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9 November 2017

Our File Ref: HDC17001

Hawke's Bay Regional Council
Private Bag 6006
NAPIER 4142

Attention: Greg Shirras, Consents Planner

Dear Greg,

Clifton Revetment (CL17034C & Others) - Response to Request for Further Information

We refer to your letter (dated 30 August 2017) requesting further information in relation to the resource consent application (CL17034C & Others) by Hastings District Council (the Applicant) to construct and maintain a coastal protection structure within Coastal Hazard Zone 1 and the Coastal Marine Area, and provide the following response on behalf of the Applicant.

Existing Environment

1. Provide further justification for the assertion that the reef does not erode at any noticeable rate.

The reef at the western end of Clifton Beach has been a feature in historical aerial photographs and plays an important role in aligning the main beach. This reef is a firm structural feature as it is resistant to frequent abrasion from gravel transport and significant wave energy.

2. Provide an updated assessment and description of erosion patterns at the site, using more recent survey data.

The report "*Clifton Beach: Engineering Assessment*", prepared by Beca Limited (dated 17 July 2017, and attached as Appendix A to the Assessment of Environmental Effects report attached to the resource consent application) describes the erosion at HB1 over the period 1973 to 2002. The annual erosion rate was estimated at 0.7m/year. Beca advise that more recent information on HB1 from 2002 to 2017, indicates a lesser amount of erosion at about 0.4m/year. Interestingly over this period there was both accretion and erosion at the HB1 site. More recently, since 2013, the erosion rate has been about 2m/year.

It is noted that verification of the longshore sediment transport model was based on the vegetation lines of rectified aerial photographs over the period 1963 to 2009. The average erosion rate at HB1 (Cell 76) was 0.69m/year.

3. Include a description and plan showing previous road locations.

Attached is a series of surveys over the period 2013-2017 by Zorn Surveying. (Attachment 1). The erosion over this period varies 0.9 to 3m/year along the erosion scarp, just seaward of the access road.

Also attached are a series of cross-sections along the existing access road. (Attachment 1)

4. *Comment on the effects of the existing revetment, and use the data required to be collected under the consent for this revetment to demonstrate the scale of any effects (or lack of effects).*

Based on the survey data in Attachment 1, Beca advise that it appears that an immediate cut-in, down-drift of the existing wall, is not evident. The maximum erosion is more evident some 200m from the existing revetment. This would indicate that the recent erosion adjacent to the access road is more attributable to the imbalance between sediment supply and longshore currents (due to waves) than the effects of the existing revetment.

Assessment of Alternative Options

5. *Provide a more detailed assessment of the 'do nothing' option, include consequences and expected timeframes of this option.*

A quantitative description of the 'do nothing option' is given in Section 3.2.1 of the Beca engineering assessment report, referred to above.

The HB1 profile indicates an erosion rate of about 0.7m/year over the years 1972-2002. The 2003/2004 Tonkin and Taylor Report[1] indicated an erosion risk set back zone of 75m (with 0.2m seal level rise) till 2060 and 107m (with 0.5m sea level rise) to 2100. Given the existing erosion trend, Beca consider that erosion of the amount estimated by Tonkin and Taylor appears likely, with the consequences of loss of public and private land and infrastructure with no access to the existing camping ground.

6. *There is no information presented on wave differences to demonstrate the increase in exposure risk regarding relocation of the boat ramp. Provide detail of wave heights based on SWAN modelling at the current boat ramp location and the alternative boat ramp location that was considered.*

There is no alterative boat ramp as part of the proposed works. There is a concrete ramp off Clifton Road included as part of the resource consent application, to provide for easier vehicle access onto the beach, but this is not intended to be used as a boat ramp.

The boat ramp mentioned in the Evaluation of Options (Section 3.2.4) in the Beca engineering assessment report was the option to relocate the boat ramp. Beca advise that, if the Applicant was to build a new boat ramp at the western end of Clifton Beach, it is in a relatively exposed location. Given health and safety requirements for a public boat ramp some form of sheltering would likely be required, such as a breakwater. This would have an adverse effect on the longshore sediment transport and would also be expensive.

7. *Provide further details on beach nourishment as alternative options to the revetment, and include estimate of volume requirements and any other reasons why this option is not considered the BPO.*

Beach nourishment would entail providing an initial placement of gravel/sand material and a commitment to continued nourishment. Beca advise that the difficulty with this option would be that placement of material just to cover the project area would produce a discontinuity in the plan profile of the beach. This could be overcome by extending the initial placement over the entire beach or placing containment structures (similar to groynes) at either end of the project area. In any event, continued nourishment of the beach would be required.

There is also the residual risk that existing infrastructure would be vulnerable to erosion during extreme sea storm conditions.

[1] Tonkin & Taylor, Hawke's Bay Regional Coastal Environment Plan: Coastal Hazards. Rep. Vol. 1. (2003).

If beach nourishment was favoured, it would probably need to be introduced on a regional scale to satisfy the littoral cell requirements.

8. *The application states that the 'do nothing' option would result in the need to find an alternative departure point to the Cape Coast (Assessment of Alternatives Report, pg. 17). Please provide additional information to support this view, given that access to the Cape is limited to around low tide periods anyway.*

To clarify, the need to find an alternative 'departure point' to the Cape Coast relates to the loss of the 'gateway' and associated parking area located at the end of Clifton Road, which would need to be relocated under the 'do nothing' option, as it would eventually disappear through coastal erosion. This is not referring to the loss of physical access to the beach (and Cape Kidnappers) which is likely to remain because of the papa rock layer on the beach.

9. *Provide further justification for determining that a 400 m long and 15 m high crested revetment is the BPO, including information which demonstrates the relative costs of this option and other options over the design period.*

The revetment is 400m long as that is approximately the length of road that needs to be protected. The revetment is not 15m high. At its highest it is 4m high, with a base level of RL 11m to a crest level of RL 15m. The crest level of 15m was chosen because it:

a) provides a reasonable level of protection against wave overtopping;

b) approximately corresponds to the existing ground level; and

c) does not provide a visual barrier.

An assessment of alternative options for maintaining access to Clifton Beach and Clifton Domain was provided with the Assessment of Environmental Effects report submitted with the resource consent application (attached as Appendix F). The report assessed the proposed revetment as one of the following six options to address the coastal erosion issues affecting access to Clifton Beach and the Domain:

- Option 1: Do Nothing / Managed Retreat;
- Option 2: Extend Existing Revetment Consent Duration;
- Option 3: Passive 'Soft' Protection (Nourishment & Planting);
- Option 4: Proposed Revetment Structure;
  - Option 4A: Low Crest Revetment Structure;
  - Option 4B: Reduced Length Revetment Structure;
- Option 5: Other 'Hard' Protection Structures (Groynes / Offshore Breakwaters /
- Sheet Pile Wall); and
- Option 6: Inland Access Route.

The report assessed each option (including the proposed revetment proposal under Option 4A) against a set of criteria developed from a review of relevant strategies and policies applying to this coastal location, and concludes that the proposed revetment, constructed with locally sourced limestone rock, is a practical and cost-effective option which best meets the following objective:

> *"to provide and maintain safe, efficient, reliable, environmentally sustainable, and affordable public access to Clifton beach and reserve, that meets the current and future social, cultural and economic needs of beach users and the public generally, tangata whenua, Clifton Marine Club members, Clifton Reserve Society members and campground users, and local tourism providers, for the medium term (35 years)"*

Design Conditions

10. *Provide additional justification for use of a derived water depth of 1 m and a design wave height of 1.2m. Consider and comment on the appropriateness of the figures for the design life of the structure.*

The design water level is taken as RL 12.0m (including RL 10.9m for MHWS, 0.8m for storm surge, and 0.3m for sea level rise over the resource consent period of 35 years). The base of the revetment will be set at RL 11.0m as this is the general level of the papa rock at the revetment toe. Where the papa rock is lower, a toe detail will be incorporated with a base level of about RL 10.7m. Therefore, where there is papa rock the water depth will be 1.0m and where there is the rock toe detail the water depth is 1.3m. Given the higher energy offshore wave climate, the revetment will be subject to frequent depth limited waves.

The site will be subject to an irregular wave field with a relatively steep beach approach gradient of 8%. With reference to the Rock Manual (2007) - Figure 4.40 - the highest significant wave height to depth ratio is 1.2, giving significant wave heights of 1.2m to 1.5m.

As the design is based on depth limited waves breaking at the toe of the structure there is no wave set-up which would affect the design water level.

It is acknowledged that larger waves will break in the near shore and reformed waves will frequently impact on the revetment structure. That condition will create wave set up at the toe of the structure but the reformed waves in an irregular wave field generally have a significant wave height to depth ratio less than for the initial breaking wave. Based on an analysis of wave attenuation through surf zone using an energy balance relationship the following results were obtained.

Off-shore significant wave height (H_s-m)	**Off-shore significant wave period (T_m-s)**	**Design significant wave height at revetment toe (H_s-m)**
5.4	10	1.1
5.0	16	1.2

Therefore, reformed waves at the revetment will be of a similar size to the adopted design wave. Because the conditions are depth limited, they will be frequently experienced.

