April 30, 2019

Alberta Energy Regulator
Suite 1000
250 – 5 Street SW
Calgary, Alberta T2P 0R4

Via email OSMiningReportsPlans@aer.ca

Attention: **Charles MacDonald**
Manager, Oil Sands West
Mining Authorizations

Re: **Horizon Oil Sands**
2018 Horizon Tailings Management Report

Canadian Natural Resources Limited ("Canadian Natural") hereby submits to the Alberta Energy Regulator (AER) the Tailings Annual Management Report for 2018 in accordance with Directive 085: Fluid Tailings Management for Oil Sands Mining Projects.

Should you have any questions or concerns, please contact the undersigned at (780) 828-5400.

Sincerely,
Canadian Natural

Brett Fairbairn
Regulatory Coordinator - Mining
Canadian Natural Resources Limited

cc: Rod Godwaldt, AER
Scott Wytrychowski, Canadian Natural
Ken MacKenzie, Canadian Natural
Alex Bagnall, Canadian Natural
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OILSANDS ENGINEERING REPORT
13-RPT-TA-0028

CANADIAN NATURAL HORIZON
2018 HORIZON TAILINGS MANAGEMENT REPORT

0	April 30, 2019	Submitted to AER	HMR	HK	AB	SW	WA
Rev #	Date	Revision Description	By	Checked	Checked	Checked	App'd

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List of Acronyms and Symbols

Acronym or Symbol	Description
AER	Alberta Energy Regulator (formerly Energy Resources Conservation Board - ERCB)
APIC	Applied Process Innovation Center
BAW	Beach Above Water
BBW	Beach Below Water
CAG	Community Advisory Group
CO_2	Carbon Dioxide
COSIA	Canadian Oil Sands Innovation Alliance
CPT	Cone Penetration Test
CWZ	Clear Water Zone
DDA	Dedicated Disposal Area
DA	Dean Stark
eNST	Enhanced Non-Segregating Tailings
EOML	End of Mine Life
EPEA	Environmental Protection and Enhancement Act
EPL	End Pit Lake
ERCB	Energy Resources Conservation Board (now Alberta Energy Regulator - AER)
esNST	Enhanced Spiked Non-Segregating Tailings
ETF/DDA1	Horizon External Tailings Facility/Dedicated Disposal Area 1
FIS	Fixed Interval Sampler
FOFW	Fines Over Fines plus Water
FT	Fluid Tailings
GCPT	Gamma Cone Penetration Test
HPW	Hot Process Water
LSC	Large Strain Consolidation
MBI	Methylene Blue Index
MFTRMP	Mature Fines Reduction Mine Plan
Mm^3	Million Cubic Meters
NRU	Naphtha Recovery Unit
NST	Non-Segregating Tailings
OPP	Ore Preparation Plant
OSCA	Oil Sands Conservation Act
Pet-coke	Petroleum Coke
PSD	Particle Size Distribution
RCW	Recycle Water
RFR	Ready for Reclamation
RTR	Ready to Reclaim
SFR	Sand to Fines Ratio
TSS	Total Suspended Solids
TMF	Tailings Management Framework for the Lower Athabasca Region

Acronym or Symbol	Description
TMP	Tailings Management Plan
UF	Thickener Under Flow
UofA	University of Alberta
WPW	Warm Process Water
WT	Whole Tailings
w/w	Weight by Weight (concentration)

1. INTRODUCTION

Canadian Natural Resources Limited's (Canadian Natural's) Horizon Oil Sands Mine and Processing Plant (Horizon) is located approximately 70 km north of Fort McMurray, Alberta. In 2004, the Energy Resources Conservation Board (ERCB) granted approval for Horizon under ERCB Approval No. 9752. The Application for the approval of Canadian Natural's Tailings Management Plan (TMP) was submitted to the Alberta Energy Regulator (AER) in September 2016 and was approved in December 2017 under the *Oil Sands Conservation Act* (OSCA) Commercial Scheme Approval No. 9752E for Horizon. This approval was updated to OSCA 9752G in December 2018 (AER 2018).

Horizon currently operates one (1) External Tailings Facility (ETF) also referred to as ETF/Dedicated Disposal Area 1 (ETF/DDA1). The Horizon ETF/DDA1 is also the source of recycle water (RCW).

Non-Segregating Tailings (NST) is the primary fines tailings treatment process at Horizon. Since the end of 2015, all tailings lines were using the Non-Segregating Tailings (NST) process. Carbon dioxide (CO_2) is also injected in-line to improve non-segregating tailings performance characteristics. Enhanced NST (eNST) technology was piloted during the summer of 2017 with a ramp up of the pilot scheduled for 2019. Direct fluid tailings (FT) treatment using FT spiking into enhanced NST technology is planned to be piloted in 2019 and initiated in 2020, pending results.

Canadian Natural will continue to evaluate the feasibility of modifying NST composition and improving NST processes to maximize fines capture, as well as developing supplemental and alternate technologies to ensure Horizon's fluid tailings profile and progressive reclamation goals are met.

To develop viable alternate and supplemental FT treatment technologies, Canadian Natural is actively investigating several technologies such as enhanced *Spiked* NST (esNST), In-situ FT Treatment, and vegetation trials on NST. Test programs are currently underway at the Horizon site in the Applied Process Innovation Center (APIC) and at the Athabasca Oil Sands sites to assist in the research and development needed to advance these technologies.

Canadian Natural is active in collaborative tailings research and an active member of the Canada's Oil Sands Innovation Alliance (COSIA). Learnings from the testing and research programs allow Canadian Natural to identify and implement opportunities for continuous improvement and adaptive management to ensure the objectives of the Tailings Management Framework (TMF) are fulfilled.

The goal of Canadian Natural's TMP is to minimize the accumulation of fluid tailings (FT) by ensuring that FT are treated and the tailings deposits are reclaimed progressively during the life of the operation while balancing environmental, social and economic needs. Canadian Natural's TMP has been designed to support self-sustaining boreal forest ecosystems are established on Dedicated Disposal Areas (DDAs) at closure. Canadian Natural has developed ready-to-reclaim (RTR) performance criteria and measurement plans for tailings deposits to support reclamation and closure of tailings facilities under Directive 085. Canadian Natural will assess the tailings deposits on an ongoing basis to determine the status with respect to RTR and Ready for Reclamation (RFR) criteria.

Based on Directive 085 (AER 2017) and Condition 46 of OSCA 9752G (AER 2018), Canadian Natural is required to submit annual fluid tailings management reports.

2. HORIZON TAILINGS MANAGEMENT ACTIVITIES

Canadian Natural has selected a Mature Fine Tailings Reduction Mine Plan (MFTRMP) and NST as the key technologies to meet Directive 085 (AER 2017) and Canadian Natural's corporate objectives for creating trafficable tailings deposits that can be progressively reclaimed. Information pertaining to the NST technology selection process, including evaluation of other tailings technologies, is outlined in the 2016 Tailings Management Plan (CNRL 2016).

As of the end of 2018, Horizon was operating 5 NST lines and 2 Naphtha Recovery Unit (NRU) lines. The NST lines follow a weekly rotation schedule: four lines are in operation while one line is in maintenance or standby. Figure 1 depicts the deposition areas of NST line 1, 2, 3, 4, and 5, and NRU during 2018.

Figure 2 provides a simplified schematic of the NST production process. NST combines thickener underflow, cyclone underflow, and carbon dioxide (CO_2) to make a non-segregating sand-and-fines mixture. CO_2 is injected into the process as a rheology modifier to increase yield strength of the slurry and decrease the potential for mixture segregation. In addition to production of NST, Canadian Natural is piloting the enhancement of NST (eNST) by injecting flocculant near the end of pipe and depositing onto beaches, in the same manner as NST. This enhanced NST will capture a greater percentage of fines in the beach.

Furthermore, in 2019 Canadian Natural is piloting the removal of FT (by pumping with submersible pumps) from ETF/DDA1, pumping the FT to the FT buffer tank, and adding (spiking) FT to the NST mix as shown in Figure 2. Flocculant will be added near the end of pipe as in the eNST process. This will result in a composite, non-segregating mixture, termed enhanced spiked NST (esNST). Preliminary lab results show esNST readily consolidates to provide a trafficable tailings deposit and will result in an increase in the fines capture rate.

Both eNST and esNST technologies continue to be developed and proven at the Horizon site. As these technologies are implemented Canadian Natural will provide updates in the required reports.

Canadian Natural has adopted a selective low-fines mine plan (MFTRMP) that continues to play an integral role in reducing the overall fines content in the feed ore and tailings streams. Implementation of MFTRMP allows for a greater amount of FT to be added to NST, and as a result, increases overall fines capture. The implementation is considered in the FT Profile. Canadian Natural received Experimental Scheme Approval No. 12403 from the AER on May 29, 2015, authorizing Canadian Natural to operate under the MFTRMP. Amendment Approval No. 9752G (AER 2018) was issued in December 2018 extending the expiry date of the Approval to September 2022.

Canadian Natural continues to evaluate other tailings treatment technologies, both through site initiatives and through collaboration with its industry partners. Canadian Natural's past and current tailings technology development projects are outlined in the 2016 Tailings Management Plan (CNRL 2016), in the 2017 Annual Tailings Management Report (CNRL 2018a), and in Appendix B of this report.

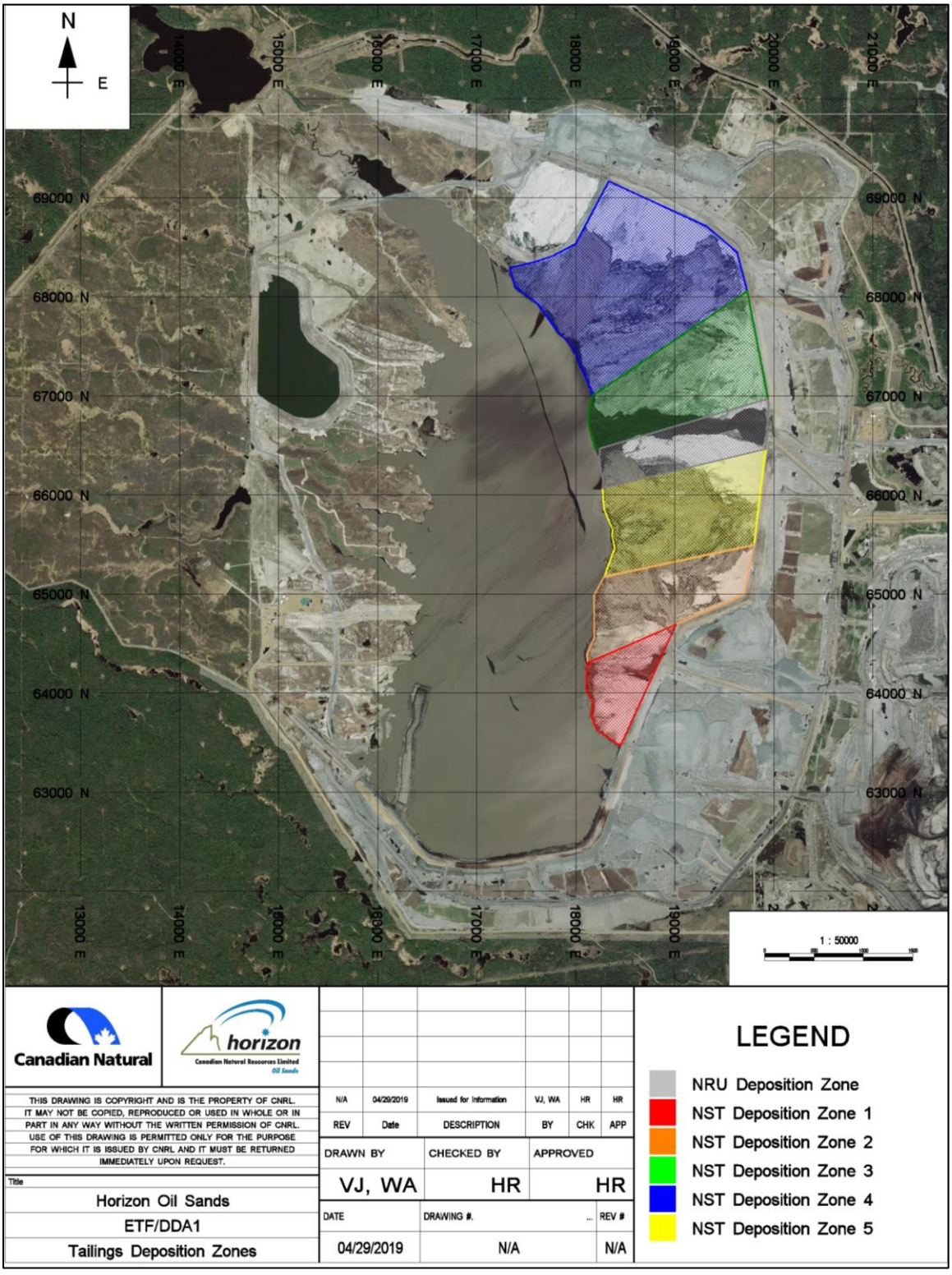

Figure 1: General Layout of Canadian Natural's Horizon Tailings Facilities

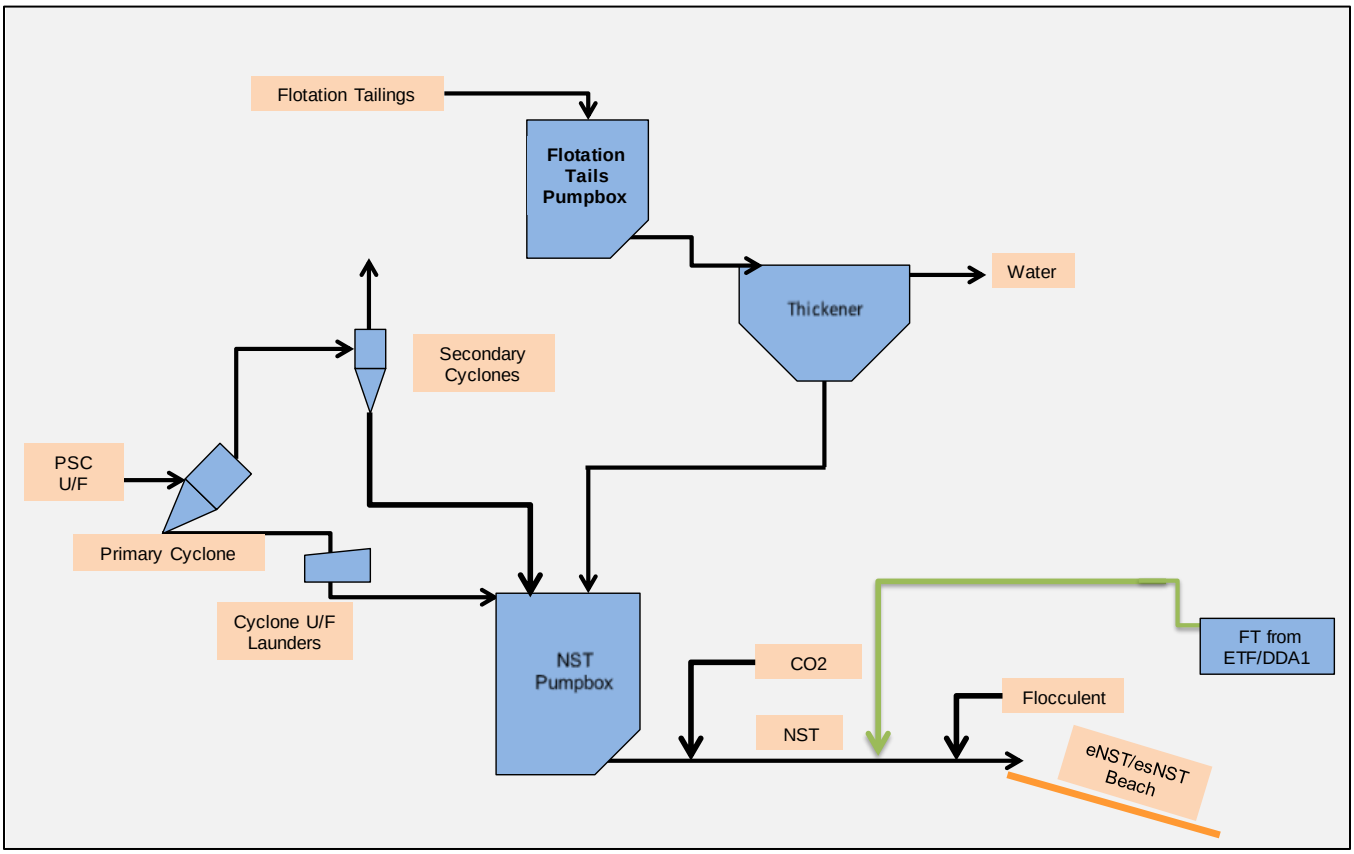

Figure 2: Simplified NST Process, illustrating eNST and esNST

3. ANNUAL TAILINGS INVESTIGATION PROGRAM (MONITORING)

The primary objectives of the annual tailings investigation program are to:

- Identify and map the fluid – solid tailings interface utilizing drop soundings (CT09);
- Collect tailings and fluid samples utilizing sonic drilling and wireline fluid sampler equipment to determine physical properties of the tailings;
- Identify mudline measurement throughout pond utilizing fixed interval sampling and marine geophysics;
- Determine soil stratigraphy, relative density, strength and fluid pressures properties utilizing cone penetration test (CPT) and gamma cone penetration test (GCPT) methods; and
- Survey the ETF/DDA1 in its entirety and develop three dimensional geometric shapes (wireframes) of the clear water zone (CWZ), FT pond zone and the incremental beach above water (BAW) and beach below water (BBW) zones that have been deposited since the previous tailings investigation took place.

This information is used to monitor and measure the tailings deposits to ensure that all regulatory and operational requirements are met to fulfill commitments made in Horizon's 2016 TMP (CNRL 2016).

This annual fluid tailings management report has been prepared relative to the objectives listed above, and based on AER Directive 085 (AER 2017) and OSCA 9752G, Conditions 46 and 52-54 (AER 2018) requirements.

3.1. 2018 Program Overview

In 2018 two pond investigation programs were performed at Canadian Natural's Horizon site, both in the ETF/DDA1. The surveys consisted of:

- Core and fluid sampling locations (BAW, BBW and fluid);
- CPT locations;
- Sonar and fixed interval sampler (FIS) mudline measurements;
- CT09 survey to define the BBW surface; and
- A light detection and ranging (LiDAR) survey of the BAW surface, as well as the greater ETF/DDA1 structure.

Figure 3 and Figure 4 provide plan views of the core hole and fluid sample testing locations for the summer and fall programs. Table 1 includes a breakdown of the type and number of tests performed.

Marine geophysics was completed during the fall 2018 investigation to map the mudline and potential muskeg matting (wide scan sonar). As well, it was initially intended to pick up the "hard bottom" with sub-surface profiling, but this did not work, likely due to elevated CO_2 in our fluid tailings.

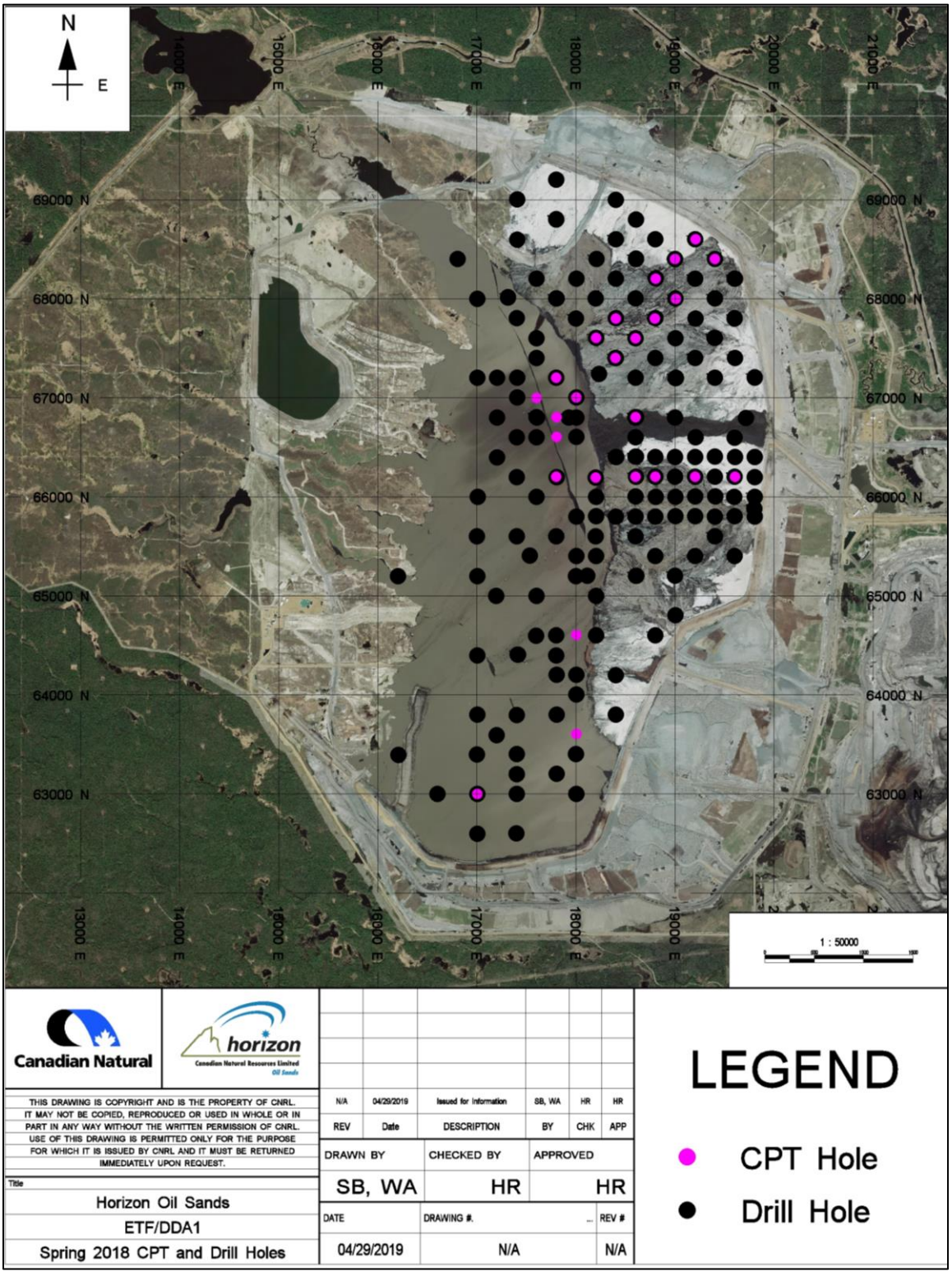

Figure 3: Summer 2018 Pond Investigation Sampling Locations

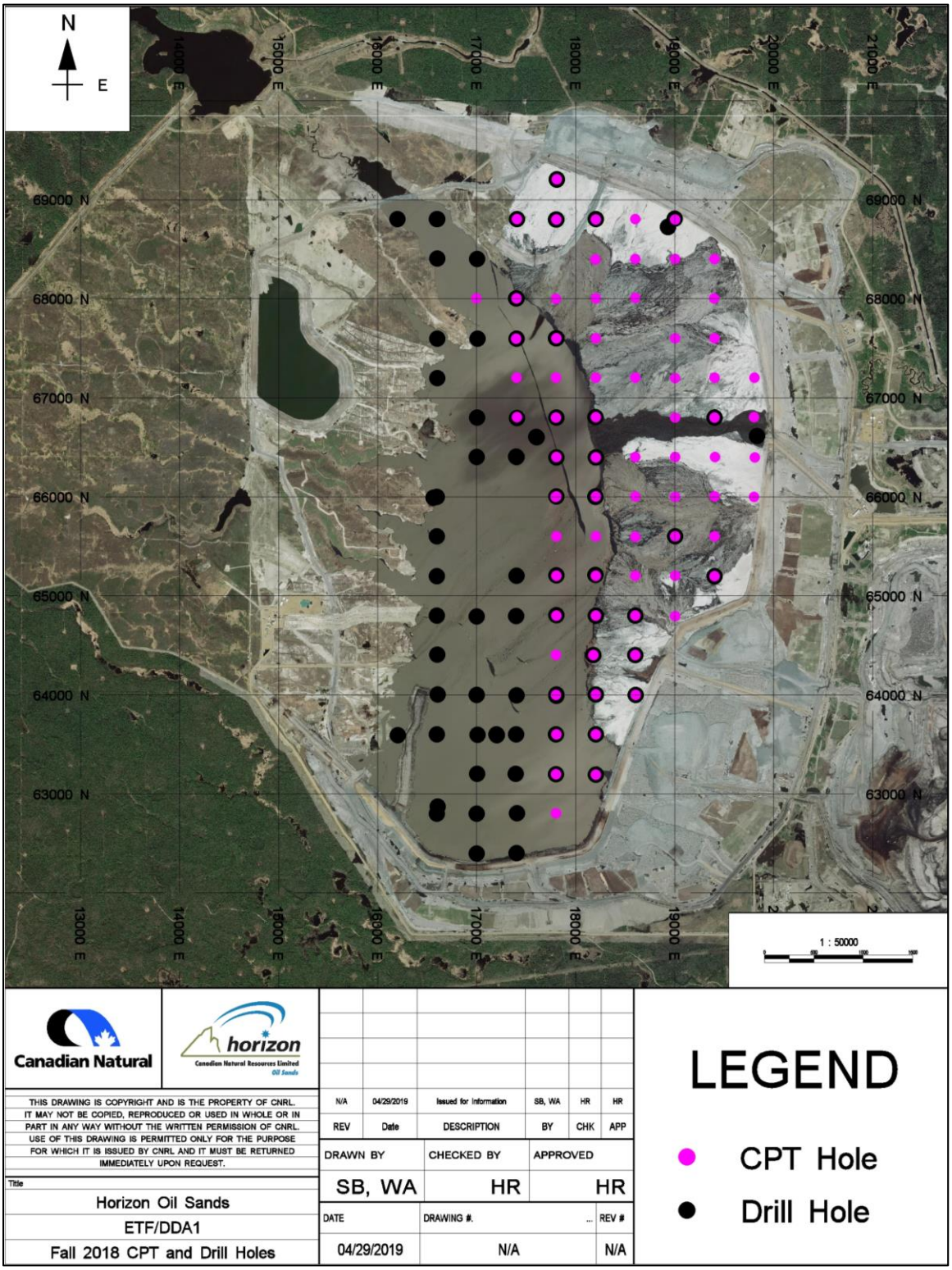

Figure 4: Fall 2018 Pond Investigation Sampling Locations

Table 1: 2018 Pond Investigation Sampling Scope

Test	Number of Tests Performed		
	Summer 2018	Fall 2018	Total 2018
Sampling Location[1]	207	108	315
Cone Penetration Test	25	72	97
Drop Sounding (CT09)[2]	183	0	183

[1]Sampling locations include beach above water, beach below water and fluid

[2]Trademark drop sounding technique and tool developed by Conetec

3.2. Laboratory Testing

A laboratory testing program was conducted on samples collected during the 2018 annual tailings investigation to characterize the Horizon tailings deposits. The laboratory testing component of the annual investigation included:

- Dean Stark (DS);
- Particle Size Distribution (PSD)* using sonicated sieve (% passing 44µ size fraction);
- Methylene Blue Index (MBI); and
- Total Suspended Solids (TSS) and water chemistry on CWZ samples.

*The lab procedure used for Dean Stark and PSD analysis was identical to that currently used for core hole sample analysis in the mine. This lab procedure consistency permits mass balance reconciliation between the mine and ETF/DDA1 model.

A total of 2,346 samples were tested for the 2018 annual investigations. All testing was conducted in accordance with Canadian Natural's standard laboratory testing procedures and American Society for Testing and Materials (ASTM) standards.

Further information on Canadian Natural's tailings investigation standard working procedures is detailed in Horizon Tailings Measurement Plan (CNRL 2018b).

3.3. Survey

As-built, LiDAR, sonar, FIS, CT09 and pond elevation surveys conducted during the time of the annual investigations were used to define the three-dimensional geometry for each depositional zone within the ETF/DDA1. Original ground, LiDAR and surfaces derived from prior investigations were used to supplement the pond survey data as required.

3.4. Classification of Treated Tailings, Fluid Tailings and Clear Water

For the purpose of this report, Canadian Natural's oil sand tailings are generally classified into three main types (or zones): solid tailings within the beach above and beach below water (BAW, BBW), FT, and CWZ.

To characterize the ETF/DDA1 zones, a sonic core hole and fluid sample drill program was completed throughout the ETF/DDA1. Samples were independently lab analyzed and the resultant assay dataset was used to create a deterministic block model, allowing for the spatial characterization of each respective zones. Core hole and fluid sample locations for the 2018 spring and fall programs are shown in Figure 3 and Figure 4. The key modelled attributes of interest include: bitumen, solids, water and fines content.

A cone penetration test program was also completed within the BAW and BBW zones.

3.5. Modelling

The survey data obtained from the 2018 annual investigations was used to generate the FT pond bottom, beach top and mudline surfaces for the ETF/DDA1. Three dimensional digital wireframes were created defining the CWZ, FT pond and incremental beach deposited since the prior ETF/DDA1 investigations took place. Total volumes for the CWZ, FT pond, BBW and BAW were estimated. Incremental volume changes from prior investigations were also estimated at this time. In the event that active deposition was taking place during the various survey activities listed in Section 3.3, the mid-point date of the CT09 survey was used to define the effective date of the model. Based on production rates, historic depositional proportioning and tailings quality, all other surfaces were volume normalized to this effective date. This normalization effort was essential to completing the mine versus ETF/DDA1 mass balance reconciliation.

