# CAIRNS SHIPPING DEVELOPMENT PROJECT

## Revised Draft Environmental Impact Statement

## Supplementary Report

## Appendix B: JFA Technical Note TN-J16021-5

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# Technical Note

| | | | |
|---|---|---|---|
| Project Number: | J16021 | Project Name: | CSD Project, Revised Draft EIS |
| Date: | 3/11/2017 | Doc Ref: | TN-J16021-5 |
| Client: | BMT WBM | | |
| Subject: | Dredge Material Placement Assessment – Alternate Northern Sands DMPA | | |

## 1 Introduction

The key objective of this work is to provide an updated estimation of the required dredged material placement area (DMPA) capacity for the proposed dredging program, including allowance for the storage of dredged material and for the clarification of the supernatant water to meet specified concentration limits prior to discharge. This builds on previous studies undertaken with the following key changes to the assessment scope:

1. *Change in the topography and available capacity at the Northern Sands site to include the full site*
2. *Change in the assumed slurry inflow rates based on revised production estimates*

This Technical Note has been prepared to document outcomes of the DMPA simulations for the Northern Sands site (refer attached Drawing 3527-SK14 D).

## 2 Material Characterisation and Laboratory Testing

The material characteristics and laboratory testing are as previously reported in Chapter 4 of the "Dredging and Dredge Material Placement Assessment Report", which formed Appendix AC of the revised draft EIS for the Cairns Shipping Development Project (BMT JFA Consultants, 2017).

## 3 DMCAT Numerical Modelling

Numerical simulations were conducted using the BMT developed *Dredged Material Containment Assessment Tool* (DMCAT) to assess the proposed dredged material placement activity. In summary, the model consists of a vertical 1-D numerical model for the settling and consolidation of suspensions coupled to a quasi 1-D steady horizontal flow model. Inputs consist of the placement area geometry, a time history of the inflow characteristics (i.e. flow rate and sediment concentrations), and calibrated sediment settling and diffusion parameters (calibrated using the laboratory test results). The model returns the expected concentration and composition of the placed material and the outflow material. The corresponding key performance output parameters are the dry density of the placed material at the completion of the dredging campaign, and the suspended sediment concentration in the supernatant outflow. For the purpose of distinguishing between sediment carried in suspension and the settled placed material, a concentration threshold of 100kg/m$^3$ is applied (concentrations greater than this may still be flowable mud).

# 4 DMPA Assumptions

## 4.1 Concept Layout and Performance Criteria

A revised DMPA concept has been developed by Flanagan Consulting Group (FCG) and this is provided in Attachment 1 (Drawing 3527-SK14D). Key details are as follows:

- Maximum Bund Height: 5.5m AHD
- Maximum Operating Water Level (MOWL): 5.2m AHD (preferably limited to 3.5m AHD, subject to tailwater quality)
- Estimated Water Level at end of Placement: 5.07m AHD
- Storage volume to estimated water level at end of placement: 2,704,283 m$^3$

Assumptions for the DMPA simulations adopted include (Akuna, 2017):

- Insitu volume of dredged material 900,000m$^3$ (Soft Material). 882,650m$^3$ are dredged by the TSHD and pumped to the DMPA (the difference remains in channel after levelling with sweep bar/plough).

Additional assumptions for the DMPA simulations include:

- No internal weirs or bunding within the DMPA
- Dredge material will enter the DMPA from the southern end initially for the disposal of the PASS material (320,000m$^3$), with a tailwater discharge point at the northern end. The dredge material inflow point will then relocate to the northern end for the remainder of the dredge program, with the tailwater discharge point to be located at the southern end
- Minimum tailwater water discharge level is +3.5m AHD.
- The dredge material is discharged below water level, just above the formed bed level in order to reduce the distribution of fines through the water column and assist in earlier settlement of the material.
- Settling and Consolidation properties of in-situ material will be based on calibrated Composite #1 (‘Muds’) from previous DMPA simulations (BMT JFA 2017)
- Design performance requirements for tailwater quality:
  - Acute exceedance 100 mg/L averaged over a 48 hr period
  - Chronic exceedance 50 mg/L averaged over a two week period

### 4.2 Geometry

The geometry was derived from the supplied drawing 3527-SK14D (refer Attachment 1), along with supplied bathymetric and terrestrial survey data. For the purposes of reproducing the filling process from RL 0.0 to RL 5.20, a trapezoidal channel shape was assumed, with base width approximated from the measured 'hole' width (existing + future sand reclamation area). The shape of the trapezoid was adjusted to reproduce the storage volumes at both RL 0.0 and RL 5.20, which produced sufficiently accurate estimates of storage volume between these elevations.


**Figure 4-1: Placement storage volume vs water level as detailed in 3527-SK14D (blue) compared with volumes used in DMPA simulations (blue)**

### 4.3 Inflow and Water Levels

The DMPA inflow time history consists of a sequence of bulk inflow rates and durations with associated sediment concentrations. The basis for the adopted inflow time is summarised in Table 4-1 (over page) and is based on the Akuna Dredging estimates (refer also to Attachment 2). The number of dredge cycles for each dredging area were rounded up to whole numbers, and the associated pumping downtime and solids concentration in the pumping mixture adjusted to maintain the specified pumped solids mass.

The DMPA water level is set to increase from 0.0m AHD to +3.5m AHD, where it remains if, and until, the 100 mg/l acute tailwater quality limit is triggered. From this point, the levels are raised continuously till the water level reaches a maximum of 5.20m AHD in order to manage the chronic tailwater discharge limits.

**Table 4-1 Summary basis for adopted DMPA inflows**

| | | *Dredging Area* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Units | Smith Creek | Crystal | Bend | 1 | 2 | 3 | 4 | 5 | **Total** |
| Dredging Duration | Wks | 1.04 | 0.76 | 0.34 | 2.41 | 4.29 | 2.54 | 0.55 | 0.14 | **12.07** |
| No. Cycles | | 25 | 19 | 9 | 68 | 123 | 76 | 17 | 4 | **341** |
| Cycle Duration (service) | mins | 419.3 | 403.2 | 380.8 | 357.2 | 351.6 | 336.9 | 326.1 | 352.8 | |
| Cycle Time (operating) | mins | 344 | 325 | 332 | 287 | 284 | 273 | 276 | 309 | |
| Filling pipeline | mins | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | |
| Pumping mixture | mins | 36 | 37 | 36 | 38 | 38 | 38 | 37 | 35 | |
| Cleaning pipeline | mins | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | |
| Pumping downtime | mins | 338.3 | 321.2 | 299.8 | 274.2 | 268.6 | 253.9 | 244.1 | 272.8 | |
| Filling pipeline flowrate | $m^3/s$ | 3.43 | 3.49 | 3.20 | 3.49 | 3.49 | 3.48 | 3.34 | 3.11 | |
| Pumping mixture flowrate | $m^3/s$ | 3.18 | 3.19 | 2.97 | 3.07 | 3.04 | 2.98 | 3.05 | 2.94 | |
| Cleaning pipeline flowrate | $m^3/s$ | 3.43 | 3.49 | 3.20 | 3.49 | 3.49 | 3.48 | 3.34 | 3.11 | |
| Mixture Solids Conc. | $t/m^3$ | 306 | 318 | 306 | 360 | 371 | 393 | 318 | 295 | |
| Total Solids Mass Pumped | t | 52,622 | 42,752 | 17,669 | 171,525 | 316,044 | 202,868 | 36,592 | 7,271 | **847,343** |
| Total Solids Vol. Pumped | $m^3$ | 54,815 | 44,533 | 18,405 | 178,672 | 329,212 | 211,321 | 38,117 | 7,574 | **882,649** |

### 4.4 Scenarios

The following scenarios were simulated by altering the intake location through the simulation – Scenario 1 is the primary concept being examined in this report:

- Scenario 1 - Dredge material will enter the DMPA from the southern end initially for the disposal of the PASS material (320,000m$^3$), with a tailwater discharge point at the northern end. The dredge material inflow point will then relocate to the northern end for the remainder of the dredge program, with the tailwater discharge point to be located at the southern end.
- Scenario 2 – all material pumped from the northern end.

### 4.5 Simulation Period

Outcomes from the DMPA simulations have been reported at:

- the end of the dredging campaign: to estimate short term bulking factors and storage requirements; and
- 4-6 months after the end of dredging: to estimate expected consolidation prior to the commencement of the following wet season.
- 16-18 months after the end of dredging: to estimate expected consolidation in the medium term

## 5 Results

BMT JFA (2017) have previously reported on model calibration details, which can be found in Chapter 5 of the Dredging and Dredge Material Assessment Report.

Modelling of the dredge placement scenarios was undertaken and the resultant average material placement parameters are reported in Table 5-1. Figure 5-1 indicates the densification of the material over the duration of the simulation, and Figure 5-2 illustrates the dry density profile at key reporting intervals at northern and eastern locations within the placement area. Figure 5-3 indicates the modelled spread of the PASS material (320,000m$^3$) that is placed at the beginning of the dredge program into the southern end of the placement site.

Regarding the overall performance:

- Each of the modelled scenarios may be considered to fit within the placement area satisfying placed volume requirements, subject to application of tailwater management measures (refer Section 7.2).
- The PASS material is predicted to remain below -1m AHD at all times, and below a layer of non PASS material at completion of the dredging.

Regarding the tailwater quality:

- Tailwater management measures will be required throughout the campaign, and in particular during the last 7 days when there may be acute periods of turbidity exceedance corresponding to the pumping cycle (Figure 5-4). The peak surface water concentrations at the discharge location in the model are around 20 g/L, which is low relative to fluid mud (whilst still requiring clarification). As the model does not have a feedback loop for reactive water quality management options (such as short term water level increases) the results reflect a case where no measures are implemented – which would not be the case in practice. The other feature to note is the high outfall concentrations at the time when the flow direction is reversed. This is mainly a product of the limitations of the modelling approach, in which high concentrations are present immediately adjacent to the new outfall upon flow direction reversal – in practice, the tailwater would be monitored to ensure release concentrations were acceptable, and the outfall would be located away from the intake. Further details and recommendations on appropriate water quality management measures are provided in Section 7.2 below.

- Based on the results of the modelling it is anticipated tailwater quality can be managed sufficiently without the need for the provision of an additional “polishing” pond.

**Table 5-1 Simulation results**

| Model Designation | Avg. Settled Bed RL (m) | Sufficient Capacity in DMPA | *Avg. placed dry density ($kg/m^3$) |
|---|---|---|---|
| Scenario 1 | | | |
| - end of dredging | 4.0** | Yes | 337 |
| - 6 months | 3.0 | Yes | 372 |
| - 18 months | 0.9 | Yes | 506 |
| Scenario 2 – end of dredging | 4.0** | Yes | 331 |

*represents the average settled material dry density of material above 100 $kg/m^3$
**average settled bed level is assessed 24 hrs after dredge campaign completion to allow a defined bed to form

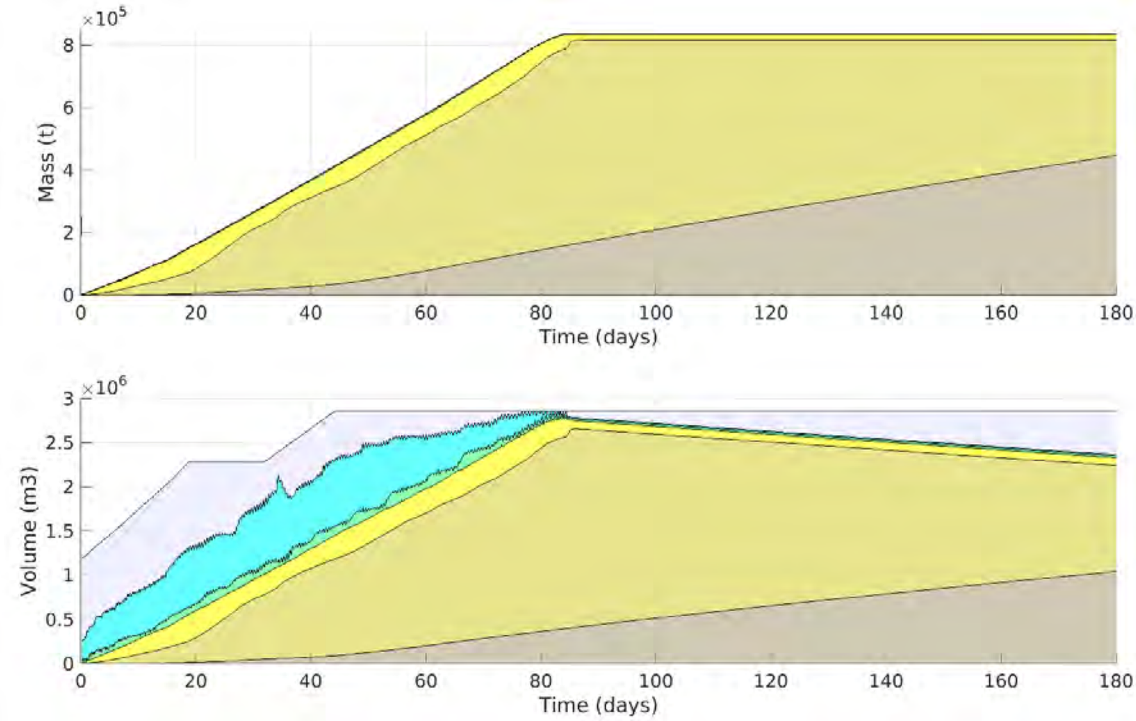



**Figure 5-1: Progressive placed mass, stored volume, and proportions of material in the disposal site for Scenario 1. The grey is clean supernatant while the light blue is supernatant which is beyond the 100 mg/l limit but still of low concentration. Light yellow is fluid mud while dark yellow and brown are self-weight consolidating mud.**