11. Consider and comment on the ability of the chosen rock armour to withstand major storm events.

For the limestone rock (with an assumed density of 2.2t/m3) and for an irregular wave field, Beca estimate that a rock size of 900mm is required for the 1.2m significant wave height and 1100mm for the 1.3m significant wave height. Beca therefore suggests a nominal rock size of 1000mm. They did not find that the rock size was too sensitive over the range of wave periods 10 to 16s.

As stated above, the revetment will be subject to frequent depth limited waves, particularly for high tidal levels. Some damage could therefore be expected from time to time.

Beca consider that the main effect of the wave conditions on the overall performance is the use of local limestone material. It is a soft rock and will need to be regularly inspected and repairs made. This is similar to what happens at Waimarama.

It is further noted that the small section of existing revetment has a rock size of 700mm. Beca's understanding is that this wall has been durable and intact over the recent sea storms. See attached memorandum from Council (Attachment 2).

Design Profile

12. There is a discrepancy in the design of the buried toe between the report (2 m width) and the cross-section (3 m width). Please clarify.

The toe should have width of 3 x Rock Diameter which equates to 3m.

13. *It is unclear if the plan views include the 3 m rock toe on the proposed revetment footprint or what the different shadings show on the plans. Please clarify.*

As discussed below, in response to Question 14, the extent of the papa rock means that the toe detail mainly comprises keying the rock revetment into the papa rock. In the revised Beca report (Attachment 4) the plan extent of the rock toe keyed into the papa rock is shown.

14. *The drawings show the cross sections to the MHWS level as the existing ground level (RL 11 m) but rock shelf levels are around 9.8 m and survey plans show levels sloping seaward down to around 9 m. Please update cross sections with accurate existing profile information and the inferred extent of the rock armour to the rock shelf.*

Recent survey information by Zorn surveyors (see Attachment 3) shows the papa rock levels. The rock levels at the toe of the revetment on the survey plan are consistently around RL 11.0m.

Cross-sections in the Beca report have been updated with approximate levels (see Attachment 4).

15. *Consider overtopping for possible sea levels over the consent period.*

Overtopping for a significant wave height (Hs) of 1.2m and wave periods of 10s to 16s is described in Section 4.2.4 of the Beca report. If the significant wave height were 1.5m for a wave period of 10s, then the overtopping rate would be 65 L/s/m which would increase to 320 L/s/m for a wave period of 16s.

Beca's assessment indicates that for wave periods of less than 14s (and Hs<1.5m), the overtopping rate will be less than 200 L/s/m which is the damage threshold for revetment structures.

16. *Comment on the degree of overtopping, and any risks this presents to public safety and measures that will be put in place to manage this risk noting the comment from T&T on the ability for waves to transmit through permeable rock armour.*

In general, the backshore area is near the same level at the crest so the issue of transmission doesn't apply over those areas. At either end of the revetment the backshore slopes down (as does the revetment) to match in with existing ground levels. Some increase in overtopping (and associated risk) will occur but cannot be designed out as there is a need to match in with the existing ground contours.

It is noted that overtopping with the revetment in place will be better than the existing situation.

Maintenance

17. *The report indicates that beach nourishment may be required due to the impounded loss. Please provide details on how the volume has been determined and the proposed trigger level for instigating this measure.*

The impoundment loss is based on a long-term ambient erosion rate of 0.7 m/year. The length of the revetment is 400m and the average scarp height is 3.4 m. This would yield about 950 m^3/year of erodible material. The gravel component of this material was assessed as 60%, which equates to about 600 m^3/year. The Coastal Processes Assessment report (attached as Appendix D to the Beca report) refers to a reduction in littoral supply of 500 m^3 - 1000 m^3/year which also has an allowance for sea level rise.

The trigger level for instigating beach nourishment is set out in the proposed Conditions of Consent that were submitted with the application.

18. Please clarify, with justification, if nourishment is to be conducted 6 or 12 monthly.

Ideally replenishment should be several times per year. Practically, however, this is difficult and disruptive – it is more likely to be an annual event, like on Westshore Beach. The need for replenishment will be determined by monitoring the immediate down-drift area, based on 6-monthly monitoring (and after sea storms), with the aim of placing it within 2 months of exceeding any trigger. The aim would be for any replenishment to take place in winter.

Environmental Effect on the Revetment (Beca, 2017b)

19. Please provide all relevant figures at A3 with better selection of label colour and better use be made of tabulated or graphed data.

These were emailed to Council (Greg Shirras) by Sage Planning on 16 August 2017.

Model Domains and Calibration

20. Please extend the model area to include HB2 and measure the change observed to the north of Te Awanga.

See response to Query 22. As little long-term coast line movement was identified or modelled at the western end of the model (Cell 39) it was considered that there would be no flow over effect into Te Awanga.

In order to resolve the complicated wave processes along the shoreline SWAN modelling was completed to provide varying wave conditions at approximately 100 m intervals along the shoreline. As the sediment transport modelling incorporated the detailed wave data alongshore, extending the model will not change the results for the study area.

21. Please confirm the process to derive the target shoreline values derived from Table 3.1 and 3.2. Note Cell 39 has small amounts of retreat in Table 3.1 but no retreat in Table 3.2.

Retreat rates were obtained by comparison of dune vegetation from historical aerial photographs over time. Each photograph was ortho-corrected to enable direct comparison. Rates were compiled at points of interest along the shoreline with respect to the model baseline.

Comparison of the aerial photographs show negligible movement of the shoreline at Cell 39. The measurements in Table 3.1 of the Coastal Processes Assessment Report are a maximum observed value of the surrounding shoreline. For the purposes of the modelling a 0 (zero) m target rate was adopted as that was considered more representative of the average shoreline movements in the area.

22. Please amend labelling in Figure 3.5.

Figures have been amended in the revised Beca report: 1980 vegetation line = green and the 2009 vegetation line = red.

23. Confirm if the modelling takes into account any nourishment. Include annual nourishment as proposed and confirm if this mitigates any identified effects.

To be conservative renourishment was not included in the modelling. Provision of compensatory loss due to sediment impoundment is not renourishment as down-drift erosion will continue.

Public Access

24. Please provide quantification of the reduction in access along the beach due to the installation of the revetment, including consideration of continued shoreline retreat and sea level change over the design life of the structure.

Clifton beach will continue to erode down-drift of the revetment at the rate of 0.7 - 1.0 m/year. The extent of access in front of the revetment is dependent on the level of the papa rock and the amount of up-drift littoral supply (from the Cape Kidnappers area). Only a mantle of gravel/sand exists above the papa rock.

On the assumption that the beach elevation down-drift will be the same as in front of the revetment until the papa rock is encountered, then the sand/gravel seaward of the proposed revetment will be lost within a 10 year period. Thereafter the papa rock will form the beach profile in front of the revetment. Because of the continued littoral movement of sediment, however, there will be some sand/gravel over the beach profile.

Sea level rise will not affect the papa rock beach profile.

Climate Change

25. *Please provide assessment of change over 10 year increments, with sea level adjustments built in step wise as a simulation of possible future change.*

See response to Query 24. There is some further discussion on the effect of sea level rise within the study area in the revised Beca report (refer to Sections 4 and 5 of the Beca report, and Sections 3.5 and 4 the Coastal Processes Assessment report in Appendix D of the Beca report).

Reclamation

26. *Cross section 5 of the provided plans appears to show that the revetment and road will move seaward from the existing shoreline position upon an area of imported fill. The AEE states that the rules relating to reclamations are not relevant as no infilling of material between the revetment and the existing foreshore will be undertaken. Please consider and comment on whether consent for a reclamation is also required.*

'Reclamation' is defined in the Regional Coastal Environment Plan as: "*means the permanent infilling of a waterbody or part of a water body with sand, rock, quarry material, concrete, or other similar material, for any purpose, and includes any embankment or causeway* …".

It is confirmed that some infilling in the Cross Section 5 location will be required to match up the current scarp with the existing revetment, bearing in mind that some down-drift erosion from the existing revetment has taken place.

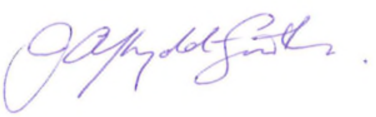
As such, a Discretionary Activity resource consent is also required for reclamation in this area under Rule 111 of the Regional Coastal Environment Plan. The Applicant therefore amends their proposal to include an application for reclamation.

27. *Given that the construction of the revetment may result in effects on public access along the beach over time (see questions above), it is important that public access along the proposed walkway and road is available. The proposed consent conditions (Appendix G) do not appear to reflect the recommendations of the recreational planner's report. Please confirm if it is intended that the public will be able to use the road and walkway over its full length.*

The proposed access road will connect Campground No. 1, which is located within the Clifton Domain (being a public reserve), from the Clifton boat ramp, along the front of the Gordon property, to an area in front of the Clifton Café. The proposed revetment will provide long term coastal protection to preserve access along this section of Clifton beach for Camp patrons and Clifton Marine Club members, as well as the public who have access through Campground No.1 to the public boat ramp, and the public carpark and picnic area at the northern end of the campground. The proposed access road will provide for a 5.0-metre-wide multimodal access road (vehicle, walking and cycling) and an amenity planting strip and two vehicle passing bays.