A single deterministic model of the ETF/DDA1 was constructed within the project extents. The surveyed ETF/DDA1 zone wireframes discussed in the paragraph above were used to populate each model block with codes to differentiate which zone each block was contained within. Similar to the mining model blocks, codes were assigned to each assay sample identifying which zone they were contained within. Model blocks and assay samples with the same zone code could then be used to interact with one another during interpolation. The assay samples within each respective zone were then used to interpolate Dean Stark (wt% bitumen, water and solids content), fines content and MBI into the model blocks. The spatial characteristics of each zone were evaluated to determine the most appropriate interpolation parameters to use within each respective zone. Following the population of the attributes listed above, a variety of other block characteristics were then calculated, which include: wet density, dry density, sand to fines ratio (SFR), sand content, dry mineral tonnage and dry fines tonnage. A series of cross sections throughout the model showing solids content, MBI, and SFR are provided in Appendix A.

Summary statistics from the annual ETF/DDA1 models from 2014 to 2018 were evaluated to ensure the dry mineral and dry fines tonnages reporting to the mine hydrotransport lines were well aligned with each of the respective models.

3.5.1. Pond Bottom and Mudline Interpretation

FT volumes for the reporting period were calculated based on the Canadian Natural's guidelines which are consistent with those outlined in the "Guideline for Determining Oil Sands Fluid Tailings Volumes" released by Canada's Oil Sands Innovation Alliance (COSIA) in June 2015 (COSIA 2015). In an effort to produce a representative FT inventory, pond bottom surfaces were modelled and reviewed against previous surveys, lab sampling, satellite imagery, and any additional available data. Commentaries relating to the interpretation of the survey data are outlined below.

The ETF/DDA1 tailings beach continues to advance further west into the FT pond due to ongoing tailings deposition. In the reporting period, this growth was primarily in the area of the NST deposition. Growth of the deposit is expected to continue. The BAW surface was determined through LiDAR surveys and volume timing corrections as required during active deposition (to normalize volumes to the CT09 effective date discussed in Section 3.5).

The current BBW surface, and where it intersects the original ground topography, was determined using the June 2018 CT09 survey. This was then confirmed with assay samples and CPT results at the FT Pond/BBW interface. The BBW zone within the ETF/DDA1 is composed of material with strengths clearly indicating soil characteristics with an average solids content ≥70% w/w. Furthermore, assay and CPT data is showing this zone to be increasing in strength and solids content over time. This is determined by comparing the model results within the BBW zone deposited in prior years, with an updated model within the same deposition zone, using 2018 core and CPT data (i.e. model the same deposition zone with assay datasets drilled a year a part and compare the difference).

Solids content within the FT pond has a very well defined and predictable vertical gradient (see Appendix A Figure A-4). Within the deepest area of the FT pond, typically along the BBW toe, the solids content exceeds 70 wt%, with fines contents ranging from 28 – 35 wt%. From a strength perspective, this high solids zone still exhibits the behaviors of a fluid (i.e. CT09 is passing through with low undrained shear strength), and is therefore reported as FT. It is suspected that this FT is being entrained by NST beach as the deposit face advances west. Canadian Natural will continue to monitor this zone until it is determined that the properties meet ready-to-reclaim (RTR) criteria.

The mudline surface, used to constrain the top of the FT pond, was determined through sonar measurements, then adjusted based on FIS sampling at the mudline interface.

3.5.2. Mass of Fines Estimation

The modelling process described in Section 3.5 outlines how the model blocks within each ETF/DDA1 zone were characterized with Dean Stark, fines and MBI data. These estimates were then used to determine dry mineral solids and dry fines solids mass within each individual model blocks. The mass of each respective model block was then accumulated to determine the total tonnage (dry mineral and dry fines) deposited into each zone. Because the FT pond is modeled in its entirety, only total FT pond tonnages can be determined. The incremental FT deposited for a given period of time can then be calculated by subtracting the pond results from the prior investigation model. The beach, on the other hand, is modeled as a depositional increment (between the prior model beach surface to the current beach surface).

As stated in Section 3.5, the incremental dry mineral and dry fines tonnages estimated between two ETF/DDA1 investigation time periods can then be compared and reconciled against the tonnages reporting to the processing hydrotransport lines for the same time period of interest.

From Aug 4, 2015 through June 27, 2018 mine processing hydrotransport tonnages are approximately 3% higher in both dry mineral and dry fines versus those contained in the cumulative ETF/DDA1 block models (based on 4 successive annual models). The majority of this small difference is attributed to consolidation of the beach which hasn't been factored into each static modeling event (i.e. the base of each beach zone remains static for each

modeling cycle). A small amount of consolidation of the beach foot print would accommodate the tonnage difference described above.

3.6. Adequacy of Dataset

There are a variety of components used to determine the adequacy of the pond investigation dataset. Survey data defines the geometric shapes of the various ETF/DDA1 zones. Survey inaccuracies will result in erroneous zone volumes. Regardless of how accurately the material is characterized within each zone, the result will likely be an over estimation or underestimate relative to what was actually deposited.

Conversely, an accurate survey dataset may create a representative three-dimensional model for each ETF/DDA1 zone, but inaccuracies in the core and fluid sample dataset, or an insufficient spatial distribution of data, may result in an inaccurate characterization within any, or all, of the zones being modeled.

An important component of the modeling process is the mass balance comparison to the hydrotransport estimates discussed in Section 3.5.2. If there is reasonable tonnage alignment between the ETF/DDA1 model and the hydrotransport estimates, this may be a good indicator that the global estimates contained within the model are representative. Validation of the survey, assay dataset and modeling assumptions is still required.

3.6.1. Survey Dataset

Most of the survey data collected can be validated against other survey data or sample point data. Examples of this include:

1. How does the sonar mudline surface compare to the FIS fluid sample CWZ/FT pond interface which has an accuracy of approximately 10cm?
2. How does the CT09 data compare to the CPT and fluid sample assay results at the BBW/FT pond interface? If the CT09 derived BBW surfaces do not agree with these additional dataset then the differences need to be reconciled.
3. Water top elevations are taken 1-2 times per day. Ensure these changes are reasonable and aligned with the tailings deposition and water intake rates.
4. Ensure the LiDAR survey accuracy by comparing to water elevation survey and manual survey data collected from the beach and ETF/DDA1 structure. In addition, the LiDAR data can be compared to the collar elevations of the sonic core hole drill program.

3.6.2. Distribution of Core and Fluid Sample Locations

The number and distribution of sample point locations needs to be sufficient to adequately characterize each ETF/DDA1 zone. The scale of pond investigation at Horizon is global (i.e. not as concerned about localized over and underestimation events within each ETF/DDA1 zone, so long as the averages are accurate and without bias in one direction or the other), the hole spacing requirements are less dense in relation to what is required in an active mining scenario.

Canadian Natural is currently completing a geostatistical study of the various zones within the ETF/DDA1 to determine the appropriate drill spacing for each zone. The appropriate spacing for each zone will be dependent

on the variability of the deposit for each zone and, as mentioned in the paragraph above, the scale of investigation requirements.

3.6.3. Accuracy of the Assay Sample Results

The accuracy of the Dean Stark, fines content and MBI results are essential to adequately characterizing the various depositional zones within the ETF/DDA1. Furthermore, completing the lab analysis in a manner that is consistent with how our mining core hole program is completed is paramount. Without collection, preparation and lab analysis consistency between samples taken at the mine versus those collected for the ETF/DDA1 investigation, accurate material balance reconciliation could likely not take place.

To confirm the accuracy and reproducibility of the assay results, a blind re-testing program of the spring 2018 samples was completed in March of 2019. 34% of our FT pond and beach samples were independently re-labeled and re-tested. The average difference in the results was +/- 0.2 wt% (absolute) for both the Dean Stark and the fines content results. This blind test demonstrated the accuracy and reproducibility of the spring 2018 assay results.

4. POND STATUS INCLUDING FLUID TAILINGS VOLUME

4.1. Annual Fluid Tailings Volumes

Horizon's project site summary of all annual fluid tailings volumes are listed in Table 2, below.

4.2. Approved Fluid Tailings Profiles

As per Figure 5, Horizon's FT accumulation is performing as predicted. At the end of 2018, Horizon's current FT volume is slightly below the D085 approved FT cumulative profile. Horizon's performance falls within Tailings Management Framework (TMF) management level 1.

As per the approved performance ramp up in the 2016 TMP (CNRL 2016), Horizon continues to seek ways of improving the NST performance and overall process. New technology developments are ongoing as per Horizon Approval No. 9752G, see Section 6.

Table 2: Annual Fluid Tailings Volumes, Mm3

Year*	Previous Year New FT Inventory	Previous Year Legacy FT Inventory	Fluid Tailings Inventory	Change in New FT Inventory	Change in Legacy FT Inventory	New FT Inventory	Legacy FT Inventory	Approved Profile New FT Inventory	Approved Profile Legacy FT Inventory	New FT Rolling Profile Deviation	Legacy FT Rolling Profile Deviation
2015	0	66.2	83.0	16.8	0	16.8	66.2	14.3	66.2	17%	0%
2016	16.8	66.2	93.3	10.3	0	27.1	66.2	37.4	66.2	-5%	0%
2017	10.3	66.2	110.6	17.3	0	44.4	66.2	51.0	66.2	-8%	0%
2018	17.3	66.2	131.8	21.2	0	65.6	66.2	67.6	66.2	-6%	0%
2019								82.9	66.2		
2020								95.1	62.6		
2021								111.5	57.7		
2022								121.8	52.4		

* End of year values are linearly interpolated from actual survey volumes

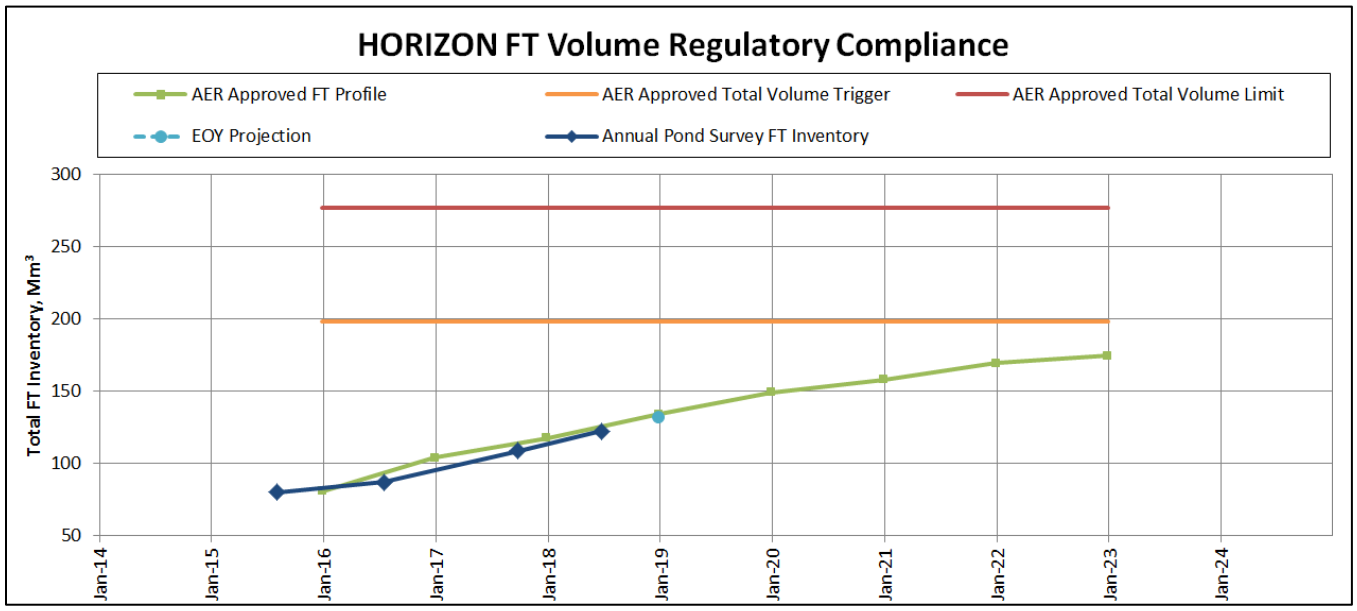

Figure 5: Approved Fluid Tailings Profile and Actual Fluid Tailings Volume

4.3. Fluid Tailings Performance

Tailings performance is related to developing an understanding of the physical characteristics of the beach and pond. In addition, understanding the proportional change in size of the BBW, BAW and FT pond, relative to one another, throughout the depositional life cycle of the ETF/DDA1 is key. Horizon's goal is to continuously improve the quality of engineered tailings product in a manner that progressively increases the rate of fines captured in the beach (dry fines tonnage ÷ total fines tonnage) between each successive pond investigation, while ensuring the geotechnical characteristics of the resultant beach continue to remain on a RTR trajectory.

The volume and composition of FT estimated to be contained in the ETF/DDA1 at the end of June 2018 is detailed in Table 3. As described in Section 3, the volumes of FT and CWZ in the ETF/DDA1 are estimated based on the results of the annual investigation program and block modelling. The composition of the FT (as measured by Dean Stark distillation and sonicated sieve analysis) is also presented. The dry fines tonnage (<44 µm), reconciled to ore processed, that were not captured is also presented in Table 3. Fines delivered to Horizon tailings ponds exclude fines of breaker rejected ore.

Table 3: Volume and Composition of FT in ETF/DDA1, end June 2018

Pond	Fluid Tailings (Mm3)	Mineral Solids Content (%, w/w)	Fines Content (%, w/w)	Bitumen Content (%, w/w)	Water Volume (Mm3)	Fluid Tailings Dry Fines Content (Mt)
ETF/DDA1	122.2	41.6	75.3	1.4	29.2	51.6

Table 4 presents a summary of the total volumes of FT, treated FT and FT meeting RTR predicted in the ETF/DDA1 for December 31, 2018. This volume is an estimate based on the measured FT volume at the end of June, 2018.

Table 4: Estimated Volume of FT in ETF/DDA1, end December 2018

Pond	Fluid Tailings (Mm3)	Treated FT (Mm3)	Fluid Tailings Meeting RTR (Mm3)
ETF/DDA1	131.8	0.0	0.0

Horizon's RTR criteria includes tailings reaching 70 % solids by weight (w/w) within 1 year of tailings placement and 81 % solids w/w within 5 years of achieving 70 % solids w/w. Cross sections in Appendix A illustrate the solids content w/w for the tailings beach in ETF/DDA1 deposited between July 2016 and July 2018. These sections show that solids content is above 70% w/w and therefore confirms that performance criteria is being met and is still appropriate. NST deposited during the current reporting period is deemed to be on a RTR trajectory and therefore the corresponding volume is not included in FT volume.

FT is considered RTR when the FT has been processed with an accepted technology, placed in a final landscape position, and meets performance criteria. Canadian Natural Horizon has no FT considered to have reached RTR status during this reporting period.

4.4. Ore Processed and Average Composition

Table 5 details the tonnage of ore processed and average ore composition (bitumen, water, solids) at Horizon during the reporting period.

Table 5: Horizon Ore Processed, 2018

Ore Processed	Mass (Mt)	Bitumen (%, w/w)	Water (%, w/w)	Solids (%, w/w)	Fines (%, w/w)
	161.6	10.6	5.1	84.3	19.0

4.5. Pond Storage Capacity

Horizon currently operates one External Tailings Facility/Dedicated Disposal Area 1 (ETF/DDA1). The remaining storage capacity for NST and fluid in the ETF/DDA1 at the end of 2018 is 264 Mm^3.

In 2020 Horizon plans to begin depositing tailings into DDA2. The total storage capacity and estimated tailings volume requirements for 2019 through 2023, based on planned dyke construction elevations, are detailed in Table 6.

Table 6: Storage Capacity and Tailings Volumes, 2019-2023

End of Year	ETF/DDA1 Capacity, Cumulative Mm^3	DDA2 Capacity, Cumulative Mm^3	Total DDA Capacity, Cumulative Mm^3	Tailings Volume, Cumulative Mm^3
2018	264		264	
2019	264	31	295	97
2020	264	94	358	179
2021	264	226	490	278
2022	264	293	557	372
2023	264	487	751	471

4.6. Fluid Tailings Treatment

No direct Fluid Tailings were treated in 2018. As per Horizon's 2016 TMP (CNRL 2016), Horizon plans to start treating FT in 2020.

NST technology is Horizon's primary technology used to capture fines. The NST tailings technology captures fines into the coarse sands interstices; therefore fines fluid tailings production is minimized. CO_2 is directly added into the NST and NRU tailings streams as an additional method of assisting in tailings settling and overall performance.

4.7. Adherence to Fluid Tailings Management Plan

NST is currently the main technology to treat fines employed at Horizon. NST technology performance adhered to the FT Management Plan in 2018, as foreseen in the 2016 TMP (CNRL 2016). Figure 5 compares the Horizon actual FT cumulative volume versus the TMP FT cumulative profile from 2014 to 2018. Horizon's NST technology continues to follow the ramp-up performance path proposed in the 2016 TMP.

4.8. Fluid Tailings Settlement and Consolidation

Settlement and consolidation of fluid tailings are not tracked in active ponds, due to the complexity and inaccuracy inherent in measuring and calculating these values. For fluid tailings, settlement and consolidation will be measured and tracked as accurately as possible once the pond no longer receives or is the source of a mineral solids transfer.

5. WATER

2018 was the first full year the Horizon Mine operated at Phase 3 production rates. The water use by various business units differed from previous years due to the increase in production rates. Water from the Athabasca River is pumped from the river water pump house to the raw water pond. In 2018, 28.6 Mm3 of water from the Athabasca River was used at Canadian Natural Horizon mine site, with 19.1 Mm3 reporting to the upgrader and 8.3 Mm3 reporting to the recycle water pond.

The Horizon plant site maintains a net negative water balance in 2018. This implies that river water was imported to the tailings pond to make up for water losses. Losses in the pond are attributed due to: evaporation, water in beaches, and water in fluid tailings. In 2018 additional river water was added to the tailings pond due to flow restrictions on the water supply “siphon system” from the tailings pond to the recycle water pond (RCW).

5.1. Site Wide Water Balance

Horizon has modified its plant block flow diagram to match the AER’s water usage diagram, in use for the past few years. Figure 6 illustrates the block flow diagram currently employed at Horizon. A few notes on this AER block flow diagram:

- Basal ground water is not used in the process at Horizon and is stored;
- No runoff water reports to the Raw Water Pond, all runoff from the plant site is shown by stream (K) which reports to the tailings pond;
- The values submitted in this balance are the actual flow meter readings and there has not been any mass balancing correction;
- Multiple blocks do not balance in the diagram as not all the streams are taken into account, such as:
    - Ore connate water;
    - Upgrading water losses; and
    - Mining & surface water to Recycling Pond.

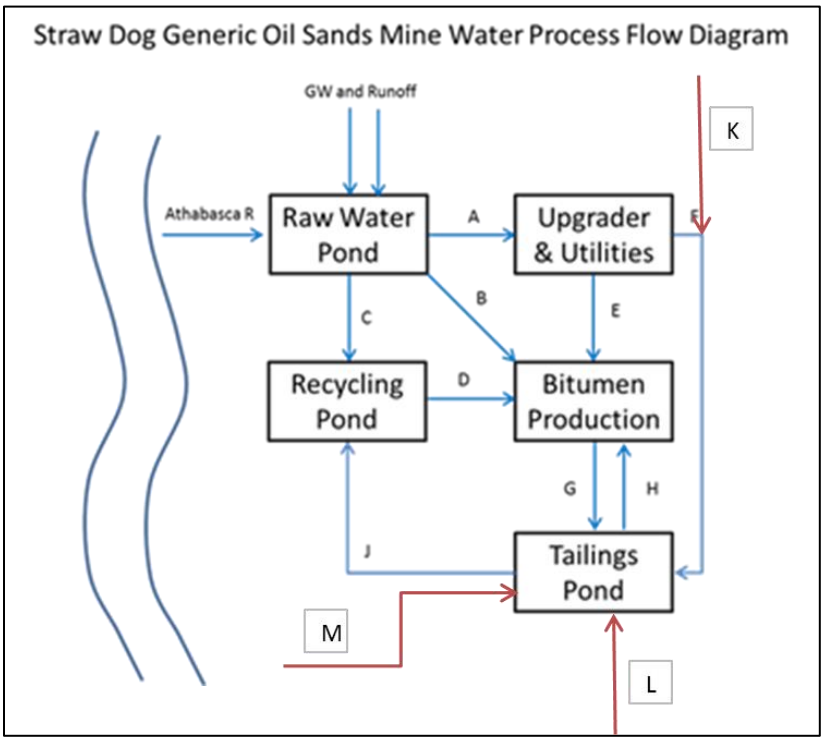

Figure 6: AER Water Usage Flow Diagram (modified for Horizon)

The measured water usage at Horizon, during the 2018 reporting period, is listed in Table 7.

Table 7: Site Wide Water Usage for 2018

Stream	Description	Volume (Mm3)
	Athabasca River Water	28.6
A	Raw water to Utilities and Upgrading	19.1
B	Raw Water to Extraction	0
C	Raw Water to Recycle Water Pond	8.3
D	Recycle Water to Bitumen Production	110.4
E	Utilities and Upgrading to Bitumen Production	4.3
F	Utilities and Upgrading Waste water to tailings pond	9.2
G	Bitumen Production to Tailings Pond	124.5
H	Tailings Pond to Bitumen Production	1.4

Stream	Description	Volume (Mm3)
J	Tailings Pond to Recycle Water Pond	99.8
K	Horizon Site Run Off Water	1.2
L	Tributary Water to ETF	2.3
M	Runoff, Precipitation and Evaporation to ETF	-4.9

5.1.1. Upgrading & Utilities

The water use by upgrading was 19.1 Mm3 in 2018 which is 0.8 Mm3 higher than in 2017. This is an increase of 8%, which gives a raw water intensity of 1.24 barrels of water per barrel of bitumen produced. During 2018 production was increased by 33%at Horizon due to Phase 3 implementation.

5.1.2. Bitumen Production

8.2 Mm3 of raw water was added to the recycle water pond. This is approximately 4 Mm3 less water than in 2017, and was used to add additional water to the tailings pond to maintain the water cap. Significantly more water was sent to the tailings pond in 2018 from 2017 due to the increase in plant production rates. The water to the tailings pond (stream “G”) is the sum of 5 NST lines, 2 NRU lines, Warm Process Water (WPW) and Hot Process Water (HPW) dump lines. With the Phase 3 plant at design rates, significantly less HPW was sent to the tailings pond. Stream “H” flow is now expected to be stable, this is the reclaim water used in the Ore Preparation Plants (OPP) 1-3.

5.1.3. ETF/DDA1

The flow out of the tailings pond (stream “J”) increased from 2017 to 2018 due to the increased Phase 3 rates. The Horizon Lake overflow to the tailings pond (stream “L”) was operated only during the winter months, which is normal operational procedure.

The tailings pond evaporation and steam evaporation was higher than the runoff and precipitation into the area which is the cause of stream “K” having a negative number.

5.2. Water Volumes for Reporting Period

In 2018, Canadian Natural Horizon project had one active tailings facility, referred to as the ETF/DDA1. The ETF/DDA1 is the only source of recycle water. Table 8 estimates the free water accumulation during 2018. The increase in water volume was caused by siphon startup issues. Upgrades to one siphon intake will be completed in Q3 2019 to reduce air entrainment to increase the flow at the intake startup.

In 2018 there was no fluid tailings recovered from the ETF/DDA1. The NST beaches all dewater into the ETF/DDA1. Therefore, the volume and quality of this water is reported as part of the recycle water system.

Table 8: Free Water in the ETF/DDA1, 2018

Period	Free Water (Mm3)
January 1, 2018 (Estimated)	29.0
December 31, 2018 (Estimated)	31.1

5.3. Water Quality for Reporting Period

The water chemistry in the ETF/DDA1 changed in 2018 from 2017 due to two main factors:

- Connate water chemistry
- CO_2 addition to the NST lines

Connate water chemistry is the largest driver for sodium and chloride levels in the recycle water system. At the start of 2018 the sodium and chloride concentrations averaged 165 & 193 ppm respectively. Towards the end of 2018 the concentrations dropped to less than 120 & 130 ppm respectively. The water chemistry in the connate water for the next 5 years is expected to remain low in sodium and chlorides which will reduce the overall salts in the process water.

CO_2 for the tailings lines is now being supplied by the upgrader, where it is captured for use in the extraction and NST processes. For the first half of 2018 the CO_2 plant struggled with reliability issues and there was an inconsistent supply for the tailings process. After the plant turn around the reliability issues were resolved and extraction increased dosage of CO_2 from 600 g/t solids to 1000 g/t solids. This was incorporated to increase fines capture in the NST beach. The unintended consequence of increased CO_2 was a lower pH. The lower pH increases the hydrogen ions in solution which exchanges on to the clay mineral, thereby releasing calcium and magnesium into the phase. The recycle water chemistry clearly shows an increase in calcium and magnesium and hardness from the previous year. The CO_2 dosage has been returned to 600 g/t solids and we are seeing a slow trend back towards to 2017 levels.

The average recycle water quality in the ETF/DDA1 for 2018 is presented in Table 9, below:

Table 9: Recycle Water Quality in the ETF/DDA1, 2018

Parameter Name	Result	Standard Deviation	Units
Alkalinity (Total as CoCO3)	884	55	mg/L
Bicarbonate (HCO3)	1007	104	mg/L
Chloride (Cl)	782	38	mg/L
Conductivity	3940	176	uS/cm
Hardness (CaCO3)	77	8	mg/L
Iron (Fe)	0.2	-	mg/L
Calcium (Ca)	13.5	1.7	mg/L
Magnesium (Mg)	10.4	1.1	mg/L
Potassium (K)	18.4	1.0	mg/L
Sodium (Na)	906	46	mg/L
Total Suspended Solids	100	130	mg/L
Total Dissolved Solids	2367	272	mg/L
pH	8.09		N/A

6. TAILINGS TECHNOLOGY: CONTINUOUS IMPROVEMENT AND DEVELOPMENT

6.1. Summary of Current Treatment Technologies

The section below describes the 2018 NST optimization activities comprising production and deposition. Ideally NST on-spec performance is directly measured by both the NST sand to fines ratio (SFR) and fines over fines plus water (FOFW) content. However, currently no viable online particle size analyzer exists to quantify the coarse and fines fraction of the NST slurry. Horizon uses the slurry density to measure NST plant performance with a minimum NST density target of 1.60 t/m^3.

Figure 7 shows the 2018 NST performance in terms of on-specification run time percentage, including year to date on-specification performance. Horizon's intent is to achieve a minimum slurry density of 1.60t/m^3 a minimum of 85% of the time by 2023 as discussed in the 2016 TMP (CNRL 2016). All NST production below 1.60 t/m^3 is considered off-specification. The plant was shut down for turnaround approximately 3 weeks from September to October 2018. For 2018, the average NST on-spec run time was approximately 56.6%.

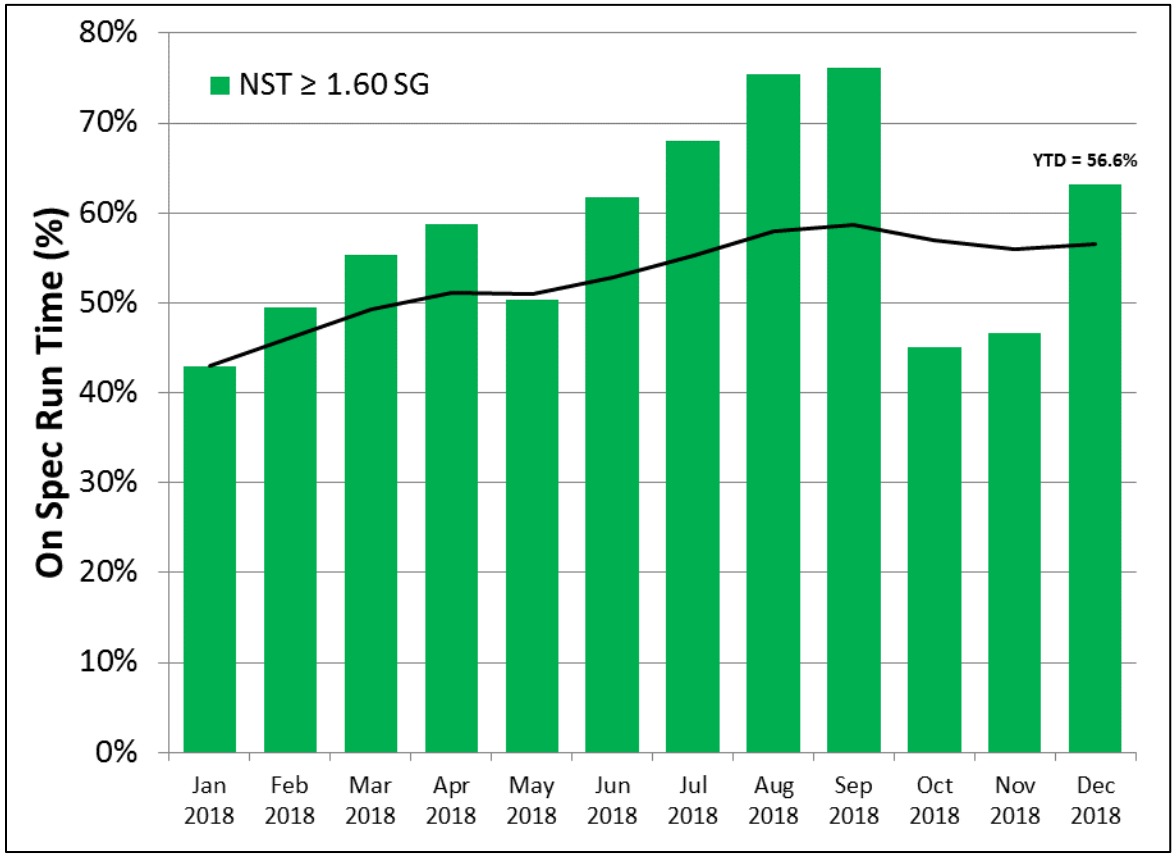

Figure 7: 2018 NST on-specification run time with slurry density ≥ to 1.6 t/m^3

The main causes of reduced on-specification time relate to:

- Higher amount of fines in ore as well as smaller particle size resulted in lower thickener and cyclone underflow densities; and

- Frequent flush events in Ore Preparation Plants resulting in lower feed density to extraction which in turn reduced density throughout the NST process.