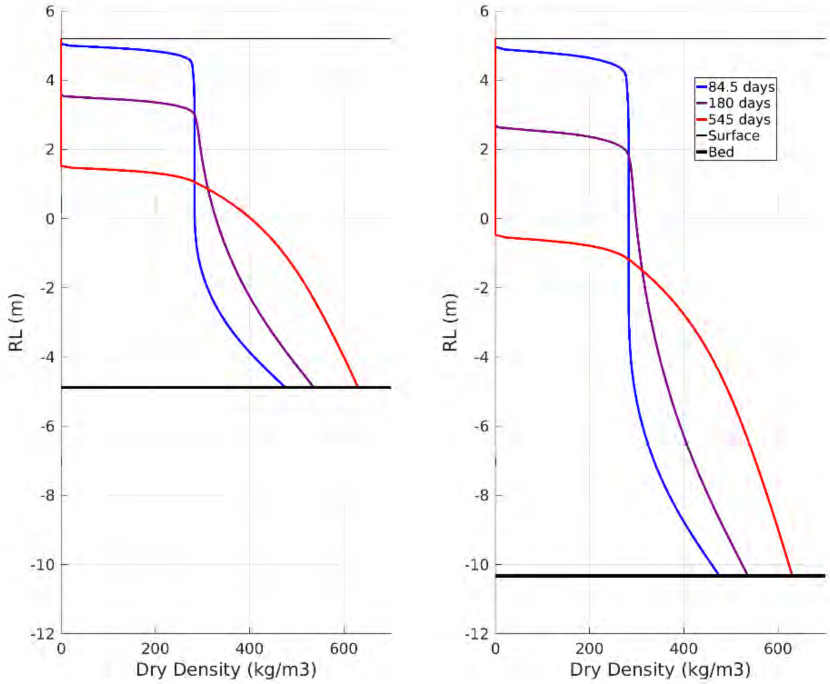



**Figure 5-2: Vertical density profile results in the northern (left) and eastern (right) zones of the placement area, at several time points (measured from the start of the dredging campaign), Scenario 1**

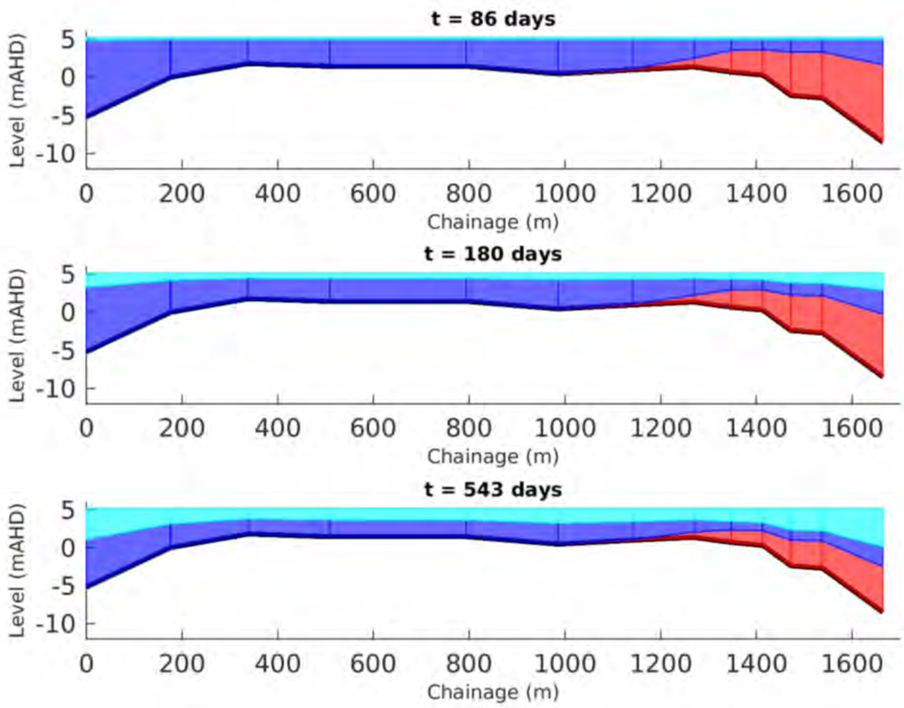



**Figure 5-3: Approximate distribution of PASS material for Scenario 1 (red). Chainage values are from north to south through the DMPA.**

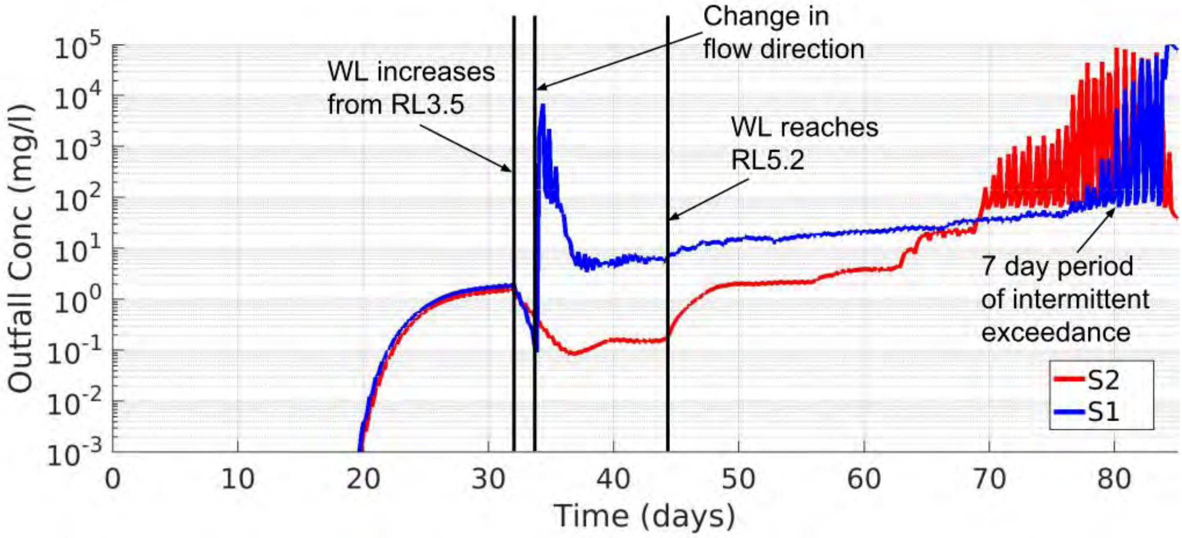



**Figure 5-4: Time Series of Outfall Concentration for Scenarios 1 and 2**

## 6 Summary

The following key results were obtained from the simulations:

- An average placed dry density at the completion of the dredging campaign (short-term) of 337 kg/m$^3$ was obtained with a settled bed level of +4.0m AHD. This figure includes the material trapped in suspension at the completion of the dredging campaign, as the solids rapidly settle out of the suspension to form the bed surface.
- An average placed dry density at the start of the wet season (1 December) of 372 kg/m$^3$ was obtained with a settled bed level of +3.0m AHD.
- An average placed dry density at 18 months of 506 kg/m$^3$ was obtained, with a settled bed level of +0.9m AHD.
- The proposed containment area, with MOWL at RL 5.20 enclosing a storage volume of 2,757,900 m$^3$, has sufficient capacity to contain the dredged material (882,649m$^3$ with an in-situ dry density of 0.96 t/m$^3$).
- Whilst the model outputs indicates periods of exceedances of water quality thresholds near the end of the program, this can be managed through implementation of management measures such as those outlined below. Particular attention is likely to be required over the last week of the campaign.

## 7 Discussion and Recommendations

### 7.1 Solids Storage Capacity

It is noted the final assessed placed density (and hence volume occupied in the disposal area) and the associated inferred bulking factor are influenced by a range of variables in both the dredge material properties and the dredging methodology (including duration, average inflow rates and concentrations). The laboratory results (standard column) achieved dry densities up to 400-450kg/m$^3$, whilst the DMCAT model indicated lower densities in the range of 337kg/m$^3$ upon completion of placement (with density increasing from there over time). Accordingly, flexibility to accommodate possible variations is in our view an appropriate risk-mitigating approach.

Noting the potential variability of the bulking factor that may result in practice, it is recommended that the following contingencies and management measures be included for to mitigate risk:

1. *Increases in the dredging volume, or lower settled densities, could be accommodated through a greater excavation of material from the disposal site prior to the start of dredging.*
2. *The settled dry density increases over time, thus reduction of the average dredge productivity (ie extension of the dredge program) will provide for increased capacity in the pond.*
3. *Discharging of the material around the pond, at depth into the pond via multiple outlets will assist in the even distribution of material into the pond and water quality management of the tailwater.*

### 7.2 Tailwater Quality

Tailwater discharge quality limits may be exceeded towards the end of the dredging campaign when the ponding water available for supernatant clarification is at a minimum, and subject to influence by short term wind conditions. As the duration of exceedance for Scenario 1 is relatively short it is expected that suitable tailwater discharge quality can be achieved with the nominated pond capacity. Measures to further address intermittent discharge water quality exceedances include:

- Active management of water levels (and hence available capacity) in the primary pond by drawing down water levels as much as is practical in advance of periods when the discharge water quality is forecast to exceed allowable discharge quality limits.
- Incorporation of internal bunds to hold back deposited sediments and allow for skimming of supernatant waters prior to discharge.
- Short term, temporary water level increases (through raising the boards in the weir box) will increase retention times and assist in settlement of fine material to improve tailwater quality.
- Reduction in dredge production rates, either via reduced cycle times, or temporary standby for the dredge.

## 8 Limitations and Considerations

The outcomes of the completed study are considered suitable to inform the overall project definition and provide input design parameters for the development of the DMPA design and EIS studies.

Key limitations to take into consideration for this study are summarised as follows:

- Material sampling and testing – the model has been calibrated to laboratory testing of one composite sample, composed of grab-samples from two locations within the Capital dredging profile. The samples are expected to be representative of similar materials identified from the geotechnical investigation but natural variations can and do occur.

- Deterministic simulations – the input parameters (including dredge pumping rates and concentrations) adopted for the model simulations are either based on professional judgements (in the case of dredging productions), or considered to represent the median, or best-fit, input value (such as the material properties). Sensitivity or stochastic simulations have not been completed to assess the possible range in placement storage or area requirements. The current DMPA sizing does however have additional capacity to accommodate any conservatism that may be present and thus the risk of insufficient capacity is lowered.
- Water salinity – water salinity is known to affect the flocculation settling and consolidation of fine grained sediments by affecting the size of flocculated particles. At the time the laboratory testing was initiated, an alternate placement location (East Trinity) which involved dredged material placement in seawater was still under consideration. At Northern Sands, the existing water is known to be of lower salinity, however the pumped slurry entering the DMPA is mixed with seawater. It is not expected this will have a large effect on the final placement outcomes but may be addressed by future studies.
- Test apparatus – the proposed depth of placement (approximately 12m) is considerably larger than the placement depths tested in the laboratory. The model's predictive capability has been confirmed for placements to the height of the test apparatus (2m), and it is expected to be accurate for larger heights, consistent with BMT JFA's experience.
- The modelling does not take into account any effects of wind waves causing resuspension of fines into the supernatant water. This may impact on the water quality at the discharge point (noting that water quality management measures previously discussed may also be suitable to manage these events).
- No groundwater seepage (inwards or outwards) is included in the numerical model.
- In the numerical modelling, following completion of material placement the water level remains at a constant level (material remains saturated). In practice it would be viable to draw down and drain the surface water (in addition to evaporation) which may result in surface drying of the placed material over time and improvements to the dry density and finished surface levels.