As noted in Section 3.1 of the Recreation Assessment Report (provided as Appendix E to the Assessment of Environmental Effects report for the resource consent applications), Hastings District Council's Draft Cape Coast Reserves Management Plan identifies an opportunity for providing improved public access (vehicle, cycling and walking) and parking, native biodiversity and ecology and recreational opportunities for the Clifton Domain, including the proposed access road from the end of Clifton Road to Clifton Campground No. 1. The proposed consent conditions do not include the recommendations in the Recreation Assessment Report, as it is considered that these are best provided by the Hastings District Council as part of their Reserves Management Plan.

Yours sincerely,



Janeen Kydd-Smith
Principal Planner

Cc: Craig Thew, Hastings District Council

ENC: Attachment 1: Zorn Figure (18/10/17) and cross-sections (3/10/17)

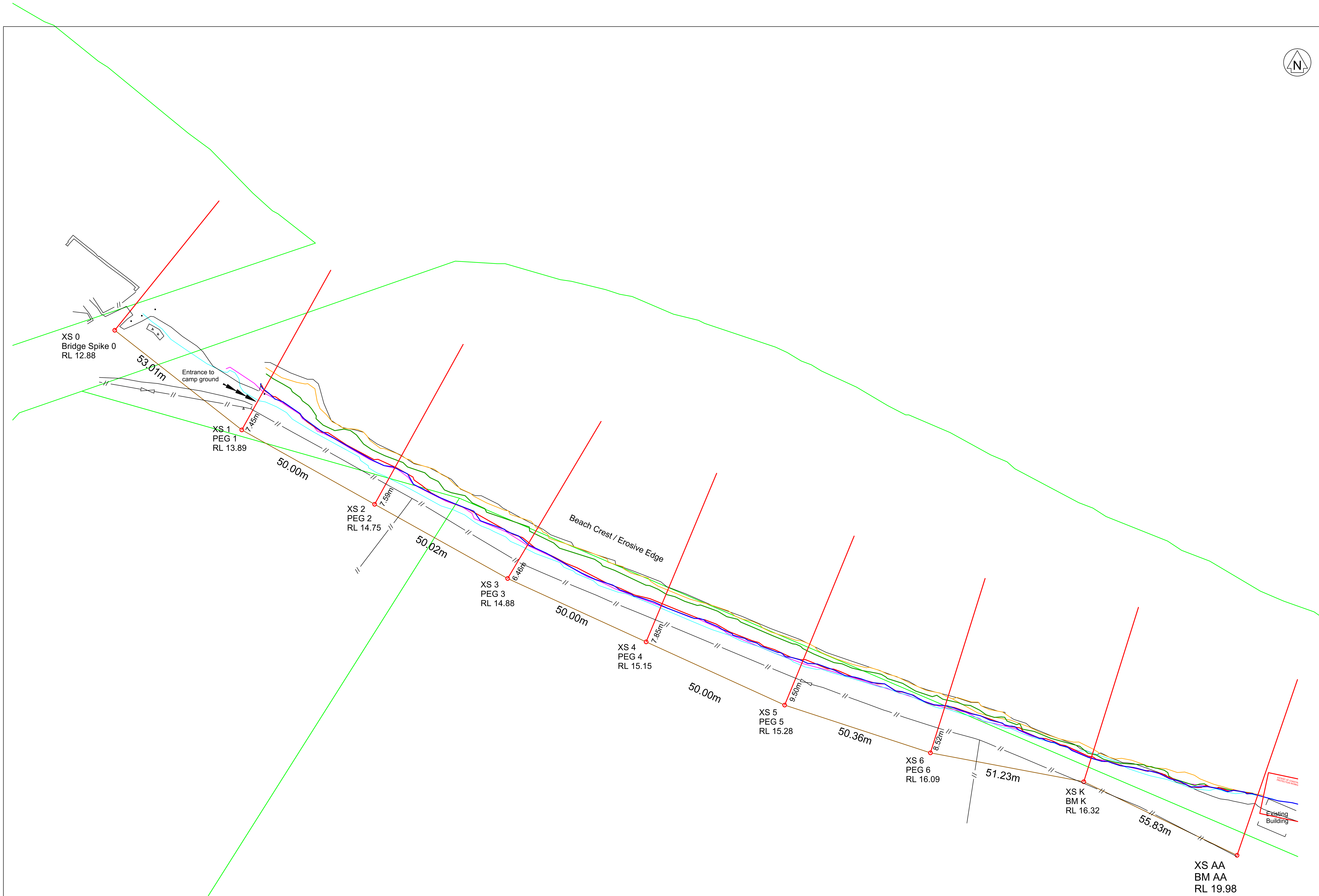
Attachment 2: Memorandum from Les Glock to John on Condition of Existing Revetment (31/10/17)

Attachment 3: Zorn Figure showing papa rock levels (18/10/17)

Attachment 4: Revised Beca "*Clifton Beach: Engineering Assessment*" report (November 2017).

ATTACHMENT 1

Zorn Figure and Cross Sections



20-11-2013 Survey 1
12-04-2014 Survey 3
24-09-2014 Survey 6
01-04-2015 Survey 9
22-06-2016 Survey 13
18-10-2017 Survey 20

NOTES:

* Refer to Spreadsheet: "Clifton Camp Access Way Excursion Distance" for Excursion Distances to Erosive Edge
* Distance from Peg to Fence Shown

Survey 20 18-10-2017
Clifton Beach
Beach Crest/Erosive Edge

DATE	: Oct 2017
SCALE	: 1:600 @ A1
DRAWN BY	: A.Eastwood
JOB NO.	: 13-DNM
PLAN NO.	: 13DNM-S20-EXLines-1

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Web www.zornsurveying.co.nz
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Site Name : Clifton Beach Rd Monitoring XS

Site Number : AA

XS ID	Distance	Type	Survey Date	Local Name
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AA	0.000	XS	26-Jul-2017	Clifton
AA	0.000	XS	23-Mar-2017	Clifton
AA	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:23 p.m.

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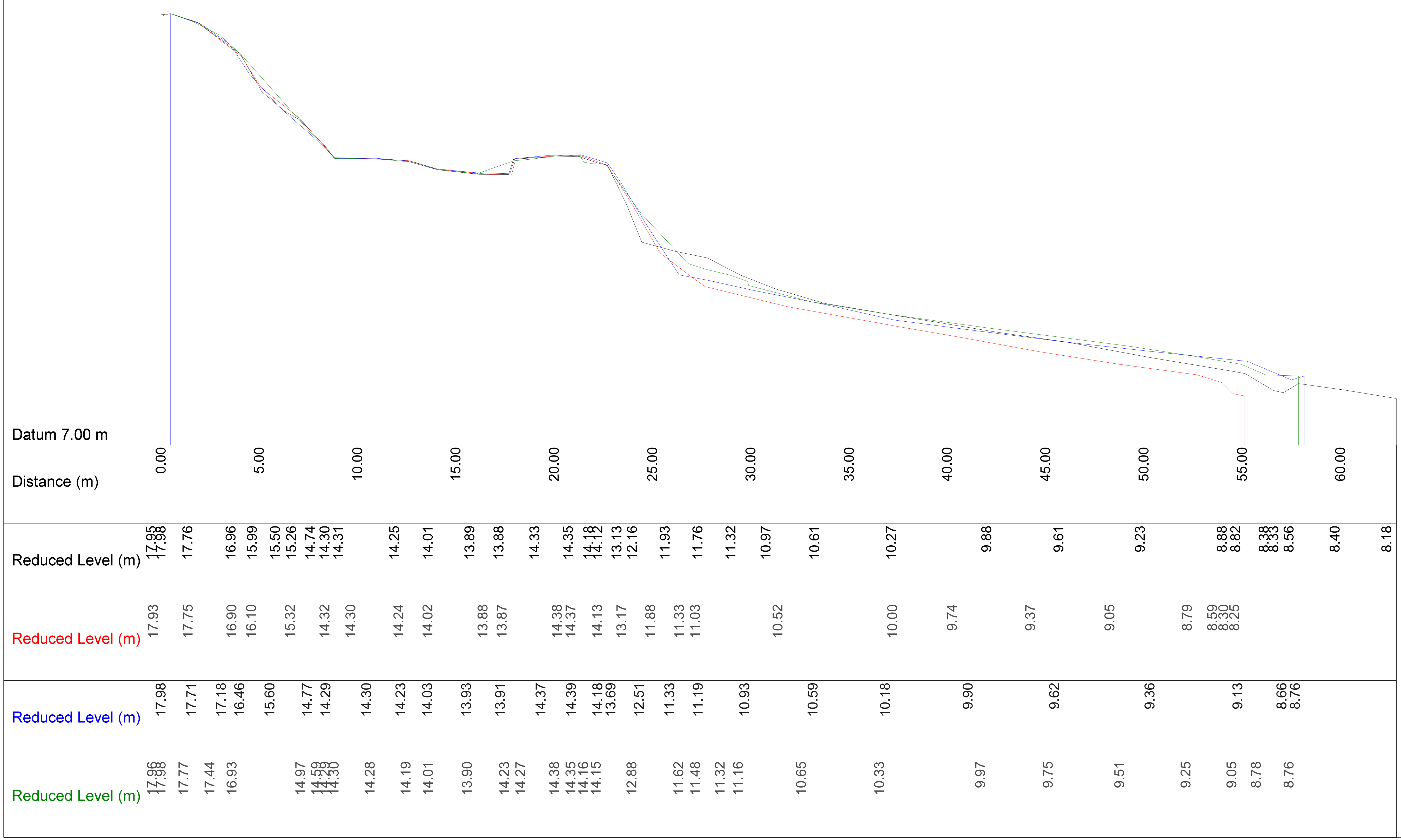

