ON INFRASTRUCTURE IS BASED ON BEST AVAILABLE RECORDS AND SHALL NOT BE CONSTRUED TO BE ACCURATE OR COMPLETE
2. ALL MEASUREMENTS ARE IN IMPERIAL UNITS U.N.O.
3. ALL ELEVATIONS ARE TO CANADIAN HYDROGRAPHIC (CHS) DATUM
4. THE FLOOD MODEL ASSUMES A CONDITION WHERE ROBERTS BANK HAS TOTAL LOSS OF POWER, INCLUDING MAINLAND AND BACKUP POWER SOURCES. AT THE FLOOD LEVELS SHOWN, THE STORM DURATION IS ASSUMED TO BE INFINITE
5. STORM WATER INFILTRATION INTO GROUND HAS NOT BEEN ACCOUNTED FOR
6. OCEAN HIGH-HIGH WATER LEVEL (HHWL) WAS ASSUMED TO BE 15'-10" (4.83M) AS OBTAINED FROM GOVERNMENT OF CANADA'S ANNUAL SURVEY
7. GRADING SHOWN IS A COMBINATION OF EXISTING AND PROPOSED GRADES
8. POTASH STORAGE BUILDING TOP-OF-CONCRETE ELEVATION SHOWN BASED ON "LONG-TERM SETTLEMENT T.O.C. ELEVATION": THE MINIMUM ALLOWABLE ELEVATION FOR THE FOUNDATION OVER THE LIFESPAN OF THE BUILDING. THIS IS RELATIVELY LOWER THAN THE "POST-CONSTRUCTION T.O.C. ELEVATION": THE ELEVATION OF THE FOUNDATION ON THE DAY OF POURING. REFER TO BINNIE MEMO 19-0925-10-DCR-007 FOR FURTHER INFORMATION.

PRELIMINARY

Ref.	Document Number	Description
R1	88305-D0006-SK0030	

No	Date	Revision Description	Drawn	Drawing Check	Design	Design Check	Disc. Approval	Proj. Approval
P3	21/05/05	ISSUED FOR USE – NEW CARGO STUDY	DY	MS	MS	CV		
P2	21/03/12	ISSUED FOR REVIEW	DY	MS	MS	CV		
P1	21/03/05	ISSUED FOR REVIEW	DY	MS	MS	CV		

STAMP

Client: Westshore Terminals LP

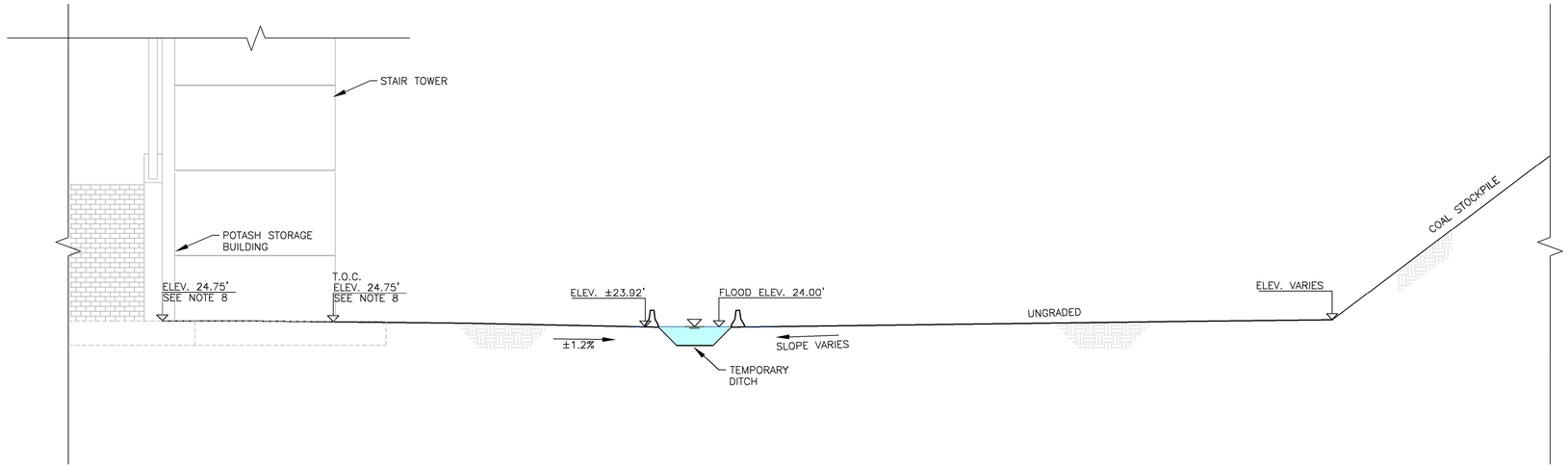
CONSULTANT
BINNIE
The people behind your infrastructure.
R.F. BINNIE & ASSOCIATES LTD.
300 - 4940 Canada Way,
Burnaby, BC V5G 4K6
TEL 604 420 1721
BINNIE.com

Proj Title: NEW CARGO STUDY

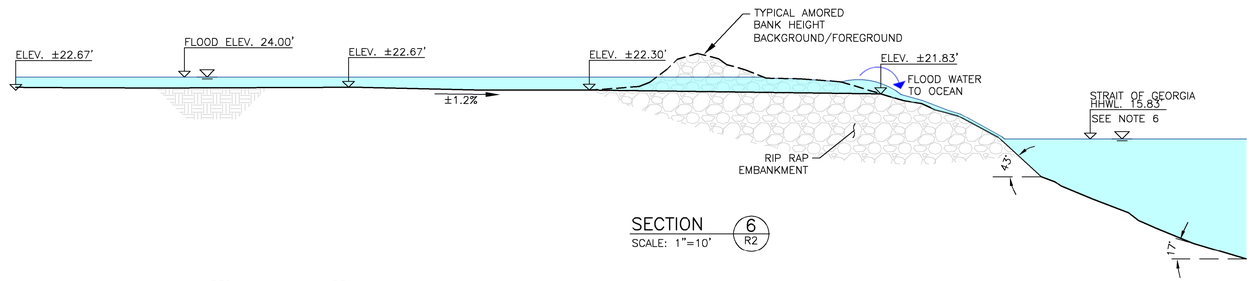
Dwg Title: GRADING AND PAVING HIGH-LEVEL FLOOD REVIEW STORAGE AREA SHT.2