In 2018, the thickener feed lines were upgraded to increase wear resistance and improve NST reliability. Material upgrades will continue in 2019.

Table 10 presents the 2018 NST technology issues, mitigations and continuous improvements. No optimization was conducted on NRU tailings in 2018.

Table 10: 2018 NST technology issues, mitigations and continuous improvements

Item	Continuous Improvement	Issue	Mitigation	Effect on Deposit Performance
Thickener	Thickener Flocculent Performance	Thickener UF density not always at target	Polymer supplier has been changed following testing and performance results analysis	Higher NST density resulting in higher fines capture
Thickener and Cyclones	Secondary Cyclone Pressure Optimization	Variable composition to the thickener affecting thickener UF density	Optimizing range of operating pressure of secondary cyclone results in better control of flow and solids classification. This will also maintain cyclone UF density on target and improve NST density	Higher NST density resulting in higher fines capture
Thickener	Thickener Bed Height Optimization	Thickener UF density not always at target	Operating based on bed height as opposed to bed tonnage allows for higher retention time in the compaction zone	Higher NST density resulting in higher fines capture
NST	Validation of segregation curve using plant data	Need to verify the segregation curve that was developed in the pilot plant with data from operation of the plant	Sample valve was installed in Q4 2018. Limited data is available. More information will be gathered in 2019 as flocculant and CO2 addition strategies have been updated	A better understanding of the segregation curve leads to a higher quality NST and therefore leads to less fines segregation.

6.2. Tailings Technology Implementation, Pilots and Research

Canadian Natural's tailings technology development is in alignment with Horizon's Tailings Management Plan (CNRL 2016), Table 10.2.5-1 and Table 12. Enhanced NST (eNST) was successfully demonstrated in 2017 and the technology will be deployed in 2019. In 2019 and 2020, the enhanced spiked NST (esNST) technology will be demonstrated and the development of a stackable tailings technology will continue in the next few years.

Table 11 provides an update of the main technologies in development at Horizon through 2018. Details for these and other tailings technology research can be found in Appendix B.

Table 11: Tailings Technology Development Status and Milestones

Technology	Discovery	Develop	Demonstration	Deployment Estimation
NST Enhancement	2015	2017	2017	2019
Improvement of FT Spiking	2013	2018	2019	2020+
NST Revegetation	2016	2018-2020	2020+	2030+
In Pit Extraction	2016	2016	2017	2023
NRU Treatment	2005	2005+	2010+	2023

To support the Horizon tailings management and closure plans, tailings treatment technology development activities are focused, but are not limited to, the following strategies:

- Reducing production of FT (developing alternative extraction processes or improving existing tailings treatment technologies such as NST);
- Treating residual FT (directly treating legacy and FT inventory at Horizon);
- Accelerating DDA terrestrial reclamation(direct revegetation on NST and therefore minimizing the need for sand capping on terrestrial DDAs); and
- Enabling End Pit Lakes (EPL) technologies (partner with Syncrude's Base Mine Lake, Suncor's Pass projects and any other EPL initiatives at COSIA).

Appendix B includes tailings technology research performed in support of tailings operations at Horizon, and excludes any research performed by Canadian Natural for MRM or JPM.

7. ENVIRONMENTAL EFFECTS AND IMPLICATIONS

The following key mitigation strategies have been adopted to prevent potential l seepage of tailings water from being released to the surrounding environment:

- Incorporation of seepage collection system in the design of Dyke 10, consisting of chimney drain and sand blanket;
- Perimeter ditches and the Dyke 10 Runoff Pond for collecting surface runoff and seepage; and
- Groundwater monitoring and sampling around the toe of Dyke 10.

The seepage and surface runoff is pumped to the ETF/DDA1 from Dyke 10 Runoff Pond and is used in the extraction process. All water that flows onto the mine area from undisturbed areas and shallow groundwater is routed to the ETF/DDA1 for use in the extraction process. The hydrologic design criteria for the Dyke 10 Runoff Pond are the 100 year return flood event.

Canadian Natural conducts an annual groundwater monitoring program at Horizon, as required under the *Environmental Protection and Enhancement Act* (EPEA) approval No. 149968-01-00, as amended. The groundwater monitoring program is designed to evaluate groundwater conditions around the ETF/DDA1, and to monitor the effectiveness of the mitigation measures described.

Based on the 2018 groundwater monitoring results, indicator parameters tested in monitoring wells fall within the historical background chemistry ranges, with further field monitoring, laboratory testing, analysis and investigation scheduled for 2019.

8. STAKEHOLDER ENGAGEMENT

In 2018, Canadian Natural has endeavored to make tailings management a focus point at regularly scheduled meetings with Indigenous communities. This approach enabled Canadian Natural to work with Indigenous communities, ensuring they understand our efforts towards treating fluid tailings (FT) and reclaiming the Horizon Mine back to equivalent landscape capability. During 2018 engagement efforts where tailings treatment and management was either discussed or was the primary focus are listed below:

- February 6, 2018 – Fort McKay First Nation and Fort McKay Métis Community (FMMC) Internal Community Advisory Group (CAG) Meeting
- April 30, 2018 – Fort McMurray First Nation 468 (FMFN 468) Meeting
- May 3, 2018 – Mikisew Cree First Nation (MCFN) CAG Horizon Tailings Dyke Tour (primary focus)
- May 8, 2018 – Fort McKay First Nation & FMMC CAG Meeting
- May 15, 2018 – Athabasca Chipewyan First Nation (ACFN) Advisory Committee (AC) Horizon Lake Tour
- October 23, 2018 – ACFN AC Meeting (primary focus)

In addition to the above-mentioned meetings, Canadian Natural conducted the first Annual Stakeholder Tailings Forum (Forum) for Horizon Oil Sands with stakeholders on November 27, 2018. The Forum was attended by Canadian Natural technical specialists in the fields of mine planning, tailings planning, conservation and reclamation, innovation, regulatory, environment and stakeholder relations. The Forum provided stakeholders with an in-depth overview of tailings treatment progress, innovative tailings treatment research, mine initiatives to reduce FT and reclamation research. Stakeholders were provided time to ask detailed questions, which were responded to directly by key experts in the fields of tailings planning and treatment, mine planning and reclamation. The proceedings of the Forum, including answers to all stakeholder questions and a complete list of outstanding action items was provided to stakeholders.

The following communities were represented at the 2018 Forum:

- Fort McKay First Nation
- MCFN
- ACFN
- FMMC
- Fort McMurray Métis Local 1935 (ML 1935)
- Fort Chipewyan Métis Local 125 (ML 125)
- FMFN 468

Representatives from the Creating Value from Waste^{TM} (CVW^{TM}) Project were also in attendance at the Forum to discuss their proposed project, with benefits from a tailings management perspective.

A detailed report on stakeholder engagement for Horizon can be found in Appendix C.

9. CONCLUSIONS

During the 2018 reporting year, Canadian Natural applied significant time and energy into surveying, collecting sample data and building models representative of the tailings deposit in Horizon's ETF/DDA1. The tailings deposition model was checked against, and reconciles with, the mine and processing material over the past 3 years. Furthermore, Canadian Natural completed a very aggressive blind sample re-test program to validate the Spring 2018 assay results with a positive outcome regarding reproducibility. Ongoing and future initiatives to improve the accuracy of future pond investigations a modeling of the tailing deposit include initiatives discussed in Section 3.6.

Highlights from the 2018 reporting year include:

- Based on the currently available data, and current projections, Horizon continues to be operated based on the plan laid out in the Horizon Tailings Management Plan (CNRL 2016);
- Mature Fine Tailings Reduction Mine Plan (MFTRMP) continues to provide a reduction in fines processed and fluid tailings produced;
- Horizon is in year 3 of a 7 year NST ramp up;
- Two pond measurements were completed in 2018;
- At the end of 2018, Horizon's estimated FT volume is slightly below the D085 approved FT cumulative profile; and
- NST plant performance issues have been identified and mitigation measures are being implemented.

This report was compiled by various authors in various disciplines to meet the reporting requirements of Directive 085. This Report was prepared in accordance with generally accepted engineering practices. Data collected to inform this report adheres to the procedures and methods described in the Horizon Tailings Measurement Plan (CNRL 2018b) and guidelines provided in the Guideline for Determining Oilsands Fluid Tailings Volumes (COSIA 2015).

10. REFERENCES

Guideline for Determining Oil Sands Fluid Tailings Volumes, Canada's Oil Sands Innovation Alliance (COSIA), June 2015 (COSIA 2015)

2016 Tailings Management Plan, submitted to AER September 2016 (CNRL 2016)

Directive 085 (AER 2017)

Oil Sands Conservation Act Approval conditions, 9752G (AER 2018)

2017 Annual Tailings Management Report, submitted to AER April 2018 (CNRL 2018a)

Horizon Tailings Measurement Plan (CNRL 2018b)

APPENDIX A

2018 Pond Investigations – Representative Cross Sections

1. 2018 POND INVESTIGATION RESULTS

In 2018 two (2) pond investigation programs were performed at Canadian Natural's Horizon site. The surveys consisted of sampling locations (beach above water, beach below water and fluid), cone penetration test (CPT) locations, marine geophysical measurements, and drop sounding (CT09) across the ETF/DDA1 tailings pond.

The data obtained from the annual investigations was used to generate the pond bottom surface, beach top surface and mudline surface definitions, creating a three-dimensional classification of tailings beach, fluid tailings (FT), and clear water zone (CWZ) for the ETF/DDA1.

Block models were generated using the surface definitions mentioned above and individual block properties were then estimated using the laboratory results.

Using the block model, 6 typical sections (section lines shown on Figure A- 5) were cut through the ETF/DDA1 model in order to illustrate the following characteristics:

- Sand to Fines Ratio (SFR) (Figure A- 6 through Figure A- 11);
- Effective Stress (Figure A- 12 through Figure A- 17);
- Pore Water Pressure (Figure A- 18 through Figure A- 23);
- Clay Content (Figure A- 24 through Figure A- 29); and
- Solids Content (Figure A- 30 through Figure A- 35).

1.1. Sand to Fines Ratio (SFR)

The assay results from the sonic core holes samples within the beach, and fluid samples from the pond, were used to populate fines and sand content into the model blocks constrained to their respective depositional zones. The SFR was then calculated in each block as shown in cross section on Figure A- 6 through Figure A- 11. Within the beach, two successive years of deposition and modeling are shown. The beach zone deposited from July 2016 through September 2017 shows the SFR results from the '2017 model'. The beach zone deposited from September 2017 through July 2018 shows the SFR results from the '2018 model'. As shown in the cross section, there is significant fines variability within the beach deposit. The average SFR within the beach deposits ranges from 6-7. As expected within the FT zone, the SFR is low with an average of 0.3. Figure A- 1 shows the average vertical gradient of fines content within the FT pond.

Figure A- 11 shows the SFR of the beach deposit within the Basal Water Storage Pond 1 (BWSP1) containment area. The dyke structure at the bottom of this containment area created a lower energy beach depositional environment created by the Basal Water Storage Pond 1 (BWSP 1) containment dyke. As a result, a relatively high percentage of fines particles were entrained in this portion of the beach. The average SFR for the BWSP1 area was approximately 4.

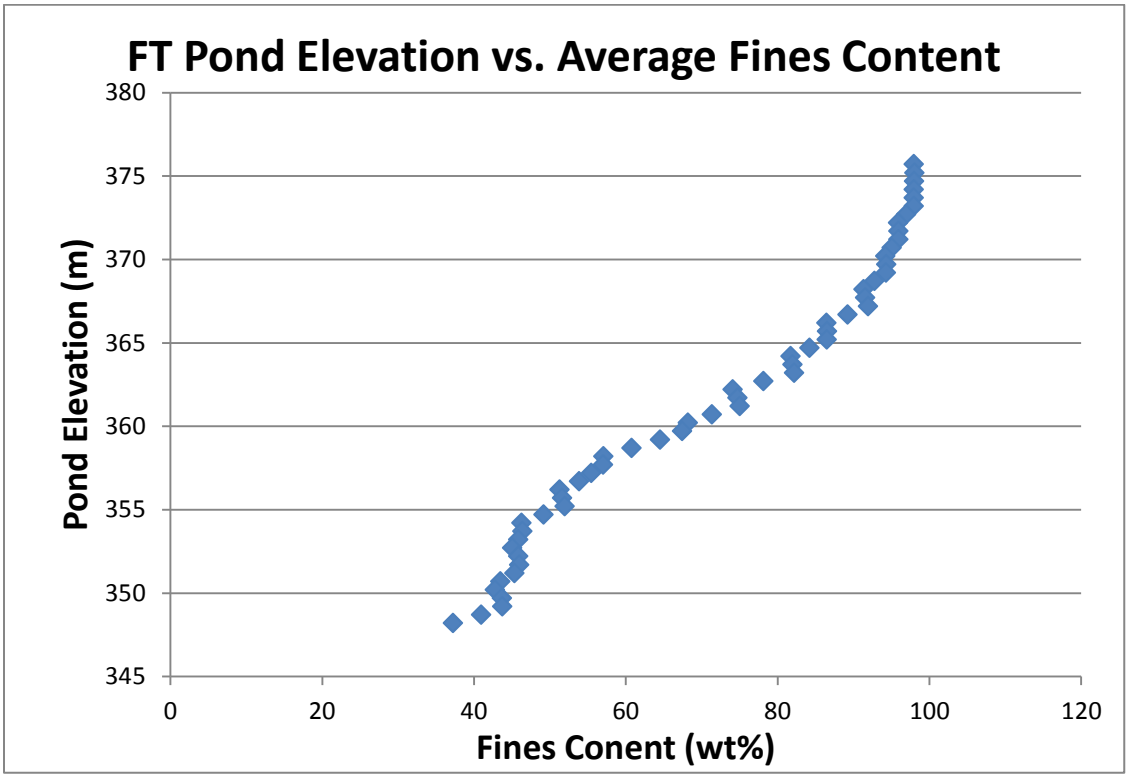

Figure A- 1: FT Pond Elevation vs. Fines Content

1.2. Effective Stress

Figure A- 12 through Figure A- 17 show CPT holes adjacent to each cross section line displaying effective stress measurements. Based on the CPT dataset, model blocks were populated with effective stress values from July 2016 through July 2018 within the beach deposit, using the top of the beach as the relative datum for aligning model blocks to CPT sample points. A well-defined gradient of effective stress is shown in relation to this horizon.

1.3. Deposit Consolidation

The 2018 and 2017 pond survey data indicates material with higher solids content and strength characteristics at the base of the Fluid Tailings (FT), Beach Below Water (BBW) and Beach Above Water (BAW) deposits. This trend indicates some degree of consolidation at the base of the DDA1 tailings deposit. However, measurement of consolidation rates in tailing ponds with ongoing active deposition is difficult.

Canadian Natural will use the 2018 and 2017 pond survey data to evaluate and understand the current consolidation rate of the tailings deposit in DDA1. The finding of this assessment will be included in the DDA1 consolidation report to be submitted to AER by the end of September 2019.

1.4. Pore Water Pressure

Figure A- 18 through Figure A- 23 show CPT holes adjacent to each cross section line displaying pore water pressure measurements. Based on the CPT dataset, model blocks were populated with pore water pressure values from July 2016 through July 2018 within the beach deposit using a horizontal datum. A well-defined vertical gradient of pore pressure is shown in relation to this horizon.

1.5. Clay Content

The assay results from the sonic core holes samples within the beach, and fluid samples from the pond, were used to populate methylene blue index (MBI) values into the model blocks, constrained to their respective depositional zones. MBI is a number used to characterize the clay content and cation exchange capacity of a material. MBI is also a good indicator for predicting surface area of the sample as the methylene blue effectively covers the clay surfaces. This can Figure A- 2 then be used to estimate the water trapped by the clay, as well as an empirical correlation between mature fine tails (MFT) volume and MBI (Omotoso et al. 2014).

MBI values were then converted to clay content using the conversion formula provided in the CanmentEnergy document titled Methylene Blue Procedure: Dean Stark Solids, dated January 6, 2008.

Clay content values are displayed in cross section on Figure A- 24 through Figure A- 29. Within the beach, two successive years of deposition and modeling are shown. The beach zone deposited from July 2016 through September 2017 shows the clay content results from the ‘2017 model’. The beach zone deposited from September 2017 through July 2018 shows the clay content results from the ‘2018 model’. As shown in the cross sections, the clay content values within the beach deposit are relatively low, with an average of 6.1 wt%. The FT pond, being predominantly fines and clay particles, has a much higher clay content average of 54.9 wt%. shows the vertical gradient of clay content in the FT pond.

Figure A- 29 shows the clay content of the beach deposit within the BWSP1 containment area. As stated in Section 1.1, above, the dyke structure at the bottom of this containment area created a lower energy beach depositional environment. As a result, a higher percentage of clay particles were entrained in this portion of the beach, resulting in an elevated average clay content of 13.4 wt%.

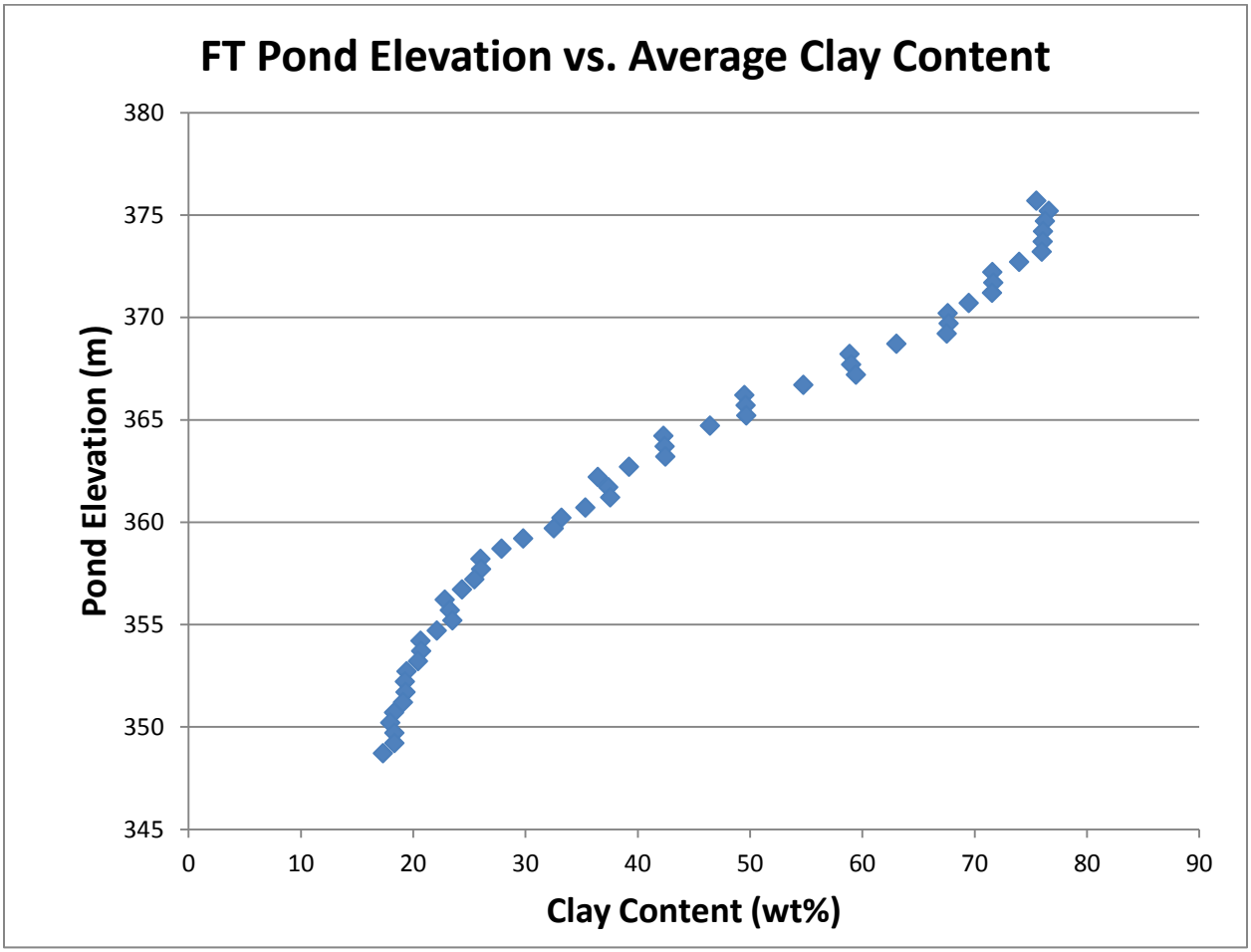

Figure A- 2: FT Pond Elevation vs. Clay Content

1.6. Solids Content

The Dean Stark assay results from the sonic core holes samples within the beach, and fluid samples from the pond, were used to populate bitumen, water and solids content into the model, constrained within their respective depositional zones. Solids content is displayed in cross section on Figure A- 30 through Figure A- 35. Within the beach, two successive years of deposition and modeling are shown. The beach zone deposited from July 2016 through September 2017 shows the solids content results from the '2017 model'. The beach zone deposited from September 2017 through July 2018 shows the results from the '2018 model'. As shown in the cross sections, the solids content of the beach is relatively consistent. Figure A- 3 shows the distribution of solids content within the beach, with an average of 78.8 wt%. As expected within the FT pond, the average solids content is significantly lower at 41.6 wt%. The solids content of the FT pond increases with depth. Figure A- 4 shows the average vertical gradient of the solids content within the FT pond.