Site Name : Clifton Beach Rd Monitoring XS

Site Number : A

XS ID	Distance	Type	Survey Date	Local Name
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A	0.000	XS	23-Mar-2017	Clifton
A	0.000	XS	23-Jan-2017	Clifton

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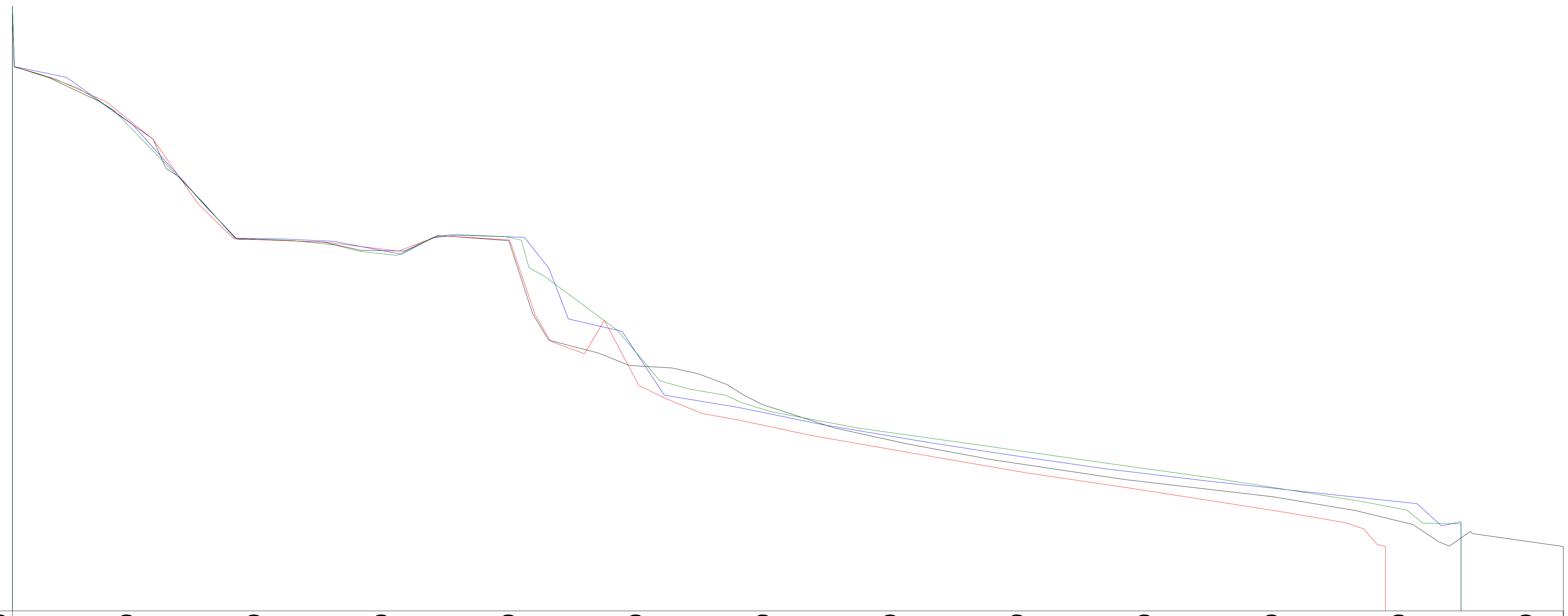

Datum 7.00 m

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Reduced Level (m) (03-Oct-2017): 18.87, 17.48, 17.01, 16.27, 15.70, 15.52, 14.94, 14.30, 14.29, 14.24, 14.09, 14.07, 14.38, 14.31, 14.27, 12.84, 12.32, 12.06, 11.82, 11.77, 11.66, 11.44, 11.24, 11.05, 10.60, 10.28, 9.97, 9.58, 9.24, 8.97, 8.70, 8.36, 8.27, 8.56, 8.27

Reduced Level (m) (26-Jul-2017): 18.88, 17.46, 17.00, 16.27, 15.01, 14.31, 14.25, 14.07, 14.37, 14.29, 12.83, 12.30, 12.05, 12.71, 11.43, 11.17, 10.88, 10.74, 10.44, 10.01, 9.72, 9.40, 9.08, 8.93, 8.74, 8.61, 8.31

Reduced Level (m) (23-Mar-2017): 18.88, 17.49, 16.57, 14.93, 14.32, 14.31, 14.26, 14.01, 14.33, 14.38, 14.34, 13.73, 12.74, 12.49, 11.24, 10.99, 10.66, 10.31, 10.10, 9.80, 9.55, 9.30, 9.11, 8.67, 8.75

Reduced Level (m) (23-Jan-2017): 18.88, 17.53, 17.28, 16.85, 14.98, 14.32, 14.28, 14.19, 14.07, 13.99, 14.34, 14.40, 14.36, 14.28, 13.57, 12.51, 11.52, 11.36, 11.23, 11.09, 10.91, 10.60, 10.25, 9.93, 9.61, 9.34, 9.15, 8.98, 8.73, 8.71

Site Name : Clifton Beach Rd Monitoring XS

Site Number : B

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B	0.000	XS	26-Jul-2017	Clifton
B	0.000	XS	23-Mar-2017	Clifton
B	0.000	XS	23-Jan-2017	Clifton

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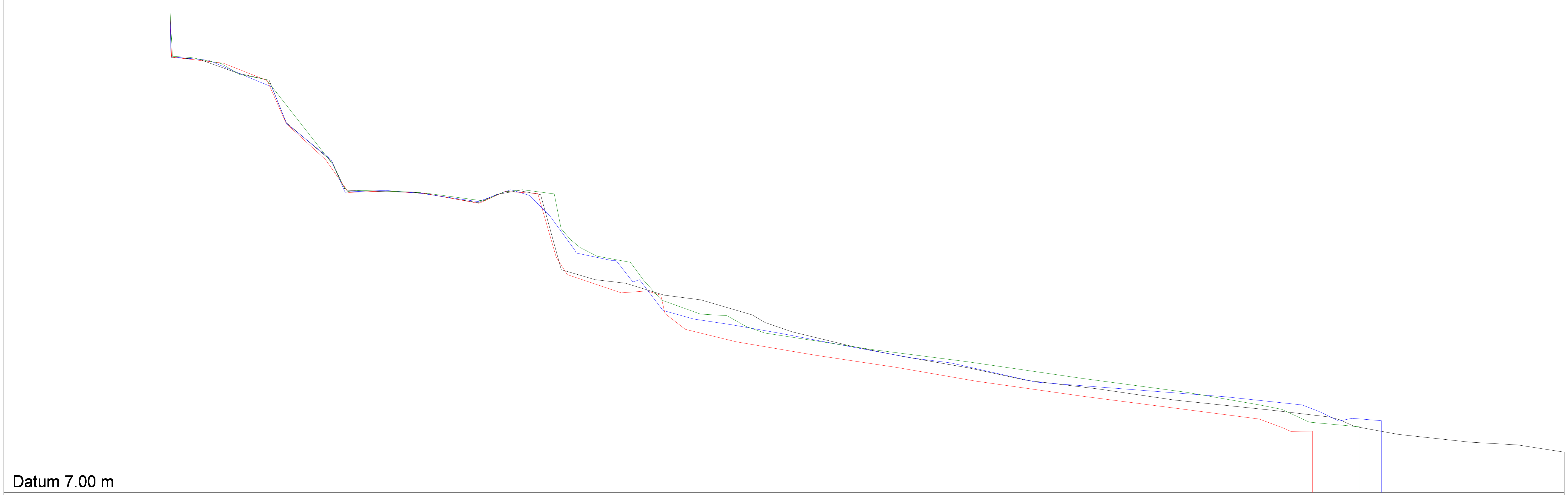

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Reduced Level (m): 18.64 17.36 16.94 15.89 15.03 14.24 14.27 14.21 13.97 14.26 14.21 12.68 12.26 11.81 11.86 11.76 10.93 10.64 10.31 10.02 9.69 9.32 9.03 8.77 8.57 8.47 8.48

Reduced Level (m): 18.64 17.43 17.06 16.78 15.89 15.03 14.24 14.29 14.22 14.01 14.30 14.16 13.66 12.85 12.60 12.07 11.39 11.18 11.05 10.84 10.59 10.50 10.24 10.13 9.66 9.31 9.11 8.94 8.72 8.79 8.73

Reduced Level (m): 18.64 17.49 17.35 17.08 16.96 14.91 14.43 14.29 14.25 14.21 14.03 14.25 14.30 14.20 13.10 12.91 12.70 12.55 12.11 11.64 11.30 11.26 11.00 10.84 10.45 10.16 9.75 9.42 9.12 9.01 8.70 8.58

Site Name : Clifton Beach Rd Monitoring XS

Site Number : C

XS ID	Distance	Type	Survey Date	Local Name
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C	0.000	XS	26-Jul-2017	Clifton
C	0.000	XS	23-Mar-2017	Clifton
C	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:27 p.m.