Drawing Number	Plot Scale	Rev
88305-D0006-SK0031	AS NOTED	P3

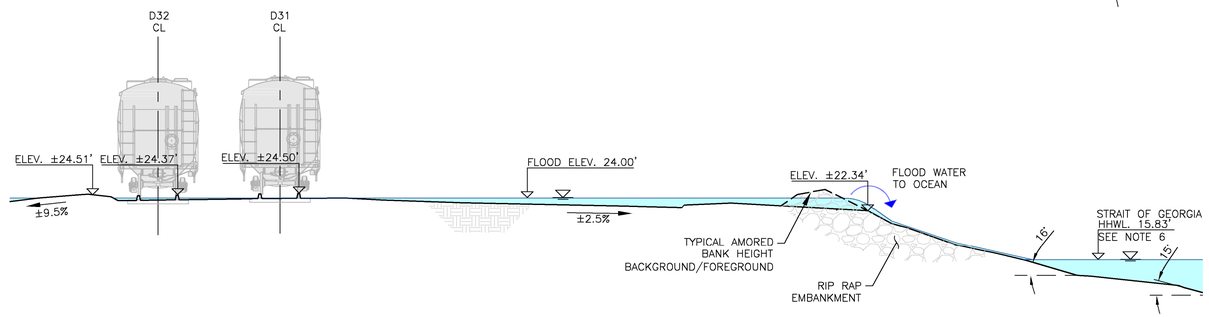
PLOTTED: 2021-05-05 10:54:38 AM FILE: P:\2019\19-092500 - CAD FILES\DWG\FINAL\88305-D0006-SK00.DWG LAYOUT: 200 USER: DYU



SECTION 5 R2
SCALE: 1"=10'



SECTION 6 R2
SCALE: 1"=10'



SECTION 7 R2
SCALE: 1"=10'

0 5 10 20
UNITS IN FEET

NOTES:

1. ALL EXISTING INFORMATION ON INFRASTRUCTURE IS BASED ON BEST AVAILABLE RECORDS AND SHALL NOT BE CONSTRUED TO BE ACCURATE OR COMPLETE
2. ALL MEASUREMENTS ARE IN IMPERIAL UNITS U.N.O.
3. ALL ELEVATIONS ARE TO CANADIAN HYDROGRAPHIC (CHS) DATUM
4. THE FLOOD MODEL ASSUMES A CONDITION WHERE ROBERTS BANK HAS TOTAL LOSS OF POWER, INCLUDING MAINLAND AND BACKUP POWER SOURCES. AT THE FLOOD LEVELS SHOWN, THE STORM DURATION IS ASSUMED TO BE INFINITE
5. STORM WATER INFILTRATION INTO GROUND HAS NOT BEEN ACCOUNTED FOR
6. OCEAN HIGH-HIGH WATER LEVEL (HHWL) WAS ASSUMED TO BE 15'-10" (4.83M) AS OBTAINED FROM GOVERNMENT OF CANADA'S ANNUAL SURVEY
7. GRADING SHOWN IS A COMBINATION OF EXISTING AND PROPOSED GRADES
8. POTASH STORAGE BUILDING TOP-OF-CONCRETE ELEVATION SHOWN BASED ON "LONG-TERM SETTLEMENT T.O.C. ELEVATION": THE MINIMUM ALLOWABLE ELEVATION FOR THE FOUNDATION OVER THE LIFESPAN OF THE BUILDING. THIS IS RELATIVELY LOWER THAN THE "POST-CONSTRUCTION T.O.C. ELEVATION": THE ELEVATION OF THE FOUNDATION ON THE DAY OF POURING. REFER TO BINNIE MEMO 19-0925-10-DCR-007 FOR FURTHER INFORMATION.

PRELIMINARY

Ref.	Document Number	Description
R2	88305-D0006-SK0030	

No	Date	Revision Description	Drawn	Drawing Check	Design	Design Check	Disc. Approval	Proj. Approval
P3	21/05/05	ISSUED FOR USE – NEW CARGO STUDY	DY	MS	MS	CV		
P2	21/03/12	ISSUED FOR REVIEW	DY	MS	MS	CV		
P1	21/03/05	ISSUED FOR REVIEW	DY	MS	MS	CV		

STAMP

Client: Westshore Terminals LP

CONSULTANT
BINNIE
The people behind your infrastructure.
R.F. BINNIE & ASSOCIATES LTD.
300 - 4940 Canada Way,
Burnaby, BC V5G 4K6
TEL 604 420 1721
BINNIE.com

Proj Title: NEW CARGO STUDY

Dwg Title: GRADING AND PAVING HIGH-LEVEL FLOOD REVIEW STORAGE AREA SHT.3

Drawing Number: 88305-D0006-SK0032
Plot Scale: AS NOTED
Rev: P3

PLOTTED: 2021-05-05 10:55:35 AM FILE: P:\2019\19-0926\00 - CAD FILES\DWG\FINAL\88305-D0006-SK00.DWG LAYOUT: 300 USER: DYU