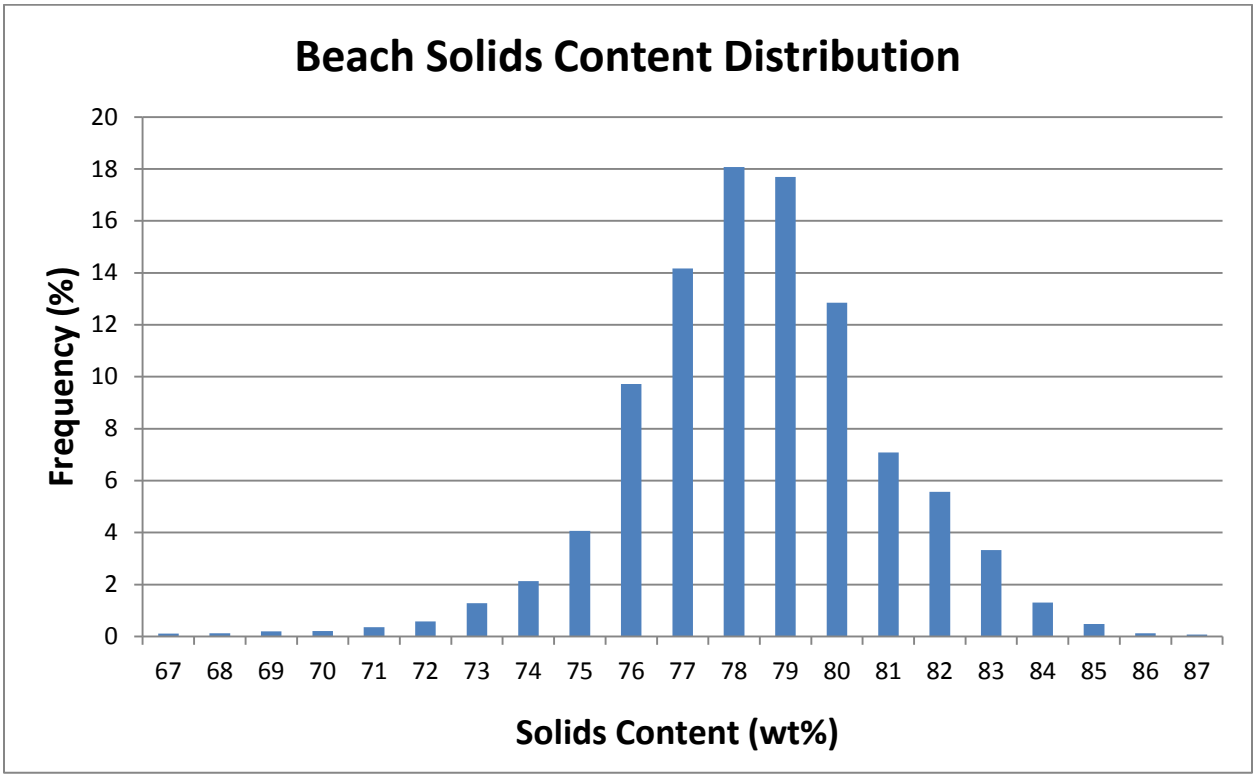

Figure A- 3: Beach Solids Content Distribution

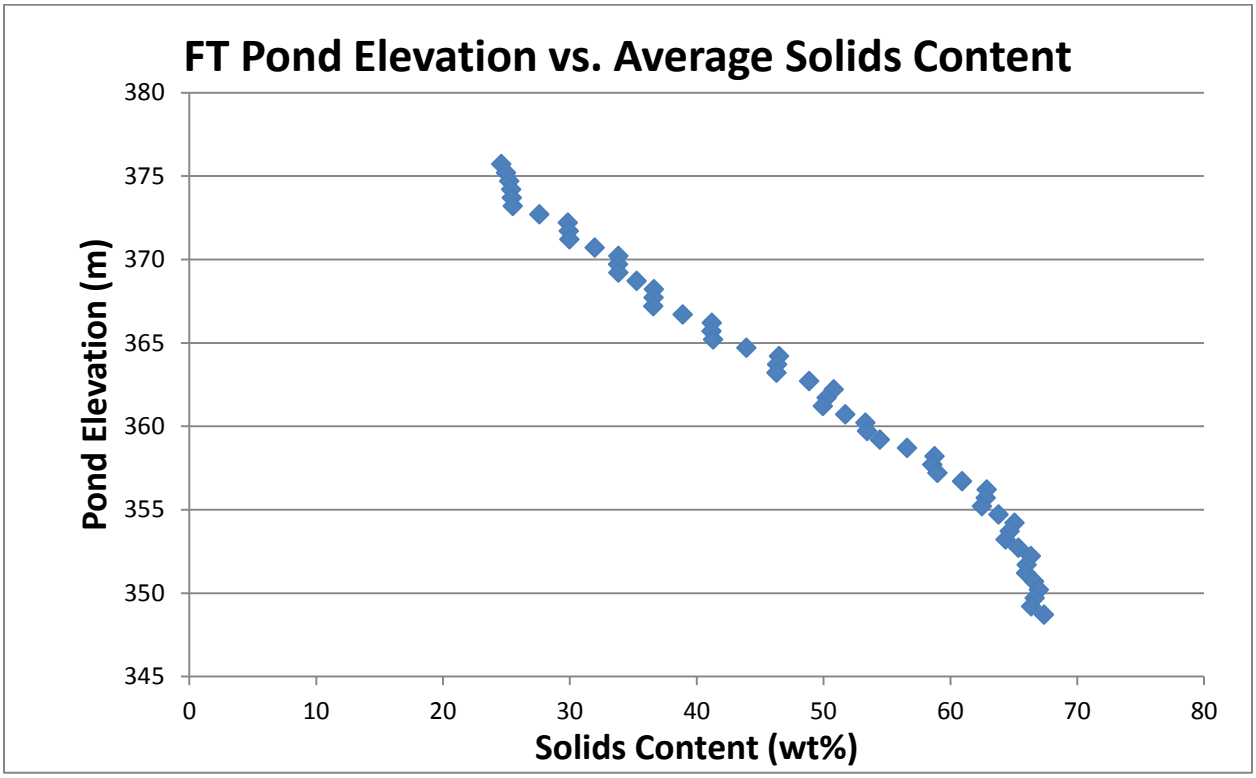

Figure A- 4: FT Pond Elevation vs. Average Solids Content

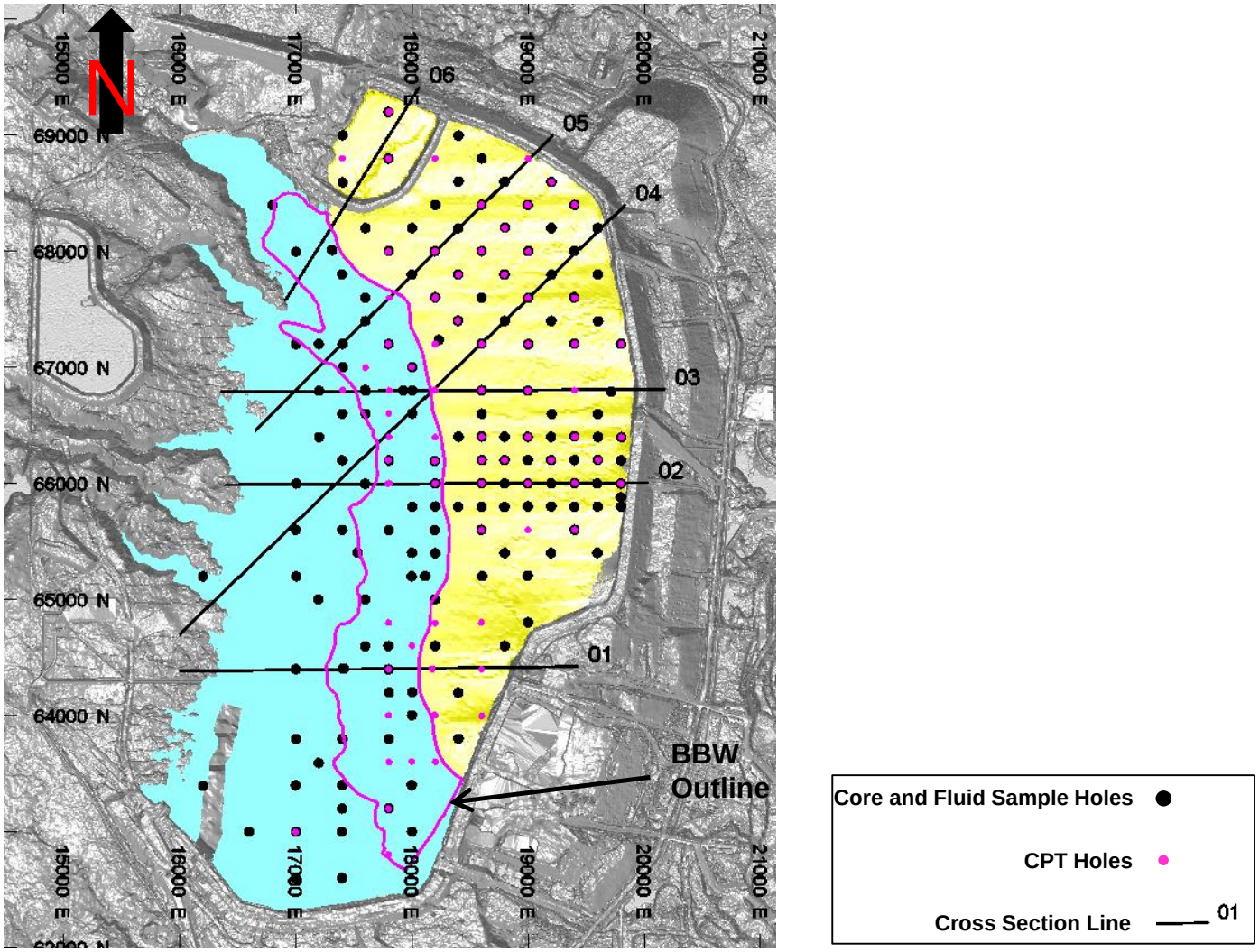

Figure A- 5: Plan View of ETF/DDA1 and Cross Section Lines

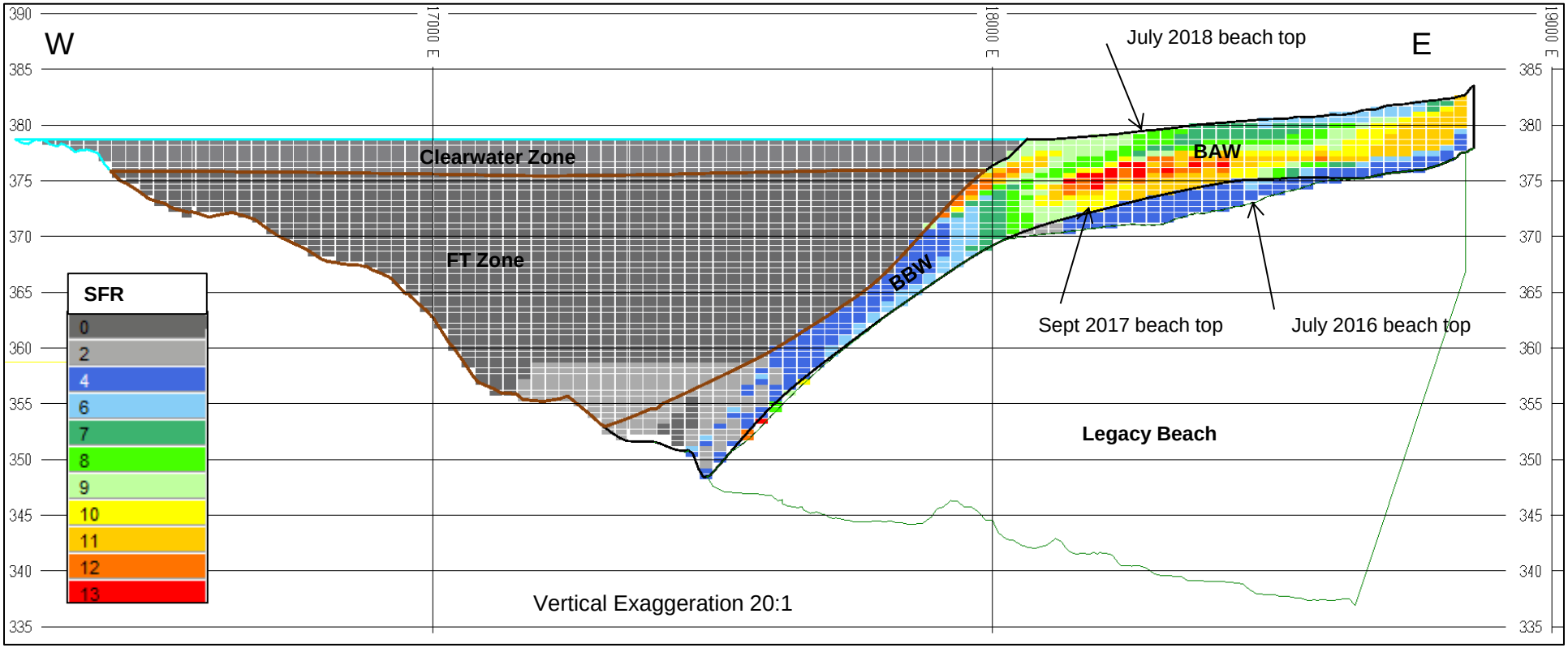

Figure A- 6: Sand to Fines Ratio, Cross Section 1

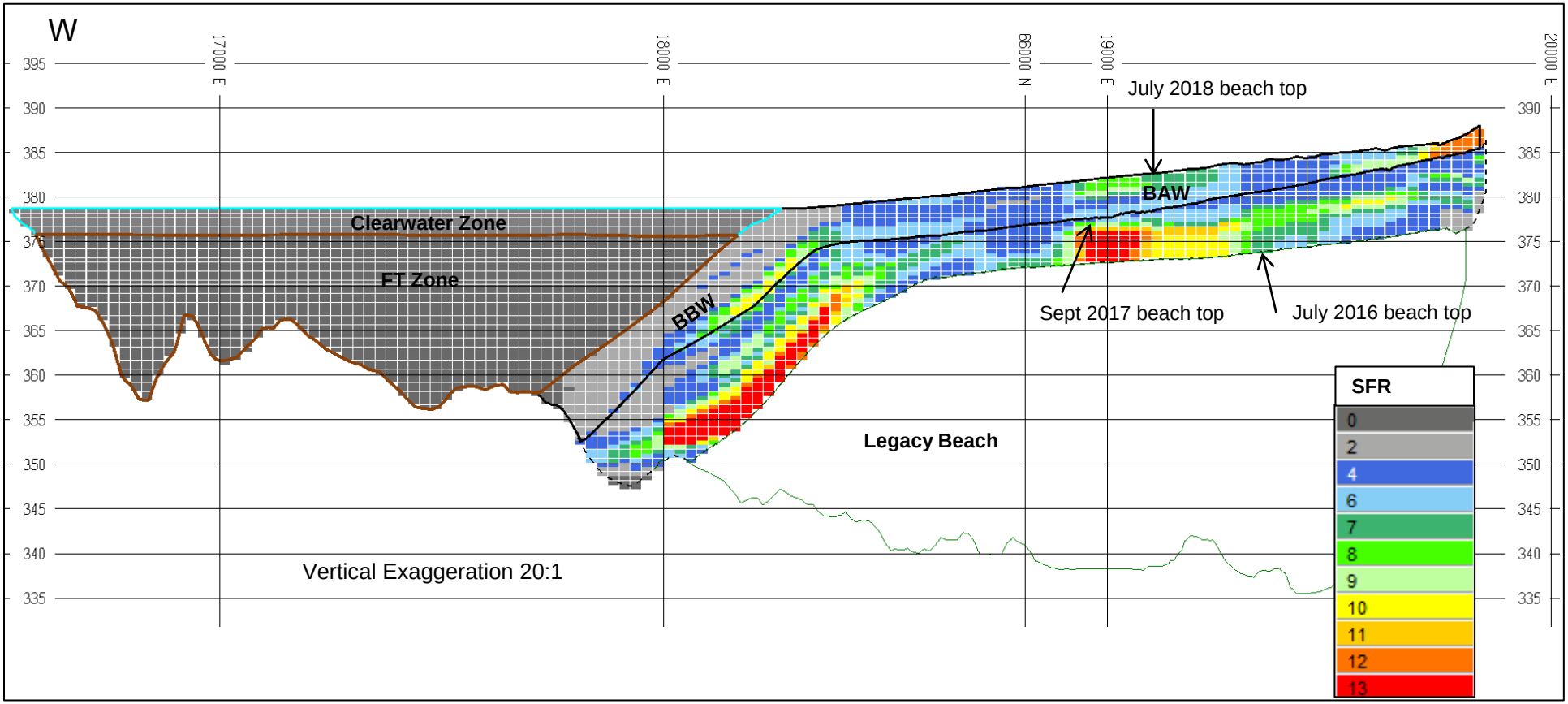

Figure A- 7: Sand to Fines Ratio, Cross Section 2

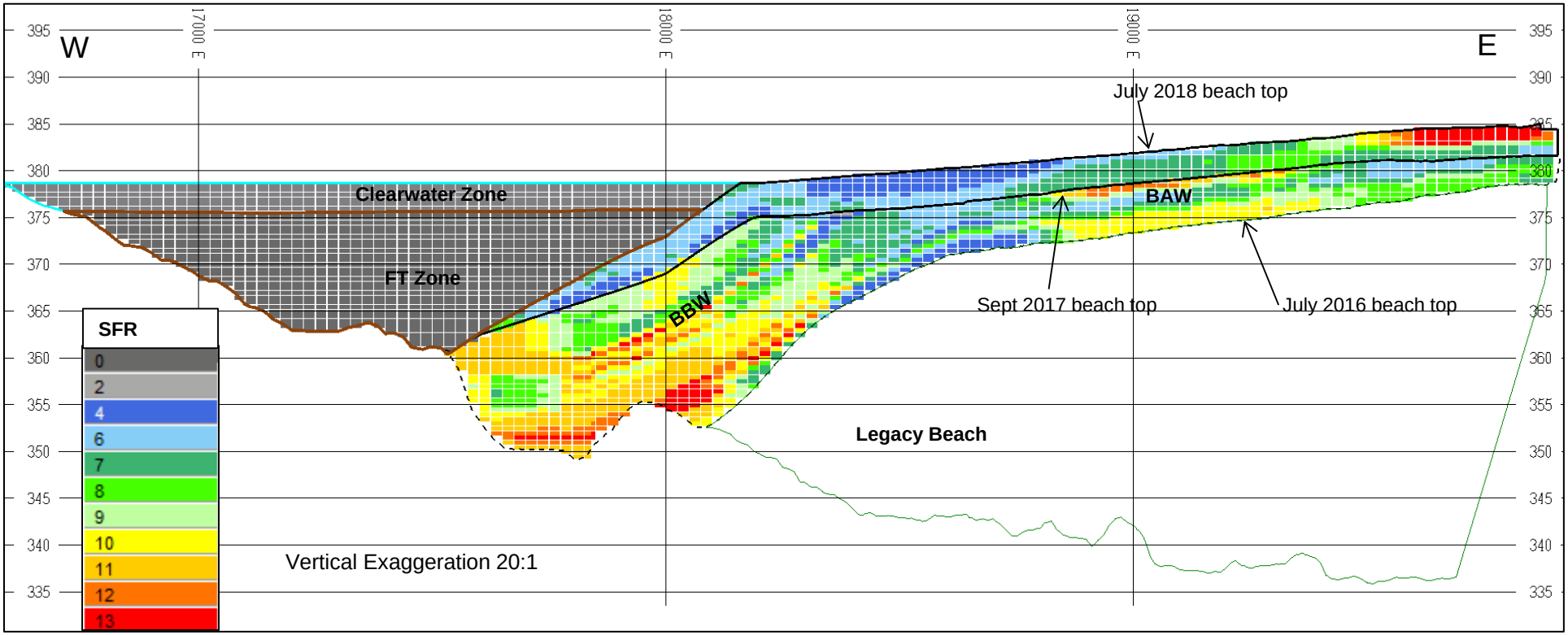

Figure A- 8: Sand to Fines Ratio, Cross Section 3

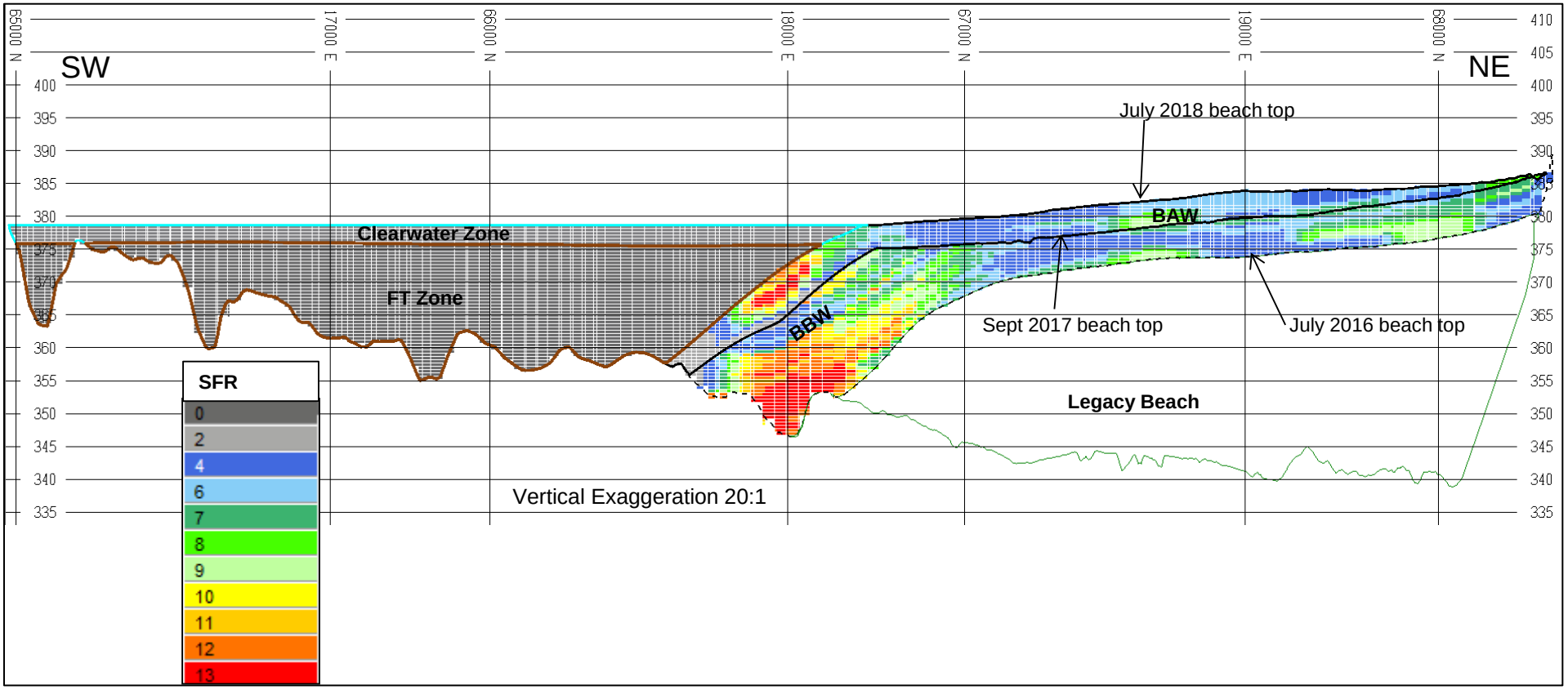

Figure A- 9: Sand to Fines Ratio, Cross Section 4

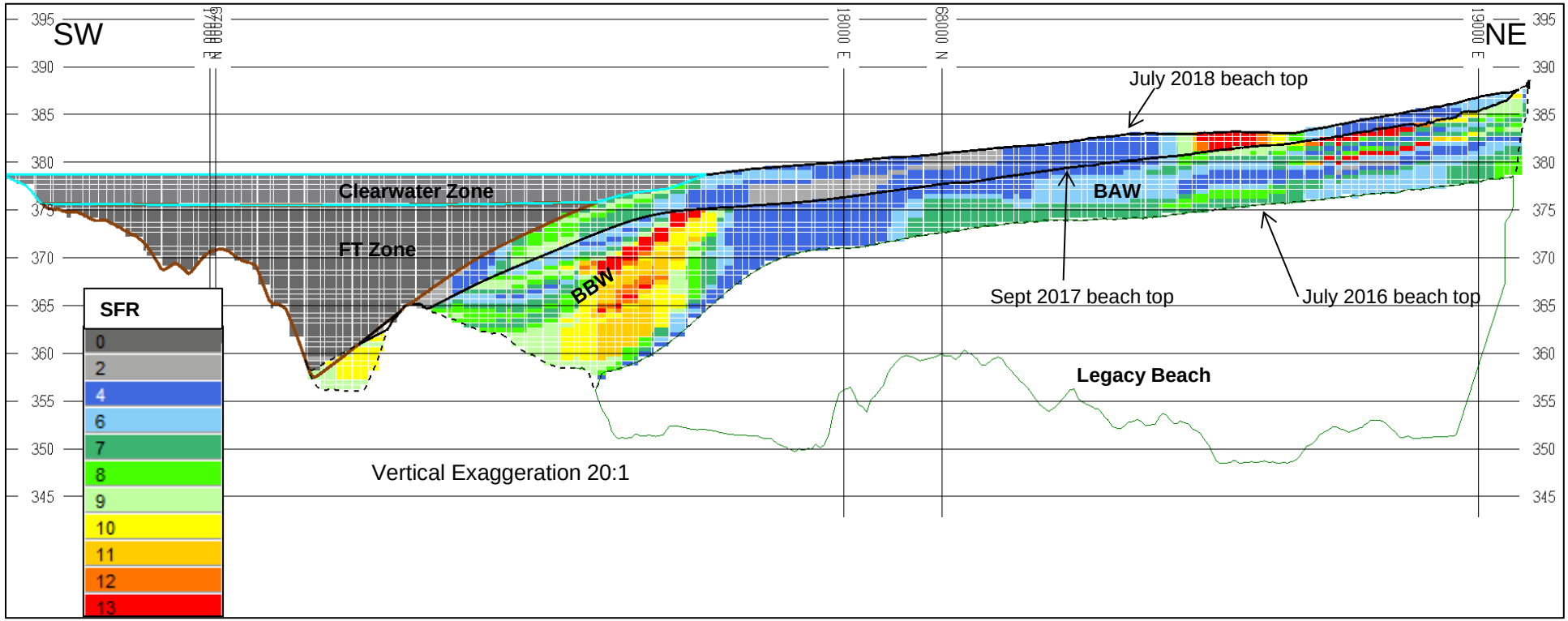

Figure A- 10: Sand to Fines Ratio, Cross Section 5

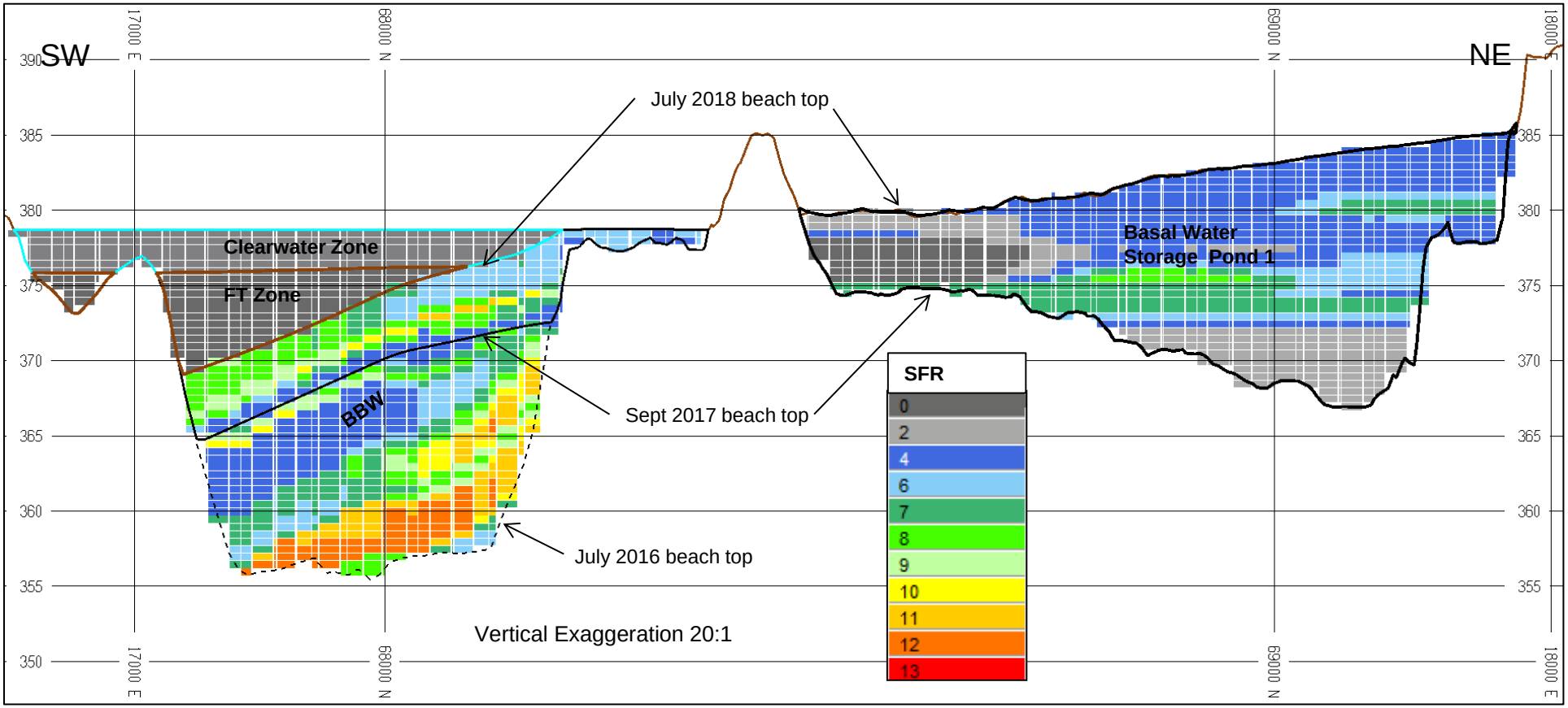

Figure A- 11: Sand to Fines Ratio, Cross Section 6

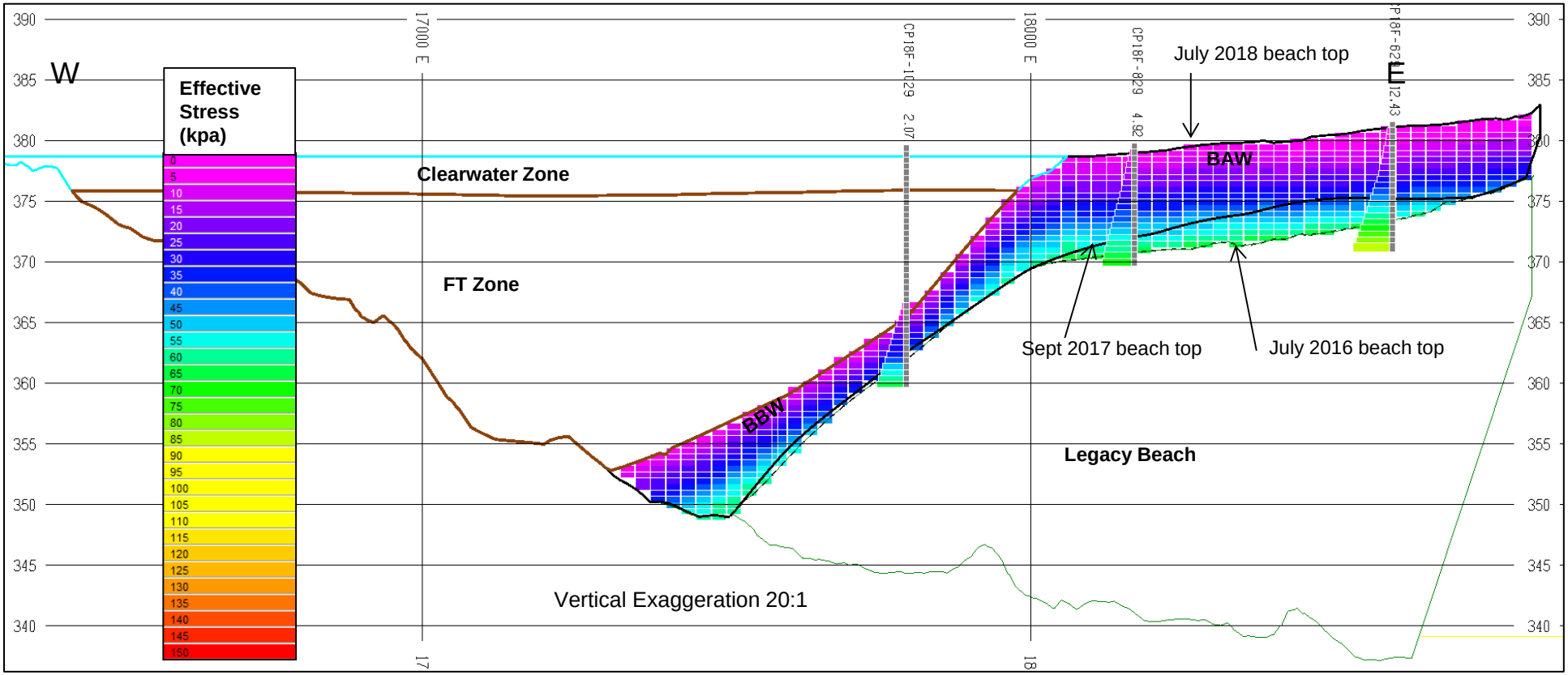

Figure A- 12: Effective Stress, Cross Section 1

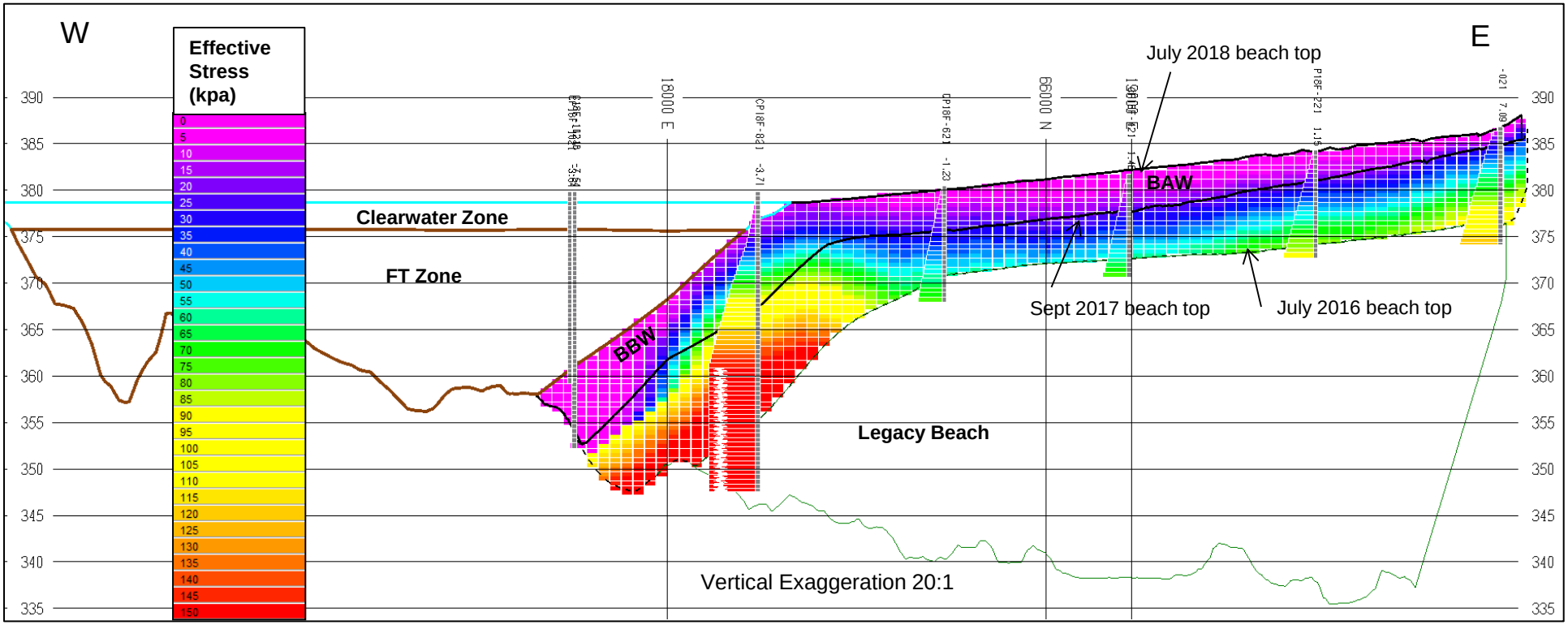

Figure A- 13: Effective Stress, Cross Section 2

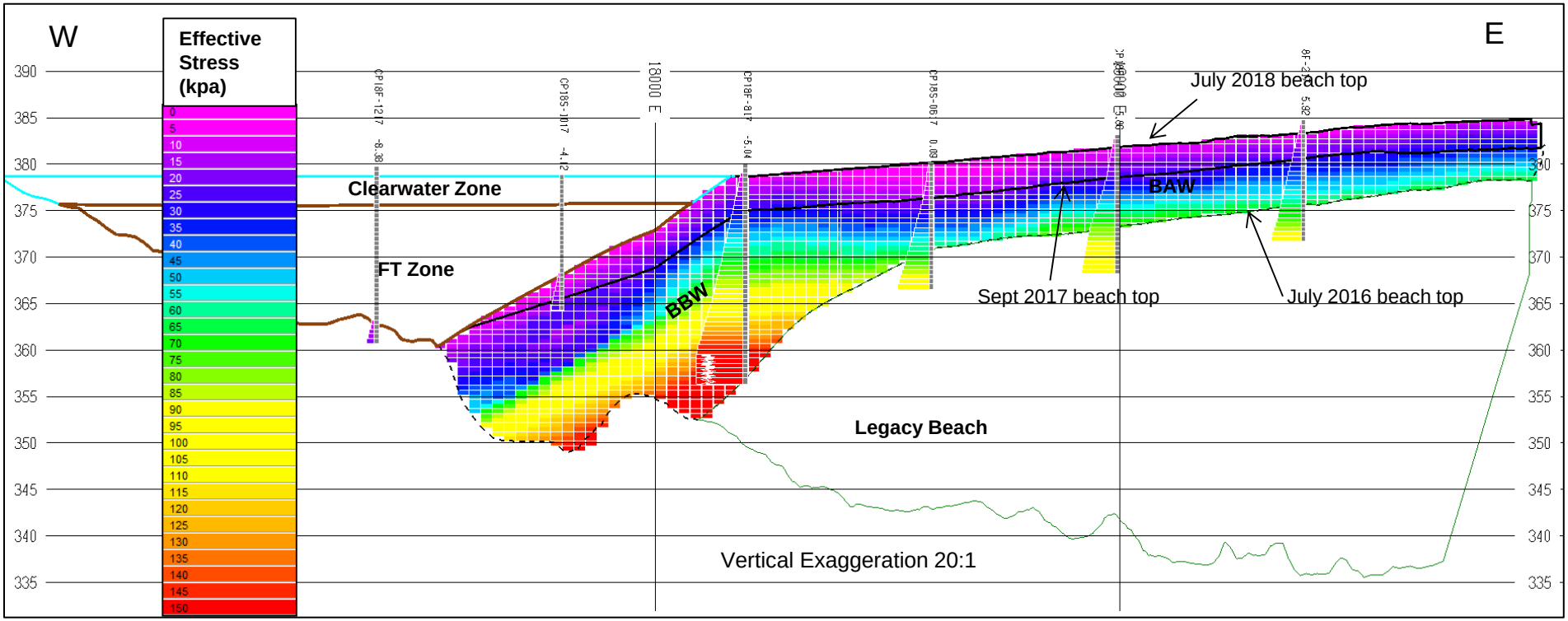

Figure A- 14: Effective Stress, Cross Section 3

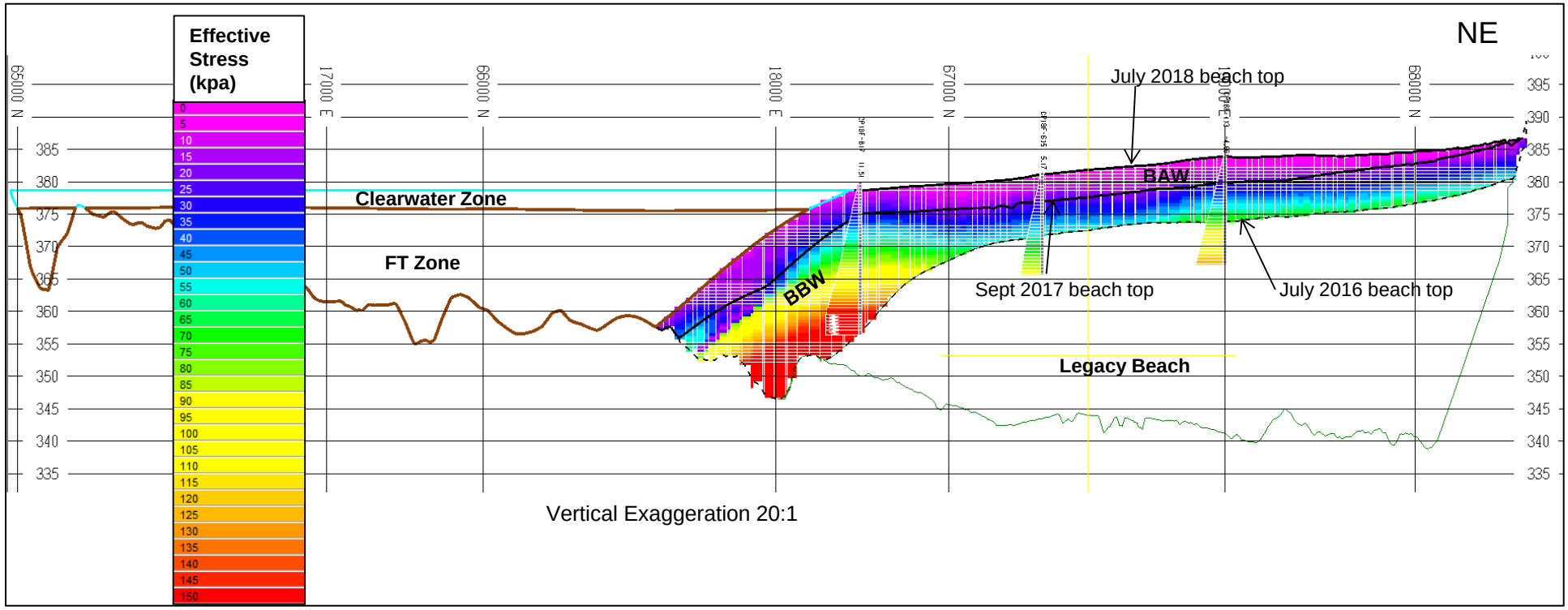

Figure A- 15: Effective Stress, Cross Section 4

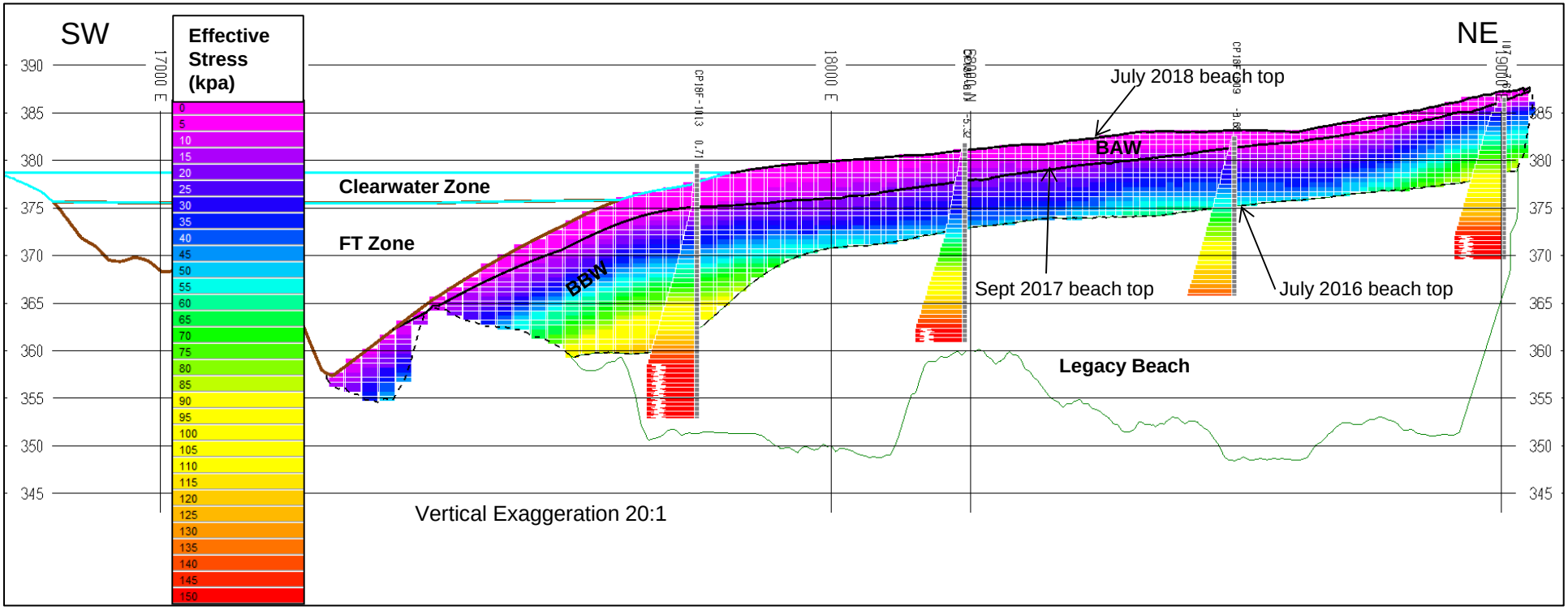

Figure A- 16: Effective Stress, Cross Section 5

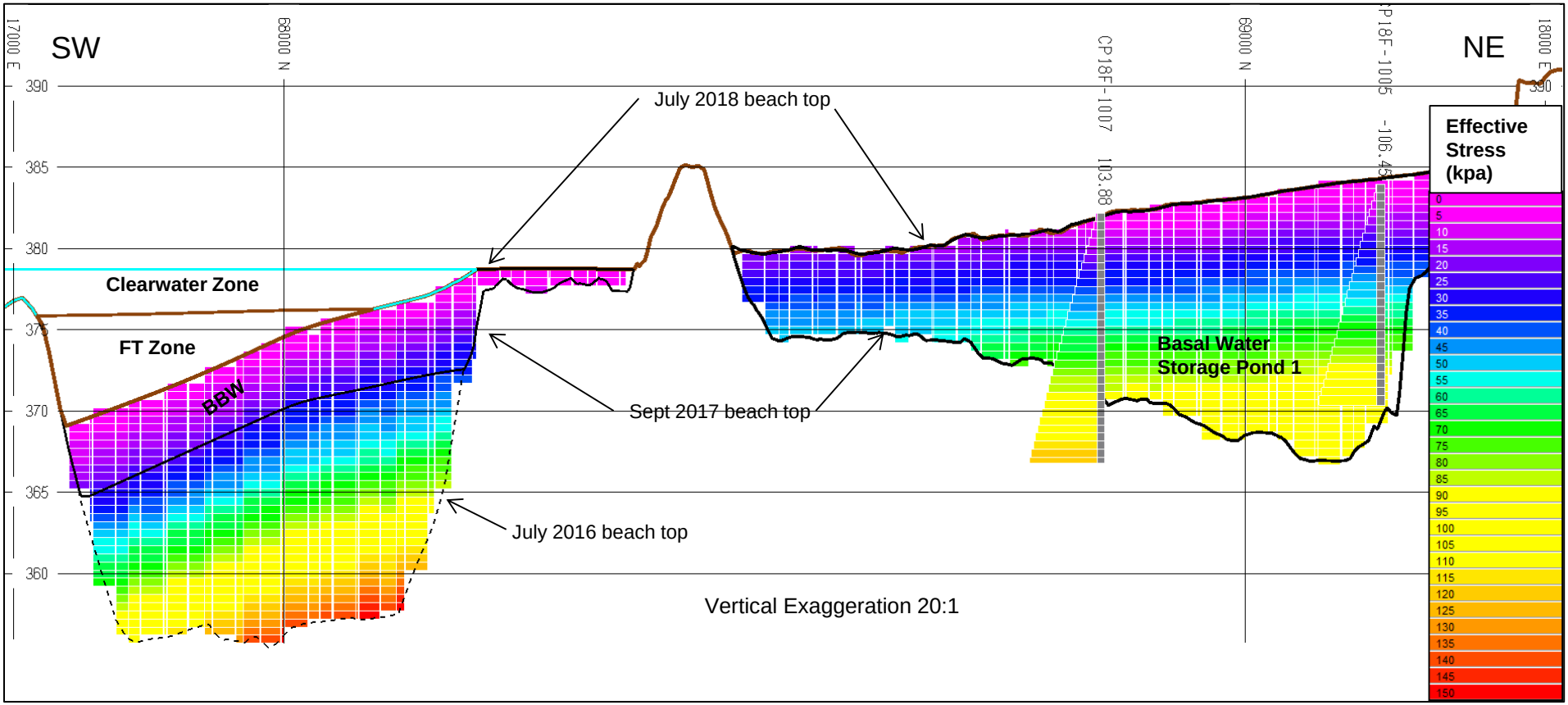

Figure A- 17: Effective Stress, Cross Section 5

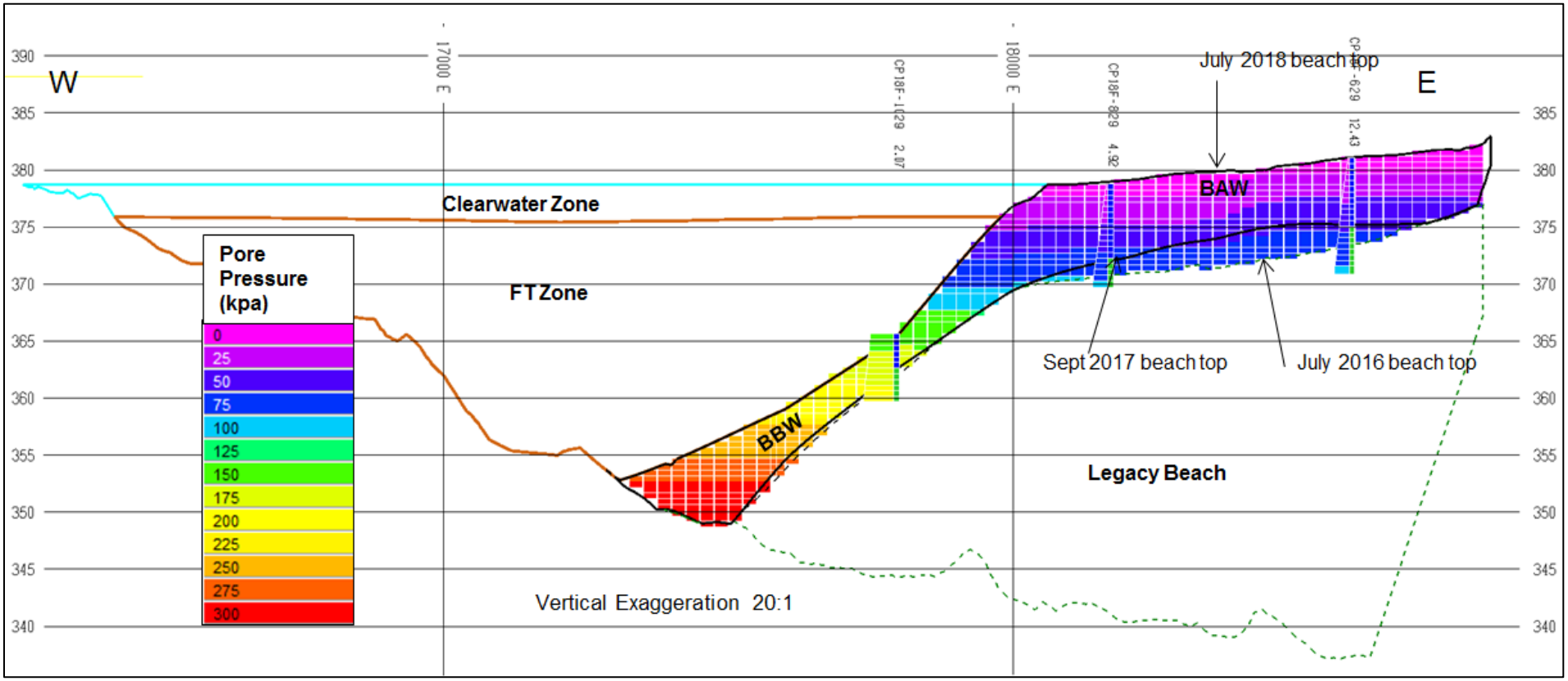

Figure A- 18: Pore Water Pressure, Cross Section 1

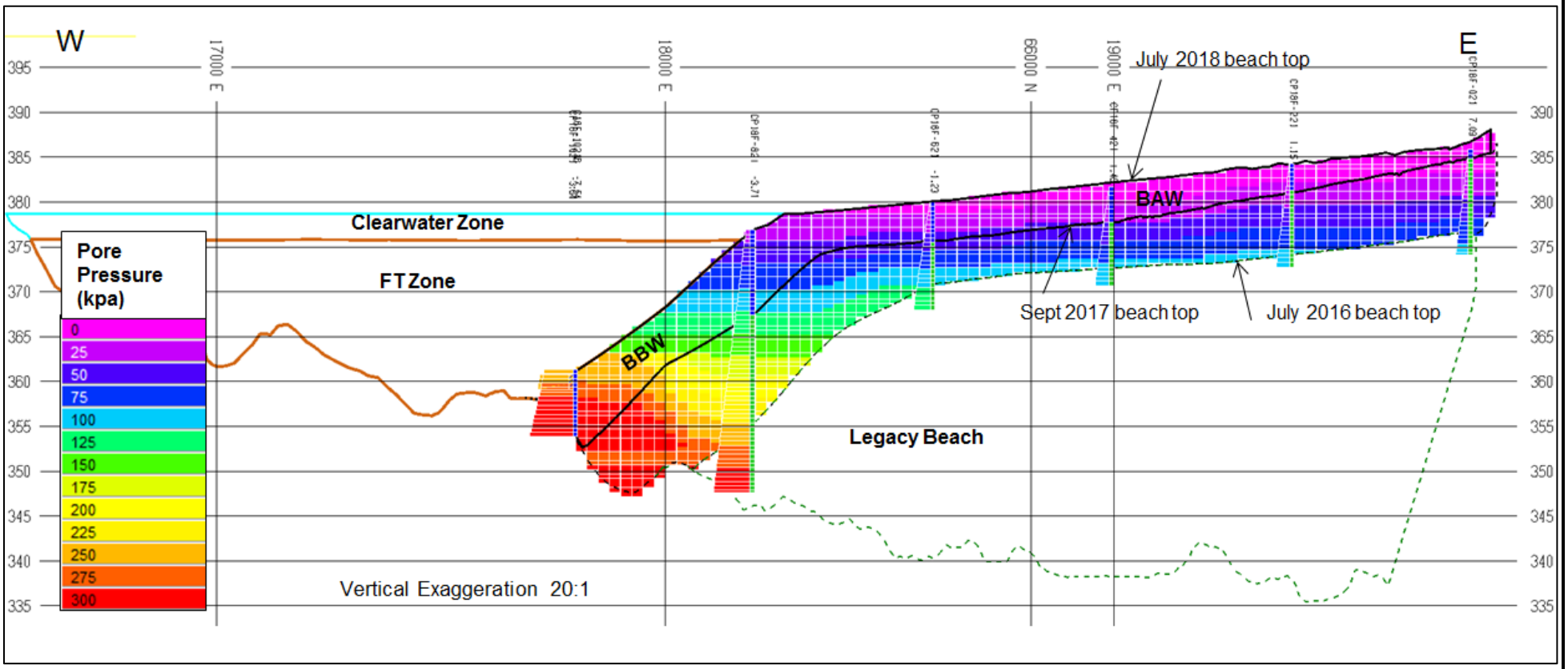

Figure A- 19: Pore Water Pressure, Cross Section 2

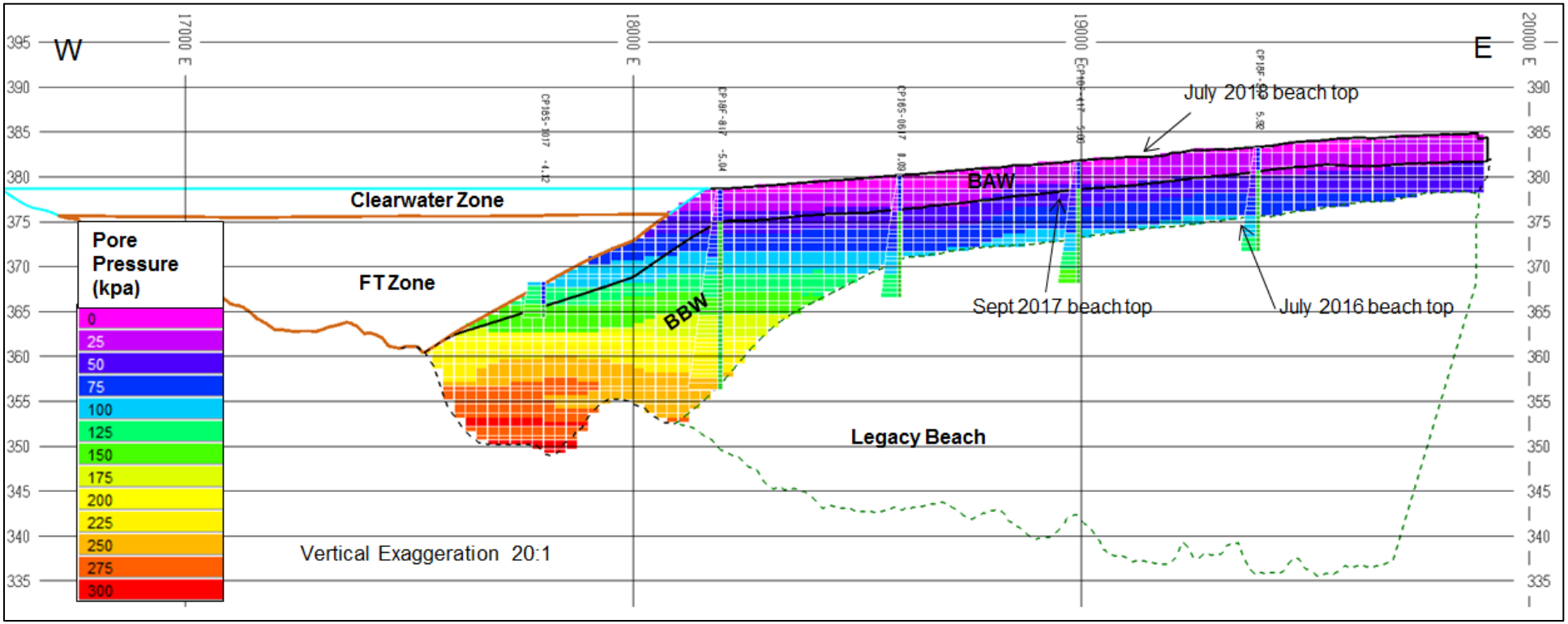

Figure A- 20: Pore Water Pressure, Cross Section 3

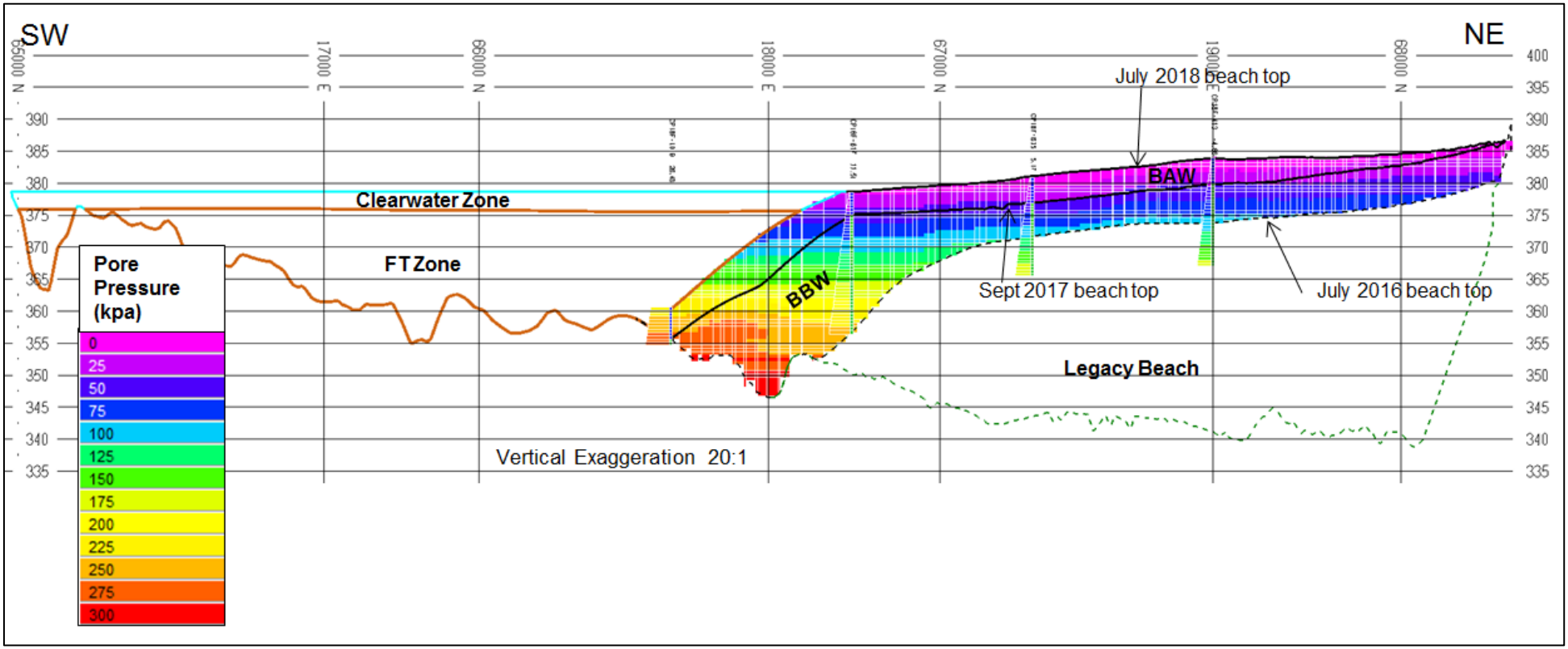

Figure A- 21: Pore Water Pressure, Cross Section 4

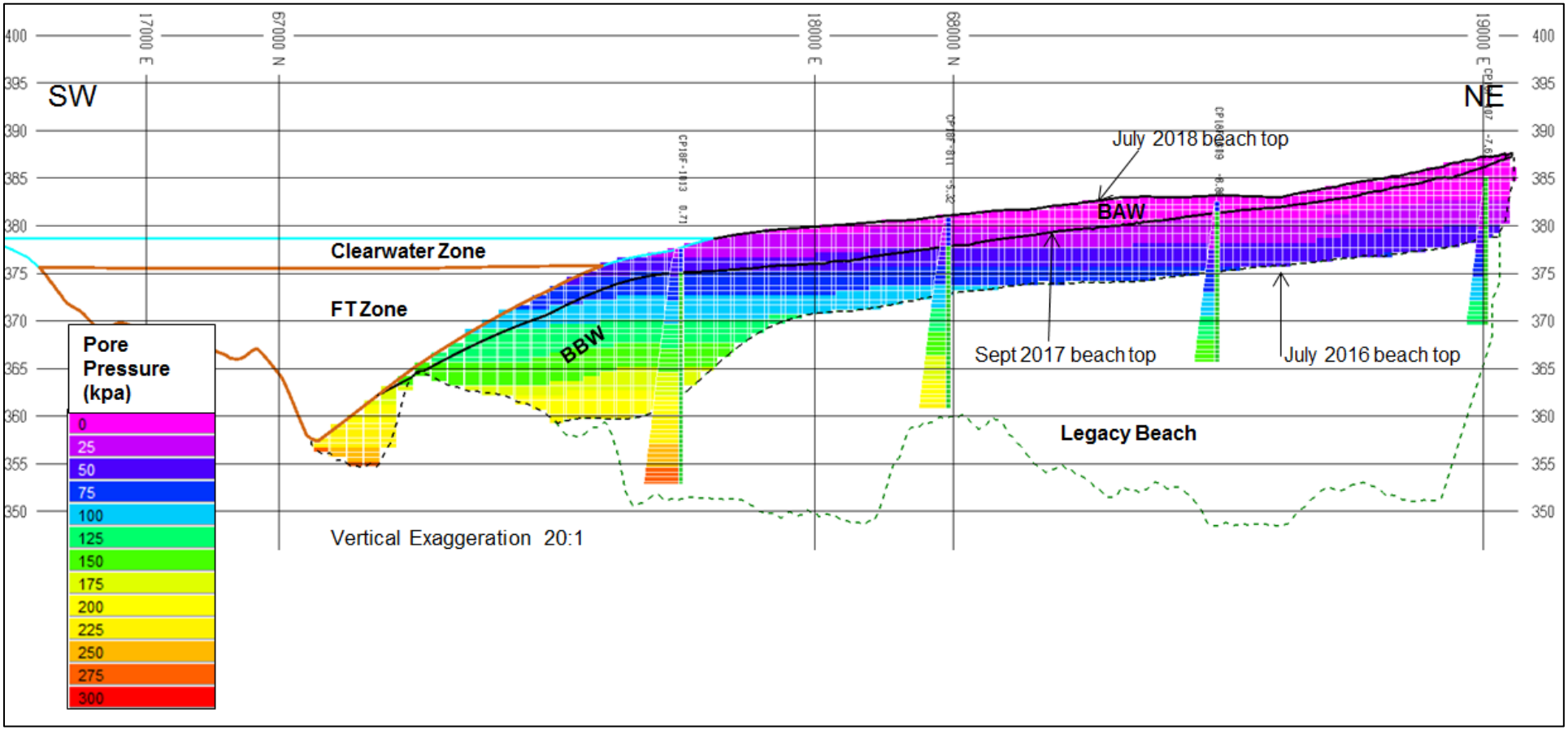

Figure A- 22: Pore Water Pressure, Cross Section 5

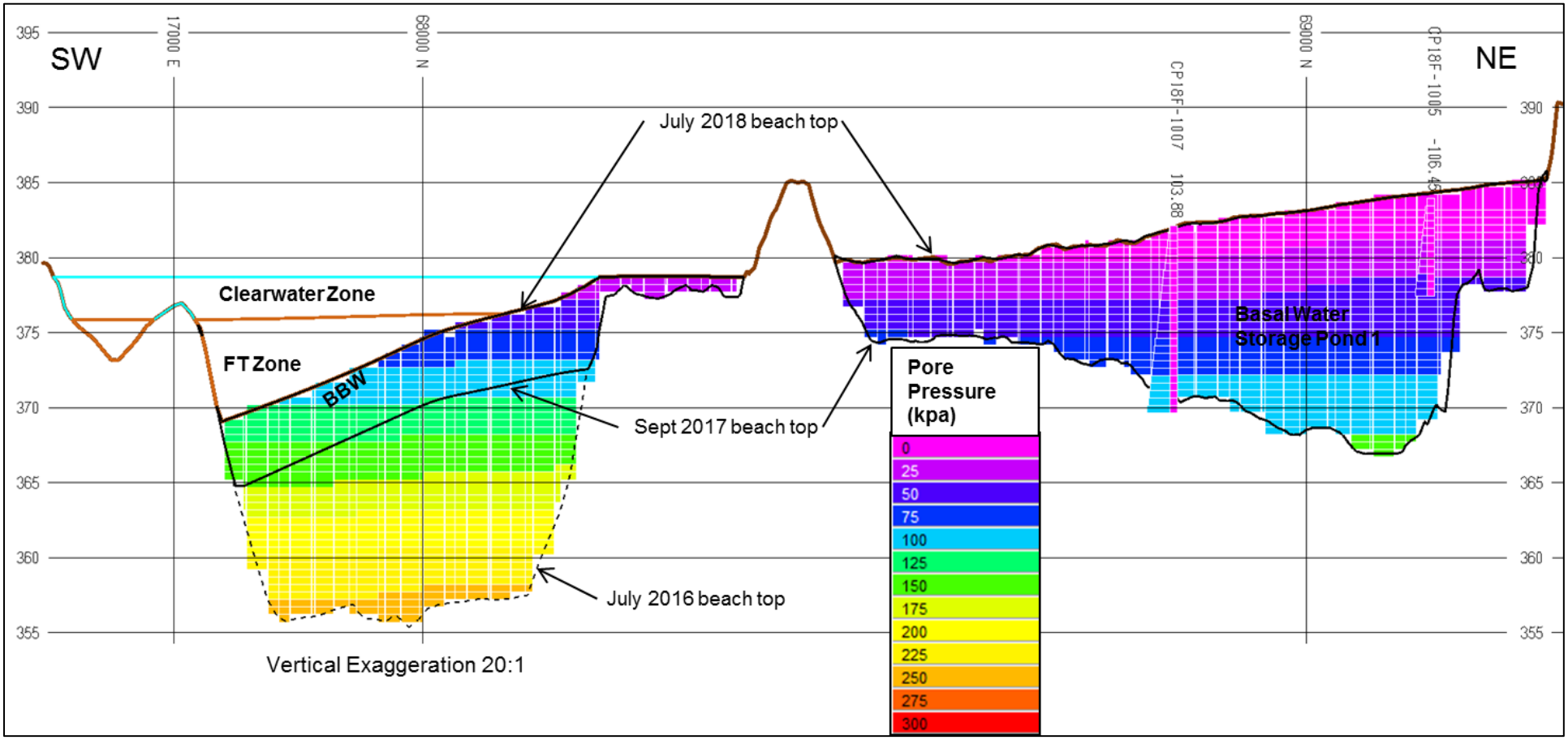

Figure A- 23: Pore Water Pressure, Cross Section 6

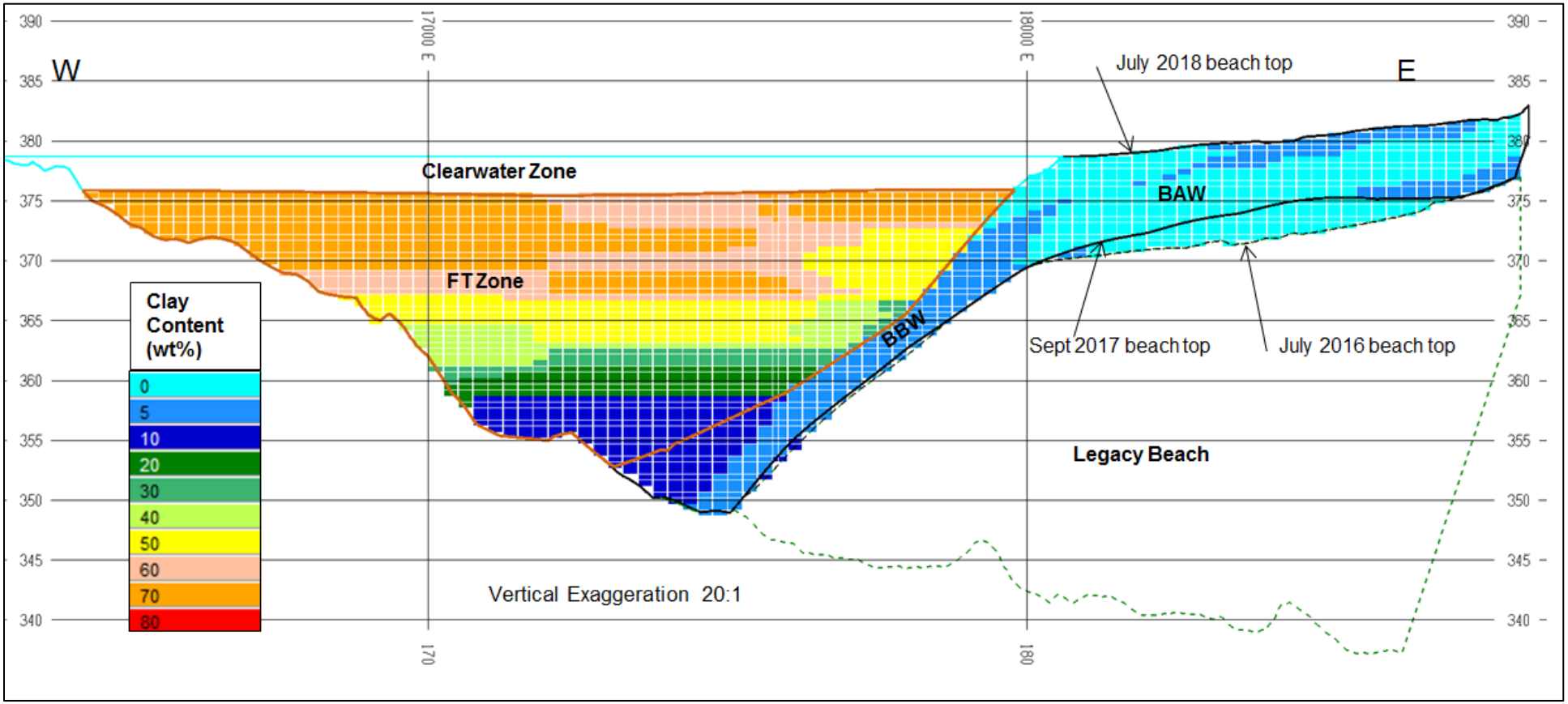

Figure A- 24: Clay Content (Percentage), Cross Section 1

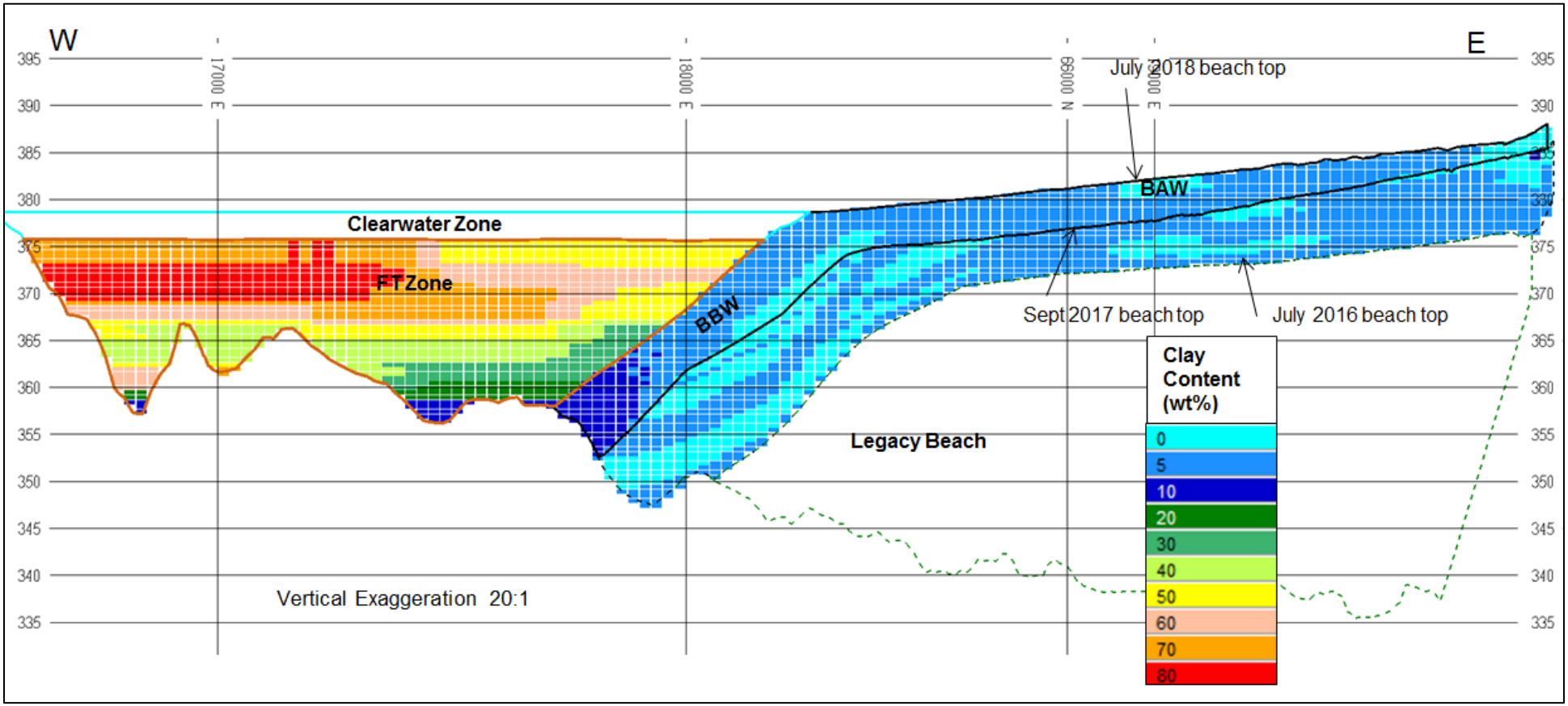

Figure A- 25: Clay Content (Percentage), Cross Section 2

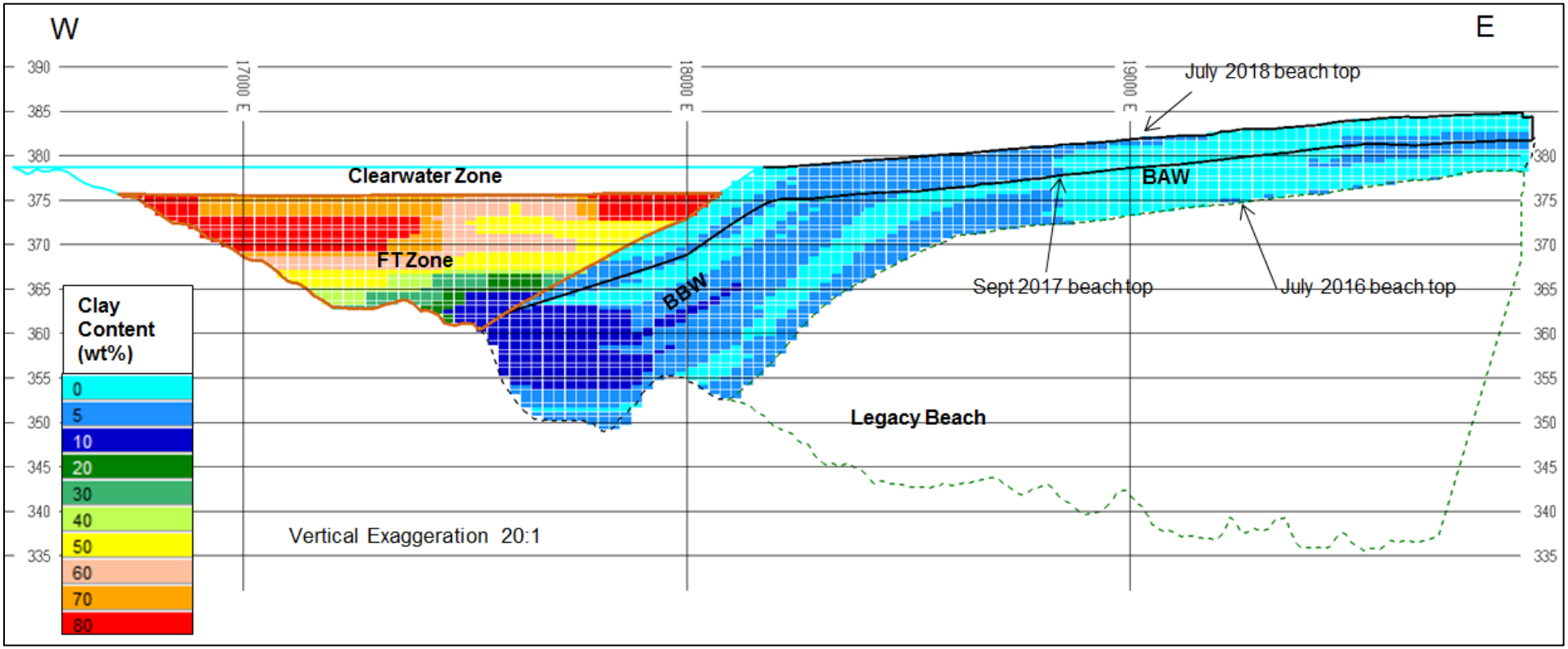

Figure A- 26: Clay Content (Percentage), Cross Section 3

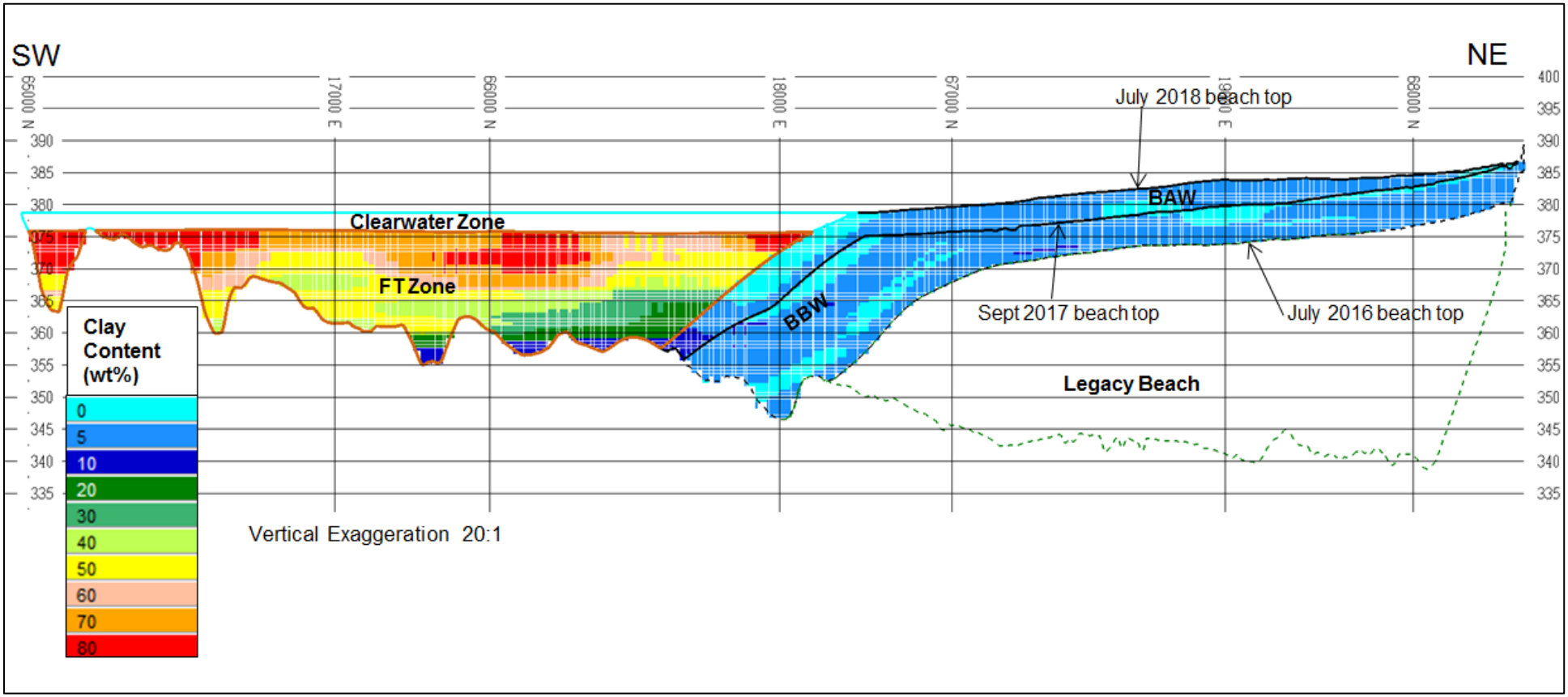

Figure A- 27: Clay Content (Percentage), Cross Section 4

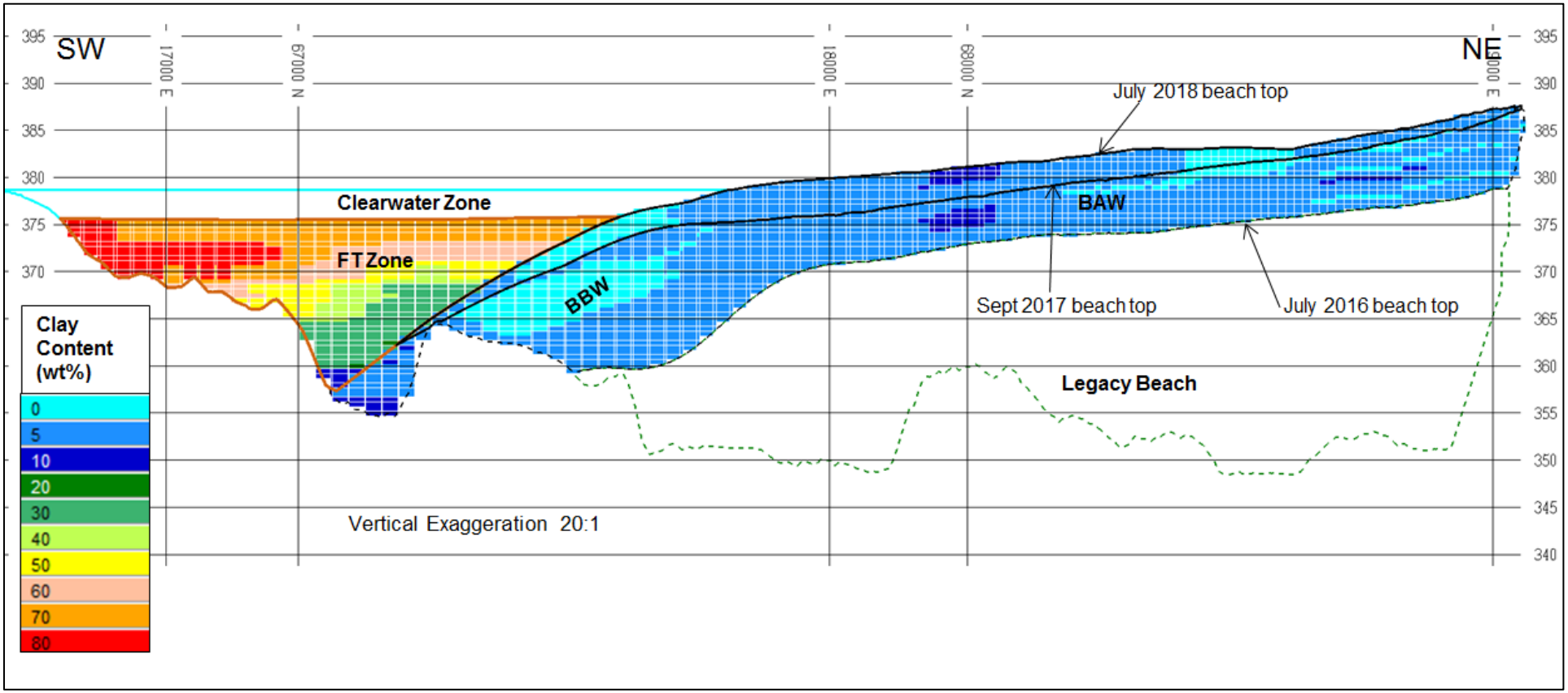

Figure A- 28: Clay Content (Percentage), Cross Section 5

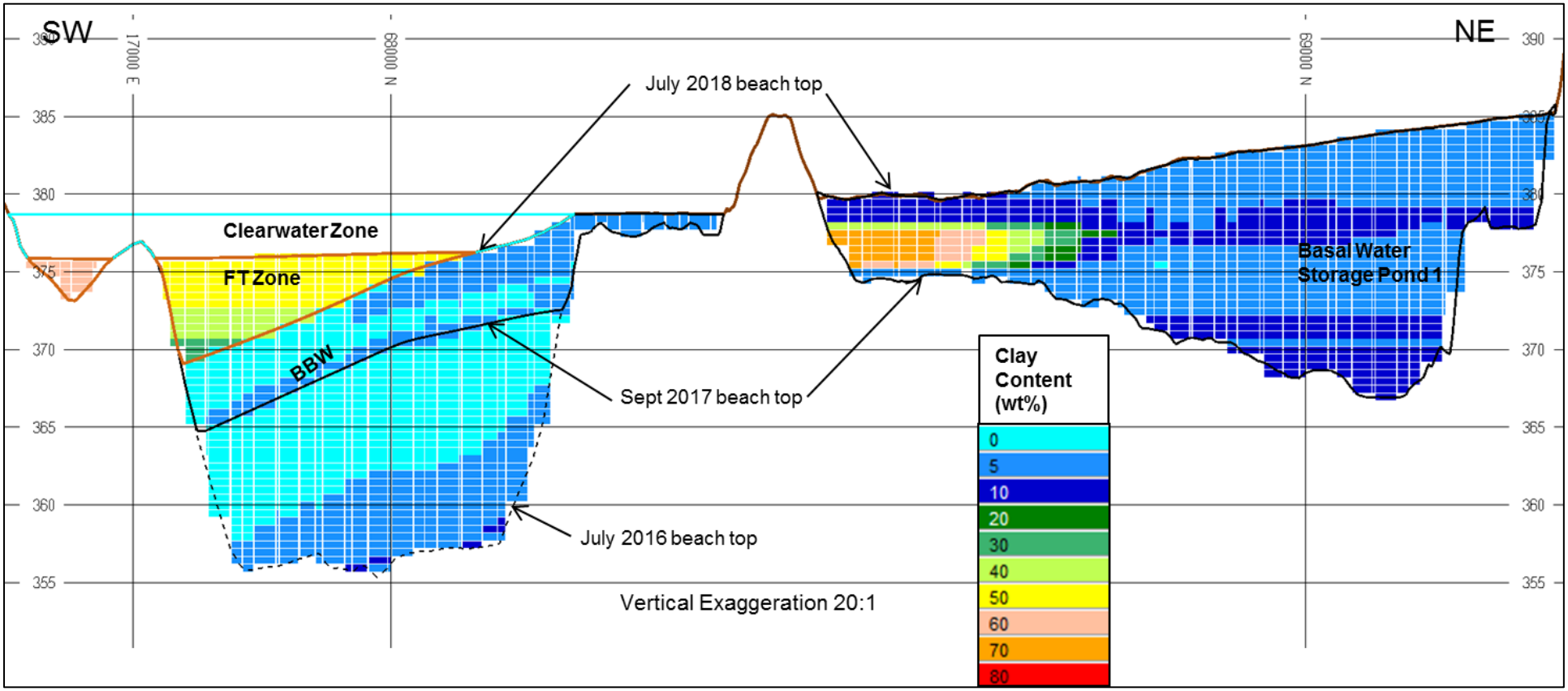

Figure A- 29: Clay Content (Percentage), Cross Section 6

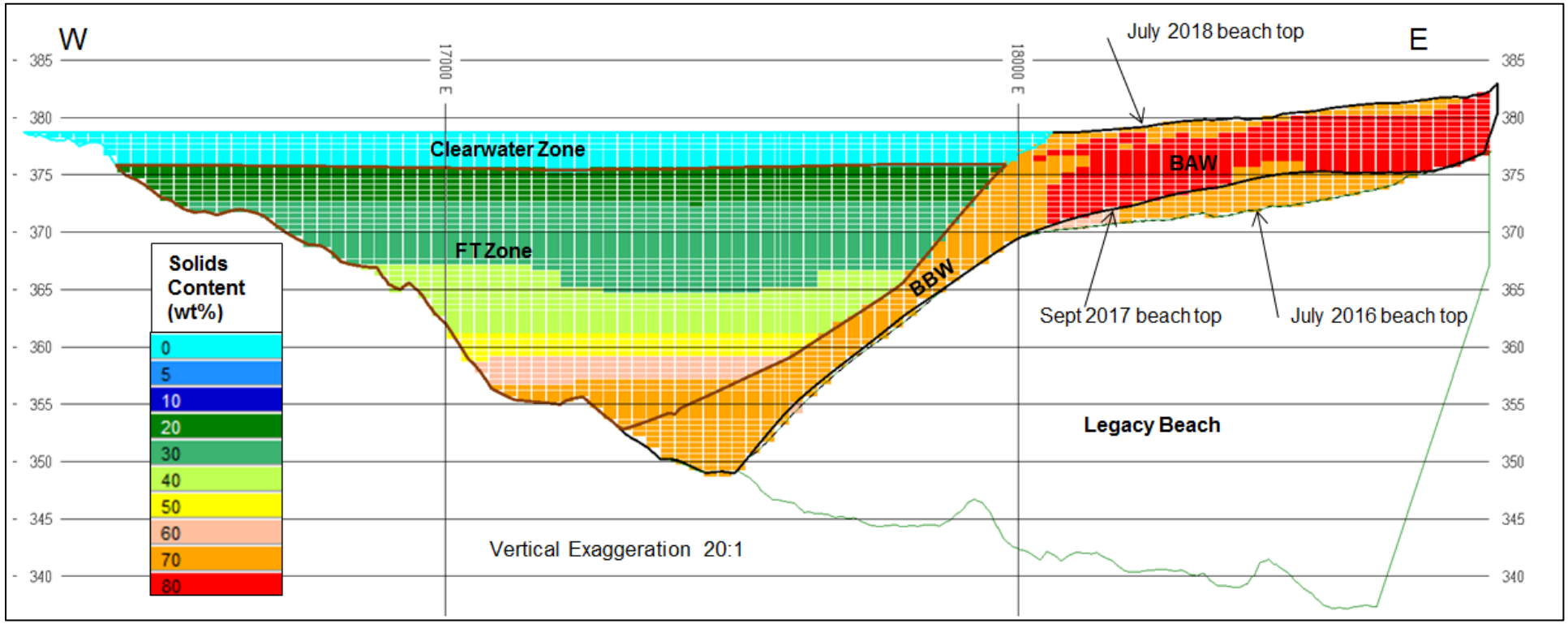

Figure A- 30: Solids Content (percentage), Cross Section 1

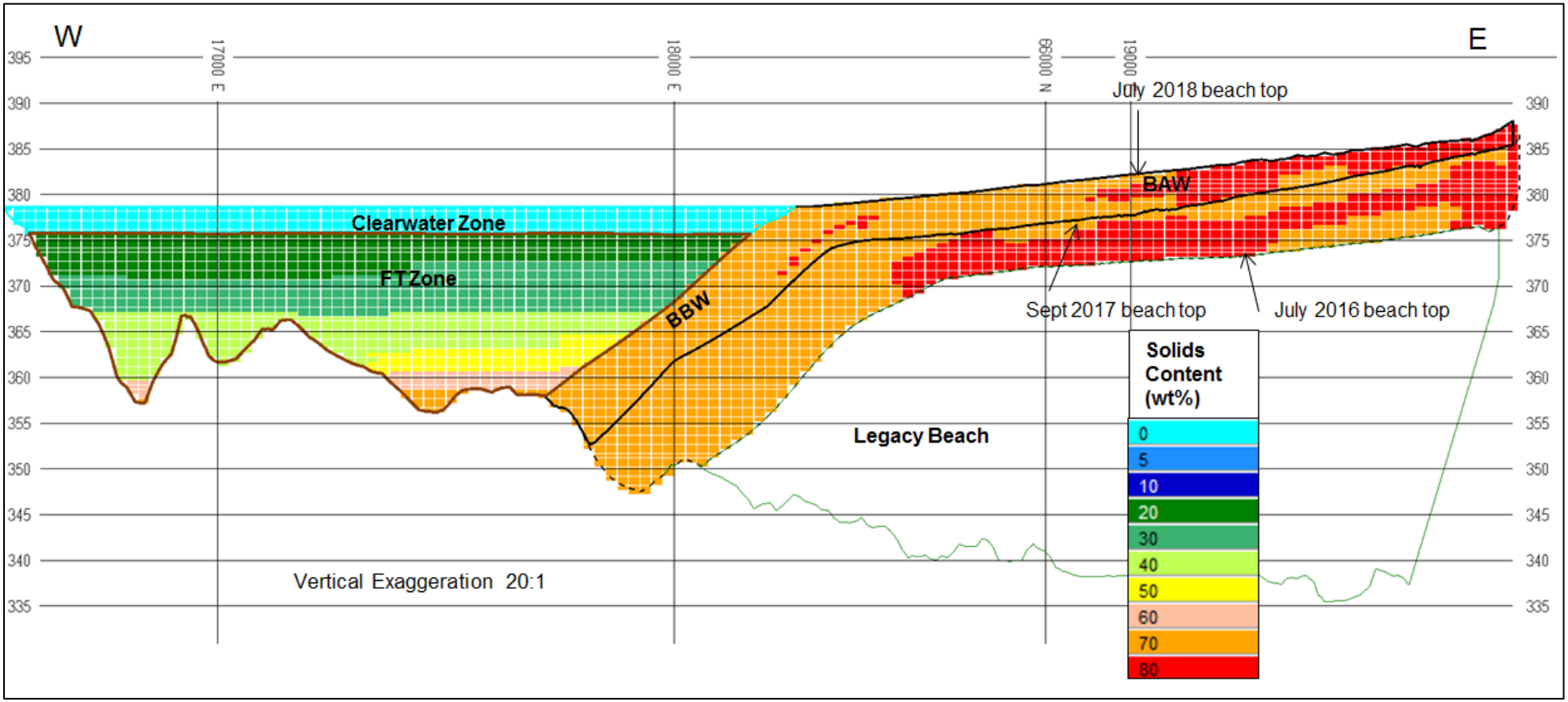

Figure A- 31: Solids Content (percentage), Cross Section 2

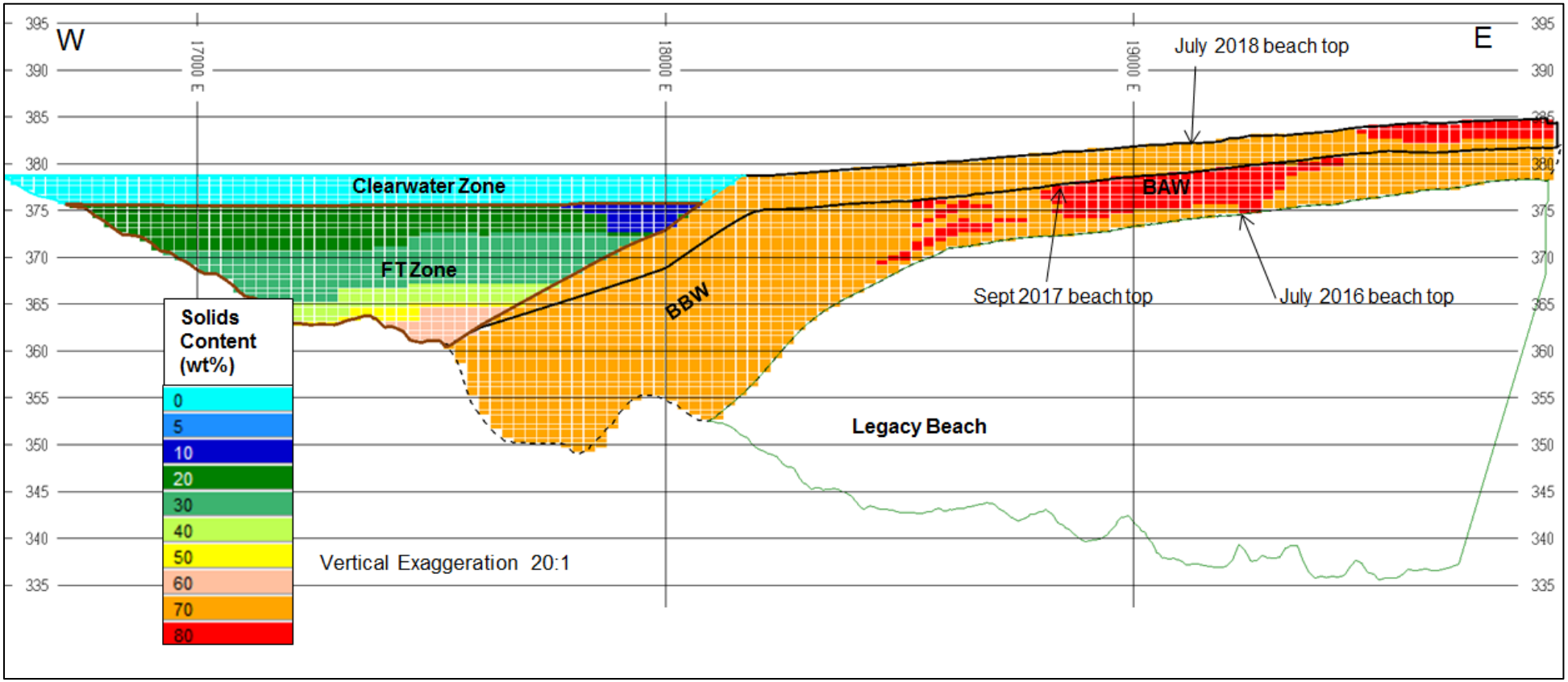

Figure A- 32: Solids Content (percentage), Cross Section 3

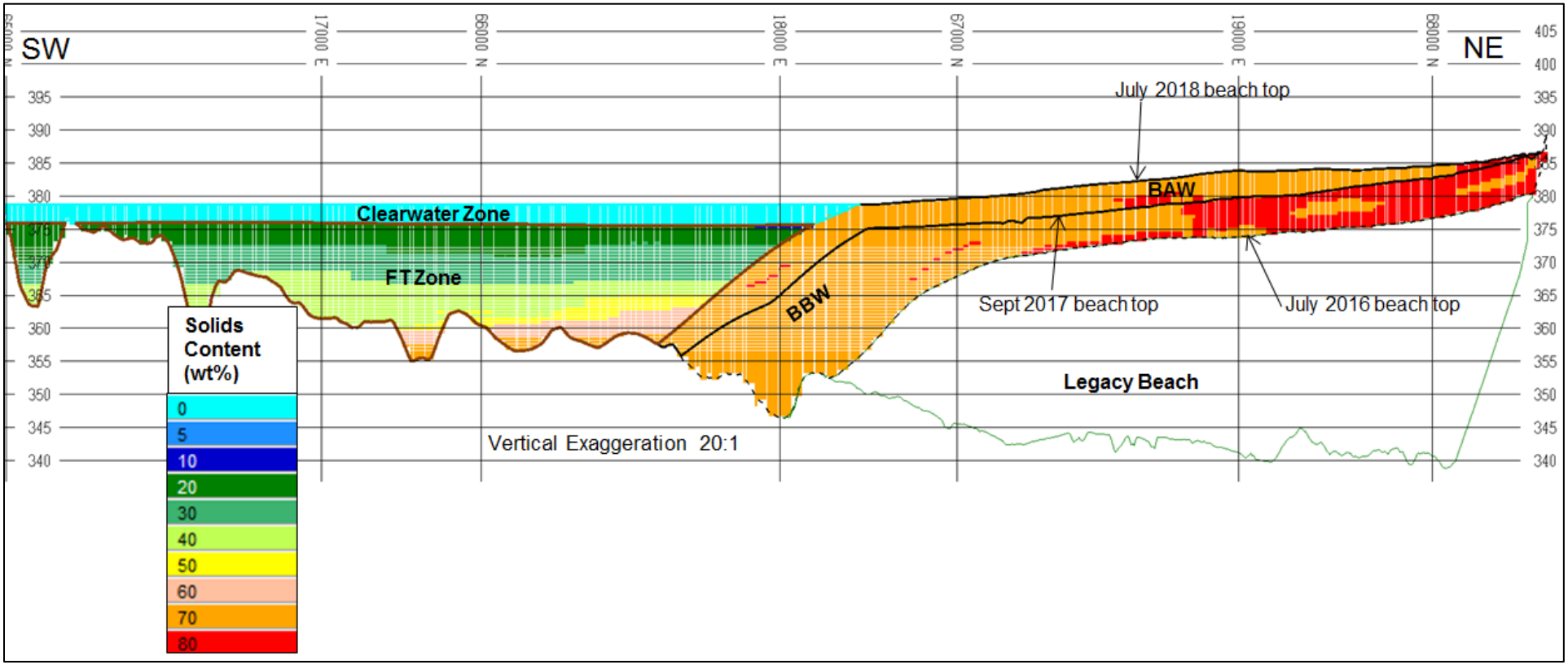

Figure A- 33: Solids Content (percentage), Cross Section 4

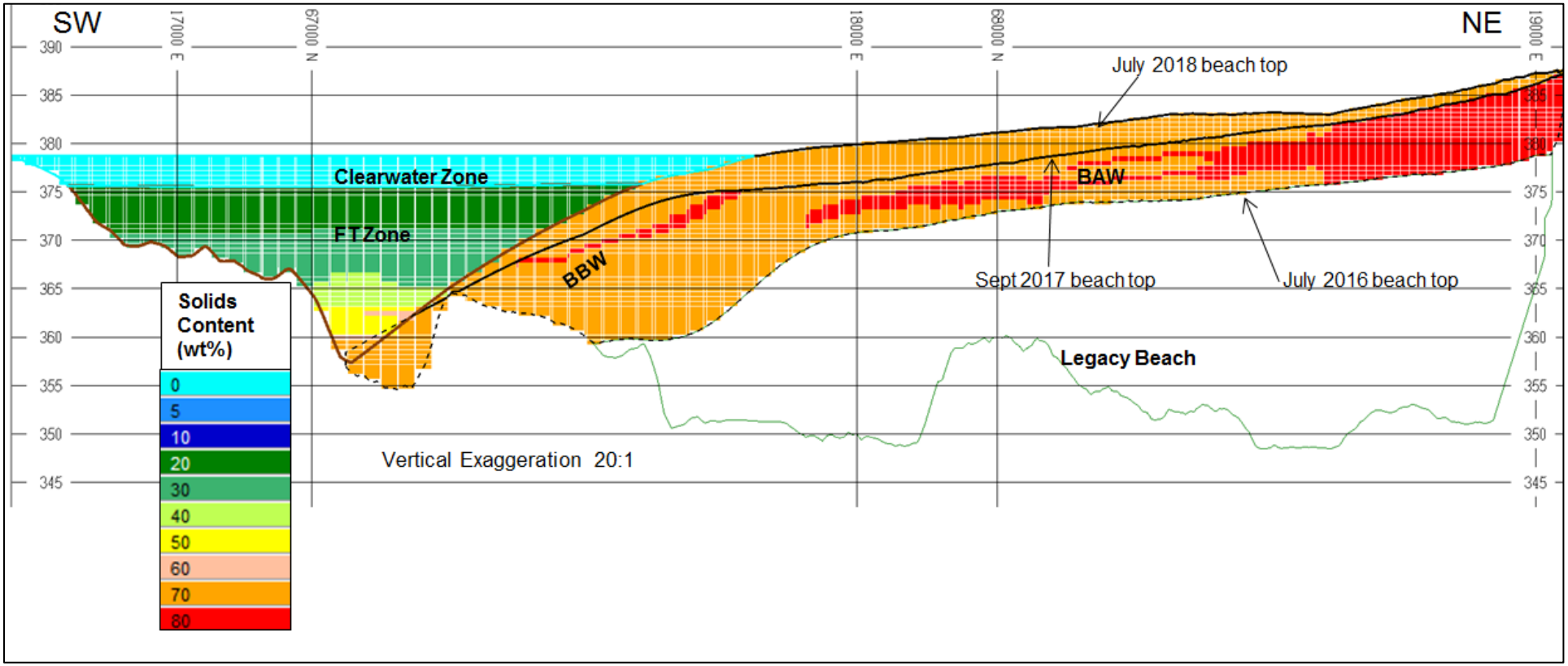

Figure A- 34: Solids Content (percentage), Cross Section 5

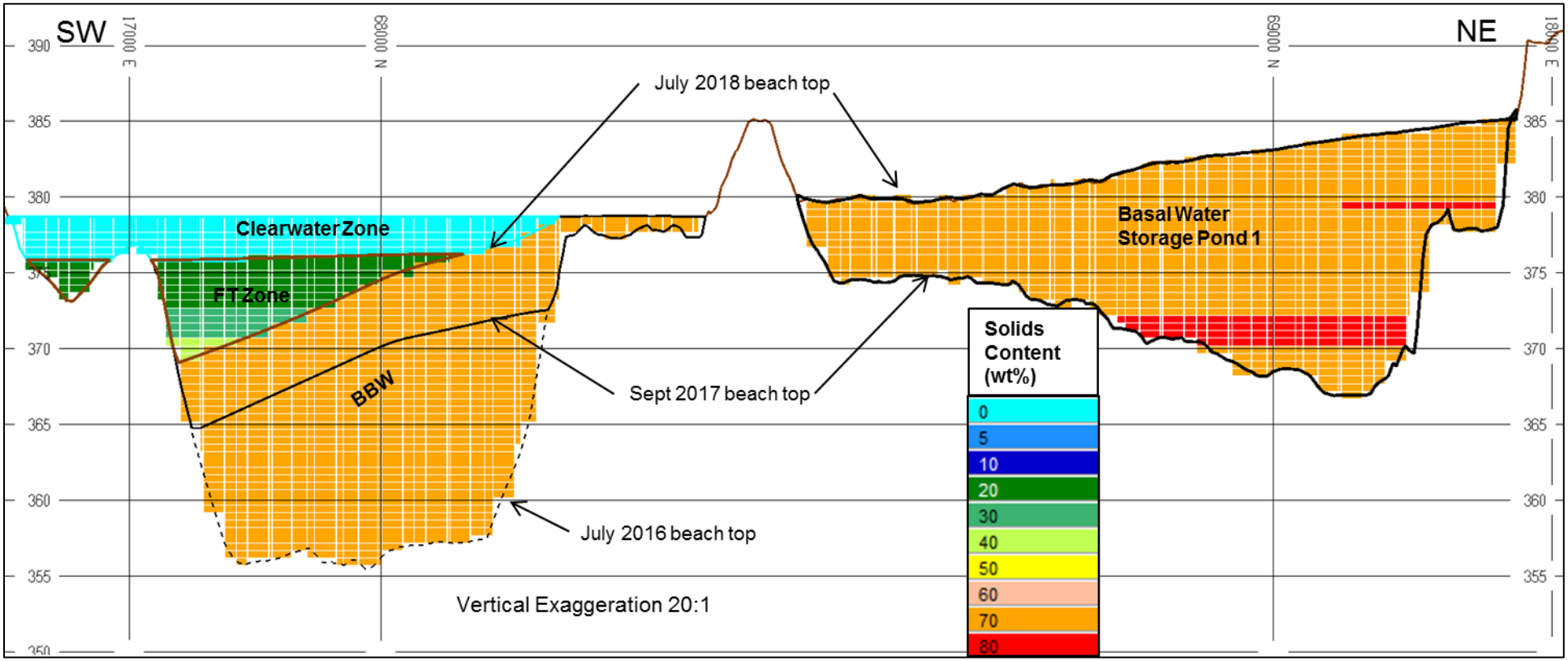

Figure A- 35: Solids Content (percentage), Cross Section 6

APPENDIX B

Tailings Technology Development

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LIST OF FIGURES