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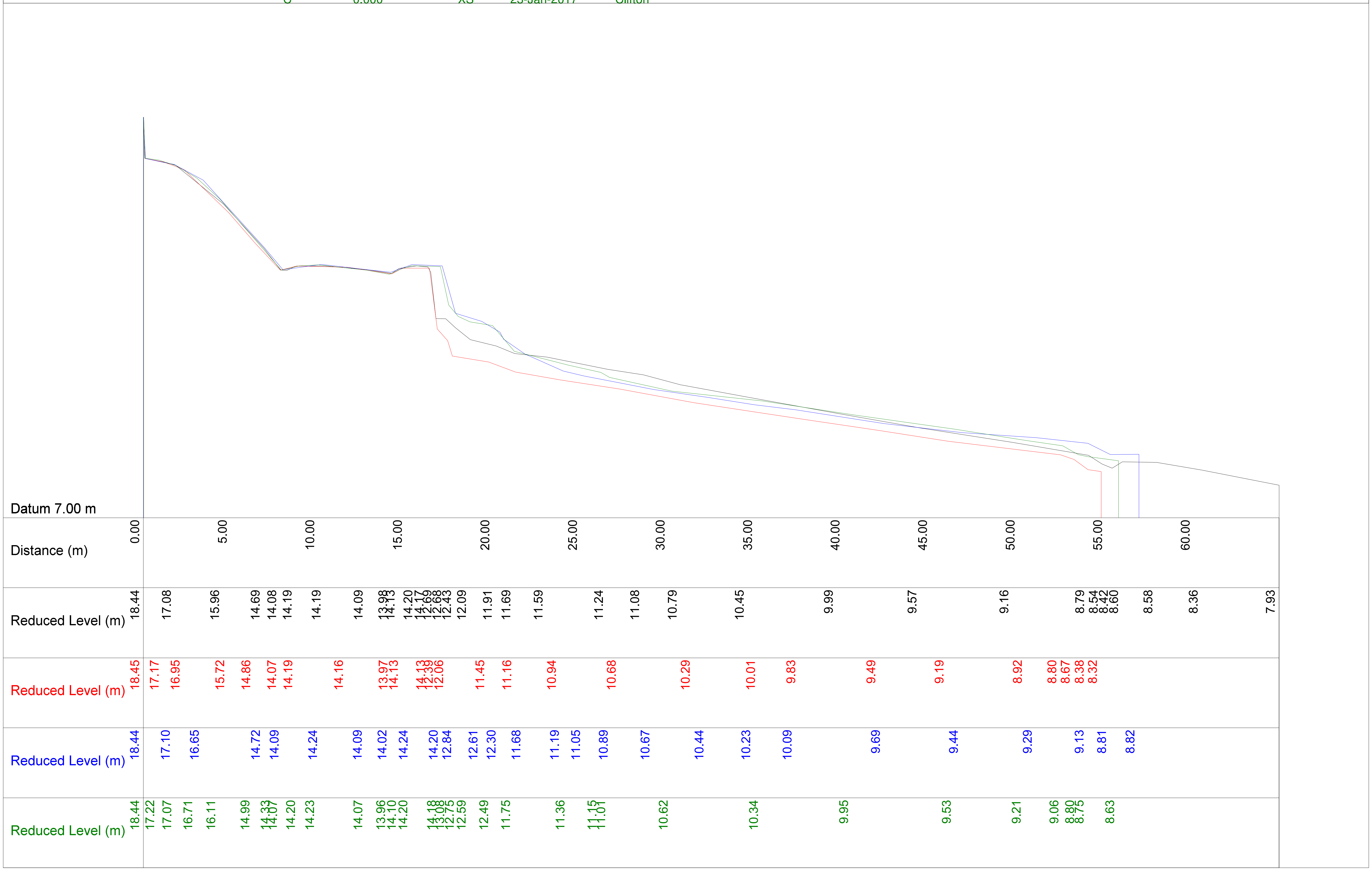

Site Name : Clifton Beach Rd Monitoring XS

Site Number : D

XS ID	Distance	Type	Survey Date	Local Name
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D	0.000	XS	23-Mar-2017	Clifton
D	0.000	XS	23-Jan-2017	Clifton

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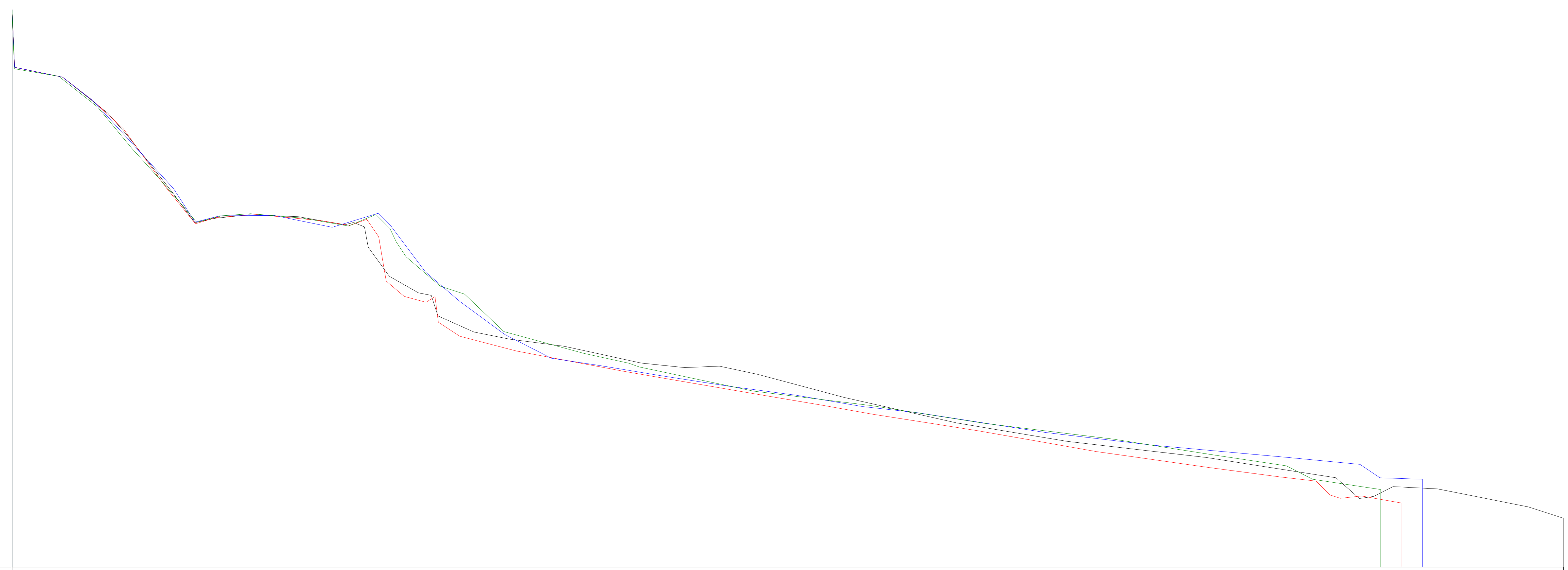

Datum 7.00 m

Distance (m): 0.00, 5.00, 10.00, 15.00, 20.00, 25.00, 30.00, 35.00, 40.00, 45.00, 50.00, 55.00, 60.00

Reduced Level (m): 18.25, 16.90, 16.17, 15.72, 14.56, 13.96, 14.04, 14.12, 14.08, 13.91, 13.87, 12.87, 12.54, 12.49, 11.75, 11.60, 11.46, 11.12, 11.03, 11.06, 10.89, 10.43, 9.91, 9.54, 9.21, 8.80, 8.38, 8.43, 8.63, 8.58, 8.21, 7.98

Reduced Level (m): 18.26, 16.90, 16.42, 15.85, 14.64, 13.93, 14.06, 14.12, 14.00, 13.90, 14.02, 13.67, 12.47, 12.35, 11.94, 11.66, 11.36, 10.95, 10.58, 10.26, 10.09, 9.75, 9.33, 9.01, 8.82, 8.74, 8.46, 8.39, 8.43, 8.29

Reduced Level (m): 18.26, 16.90, 16.42, 14.65, 13.97, 14.09, 14.10, 13.86, 14.14, 13.88, 12.96, 12.37, 11.70, 11.22, 11.08, 10.87, 10.65, 10.47, 10.24, 10.12, 9.72, 9.46, 9.22, 9.07, 8.80, 8.77

Reduced Level (m): 18.26, 16.92, 16.29, 15.46, 14.90, 14.26, 13.96, 14.10, 14.14, 14.05, 13.89, 14.01, 14.12, 13.84, 13.27, 12.67, 12.51, 11.76, 11.32, 11.11, 11.04, 10.56, 10.26, 9.90, 9.58, 9.26, 9.05, 8.77, 8.57

Site Name : Clifton Beach Rd Monitoring XS

Site Number : E

XS ID	Distance	Type	Survey Date	Local Name
E	0.000	XS	03-Oct-2017	Clifton Acess Rd
E	0.000	XS	26-Jul-2017	Clifton
E	0.000	XS	23-Mar-2017	Clifton
E	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:30 p.m.