## 9 References

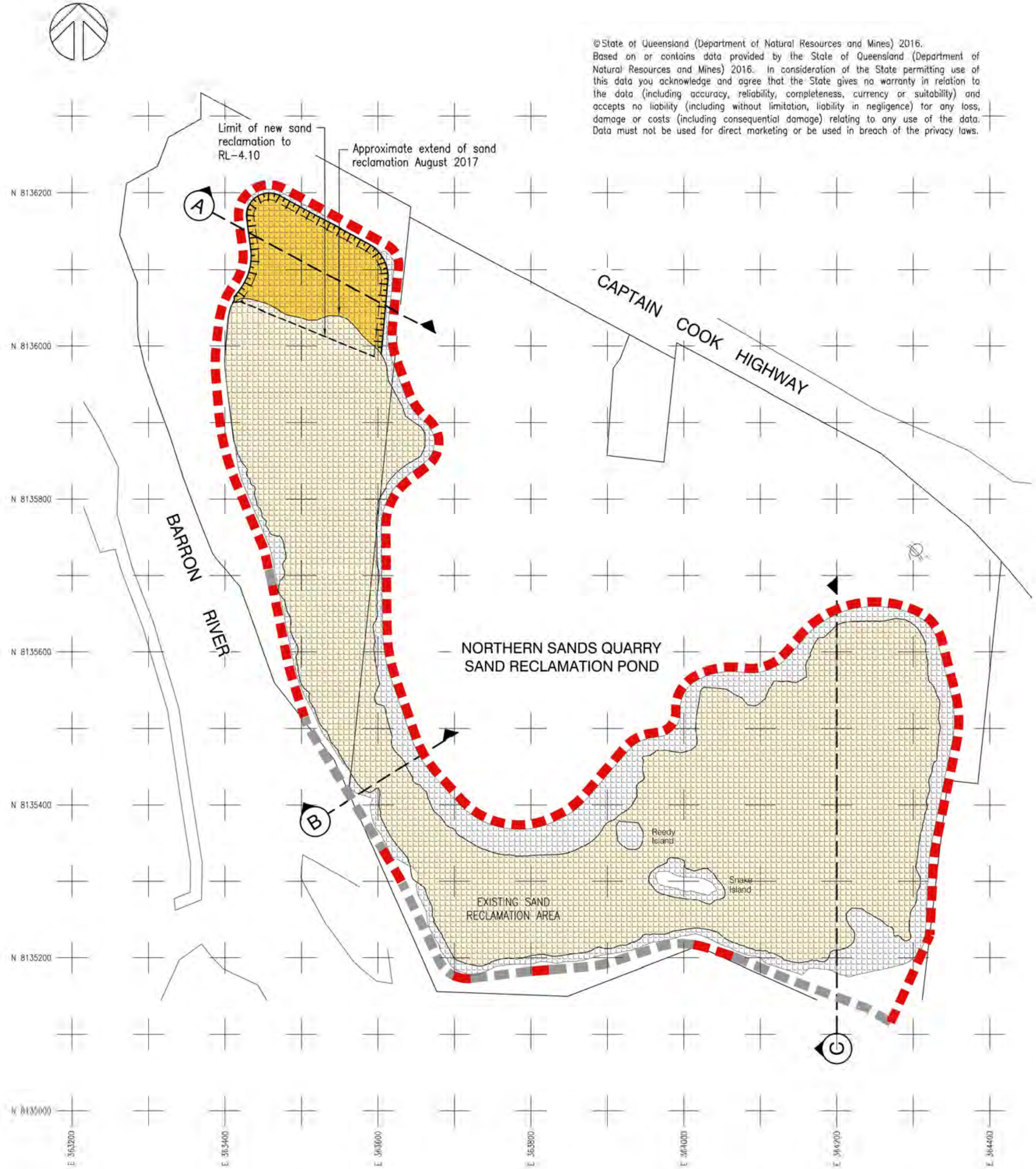
Akuna Dredging Solutions Limited 2017, *Budget Cost Estimate, Trailer Suction Hopper Dredge Scope,* (Appendix Z of Revised EIS for Cairns Cruise Ship Development Project).

BMT JFA 2017, *Dredging and Dredge Material Placement Report*, Ref: R-16021-2 (Appendix AC of Revised EIS for Cairns Cruise Ship Development Project).

## Document Control:

| Rev | Issue | Prepared by | Submitted to | Date | Copies |
|---|---|---|---|---|---|
| A | Draft – Internal Review | TG | ZC | 12.10.17 | 1 elec |
| B | Draft – Client Review of Assumptions | TG | FCG, BMT WBM | 16.10.17 | 1 elec |
| C | Draft – Updated Assumptions for Review | TG | FCG, BMT WBM | 17.10.17 | 1 elec |
| 0 | Issued to Client for Review | ZC | FCG, BMT WBM | 31.10.17 | 1 elec |
| 1 | Issued for Use | TG | FCG, BMT WBM | 03.11.17 | 1 elec |

# ATTACHMENT 1:
# NORTHERN SANDS DREDGE MATERIAL PLACEMENT CONCEPT
# DRAWING 3527-SK14D
# DRAWING 3527-SK15A




## DREDGE MATERIAL PLACEMENT ZONE

1:3000

## STORAGE VOLUMES

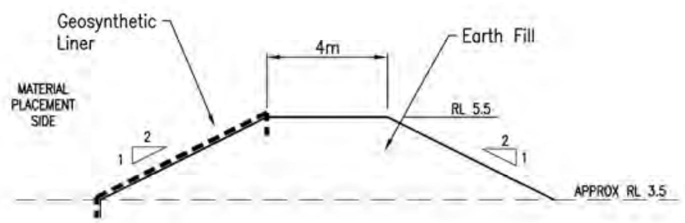
| LEVEL (AHD) (m) | VOLUME BELOW ($m^3$) | COMMENT |
|---|---|---|
| 5.50 | 2,861,218 | Top of Bund |
| 5.07 | 2,704,283 | Top of Water at end of placement |
| 5.00 | 2,678,922 | |
| 4.50 | 2,499,222 | |
| 4.07 | 2,347,020 | Top of Material at end of placement |
| 4.00 | 2,322,488 | |
| 3.69 | 2,214,742 | Top of Water at end of 2019 |
| 3.50 | 2,149,522 | |
| 3.00 | 1,980,296 | |
| 2.69 | 1,878,100 | Top of Material at end of 2019 |
| 2.50 | 1,813,865 | |
| 2.00 | 1,650,110 | |
| 1.50 | 1,489,590 | |
| 1.00 | 1,332,605 | |
| 0.50 | 1,182,965 | |
| 0.00 | 1,044,381 | Lowest Groundwater Level |
| -0.50 | 906,260 | |
| -0.59 | 882,650 | Top of Material at end of settlement |
| -1.00 | 769,307 | |
| -1.50 | 637,009 | |
| -2.00 | 518,746 | |
| -2.50 | 418,862 | |
| -3.00 | 340,807 | |
| -3.50 | 278,403 | |
| -4.00 | 226,313 | |
| -4.50 | 190,502 | |
| -5.00 | 161,571 | |
| -5.50 | 136,119 | |
| -6.00 | 113,693 | |
| -6.50 | 94,419 | |
| -7.00 | 77,728 | |
| -7.50 | 64,196 | |
| -8.00 | 52,556 | |
| -8.50 | 41,997 | |
| -9.00 | 32,618 | |
| -9.50 | 25,109 | |
| -10.00 | 19,484 | |
| -10.50 | 14,766 | |
| -11.00 | 11,156 | |
| -11.50 | 8,191 | |
| -12.00 | 5,669 | |
| -12.50 | 3,849 | |
| -13.00 | 2,357 | |
| -13.50 | 1,121 | |
| -14.00 | 225 | |
| -14.50 | 0 | |

## LEGEND

- EXISTING SAND RECLAMATION AREA (approx 26.2ha)
- FUTURE SAND RECLAMATION AREA (approx 2.4ha)
- DREDGE MATERIAL PLACEMENT ZONE (approx 34.6ha – Surface Area at RL 3.50)
- EARTH BUND (RL 5.50 – approx 96,000$m^3$)
- EXISTING EARTH BUND (RL 5.50 or greater)

## NOTES

1. Volumes shown are approximate only and based on a combination of site hydrographic survey and LiDAR survey.
2. For Cross Sections depicting placement of dredged material at weekly intervals, refer Drg 3527-SK15.




Total Bund length approx 4000m. Comprising approx 3150m of new bund & 850m of existing surface above RL5.5

## PERIMETER EARTH BUND

NTS

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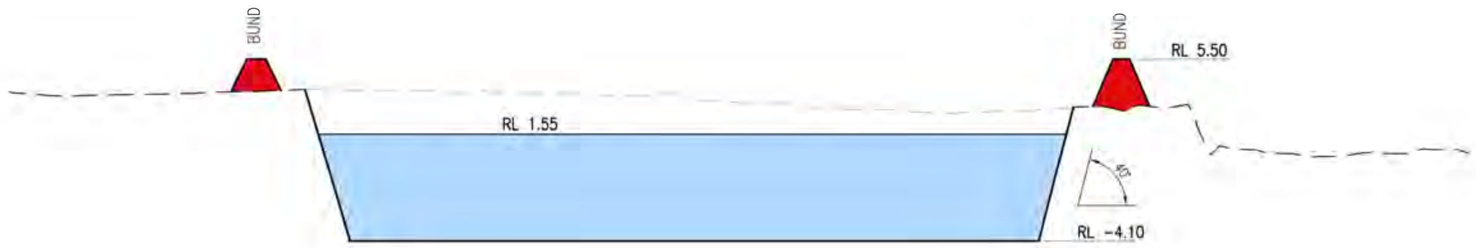
NORTHERN SANDS
Dredge Material Placement
Placement Zone Plan & Volumes

3527-SK14D

1:3000
A1 Full Size

Acad No. 3527-SK14D

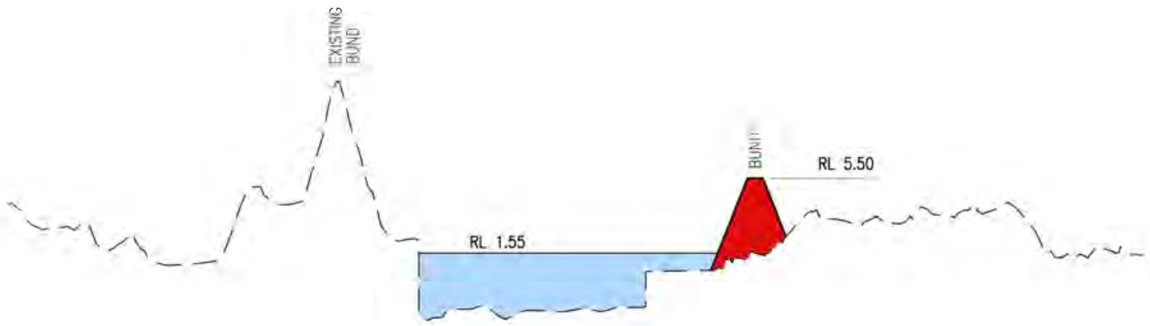
4 October 2017



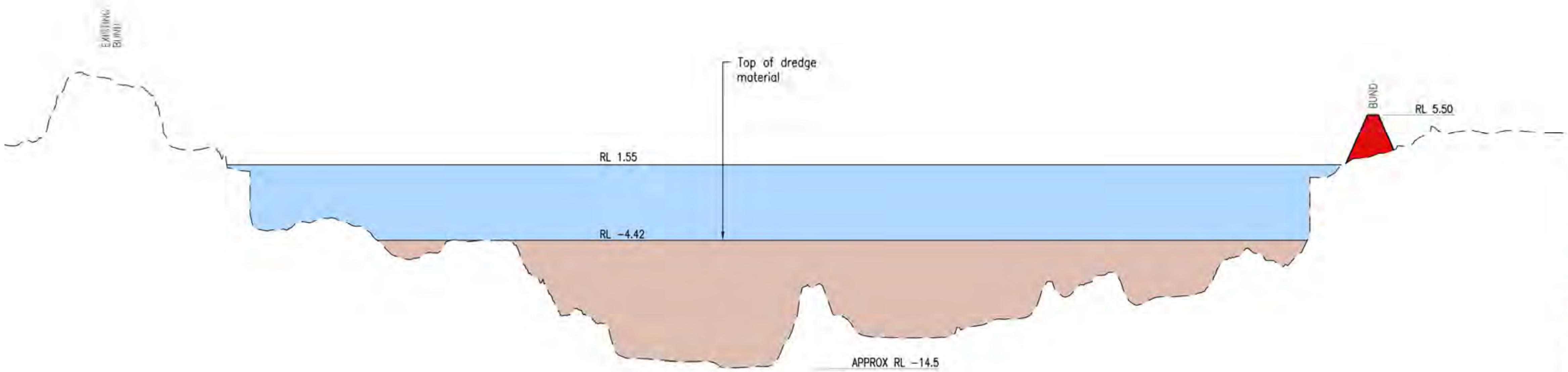

SECTION A

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund




SECTION B




SECTION C

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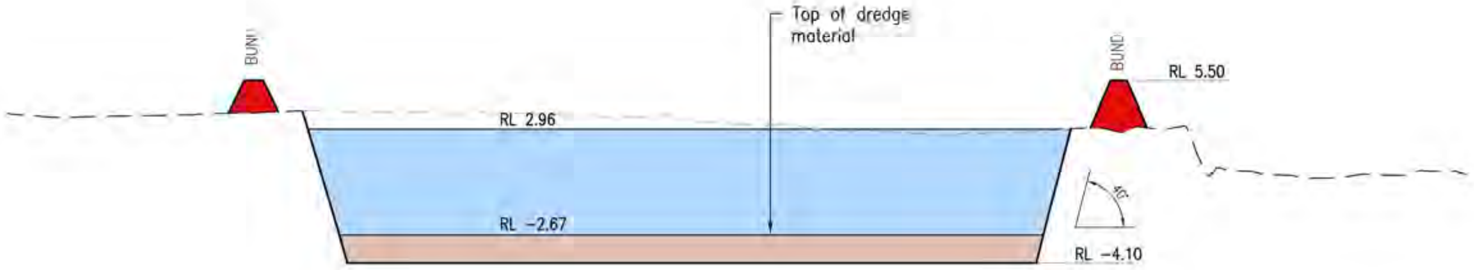
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 1