1. IN PIT EXTRACTION PROCESS

Canadian Natural has identified a number of opportunities to enhance current extraction processes, one of them being the in-pit extraction process (IPEP). The intent of the process is to significantly reduce greenhouse gas (GHG) emissions and fluid tailings creation from mineable oil sands production, and improve cost efficiency.

IPEP is an alternative bitumen extraction process that separates oil sands ore into coarse solids, fine solids, bitumen froth, and water. After separation, the bitumen froth is transported to the froth treatment plant for further processing, and the coarse and fine solids are recombined into stackable tailings.

In 2017, an IPEP pilot plant with a capacity of 100 tonnes per hour (tph) was tested at the Horizon Oil Sands Mine (Horizon). As a result of this pilot, Canadian Natural proved the concept's feasibility and the pilot plant was scaled up to 500 tph for testing in 2018. The major objectives of the 500 tph plant were to:

- Achieve commercial scale production rates while running a continuous (24 hours per day) process;
- Implement learnings and improvements from the 100 tph test;
- Evaluate recovery rates and process parameters at commercial scale;
- Produce stackable tailings material in sufficient quantities to perform geotechnical testing; and
- Evaluate equipment wear and maintenance requirements.

The IPEP process reduces GHG emissions by reducing the number of diesel powered haul trucks and auxiliary equipment, and power consumption by eliminating the need to pump slurry over extended distances.

The IPEP process generates a tailings output that is a mixture of centrifuge cake (treated fines) and dewatered coarse solids. The tailings output is approximately 80% solids. This material will form the vast majority of the stackable tailings that backfills the pit.

Consolidation times for slurry tailings are typically measured in years or even decades. Consolidation must occur before an area can be considered ready for reclamation (RFR). The IPEP stackable tailings will require minimal consolidation time and could achieve an RFR status significantly faster.

The IPEP process separates and dewaters the sand and fines solids while producing the bitumen in the form of froth. The volume of new fluid tailings generated is significantly reduced compared to the traditional extraction process because the sand and the majority of fines are dewatered and recombined to produce stackable tailings. The IPEP stackable tailings product is presented in Figure 1.

Figure 1: IPEP Stackable Tailings

In addition to testing higher production equipment in 2018, alternative dewatering equipment including a thickener, cyclones, a horizontal vacuum belt filter, and different polymer amendments were also trialed. The current plan is to continue testing in 2019 while designing full-scale commercial modules.

2. ENHANCED NON-SEGREGATING TAILINGS TECHNOLOGY

Non-Segregating Tailings (NST) technology is the primary tailings treatment method adopted by Canadian Natural. The NST process involves combining thickener underflow and cyclone underflow to create a non-segregating coarse and fines solids mixture that is pumpable and will rapidly settle or consolidate to a relatively high density, trafficable deposit. Carbon dioxide (CO_2) is injected into the slurry as a rheology modifier to increase yield strength and promote fines capture during deposition.