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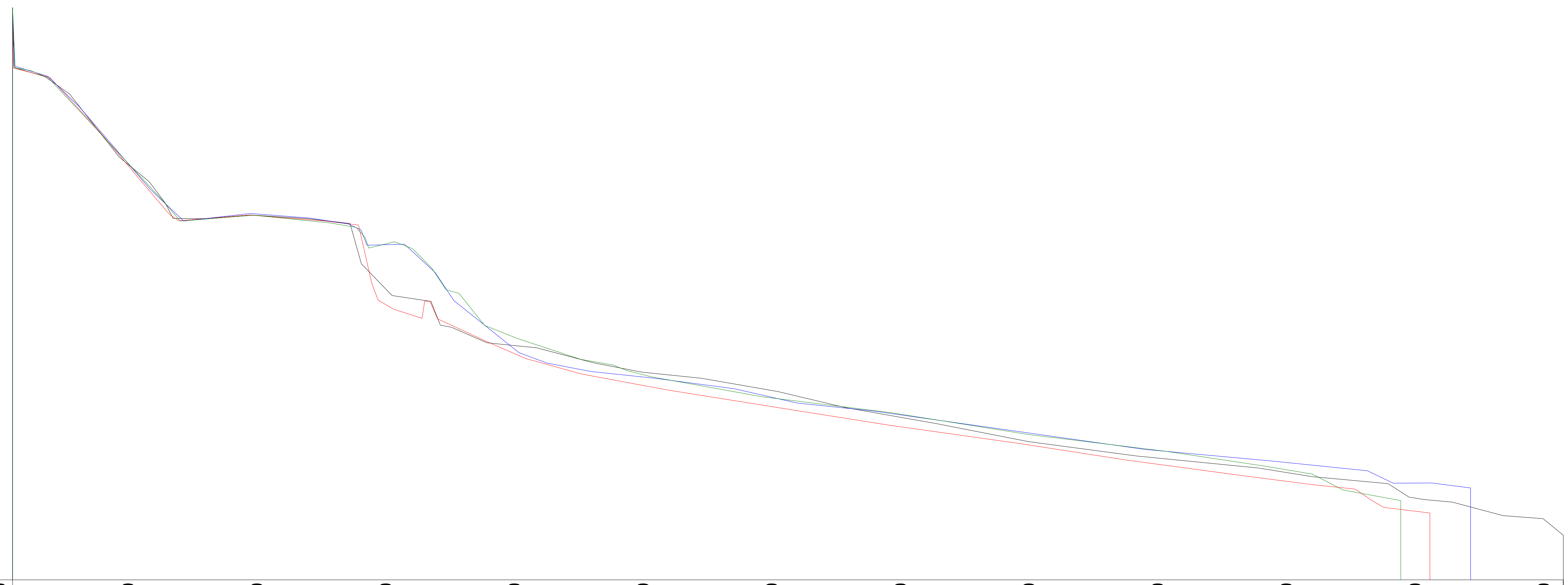
V 1 : 100



Datum 7.00 m

Distance (m): 0.00, 5.00, 10.00, 15.00, 20.00, 25.00, 30.00, 35.00, 40.00, 45.00, 50.00, 55.00, 60.00

Reduced Level (m): 18.11, 16.78, 16.45, 15.21, 14.74, 14.33, 14.02, 14.09, 14.02, 13.93, 13.74, 12.52, 12.41, 11.91, 11.61, 11.51, 11.22, 11.03, 10.91, 10.66, 10.35, 10.04, 9.69, 9.41, 9.18, 9.01, 8.87, 8.61, 8.56, 8.51, 8.25, 8.19, 7.87

Reduced Level (m): 18.12, 16.77, 15.72, 14.73, 14.10, 14.09, 13.97, 13.89, 12.76, 12.26, 12.08, 12.07, 11.64, 11.30, 11.00, 10.69, 10.31, 10.01, 9.65, 9.33, 9.02, 8.85, 8.77, 8.55, 8.41, 8.30

Reduced Level (m): 18.12, 16.79, 16.20, 14.59, 13.97, 14.12, 14.03, 13.92, 13.80, 13.53, 12.97, 12.43, 11.41, 11.21, 11.05, 10.92, 10.71, 10.44, 10.29, 9.95, 9.54, 9.31, 9.12, 8.88, 8.88, 8.79

Reduced Level (m): 18.12, 16.90, 16.76, 16.07, 14.35, 13.97, 14.01, 14.09, 13.94, 13.85, 13.45, 13.57, 13.44, 13.06, 12.64, 12.57, 11.94, 11.69, 11.28, 11.17, 11.06, 10.94, 10.56, 10.25, 9.82, 9.50, 9.21, 9.06, 8.75, 8.54

Site Name : Clifton Beach Rd Monitoring XS

Site Number : F

XS ID	Distance	Type	Survey Date	Local Name
F	0.000	XS	03-Oct-2017	Clifton Acess Rd
F	0.000	XS	26-Jul-2017	Clifton
F	0.000	XS	23-Mar-2017	Clifton
F	0.000	XS	23-Jan-2017	Clifton

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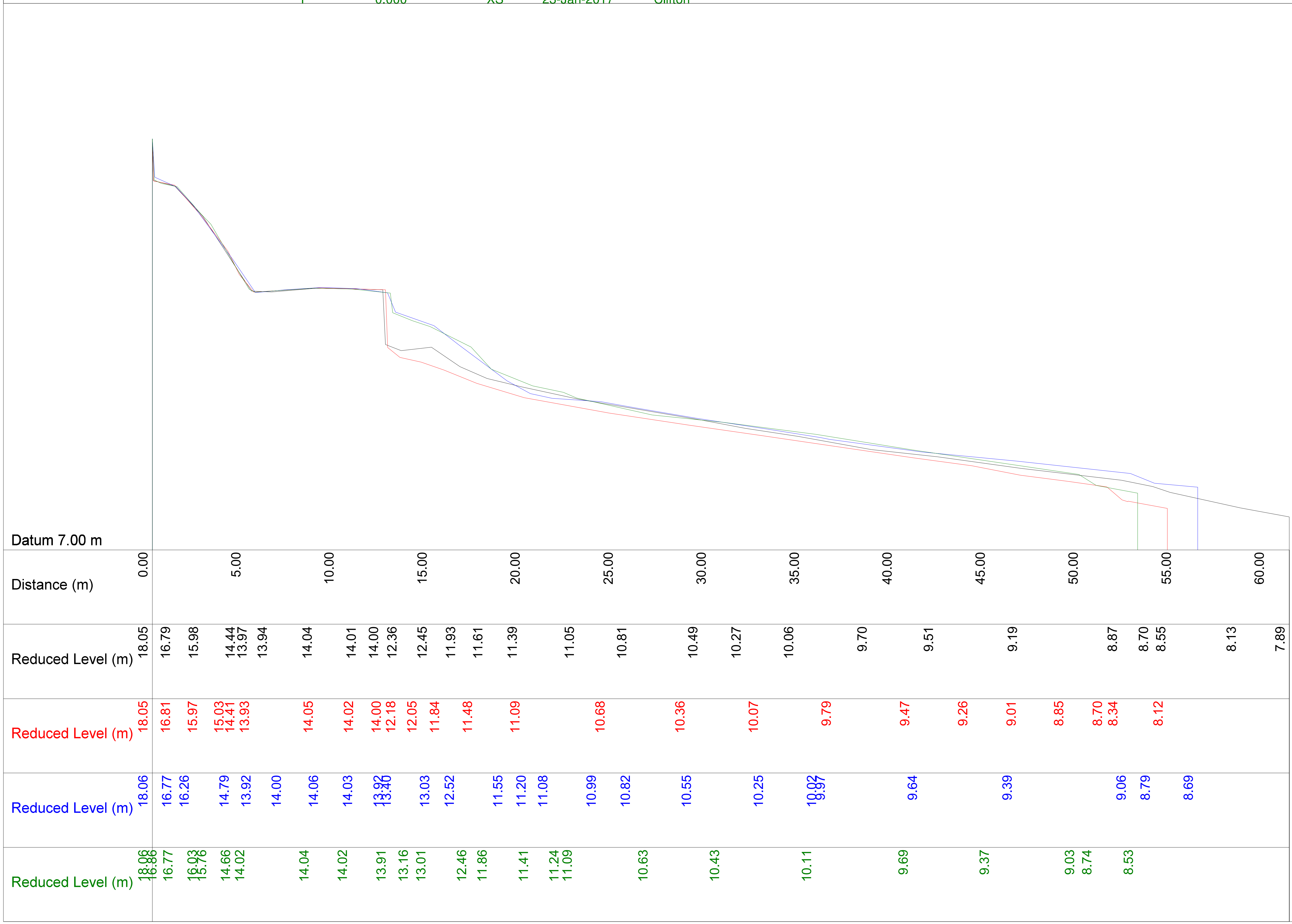

Site Name : Clifton Beach Rd Monitoring XS

Site Number : G

XS ID	Distance	Type	Survey Date	Local Name
G	0.000	XS	03-Oct-2017	Clifton Acess Rd
G	0.000	XS	26-Jul-2017	Clifton
G	0.000	XS	23-Mar-2017	Clifton
G	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:33 p.m.