3527-SK15A — 1:1000H / 1:200V, A1 Full Size

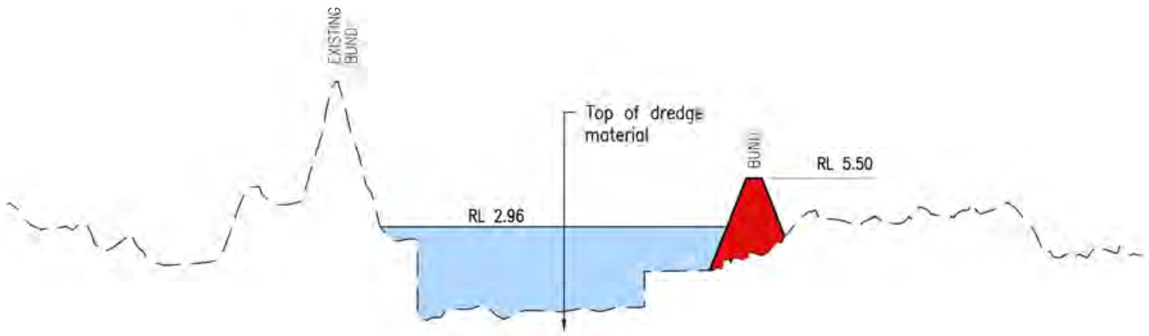
Acad No. 3527-SK15A — 5 October 2017



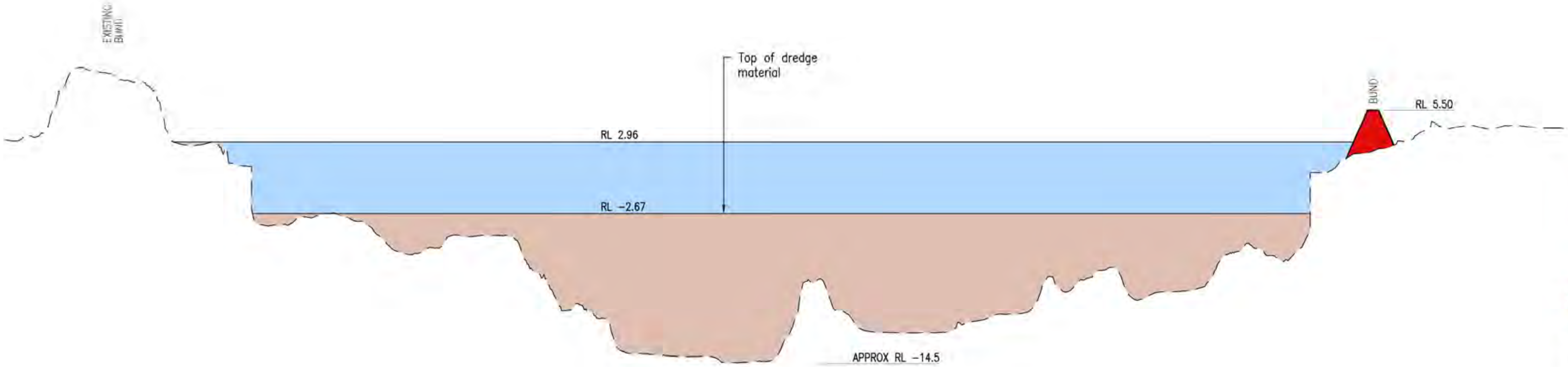

SECTION A

**LEGEND**

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund




SECTION B




SECTION C

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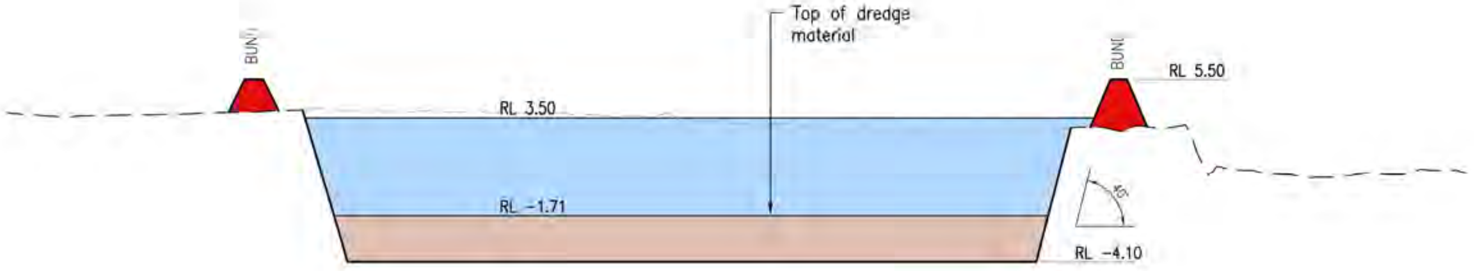
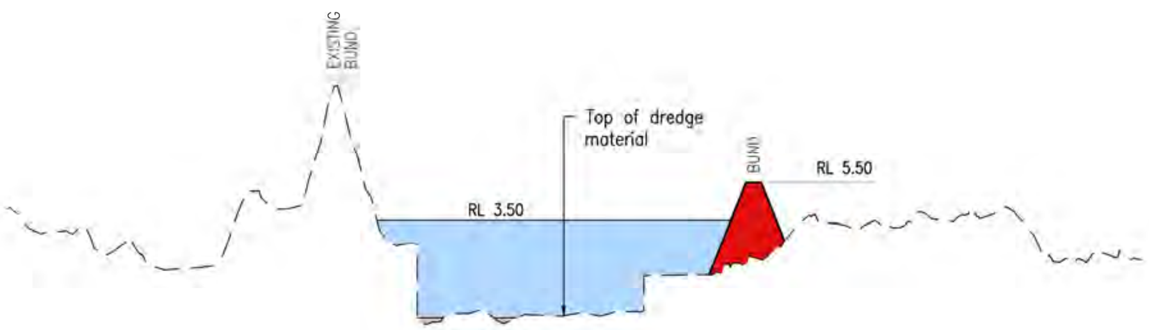
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 2

3527-SK15A — 1:1000H / 1:200V — A1 Full Size

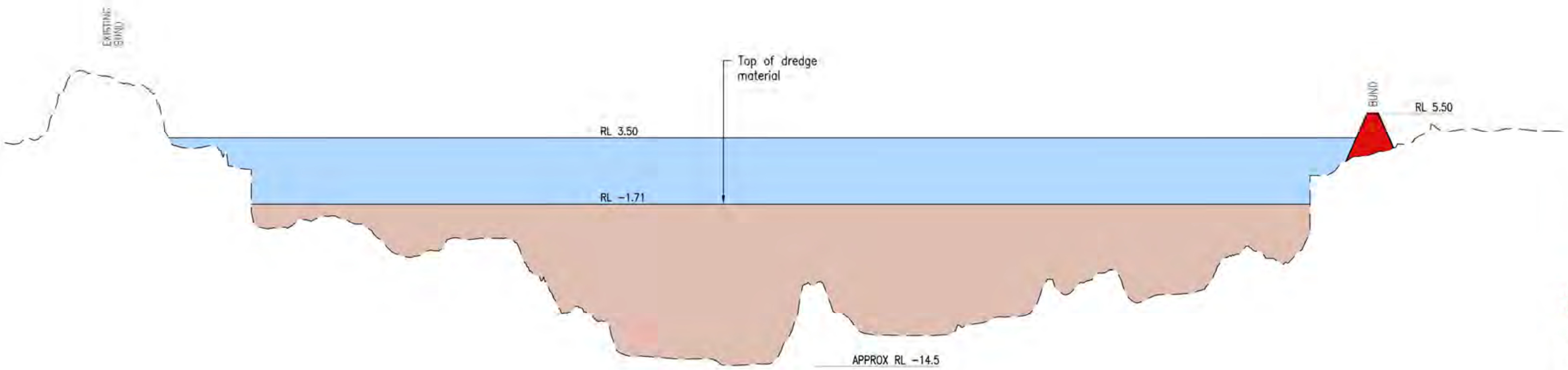
Acad No. 3527-SK15A — 5 October 2017




SECTION A




SECTION B




SECTION C

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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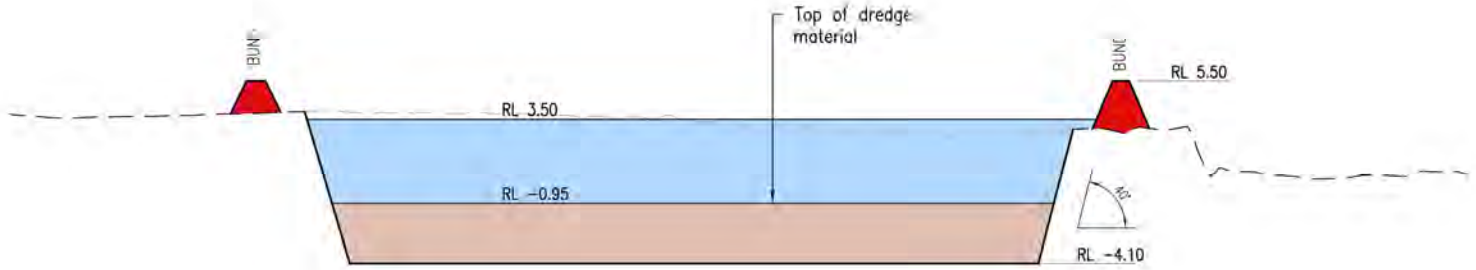
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 3

3527-SK15A
1:1000H / 1:200V
A1 Full Size

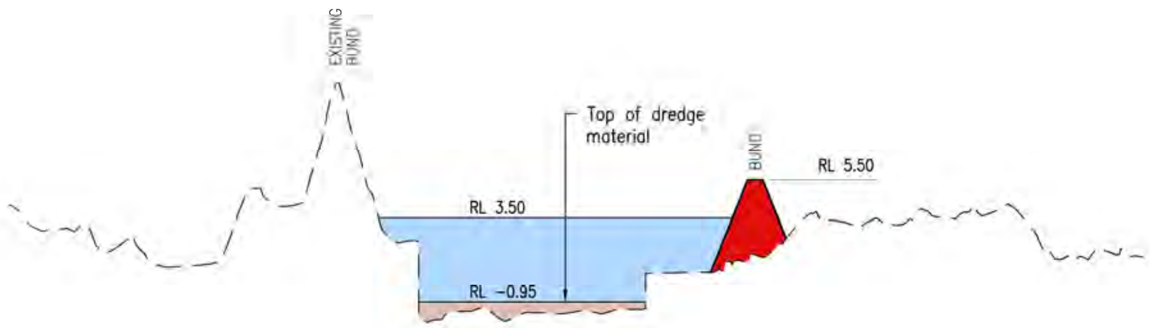
Acad No. 3527-SK15A
5 October 2017




SECTION A

**LEGEND**

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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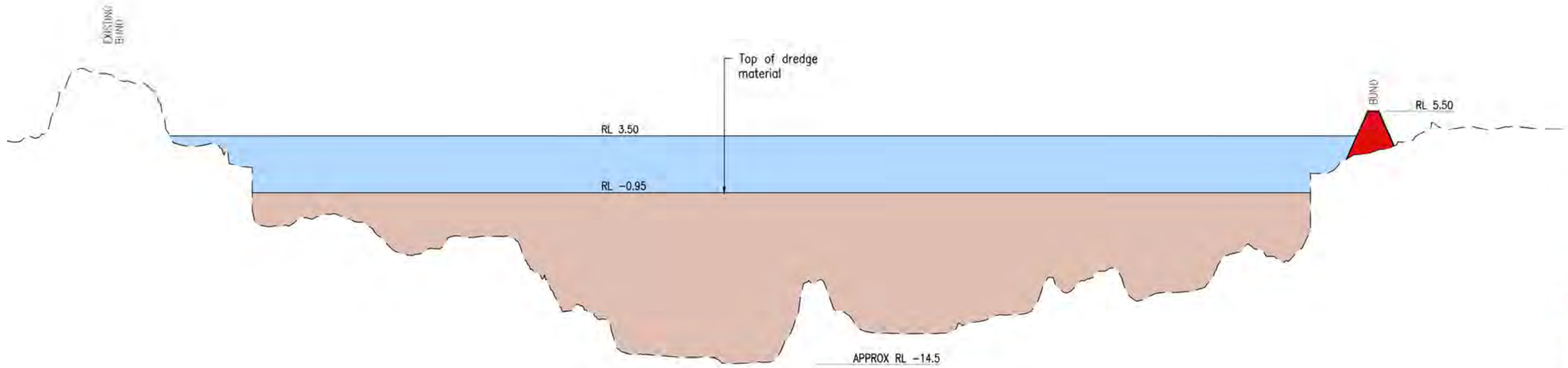