In order to increase the performance and reliability of the NST process, maximize fines capture and minimize FT generation in tailings pond, Canadian Natural has developed a technology which can be deployed in the event of a process upset, off-spec NST production, or to improve the performance of NST by increasing overall fines capture during deposition.

The Enhanced NST (eNST) technology comprises an inline flocculant (polymer) injection to the NST to further improve fines capture during deposition. The technology was piloted in 2016 and the first deposition test was conducted during the summer of 2017. NST and eNST were discharged by open ended pipeline into beach above water (BAW) plunge pools into the Horizon External Tailings Facility/Dedicated Disposal Area 1 (ETF/DDA1). A

conceptual schematic is presented in Figure 2. The flocculant injection point and the discharge plunge pool are shown in Figure 3.

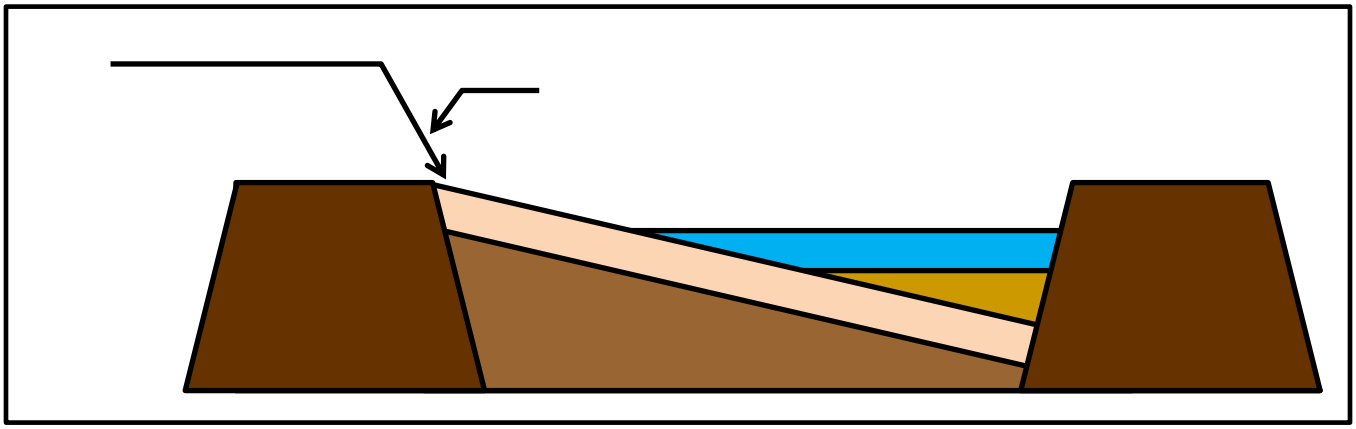

Figure 2: eNST Technology Deposition Concept

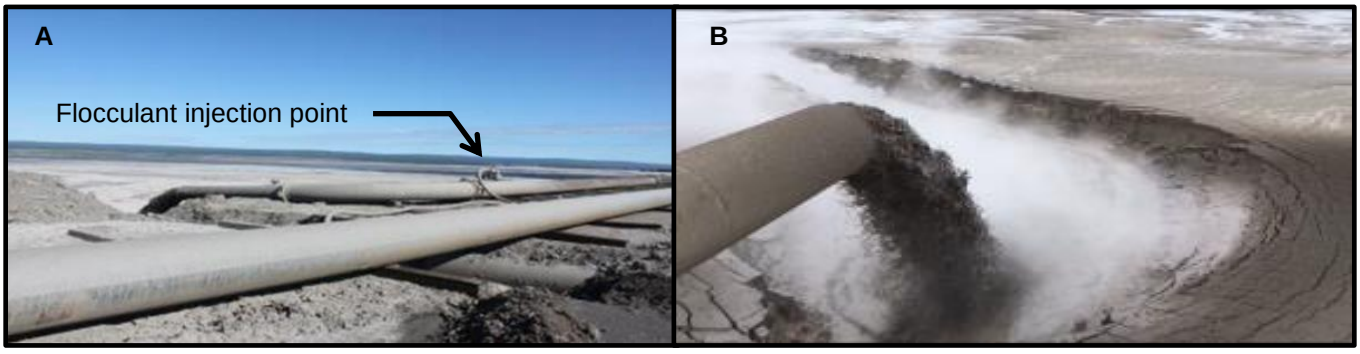

Figure 3: Flocculant Injection Point (A) and Discharge Plunge Pool (B)

A second deposition test is planned for 2019. The test will be carried out on adjacent pipelines, which will discharge NST and eNST. The distance between discharge locations will be sufficient to clearly distinguish the NST and eNST deposits. Deposit performance assessment will be completed by the end of 2019.

3. ENHANCED SPIKED NON-SEGREGATING TAILINGS TECHNOLOGY

Enhanced spiked NST (esNST) was developed as an alternative technology to treat fluid tailings, as proposed in the Horizon's 2016 Tailings Management Plan – Section 10. The technology comprises injecting fluid tailings (FT) inline first and then injecting flocculant (polymer) inline close to the discharge point. A conceptual schematic is presented in Figure 4. The concept is very similar to eNST (Section 2). Despite capturing additional fines within the sand matrix, the esNST deposit should exhibit acceptable consolidation behavior and achieve RFR status.

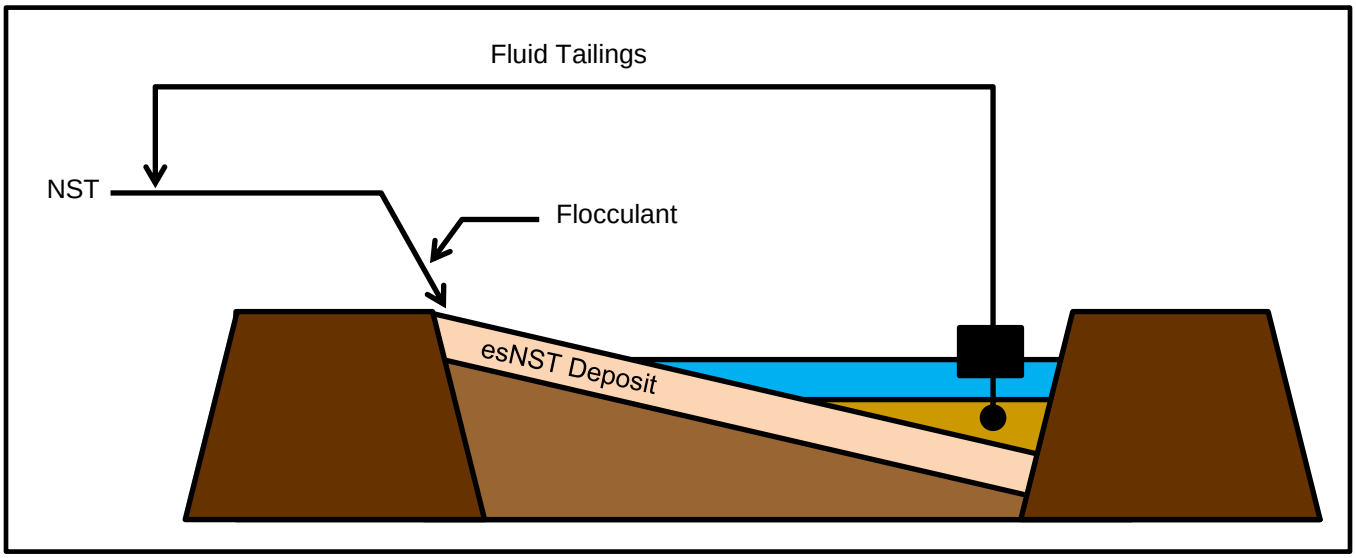

Figure 4: esNST technology deposition concept

The first deposition test is planned for 2019. The test will be carried out on adjacent pipelines, which will discharge eNST and esNST. The distance between discharge locations will be sufficient to clearly distinguish the eNST and esNST deposits. The esNST technology will be compared to eNST technology for fines capture and consolidation performances. Deposit performance assessment will be completed by the end of 2019.

4. esNST CONSOLIDATION AND SIMULATION STUDY

Six geo-column and large-strain consolidation (LSC) tests are in progress for various sand-to-fines ratios (SFR) to evaluate the esNST consolidation behavior. The geo-column consolidation tests are conducted at Horizon's Applied Process Innovation Centre (APIC). Each geo-column is approximately 0.66 m in diameter and 3 m in height. The geo-columns are made of acrylic material and equipped with piezometers and load cells. Consolidation settlements can be monitored visually and pore water pressure changes can be monitored with piezometer readings. Figure 5 shows four geo-columns infilled with esNST.