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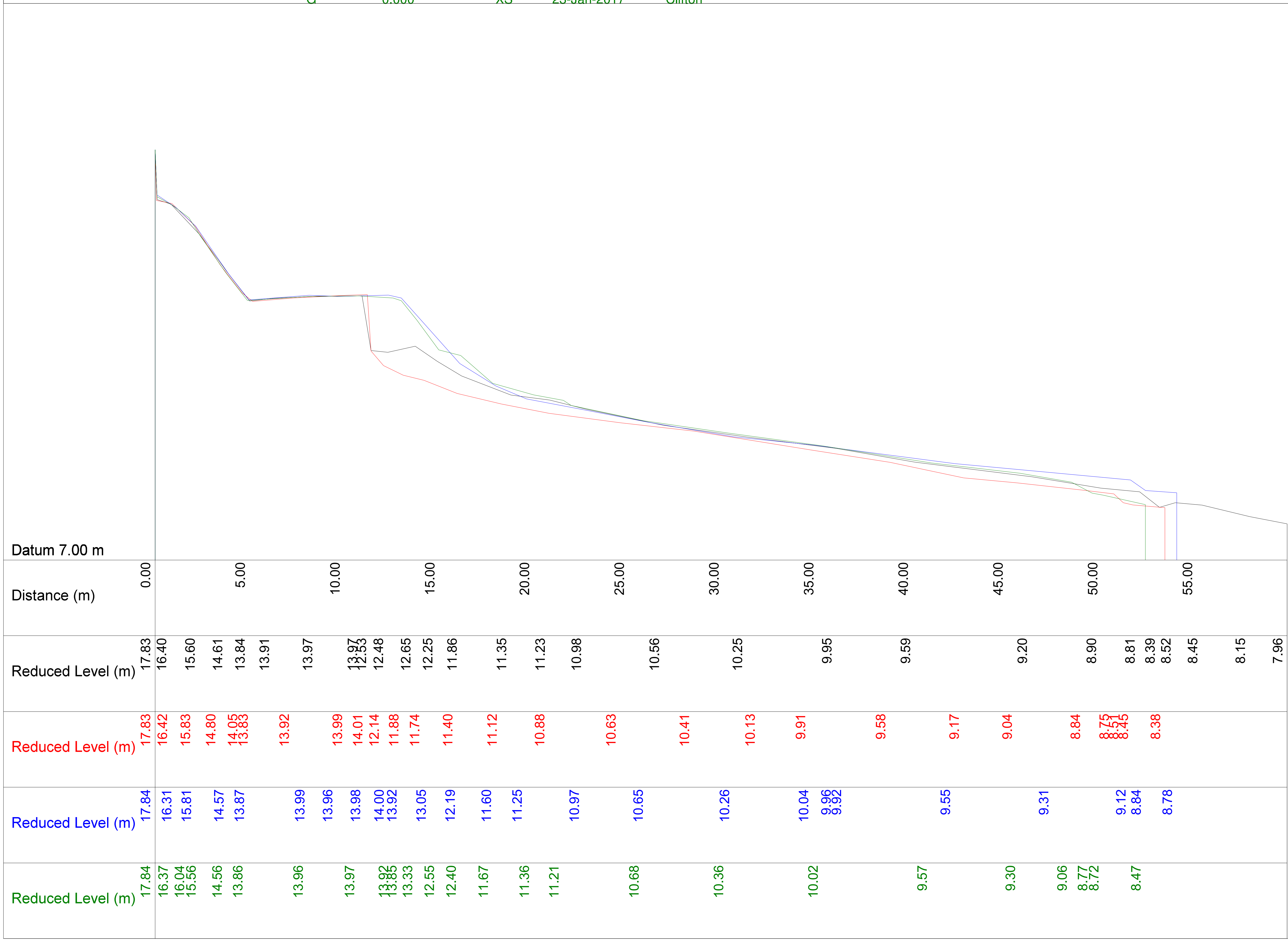

Site Name : Clifton Beach Rd Monitoring XS

Site Number : H

XS ID	Distance	Type	Survey Date	Local Name
H	0.000	XS	03-Oct-2017	Clifton Acess Rd
H	0.000	XS	26-Jul-2017	Clifton
H	0.000	XS	23-Mar-2017	Clifton
H	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:34 p.m.

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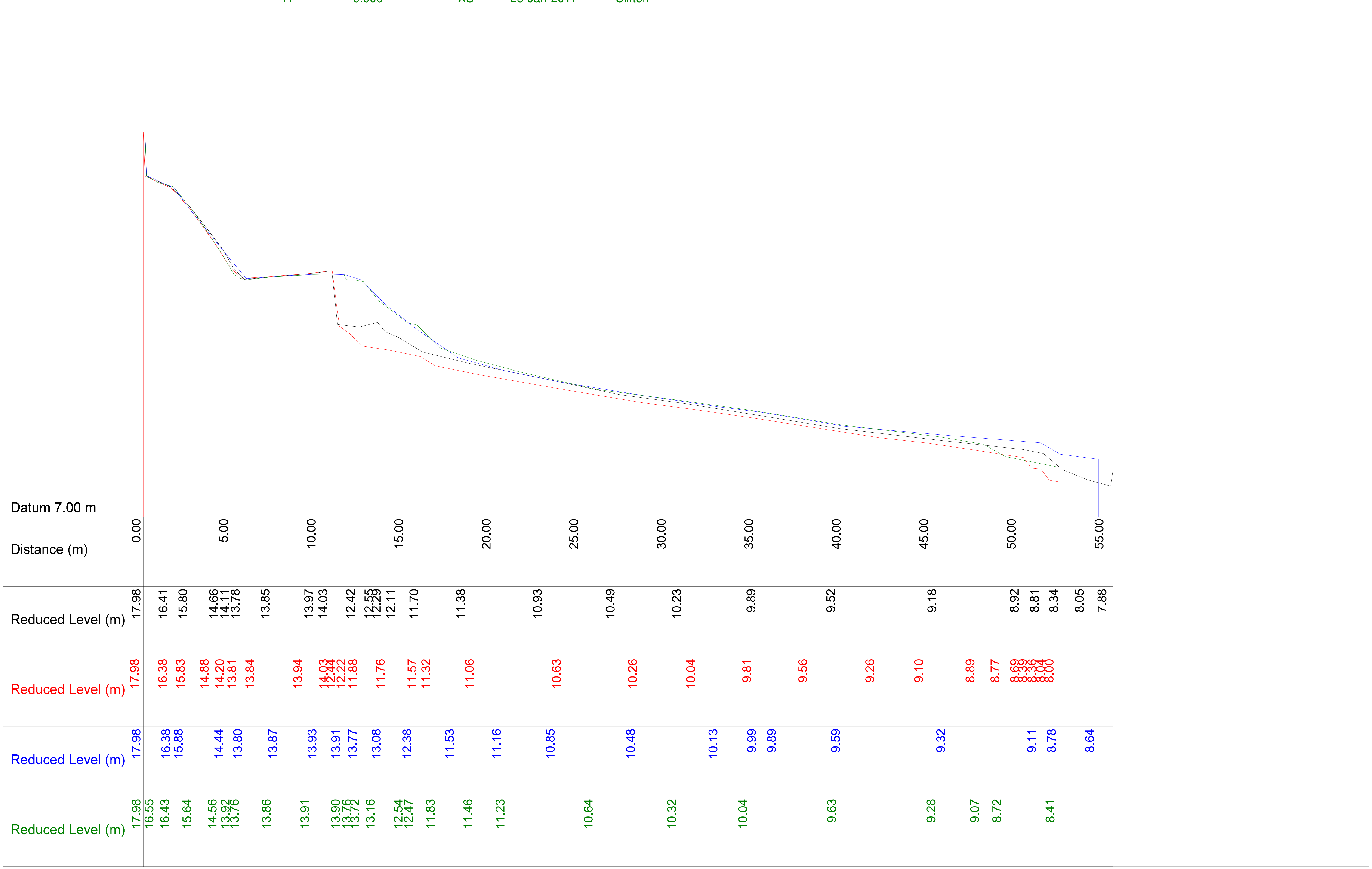
V 1 : 100



Site Name : Clifton Beach Rd Monitoring XS

Site Number : I

XS ID	Distance	Type	Survey Date	Local Name
I	0.000	XS	03-Oct-2017	Clifton Acess Rd
I	0.000	XS	26-Jul-2017	Clifton
I	0.000	XS	23-Mar-2017	Clifton
I	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:35 p.m.