SECTION C

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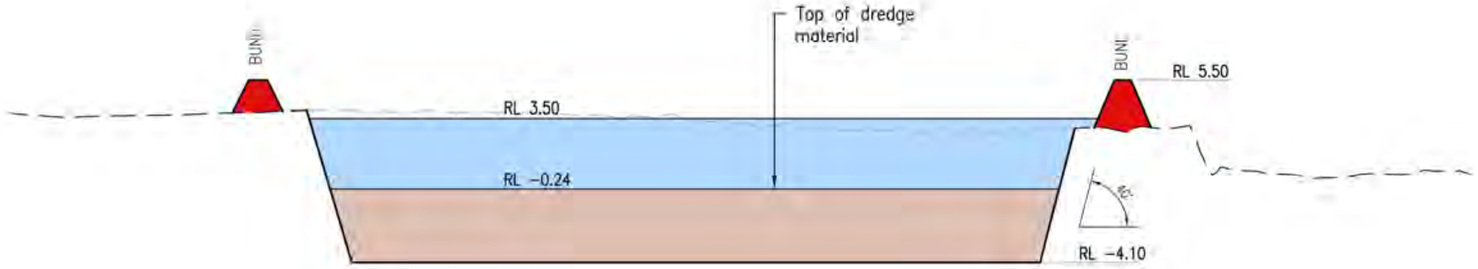
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 4

3527-SK15A — 1:1000H / 1:200V, A1 Full Size

Acad No. 3527-SK15A — 5 October 2017

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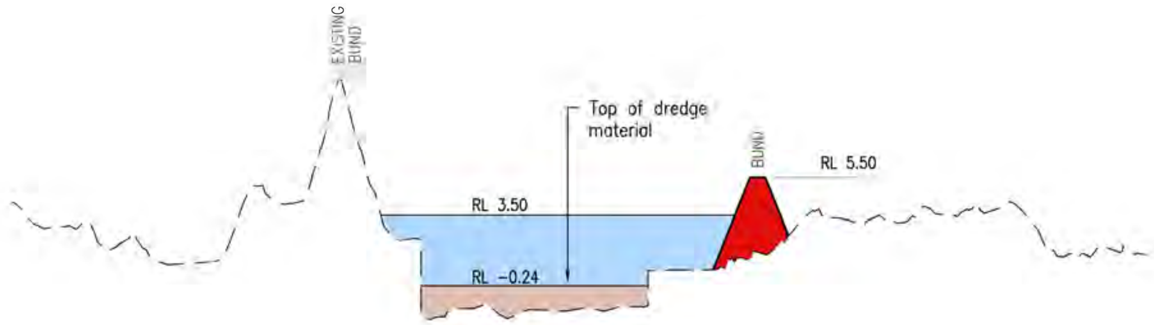


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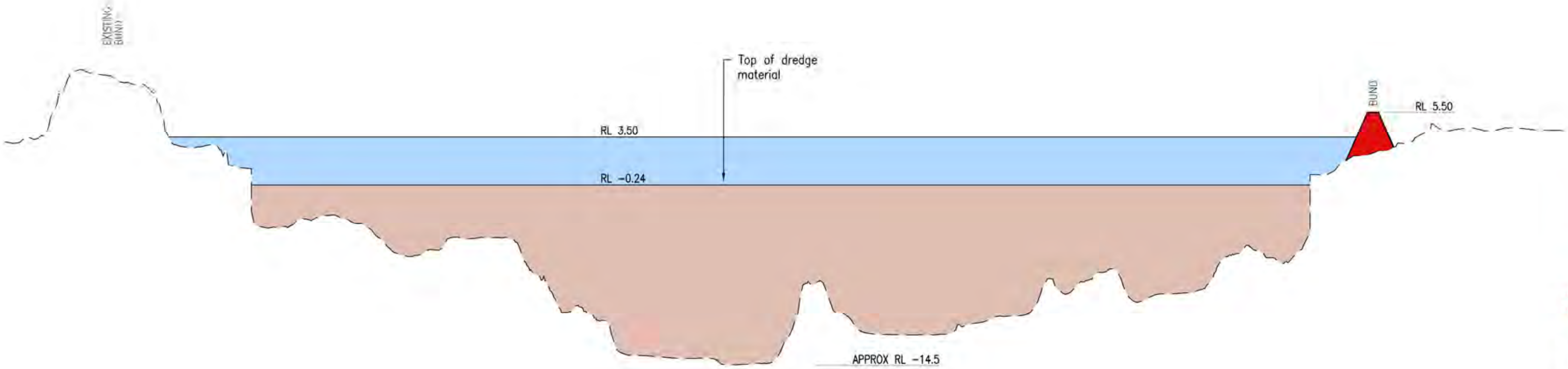


SECTION C

## LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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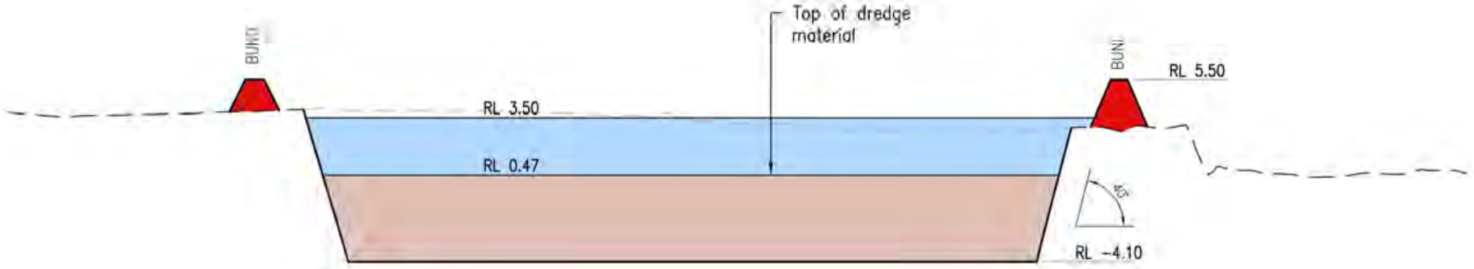
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 5

3527-SK15A
1:1000H / 1:200V
A1 Full Size

Acad No. 3527-SK15A
5 October 2017

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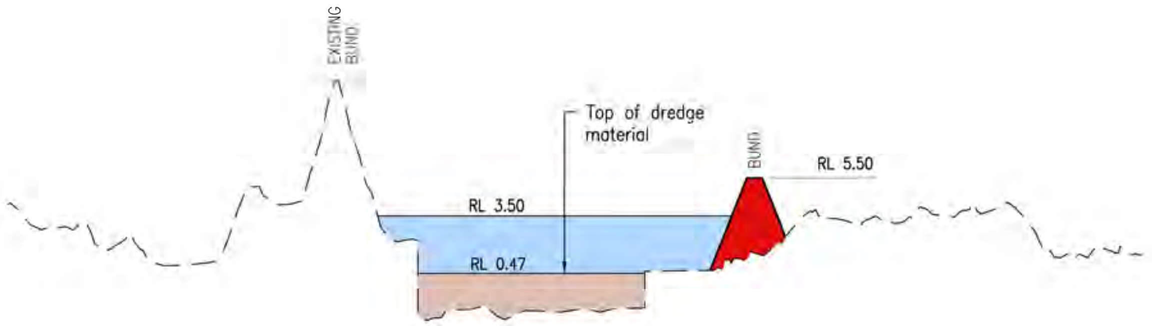


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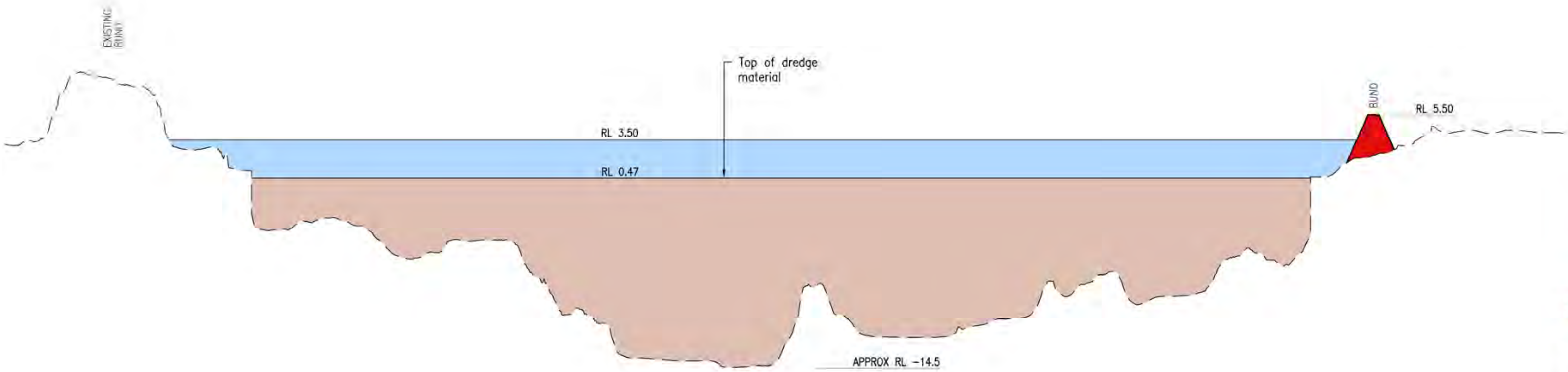


SECTION C

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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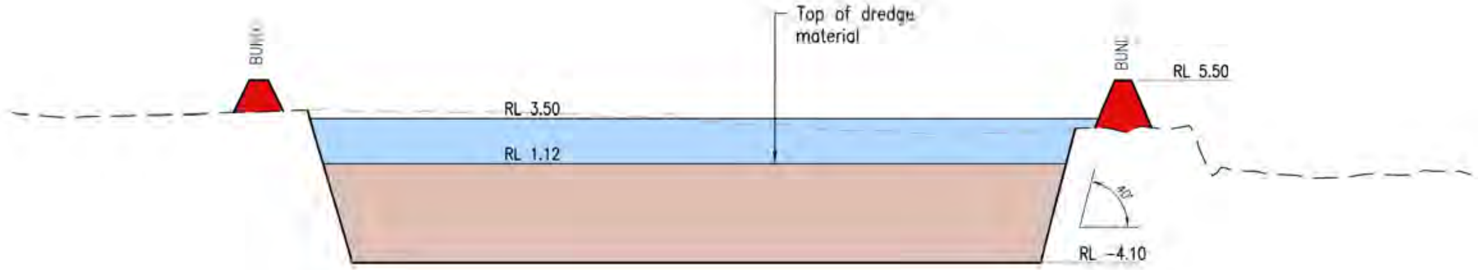
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 6

3527-SK15A
1:1000H / 1:200V
A1 Full Size

Acad No. 3527-SK15A
5 October 2017

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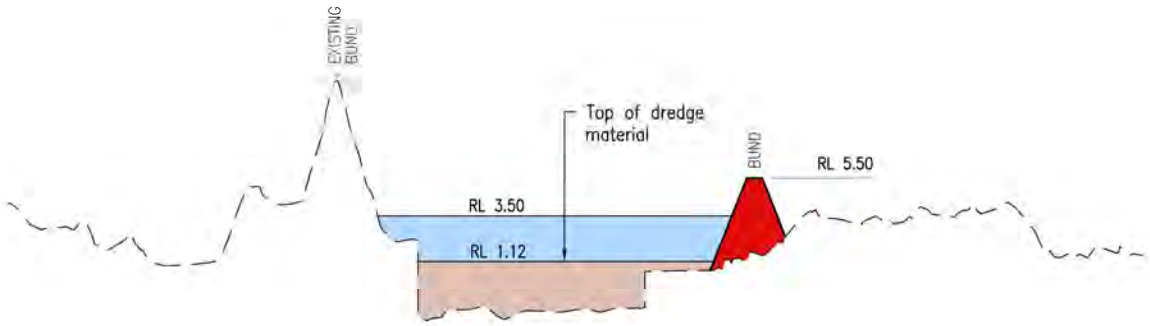


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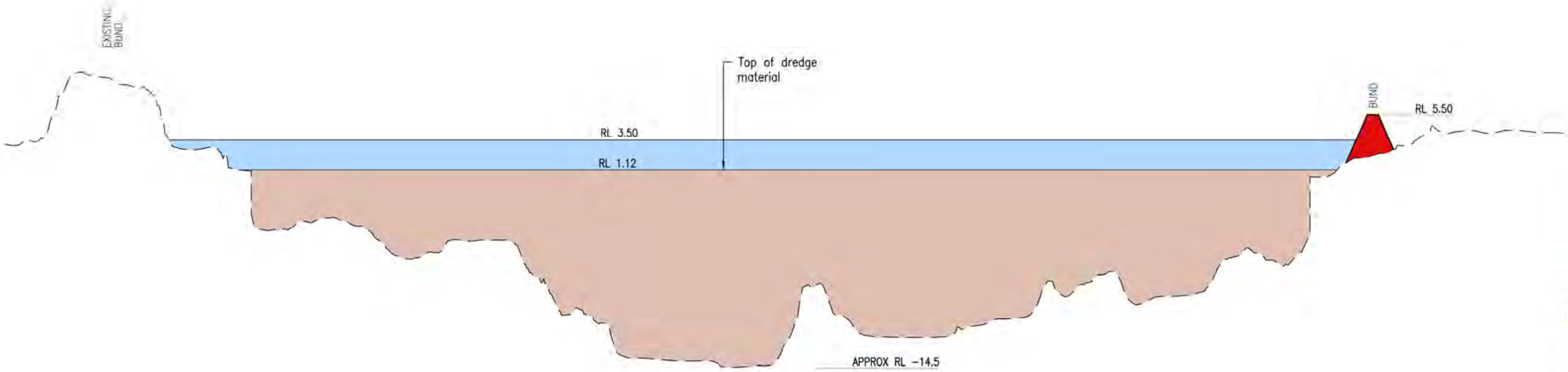