The geo-column and LSC tests are scheduled to be completed at the end June 2019. With the consolidation data obtained from geo-column and LSC tests, a compressibility and hydraulic conductivity constitutive model for esNST technology will be developed.

The compressibility and hydraulic conductivity constitutive model for esNST will be used to back analyze the esNST beach consolidation performance in the Horizon ETF/DDA1. The back analysis will be used to assess the model accuracy at predicting the esNST consolidation. The model will estimate post settlement, pore water pressure dissipation, and release water volume during esNST deposition.

Figure 5: Geo-Column tests for esNST in APIC at Horizon.

5. INLINE PARTICLE SIZE DISTRIBUTION ANALYSIS

Canadian Natural is leading a joint industry project (JIP) through Canada's Oil Sands Industry Alliance (COSIA) to perform field tests on an inline particle size distribution (PSD) analyzer. The Outotec PSI 500i Instrument Field Test is planned to be completed in 2019.

The objective of the JIP is to test the Outotec's PSI 500i inline PSD analyzer in the field with a few improvements and determine if this instrument is fit for eNST and esNST process control. This work will include assessing PSD measurement performance, fouling mitigation solutions, and the frequency and scope of operator intervention required to maintain operability. Current hypothesis is that the instrument can give accurate PSD analysis without any manual cleaning over a one week period.

Key performance of the instrument will be evaluated through:

- Accuracy – the accuracy will be monitored by comparing the laser diffraction signal to samples taken and analyzed by conventional Laser Diffraction methods.
- Operating range – how does the instrument perform with various SFR and solids content range of flotation tailings?

- Maintenance requirement (with/without automatic wiper) – how often the instrument maintenance and manual cleaning is needed to obtain useful PSD signal, and what steps, time requirements, and other challenges and opportunities are associated with these maintenance activities?

Preliminary results indicate that the instrument's 200 mm laser head performs better than the 300 mm one. The 200 mm laser head alignment provides a stable reading. The instrument requires slurry feed rate of 50-100 L/minute. Because of petrified wood in the flotation tailings, it becomes a challenge to get a constant feed flow rate to the instrument. The Outotec PSI 500i and petrified wood pieces are shown in Figure 6.

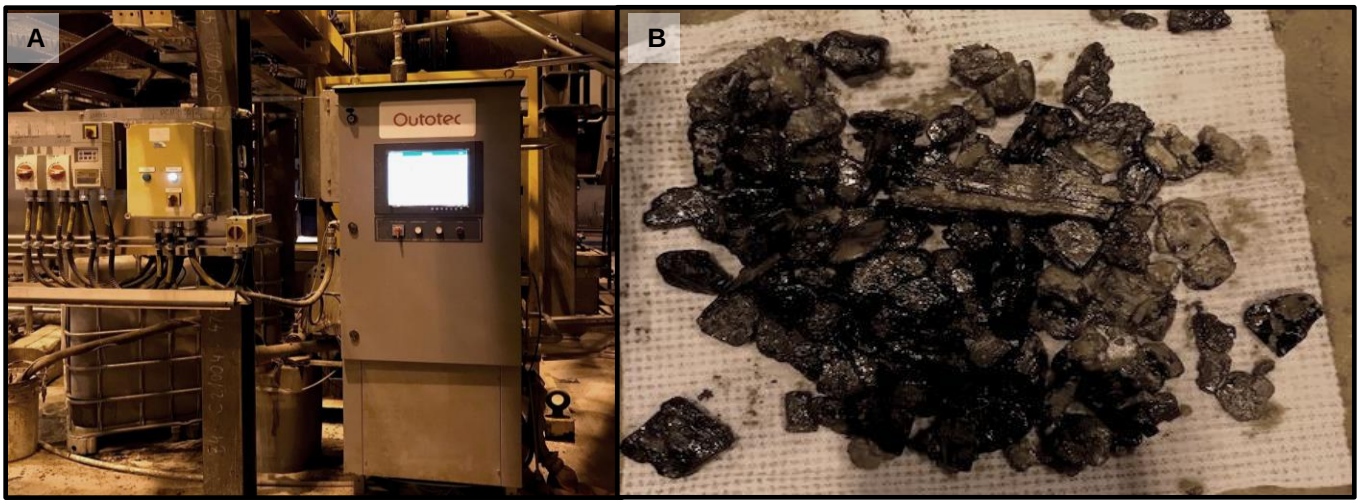

Figure 6: Outotec PSI 500i Installation (A) and Petrified Wood Pieces in the Flotation Tailings (B)

The instrument installation and configuration must be adapted for the location and application. Instrument performance is promising so far. It may eventually result in being incorporated into tailings control systems with the proper configurations and fouling mitigation strategies. Continuous testing has been hampered by upstream sample line plugging, which will be mitigated in the 2019 campaign.