SECTION C

## LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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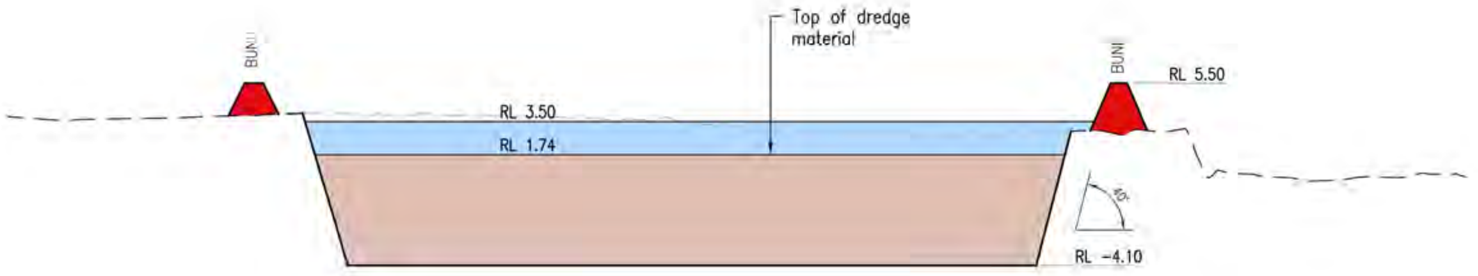
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 7

3527-SK15A
1:1000H / 1:200V
A1 Full Size

Acad No. 3527-SK15A
5 October 2017

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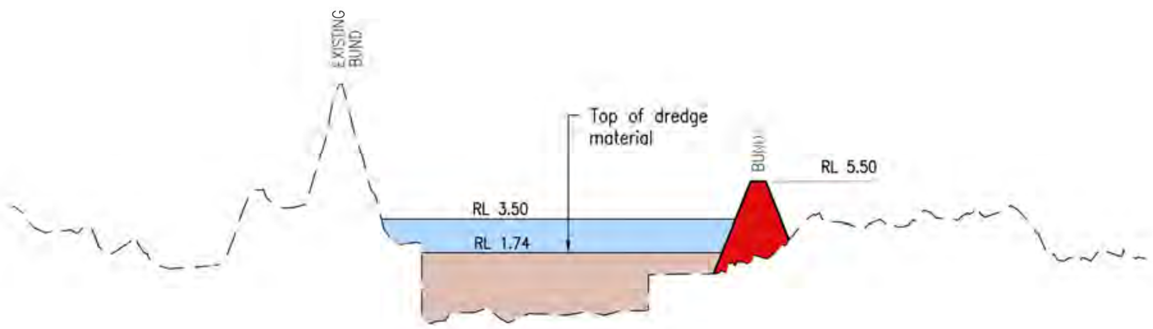


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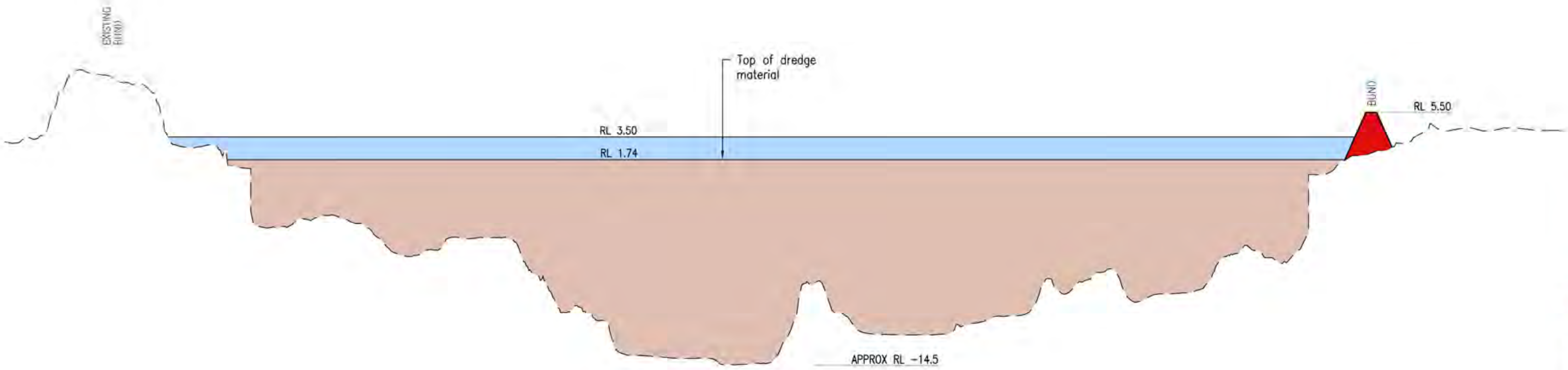


SECTION C

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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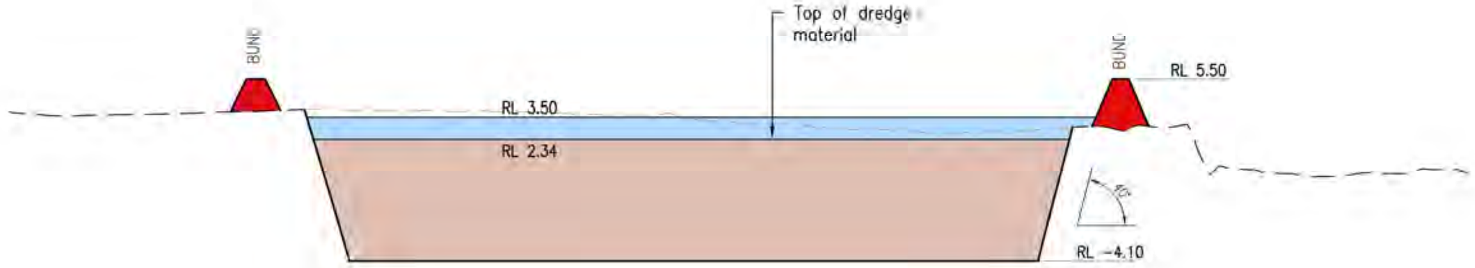
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 8

3527-SK15A — 1:1000H / 1:200V — A1 Full Size

Acad No. 3527-SK15A — 5 October 2017

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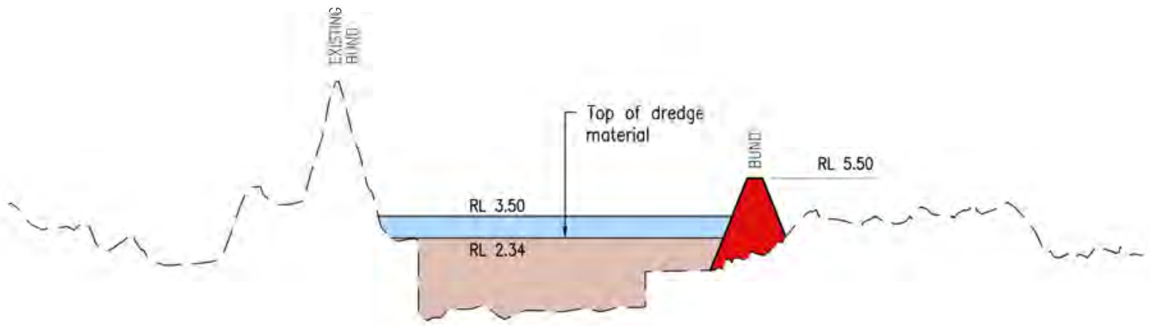


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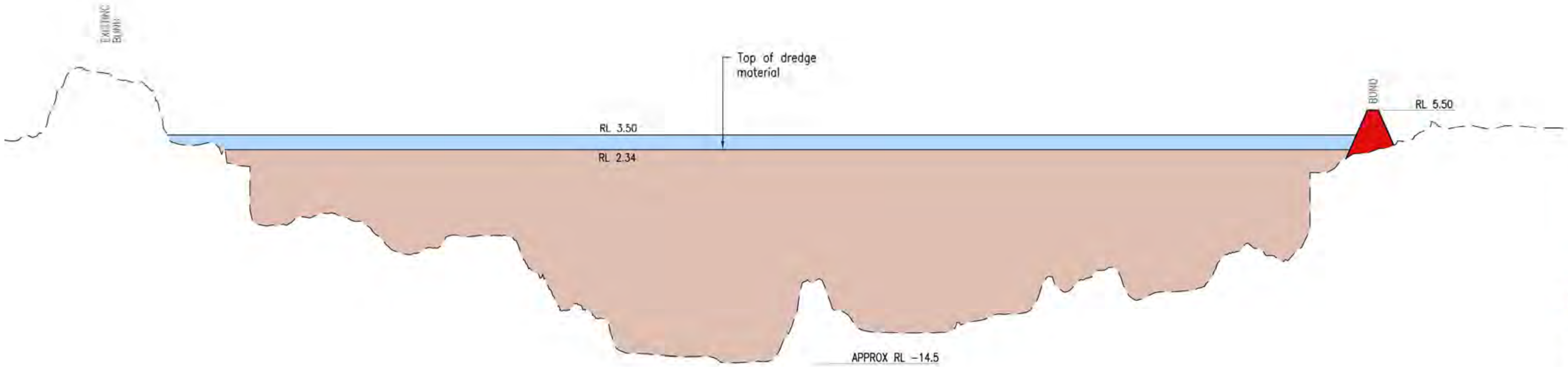


SECTION C

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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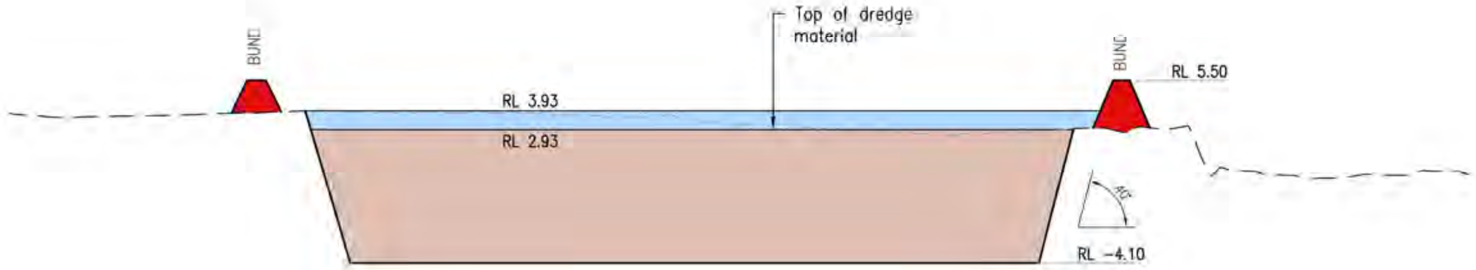
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 9

3527-SK15A — 1:1000H / 1:200V — A1 Full Size

Acad No. 3527-SK15A — 5 October 2017

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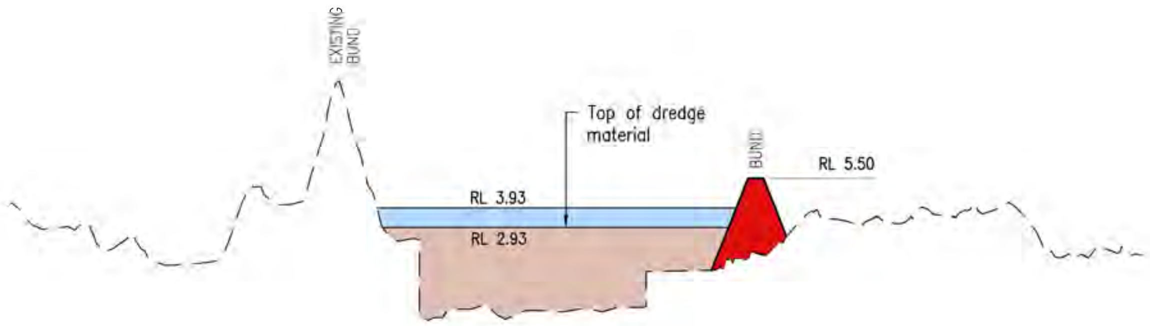


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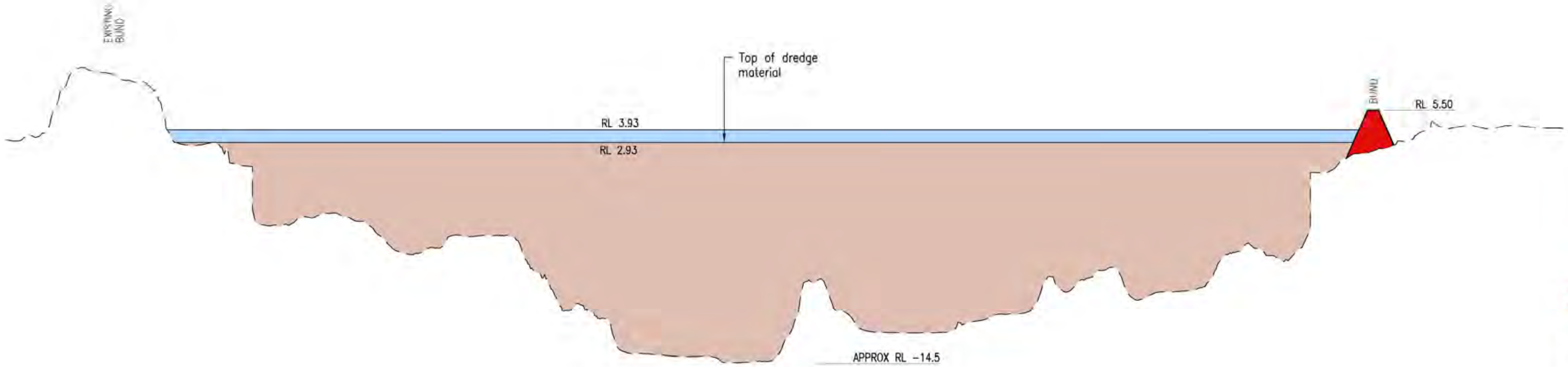


SECTION C

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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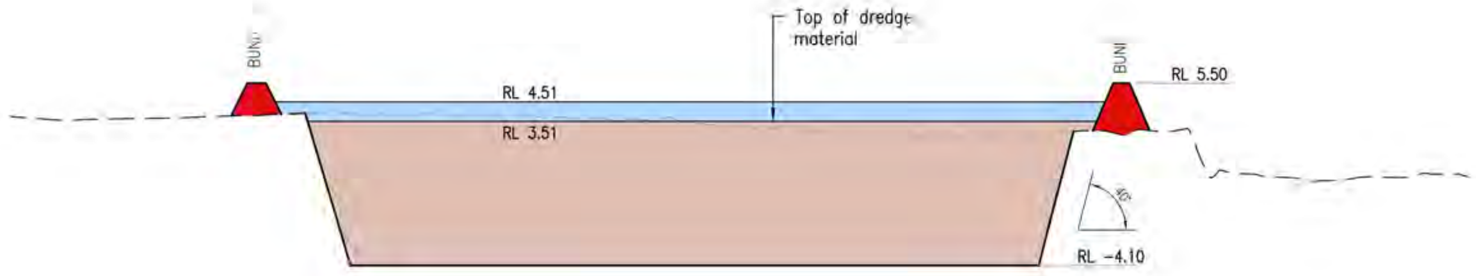
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 10

3527-SK15A — 1:1000H / 1:200V — A1 Full Size

Acad No. 3527-SK15A — 5 October 2017

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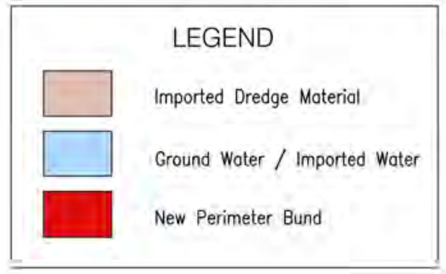
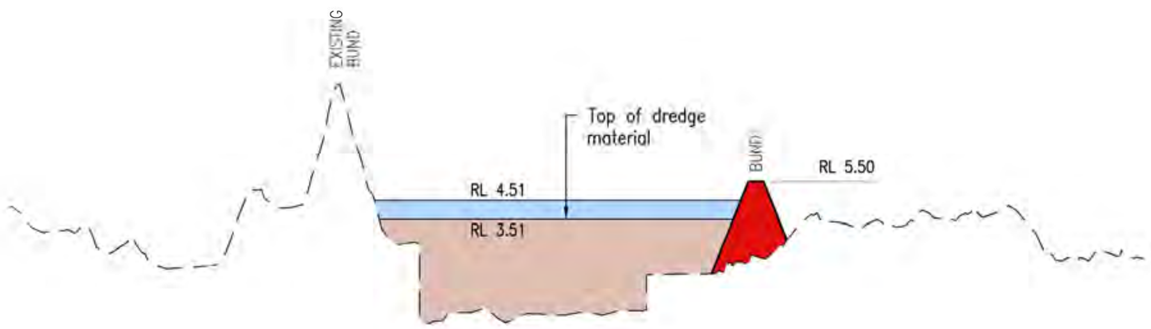
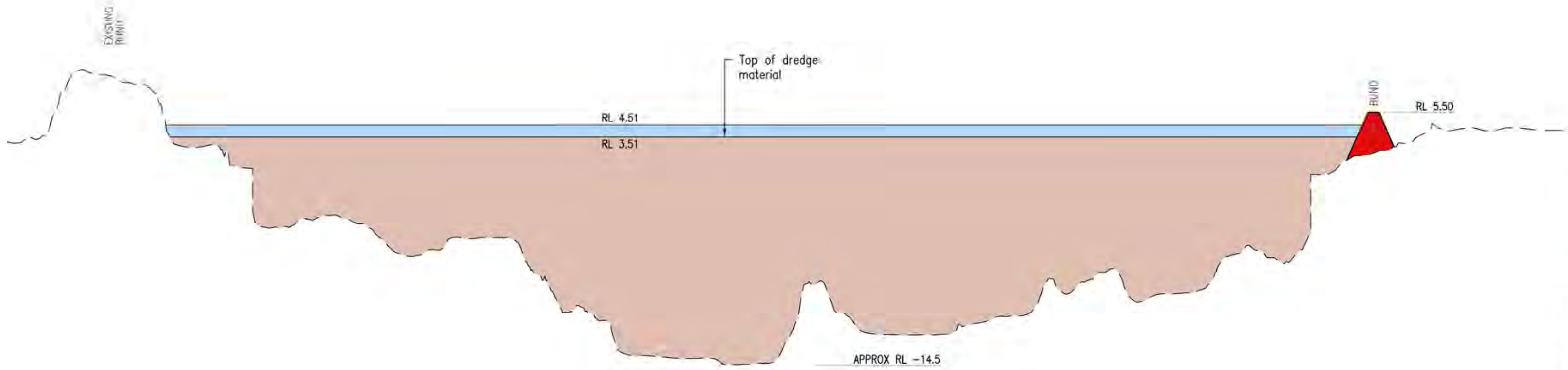



SECTION B




SECTION C

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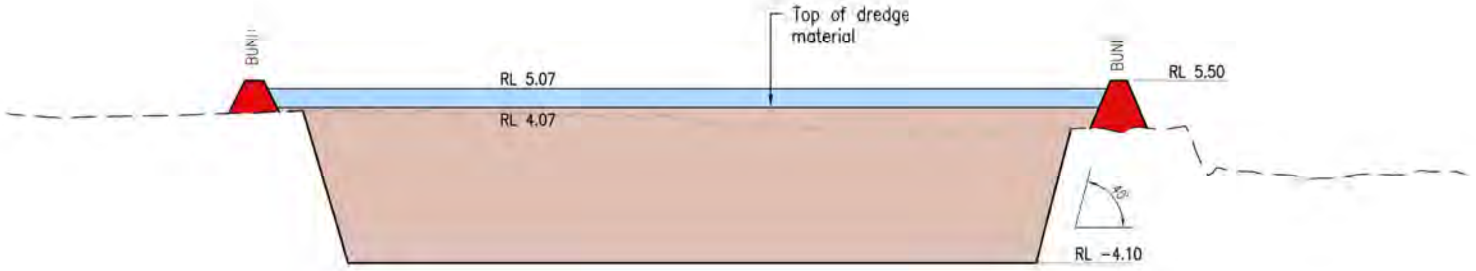
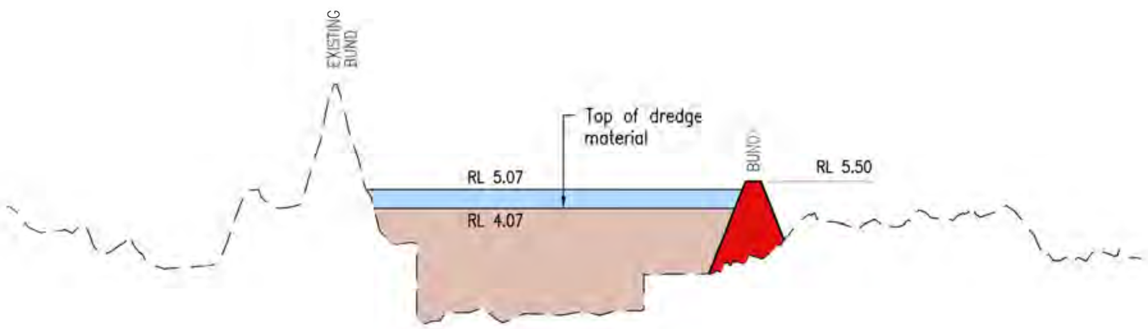
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 11

3527-SK15A — 1:1000H / 1:200V, A1 Full Size

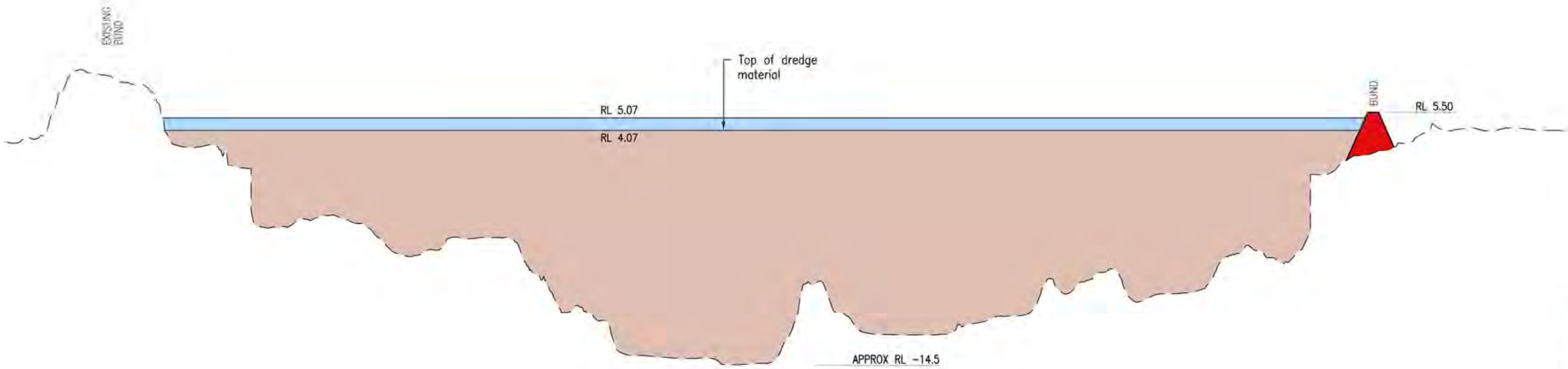
Acad No. 3527-SK15A — 5 October 2017




SECTION A




SECTION B




SECTION C

**LEGEND**

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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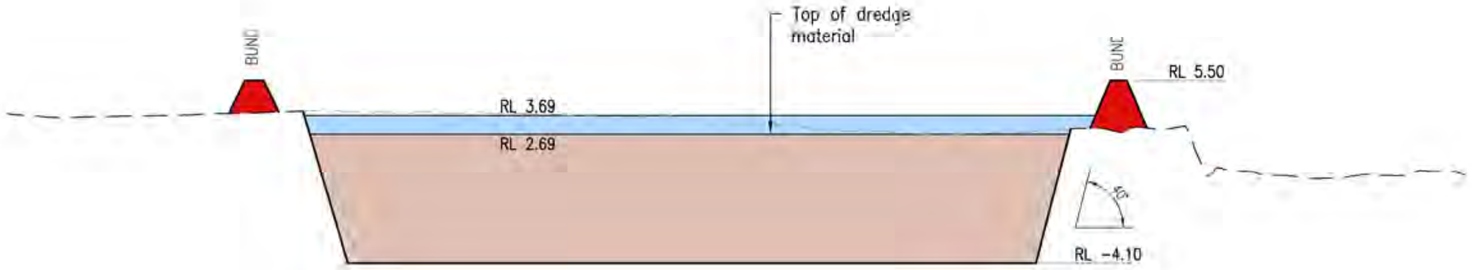
NORTHERN SANDS
Dredge Material Placement
Cross Sections
End of Week 12