6. PROPRIETARY THIRD PARTY BITUMEN AND NAPHTHA RECOVERY

Canadian Natural is engaged with a third party technology provider and an engineering firm to develop a scope and Class III cost estimate for deploying a bitumen and naphtha recovery technology at Horizon. Among the primary goals of the project is to recover the bulk of residual bitumen and naphtha in the Naphtha Recovery Unit tailings (NRU). The engineering study was completed in February 2019. The study showed that it is technically feasible to achieve the desired results but that the project, as originally envisioned, was more costly than expected. Several options for improvements were identified and assessed during the study. Canadian Natural is now engaged with the third party to optimize the process and improve the economics.

There was also an experimental program to test the thickening and consolidation behavior of the NRU tailings, with varying levels of residual bitumen and naphtha. Final results will not be available until the end of 2019 but preliminary indications are that removing the hydrocarbon helps significantly with NRU tailings thickening.

7. MECHANISMS OF POLYMER SYNTHESIS AND EFFECTIVE APPLICATIONS

Canadian Natural investigated synthesis and chemistry modification of acrylamide base polymers used for tailings treatment through a series of bench scale tests in 2017. The objective of the project was to learn about the polymer synthesis and manufacturing with the purpose of lowering polymer consumption cost by optimizing its chemistry and/or refurbishing Horizon's Polymer Preparation Plant with the purpose of manufacturing the required polymer at site in a solution form.

A modified chemistry was developed based on hydrolysis of hybrid $Al(OH)_3$ polyacrylamide (PAM) and proved to increase performance in terms of the required dosage and tailings dewatering rate compared to polymers provided by various vendors through a series of flume tests.

A high level literature survey was conducted in 2018 in order to understand the prerequisites of scaling up the polymer synthesis process at Horizon site.

Various processes were reviewed and solution polymerization was selected for further evaluation. Basic PAM manufacturing, starting from acrylonitrile, composed of various steps including:

- Hydrolyzing acrylonitrile by treatment with sulfuric acid and water in the presence of a polymerization inhibitor to form acrylamide monomer;
- Neutralizing the acrylonitrile hydrolysis product by treatment with base;
- Substantially removing the polymerization inhibitor from the acrylonitrile hydrolysis product; and
- Polymerizing the hydrolyzed and neutralized acrylonitrile solution at a temperature in the range of about 10° to about 90° C in the presence of a polymerization catalyst to form polyacrylamide.

A simpler process will start the polymerization step from acrylamide. However, regardless of the selected process, the scale up process requires considerable refurbishing of the polymer preparation building and unit operations, including addition of hydrolyzer and neutralizer columns, rotary drum filters, heat exchangers and polymerizer unit. Additionally, required logistics relevant to switching to batch mode of operation and dealing with toxic chemicals such as acrylamide and new process safety concerns such as ammonia release resulted in dismissal of the idea of in-house polymer manufacturing.

8. RESIDUAL HYDROCARBON REMOVAL VIA COMBUSTION

Canadian Natural is currently evaluating technologies for the combustion of the residual hydrocarbon in NRU tailings while still in slurry form. It is expected that this would result in very low residual light hydrocarbons content in the treated NRU tailings. The technology license agreement is under negotiation. A lab-scale combustion test will be conducted in the summer of 2019 if the agreement is reached. The goal is to create a dense tailings product with very low light hydrocarbon content that is ready for co-disposal with other tailings streams in terrestrial Dedicated Disposal Areas (DDAs). The test results will feed into an engineering study to be completed in 2019. The success of the lab scale will move the program to pilot stage in 2020.

9. CARBON CAPTURE IN HORIZON TAILINGS POND

The objective of this project is to quantify the carbon capture potential at the Horizon ETF/DDA1. The project was initiated in 2018 and should be completed by the end of 2019.

Horizon has injected CO2 inline in tailings streams since the mine startup in 2010. The CO_2 acts as a coagulant by decreasing the tailings slurry pH and significantly decreasing the total suspended solids (TSS) in the process water stored in the ETF (see Application for the Approval of Canadian Natural's TMP, section 4.3.5 and Figure 4.3.5-1). In laboratory testing, NST fines capture is increased when CO_2 is injected. Currently, CO_2 is injected into NST and NRU tailings lines.

From 2010 to 2017, CO_2 for in-line injection was produced by cryogenic technology. In 2017, Horizon started producing its owned CO_2 and stopped CO_2 procurement. CO_2 produced by cryogenic technology contains carbon-14 isotopes (C14) while CO_2 produced through bitumen processing does not. During tailings deposition, a fraction of the injected CO_2 is released to the atmosphere and a fraction of injected CO_2 reacts in the tailings to produce carbonate compounds. The carbonate compound can stay in solution and/or precipitate on tailings sand surfaces. Therefore, C14 can be found in recycle water, fluid tailings, and tailings beach.

Specifically, the carbon capture quantification project will consist of quantifying the C14 in the recycle water, fluid tailings, and tailings beach. The carbon capture will be correlated with the initial C14 concentration in typical cryogenic CO_2. Quantification of carbon capture in the tailings beach will be calculated from the correlation.

10. RECLAMATION TECHNOLOGY DEVELOPMENT

10.1. NST Field Research Program

Canadian Natural will establish a NST field research program to investigate the ability to establish Boreal Forest plant communities on closure Dedicated Disposal area landforms. The goal of the research program is to address knowledge gaps on the establishment of various upland and lowland vegetation communities on NST. Horizon's current Environmental Approval requires 1 meter of tailings sand or suitable overburden to be placed over NST. Canadian Natural is conducting research to explore alternative options that prove attractive alternatives to this approach. Coke has been wildly used in the oil sands region to provide drainage for dyke structures and as a capping material for DDAs. Canadian Natural is looking at the potential for a layer of pet-coke to act as a substrate or cap on the NST deposits to aid in the development of lateral ground water drainage prior to the application of cover soils. This approach of placing coke on DDAs has been used effectively at other oil sands mining operations and aids in developing a trafficable surface on the DDA. Research will look at layering pet-coke on NST prior to placing a coversoil layer, planting of specific vegetation communities, with NST at varying depths and different coversoil types. Optimization of coversoil types able to mitigate possible negative effects of the Oil Sands Process Affected Water contained in the NST will also be included.

Development of the field study site is based on the assumption that NST is placed in the selected location by the end of 2020 and is safe to operate equipment on the surface. The following is the proposed schedule:

- 2022 – Site constructed during the winter months. Summer tree planting, field experiment set-up, and initial measurements of soil and vegetation
- 2023 through 2029 – Field and greenhouse studies run in parallel
- 2030 – Final field measurements

This collaborative study will provide learnings, as well as methods that can be used for reclamation of all DDAs that are planned for the Horizon operation. Canadian Natural expects to develop:

- Operational recommendations for NST and petroleum coke use in reclamation
- Annual research reports

Additional outcomes may become evident as the study develops and conditions change as a result of weathering and flushing of the NST deposit by precipitation.

The NST Field Research Program is proposed to be located in of the former Basal Water Storage Pond 1 over-boarding area (**Error! Reference source not found.**). This is an isolated site that is currently being filled with ST. The soil materials for the study will be placed by a contractor during the winter with material placement monitored by Canadian Natural. Field study plots will be set up with researchers on site to conduct the sampling and analysis of the plots.

Eleven (11) unique soil treatments have been proposed for this research program. The sites will be constructed in order to maximize efficiency of placement operations. Statistical rigor will arise from multiple blocks having the same treatment prescription.

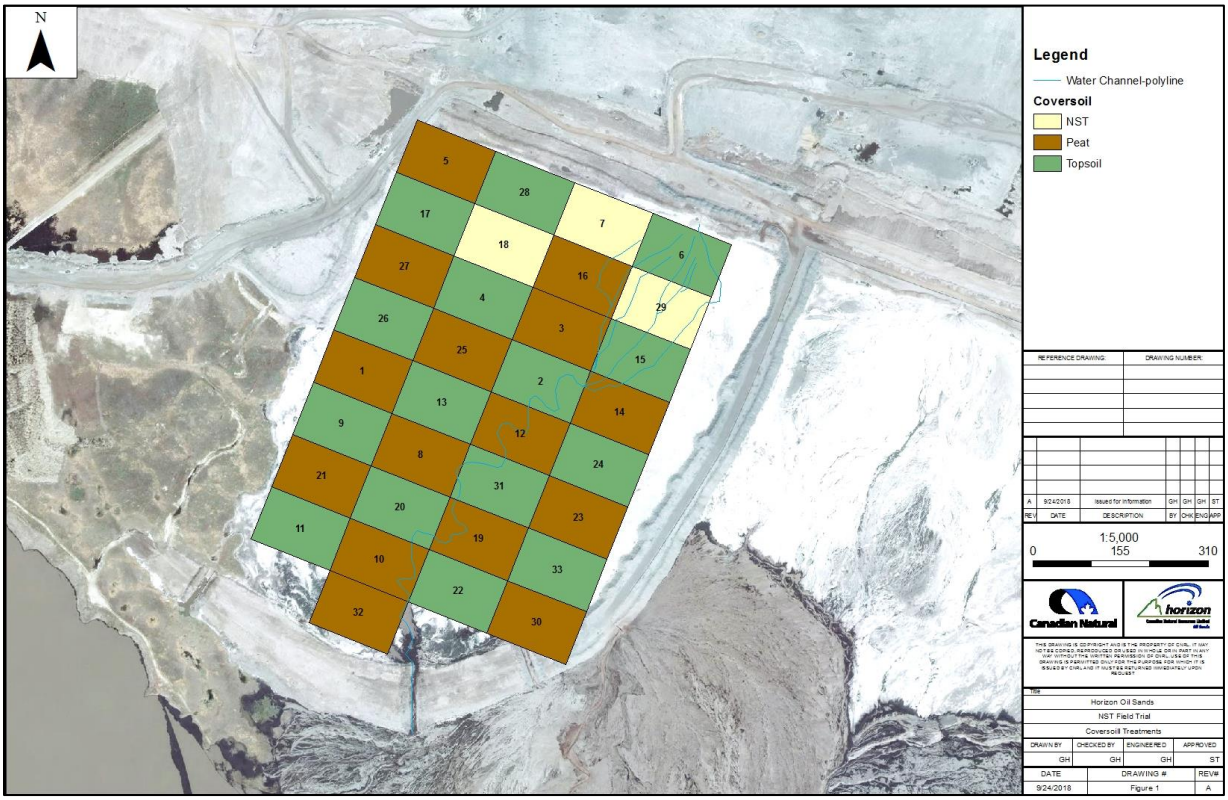

Figure 7: Proposed NST Field Research Program Location

10.2. University of Alberta Studies into the Effects of NST on Growth of Oil Sands Reclamation Plants

Canadian Natural has implemented a greenhouse study at the University of Alberta (UofA) to outline options for Boreal Forest reclamation plant species and provide information on possible reclamation treatment options. Three years of the five year study have been completed. This study considers the following:

- Experimental soil prescriptions including NST, petroleum coke (pet-coke), and other soils
- Soil amendments such as biochar, organic matter, fertilization
- Plant competition on different soil types
- Mycorrhizal characterizations and/or inoculations

Canadian Natural has completed the third year of a five-year study with the University of Alberta, led by Dr. Janusz Zwiazek and Dr. Wenqing Zhang. The intent of this study is to address knowledge gaps concerning hypothesized potential stressors to vegetation growth, caused by underlying placement of NST. Although reclamation vegetation would be growing in coversoil, an understanding of barriers to plant growth in NST is beneficial in understanding potential options for material capping depth. It was hypothesized that NST may yield a limited supply of important plant growth nutrients, such as Na, Mg, K Ca, P Fe Mn, and Zn. It was also hypothesized that NST would have a relatively high pH and Sodium Adsorption Ratio (SAR), compared to suitable overburden or reclamation cover soils that would be used in overburden reclamation. Lastly, there was a concern

that underlying NST could be a source of potentially phytotoxic substances, such as fluoride or naphthenic acids. These substances can affect water and nutrient uptake in the plant, as well as the establishment of microbial and fungal community development in reconstructed soils. To determine if NST adversely affects the establishment of important microbial communities, this study is designed to investigate the inoculation potential and diversity of ectomycorrhizal and ericoid mycorrhizal fungi in reconstructed NST soils and the roots of reclamation vegetation growing within these soils.

This research has been successful in outlining several constraints and opportunities that need to be incorporated into a field research program. The aim of the field research program is to better answer some of the longer term forest plant community development questions.

10.3. End Pit Lake Technology Development

Section 6.2 of Canadian Natural's Environmental Protection and Enhancement Act (EPEA) approval 149968-01-00, as amended, requires End Pit Lakes (EPL) research and development report to be submitted to the Director by April 15th, 2019. The Research and Development report focuses on research activities that will be undertaken at Horizon to minimize the environmental risks associated with water-capped tailings in order to meet "ready-to – reclaim" (RTR) performance criteria for mine closure.

Canadian Natural is participating in Syncrude's Base Mine Lake demonstration and Suncor's Demonstration Pit Lake through COSIA.

10.4. Mesocosms Testing

Innotech-Vegreville was selected as the research facility to conduct mesocosms testing. The test program was developed in consultation with the expert researchers from academia, consultants and industry, with backgrounds in limnology, geochemistry, biology and oceanography. Approximately 30 in-ground mesocosms of over 10m3 each have been constructed at Innotech's Vegreville facility to evaluate the impact of process water, fluid tailings, and plants on water quality.

In 2017 the control mesocosms were filled in with river water. Soil and treatment mesocosms were filled with tailings and process water, supplied by Suncor. Plants were chosen based on their natural occurrence in Athabasca oil sands region and were planted following spring thaw in 2017. The studies continued through 2018. Data was collected describing physicochemical and biotic conditions of the mesocosms.

Analyses included:

- Weekly data sonde measurements of temperature, turbidity, conductivity, and dissolved oxygen at 3 depths
- 3-point (study beginning, middle, and end) laboratory-based chemical analyses including standard water quality parameters, phenols, polyaromatic hydrocarbons (PAHs), naphthenic acids via Orbitrap mass spectrometry, and analysis of total and dissolved metals via inductively coupled plasma mass spectrometry
- 3-point dFFT pore-water quality analysis
- Bi-weekly assessments of submerged and emergent plant growth as well as terminal dry biomass
- Monthly periphyton biomass as a measure of primary productivity
- 3-point aquatic macroinvertebrate community

- Monthly zooplankton community analysis
- Diurnal swings conductivity and dissolved oxygen (control tanks only)
- 3-point determination of mesocosm water toxicity to trout (96 hour LC50)
- 3-point determination of mesocosm water toxicity via Microtox assay (IC50)
- Terminal tissue and soil pore water analysis for emergent plants

The mesocosm-based approach allows the control and replication of laboratory experiments combined with “real world” environmental conditions and complex interactions between biotic and abiotic ecosystem components. All mesocosms were housed in a single secure location and were commissioned simultaneously; eliminating ecosystem age and environmental conditions as factors which could confound interpretation. The mesocosms were allowed to freeze over the winter of 2017/18. Data collection was resumed in 2018 with the data analysis continuing. Some aspects of the study design have been modified for the 2019/2020 operation of the facility which will include tailings and OSPW from Imperial Oil’s Kearl operation and from Suncor’s operations.

APPENDIX C

Report on Annual Stakeholders Forum

1. IDENTIFYING STAKEHOLDERS

Canadian Natural identified the key stakeholders and Indigenous communities for engagement efforts based on previous consultation referrals made for current Horizon regulatory applications, where consultation was required, through the Aboriginal Consultation Office (ACO). Typically, Canadian Natural is required to consult with four key First Nation communities, and as such, these First Nation communities were identified first. In addition to the four First Nations identified through the ACO processes used for regulatory applications, Canadian Natural also engaged with three Métis Locals on tailings initiatives at the 2018 forum.

2. LIST OF STAKEHOLDERS

The list of seven identified stakeholders includes both First Nations and Métis Communities. These are all listed below:

- Athabasca Chipewyan First Nation;
- Fort McKay First Nation;
- Fort McMurray First Nation #468;
- Mikisew Cree First Nation;
- Fort McKay Métis Community Association (formerly Fort McKay Métis Local 63);
- Fort Chipewyan Métis Local 125; and
- Fort McMurray Métis Local 1935.

3. OBJECTIVES FOR ENGAGEMENT

Through the engagement efforts outlined under OSCA 9752G, condition 53, Canadian Natural set out to provide stakeholders with an overview and update of its tailings performance at Horizon Oil Sands, including updates on new advancements in tailings treatment technology.

The Annual Stakeholder Tailings Forum (Forum) held on November 27, 2018 was Canadian Natural's first Forum specifically focused on tailings management. The primary objective of the Forum was to present relevant tailings related information to the Indigenous community representatives and subject matter experts (consultants attending on behalf of Indigenous communities) and to gather feedback for consideration in tailings treatment, mine planning and reclamation planning, where appropriate. After the Forum, input was solicited from Indigenous communities to help shape future annual tailings forums to ensure Indigenous communities are deriving value from these events.

4. TYPES OF ENGAGEMENT ACTIVITY

Table C- 1 provides the type of engagement activity that was undertaken by Canadian Natural in 2018, including stakeholders in attendance and the topics that were discussed.

Table C- 1: Summary of 2018 Engagement Activities with Tailings as a Key Focus Area

Date	Event Type	Stakeholders Present	Topics Discussed	Stakeholder Feedback	Canadian Natural Response
February 6, 2018	Fort McKay First Nation and FMMC internal CAG Meeting[1]	Fort McKay First Nation and FMMC community members Fort McKay First Nation Sustainability Department	Tailings management	Community determined that tailings are an important topic to be discussed with Canadian Natural in 2018.	Canadian Natural planned a Tailings Tour for the Fall Site Tour of Horizon. Due to extenuating circumstances within the community and then year-end timing, the tour was postponed to 2019.
April 30, 2018	FMFN 468 Community Meeting	Canadian Natural's Horizon Stakeholder Relations team FMFN 468 community members Consultants representing FMFN 468	Reclamation Water External Tailings Facility (ETF/DDA1) End Pit Lakes (EPLs) Dyke 10 Tailings treatment technologies Tailings treatment technology aimed at developing dry tailings	Concern related to amount of open water in the tailings pond.	The current technology means that Horizon will be left with dry tailings and a couple of end pit lakes versus a huge legacy pond.
May 3, 2018	MCFN tour Horizon tailings	Canadian Natural's Horizon Stakeholder Relations team	NST Groundwater monitoring,	Questions were asked about life of ETF/DDA1	Canadian Natural explained the groundwater monitoring, approved levels, treatment of

[1] This meeting was not held by Canadian Natural but provided valuable information to help Canadian Natural understand the priority of tailings management to this community.

Date	Event Type	Stakeholders Present	Topics Discussed	Stakeholder Feedback	Canadian Natural Response
	management infrastructure, including discussion	Canadian Natural's Tailings Management and Innovation team MCFN community members MCFN Government, Industry Relations (GIR) staff Consultants representing MCFN	Tailings treatment technology Progressive reclamation Ongoing research into tailings items such as nutrient study (NST Revegetation Project) Swell factor, and storage of tailings Sand, fines and polymers Tailings minerals Life of ETF/DDA1 Tour of tailings area: Tailings management infrastructure such as pump houses and NST lines Recycle water pond Reclamation areas		water, and progressive reclamation. If Canadian Natural cannot restore the land to what was there before, they will reclaim the land to a similar state. The University of Alberta is in year three of a five year study researching nutrients and plant growth in Canadian Natural's tailings.
May 15, 2018	ACFN AC Meeting and Horizon Lake Tour	Canadian Natural team members ACFN community members ACFN Industrial	Environment, including water and wildlife Confirmation of no seepage from the ETF/DDA1 into Horizon Lake, as Horizon Lake	Concern about potential seepage from ETF/DDA1 into Horizon Lake, as well as seepage from ETF/DDA1 into Athabasca River	Canadian Natural assured ACFN that Horizon Lake fluctuates naturally and is at a higher elevation than the tailings pond, so as water flows down there will not be any

Date	Event Type	Stakeholders Present	Topics Discussed	Stakeholder Feedback	Canadian Natural Response
		Relations Corporation (IRC) staff	is at a higher elevation Air and groundwater monitoring Monitoring of the ETF/DDA1, to clarify that any potential seepage would be detected prior to reaching the Athabasca River		seepage from the tailings pond to the Lake. Canadian Natural monitors water from the tailings dyke to the Athabasca River and there is no presence of seepage water. The drainage ditch collects water and pumps it back in; no tailings water is allowed to be released.
October 23, 2018	ACFN AC Meeting	Canadian Natural team members ACFN community members ACFN IRC staff	Mining, extraction, and tailings process Non-segregated tailings (NST) NST Revegetation Project In-Pit Extraction Process (IPEP) Oil in ETF/DDA1, and how it is recovered (cleaned up) Life of the ETF/DDA1 Tailings treatment as production increases at Horizon Life of Mine Closure Plan	Concern about life of ETF/DDA1 and additional tailings to treat/manage as production increases at Horizon	There is a small amount of bitumen in the tailings pond, however at this time Canadian Natural is not currently recovering it. When reclaiming, Canadian Natural will take all the water and continue the process to cover the tailings pond with sand, then overburden/subsoil, and then trees, grasses, and native species. Reclamation will not happen for a while. Canadian Natural is unable to capture 100% of the fines but are continually improving how

Date	Event Type	Stakeholders Present	Topics Discussed	Stakeholder Feedback	Canadian Natural Response
					much can be captured. Tailings placement follows the mine progression and as each area is finished, the holes will be filled with a combination of tailings and end pit lakes.
November 27, 2018	1st Annual Tailings Stakeholder Forum	Canadian Natural technical specialists in the fields of: • mine planning • tailings planning • conservation and reclamation • tailings research and innovation • regulatory • environment • stakeholder relations Fort McKay First Nation MCFN	Tailings planning processes and performance at Horizon End of Mine Life (EOML) FT Volumes Mature Fines Tailings Reduction Mine Plan Bird Deterrent Systems Joslyn North Mine acquisition, and related tailings aspects Non-Segregating Tailings (NST) Reclamation Research Tailings Treatment Technologies and Innovation In-Pit Extraction Process Overview of Titanium Corporation's (Titanium's) Creating Value from Waste	Interested in many aspects of tailings management Communities would like to be involved in reclamation planning/ NST Revegetation Program Communities confirmed Horizon's traditional plant list Communities commented that the Forum was helpful and appreciated having technical experts present to answer their questions	Canadian Natural provided the minutes and action items from the Canadian Natural Horizon Annual Stakeholder Tailings Forum as a 127 page document (including the Forum presentation PowerPoint Slides) to the participants, as well as the 2017 Horizon Tailings Management Report and the Final Horizon Mature Fine Tailings Reduction Mine Plan public report.

Date	Event Type	Stakeholders Present	Topics Discussed	Stakeholder Feedback	Canadian Natural Response
		ACFN FMMC ML 1935 ML 125 FMFN 468	(CVW™) Project Overview of the High Temperature Paraffinic Froth Treatment (HTPFT) Project, and tailings related aspects		

5. FREQUENCY AND DURATION OF ENGAGEMENT

Canadian Natural endeavors to engage with all key Indigenous stakeholders for Horizon Oil Sands on a quarterly basis. These quarterly engagement events will continue to include relevant and timely tailings related topics.

Past engagement efforts with key Indigenous stakeholders at Horizon included meetings on issues related to current tailings management approaches, as well as tours of the Applied Process and Innovation Center (APIC). These engagement activities have been underway since September 22, 2015 and are summarized in Table 13.6-1 of Horizon's Tailings Management Plan (TMP) (Canadian Natural 2016, Application 1869003), which provides a comprehensive list of all tailings engagement activities from September 22, 2015 until submission of the TMP in December 2016. The TMP regulatory application was also part of an enhanced regulatory process, which included a public notification period, responses to Indigenous community Statements of Concern (SOCs), responses to two Technical Reviews and a Tailings Workshop. Since this time, engagement efforts with key Indigenous stakeholders have continued and have been summarized in Table C- 1.

Canadian Natural was also an active member of the Tailings Regulatory Management Technical Advisory Committee (TAC), which was a multi-stakeholder committee consisting of participants representing environmental nongovernment organizations, First Nations, industry, Métis organizations, the municipality of Wood Buffalo and the AER. The types of issues discussed at TAC meetings included:

- *Directive 085* principles, including:
  - Thresholds and performance monitoring
  - Net environmental effects
  - Continuous improvement
  - Enforceability and compliance
- Treatment of legacy tailings
- Water management
- Contingency planning
- Performance indicators and criteria

6. COMMUNITY SPECIFIC FEEDBACK

See Table C- 1 for the community feedback identified through engagement efforts in 2018. Canadian Natural received one formal response as feedback to the 2018 Annual Tailings Forum which was sent to Canadian Natural and copied to/on behalf of Fort Chipewyan Métis Local #125, Fort McMurray #468 First Nation, and Fort McKay Métis Community. These groups noted the session was very informative and showed that Canadian Natural is employing innovative technologies to manage tailings. The groups appreciated Canadian Natural having appropriate representatives from each of the areas present, which allowed for real-time questions and answers.

7. COMMUNITY SPECIFIC FEEDBACK ON REPORTING

This is the first Annual Tailings Management Report submitted under Directive 085 and OSCA 9752G conditions. As such there has not been an opportunity for communities to provide feedback specifically relating to annual reporting.

8. INCORPORATION OF FEEDBACK INTO TAILINGS MANAGEMENT

Following the Forum close, Canadian Natural requested feedback on the Forum format and structure. All feedback will be used to inform future engagement activities (tailings management or otherwise).

Feedback will also be used to help improve tailings management, mining and reclamation programs, where most appropriate and possible to do so.

Final Forum notes were provided to the participant communities/stakeholders and Canadian Natural has already begun preparing for the 2019 Forum. Subject Matter Experts (SMEs) from Canadian Natural will attend the Forum, and these SMEs will incorporate Indigenous stakeholder feedback into tailings, mining and reclamation planning and management, where practical. Based upon feedback received (see Section 6 0 Community Specific Feedback), Canadian Natural plans to undertake the 2019 Annual Tailings Forum in the same format as the 2018 Annual Tailings Forum. The participants expressed that the Forum was done well.

9. OUTSTANDING CONCERNS

Canadian Natural, through ongoing community engagement and the annual forum, will address any outstanding concerns, where reasonable and practical, in line with the approved tailings management plan. Outstanding action items are being tracked by Canadian Natural. Canadian Natural is putting plans in place to address all outstanding items from the 2018 Forum, as outlined in Table C- 1.

10. FORUM OUTCOMES

Canadian Natural has a list of action items from the 2018 Indigenous engagement activities. These action items (detailed in Table C- 2) will be reviewed with communities at regularly scheduled meetings to ensure that all items are accomplished or that communities are informed of progress towards achieving these action items.

Table C- 2: Stakeholder Feedback from Annual Tailings Forum

Stakeholder Feedback	Canadian Natural Response
Provide 2017 Annual Tailings Report	Uploaded to CKK
Community capacity to review the 2017 Annual Tailing Report	CN proposed to upload the 2018 Horizon Annual Tailings Report to the CKK in 2019. The next tailings forum will take place in May 2019 whereby communities can ask CN questions on the reports. No further capacity will be provided for the 2017 report review.
Exchange FT Annual Generation Calculation	CN proposed to discuss the methodology more fully at the 2019 annual tailings forum. A tentative date has been set for the end of May, following submission of the 2018 Annual Tailings Report in April 2019.

Provide a 'coles notes' version of the Benefits and Potential Drawbacks of the MFTRMP to communities.	See Table 1.3-2, Section 1.3 of the meeting minutes.
Provide MFTRMP Final Report	Uploaded to CKK.
Community involvement in reviewing tailings and reclamation plans.	The Annual Tailings Reports will be uploaded to the CKK, starting with the 2017 report. The 2019 Life of Mine Closure Plan will also be uploaded to CKK when completed, and the NST Revegetation Final Reports will be uploaded to CKK. The Annual Tailings Forums will provide the communities with an opportunity to ask questions on these reports.
Share data on bird deterrent program.	CN will confirm with OSBTT if the regional report can be released to communities. If it can be released, this report will be uploaded to CKK.
Work with communities to get their feedback and input into NST Revegetation Program. **Share final NST Reclamation Report.**	Horizon stakeholder relations to develop approaches to get stakeholder feedback on NST Revegetation Program.
Send communities list of approved Traditional Plants.	See Table 1.6-2 of the meeting minutes.
Send communities MSDSs for polymers.	Attached as Appendix B of meeting minutes.
Set up engagement strategy for communities on IPEP.	Horizon stakeholder relations to develop approach with Horizon innovation team.
Titanium to provide tailings streams.	Details on Titanium's proposed project will be provided in the Integrated Application to the AER.
Titanium to follow up with interested communities on employment, training and business opportunities.	Titanium will follow up directly with communities on all inquiries.