3527-SK15A — 1:1000H / 1:200V, A1 Full Size

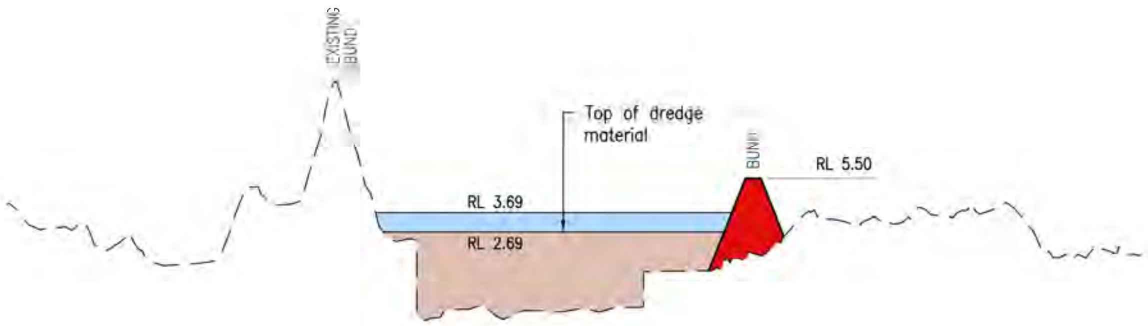
Acad No. 3527-SK15A — 5 October 2017



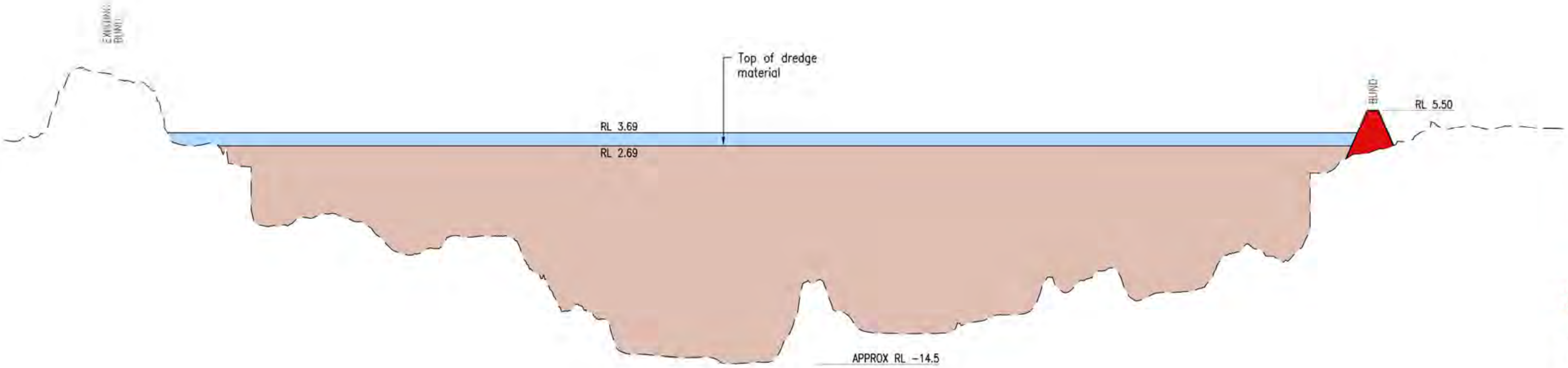

SECTION A

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund




SECTION B




SECTION C

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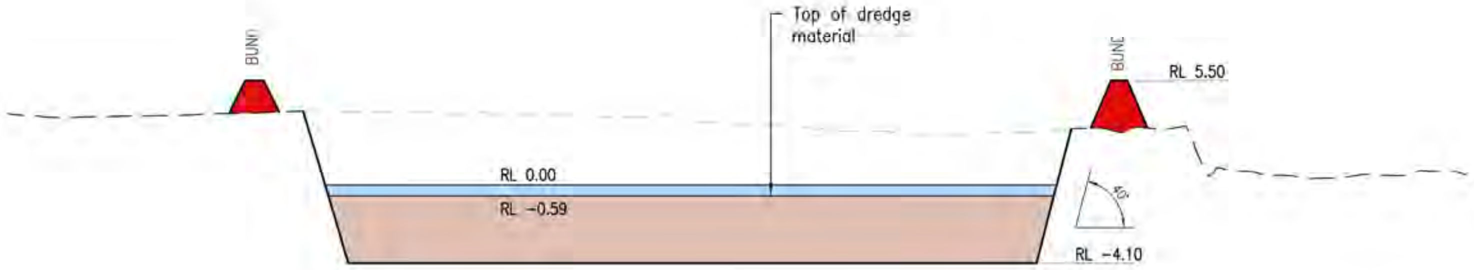
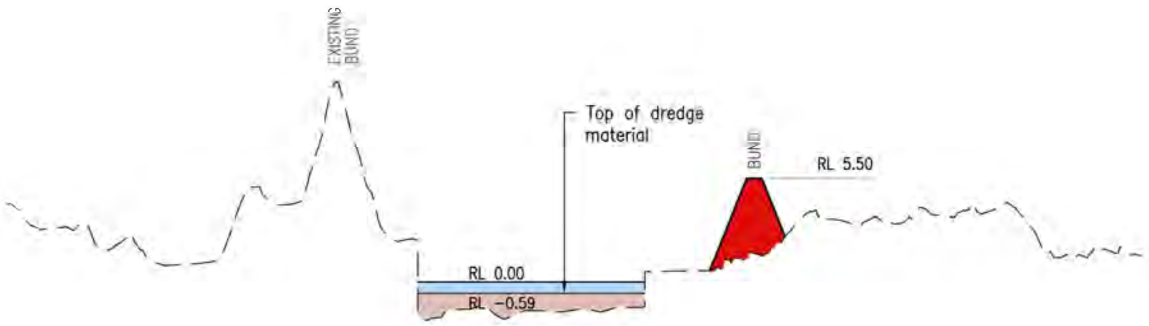
NORTHERN SANDS
Dredge Material Placement
Cross Sections
At End of Year 2019

3527-SK15A | 1:1000H / 1:200V | A1 Full Size

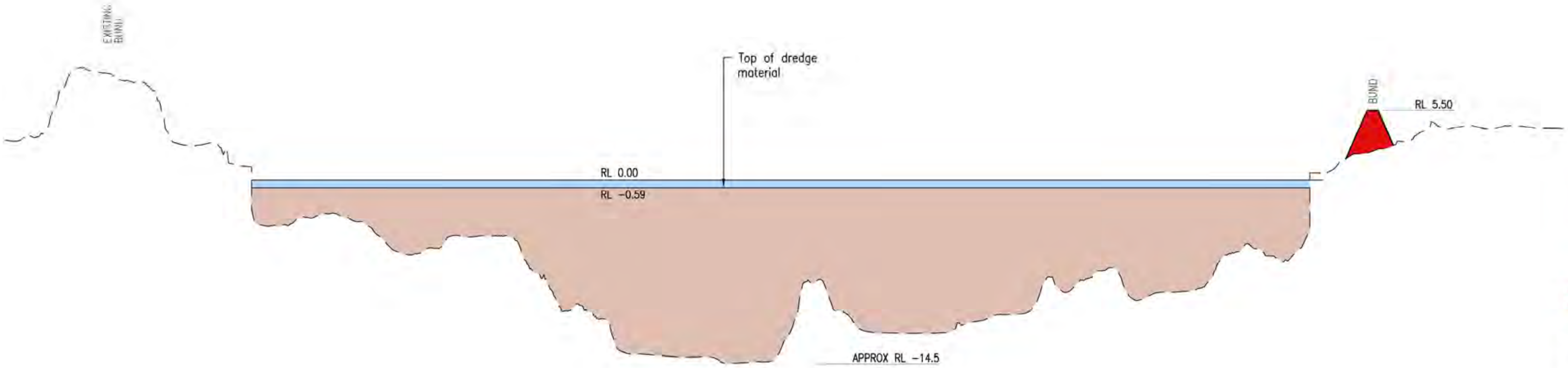
Acad No. 3527-SK15A | 5 October 2017




SECTION A




SECTION B




SECTION C

LEGEND

- Imported Dredge Material
- Ground Water / Imported Water
- New Perimeter Bund

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NORTHERN SANDS
Dredge Material Placement
Cross Sections
At Time of Ultimate Settlement

3527-SK15A — 1:1000H / 1:200V, A1 Full Size

Acad No. 3527-SK15A — 5 October 2017

# ATTACHMENT 2: ASSUMED TSHD PRODUCTION RATES (AKUNA 2017)

Ports North

**CAIRNS SHIPPING CHANNEL**
**DREDGED QUANTITY GROSS 900,000 m3**

April 2017

**PRODUCTIONS**

| | | |
|---|---|---|
| **Service Hours / week** | | **168** |
| **Delays / week** | | 33 |
| | Bunkering | 4 |
| | Technical | 8 |
| | Weather | 12 |
| | Operational | |
| | Shipping | 6 |
| | Blockage/debris | |
| | Other delays | 3 |
| **Operational Hours / week** | | 135 |

| **Cycle times and weekly production** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Dredging area | | Smith Creek Swing basin | Crystal Swing basin | Bend | | | | | | **TOTAL** |
| From Chainage | | 10,800 | 11,500 | 13,250 | 14,500 | 16,500 | 18,500 | 20,500 | 22,500 | |
| To Chainage | | 11,500 | 13,250 | 14,500 | 16,500 | 18,500 | 20,500 | 22,500 | 24,500 | |
| Quantity | | | | | | | | | | |
| Gross (incl. OD) | situ m3 | 54,815 | 46,877 | 19,374 | 188,076 | 329,212 | 211,321 | 42,352 | 7,973 | **900,000** |
| By Sweep bar | % | - | 5 | 5 | 5 | - | - | 10 | 5 | |
| | situ m3 | | 2,344 | 969 | 9,404 | - | - | 4,235 | 399 | **17,350** |
| By TSHD | situ m3 | 54,815 | 44,533 | 18,405 | 178,672 | 329,212 | 211,321 | 38,117 | 7,574 | **882,650** |
| Layer thickness | m | 0.8 | 0.8 - 1.3 | 0.6 | 0.3 | 0.3 - 0.5 | 0.3 - 0.6 | 0 - 0.6 | 0.1 | |
| Load in Hopper | situ % | 40 | 42 | 40 | 47 | 48 | 50 | 42 | 38 | |
| | situ m3 | 2,240 | 2,352 | 2,240 | 2,632 | 2,688 | 2,800 | 2,352 | 2,128 | |
| Cycle: | | | | | | | | | | |
| Loading | min | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | |
| Overflow | min | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | |
| Lean Mixture Over Board | min | 6 | 10 | 55 | 31 | 22 | 16 | 34 | 106 | |
| Turning | min | 15 | 11 | 5 | 5 | 5 | 5 | 8 | 5 | |
| Sailing to turning area | min | - | - | 7 | - | 20 | 28 | 24 | - | |
| Sailing Loaded | min | 95 | 85 | 66 | 58 | 51 | 44 | 38 | 33 | |
| Anchoring | min | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | |
| Coupling | min | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | |
| Filling pipeline | min | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | |
| Pumping mixture | min | 36 | 37 | 36 | 38 | 39 | 38 | 37 | 35 | |
| Cleaning pipeline | min | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | |
| Sailing Empty | min | 92 | 82 | 63 | 55 | 48 | 42 | 35 | 31 | |
| Total Cycle | min | 344 | 325 | 332 | 287 | 284 | 273 | 276 | 309 | |
| Trips per week | | 23.5 | 24.9 | 24.4 | 28.2 | 28.5 | 29.7 | 29.3 | 26.2 | |
| Weekly production | | | | | | | | | | |
| Hopper m3 /week | | 52,744 | 58,619 | 54,651 | 74,283 | 76,665 | 83,077 | 69,026 | 55,783 | |
| Duration | weeks | 1.04 | 0.76 | 0.34 | 2.41 | 4.29 | 2.54 | 0.55 | 0.14 | **12.07** |
| Total number of loads | | 24.5 | 18.9 | 8.2 | 67.9 | 122.5 | 75.5 | 16.2 | 3.6 | **337** |

| **Northern Sands Quarry** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Volume pumped | | | | | | | | | | |
| Filling pipeline | m3 | 128,473 | 99,404 | 43,137 | 356,394 | 642,992 | 396,227 | 85,082 | 18,687 | **1,770,396** |
| Pumping mixture | m3 | 171,786 | 134,508 | 57,681 | 475,939 | 851,689 | 516,227 | 115,128 | 24,666 | **2,347,625** |
| Cleaning pipeline | m3 | 102,778 | 79,523 | 34,510 | 285,115 | 514,394 | 316,982 | 66,066 | 14,949 | **1,416,317** |
| Total water and mixture | m3 | 403,037 | 313,436 | 135,328 | 1,117,448 | 2,009,075 | 1,229,435 | 266,276 | 58,303 | **5,534,339** |
| Situ m3 (check) | | 54,815 | 44,533 | 18,405 | 178,672 | 329,212 | 211,321 | 38,117 | 7,574 | **882,650** |
| Dilution factor | | 6.35 | 6.04 | 6.35 | 5.25 | 5.10 | 4.82 | 6.04 | 6.70 | **5.27** |

Extracted from Appendix A, Page 18/20 (Akuna 2017).