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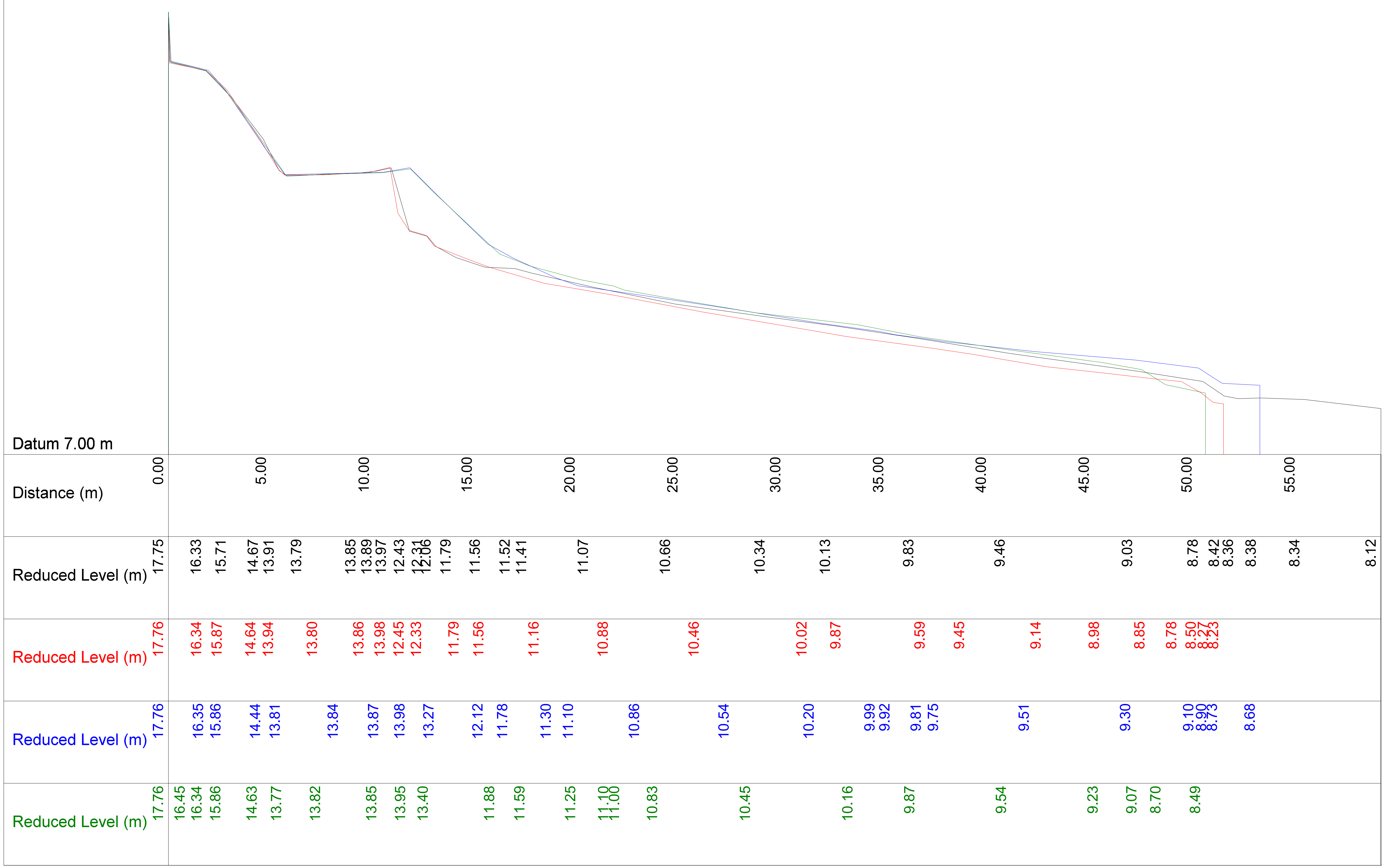
V 1 : 100



Site Name : Clifton Beach Rd Monitoring XS

Site Number : J

XS ID	Distance	Type	Survey Date	Local Name
J	0.000	XS	03-Oct-2017	Clifton Acess Rd
J	0.000	XS	26-Jul-2017	Clifton
J	0.000	XS	23-Mar-2017	Clifton
J	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:36 p.m.

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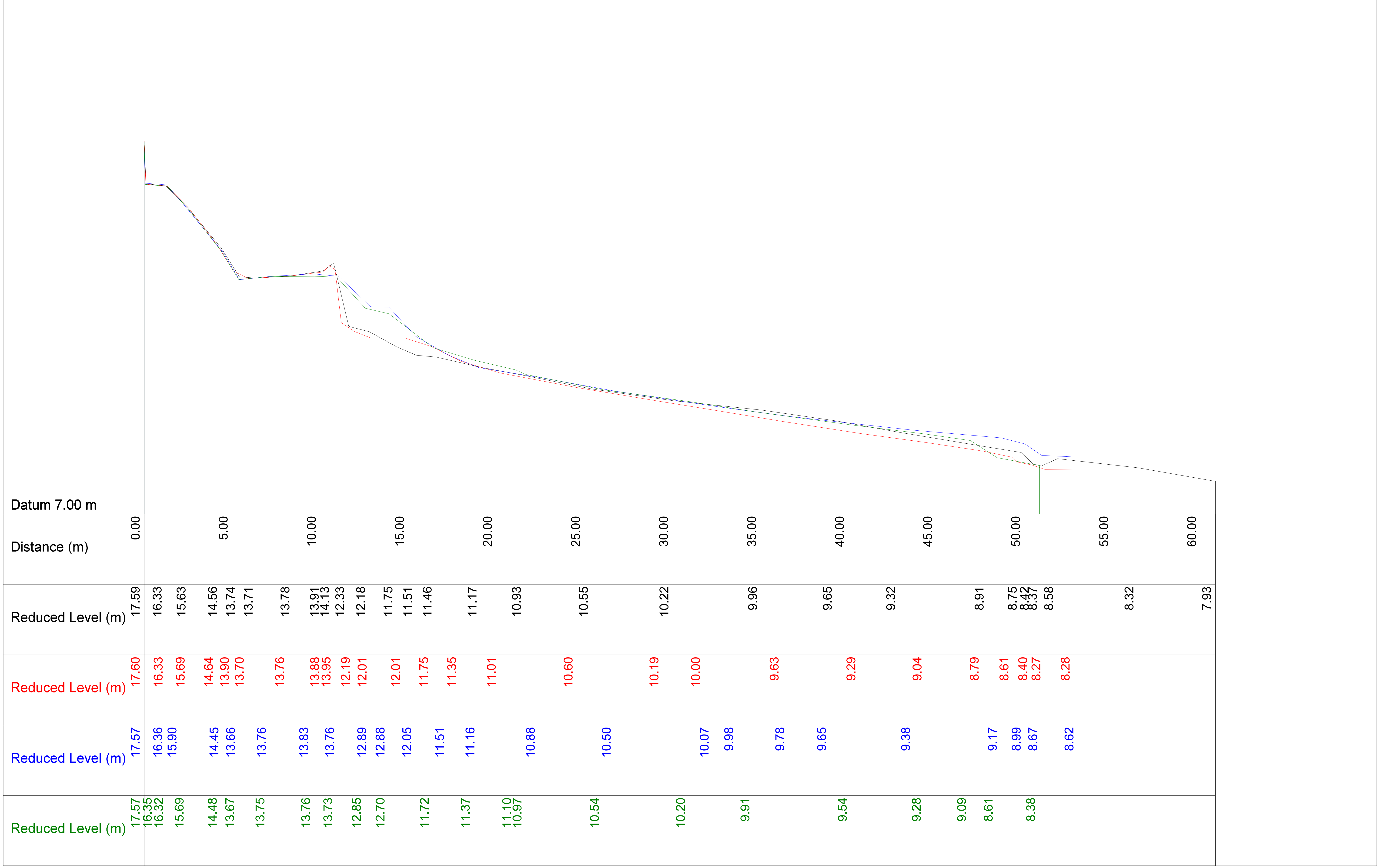
V 1 : 100



Site Name : Clifton Beach Rd Monitoring XS

Site Number : K

XS ID	Distance	Type	Survey Date	Local Name
K	0.000	XS	03-Oct-2017	Clifton Acess Rd
K	0.000	XS	26-Jul-2017	Clifton
K	0.000	XS	23-Mar-2017	Clifton
K	0.000	XS	23-Jan-2017	Clifton

03-Oct-2017 04:37 p.m.

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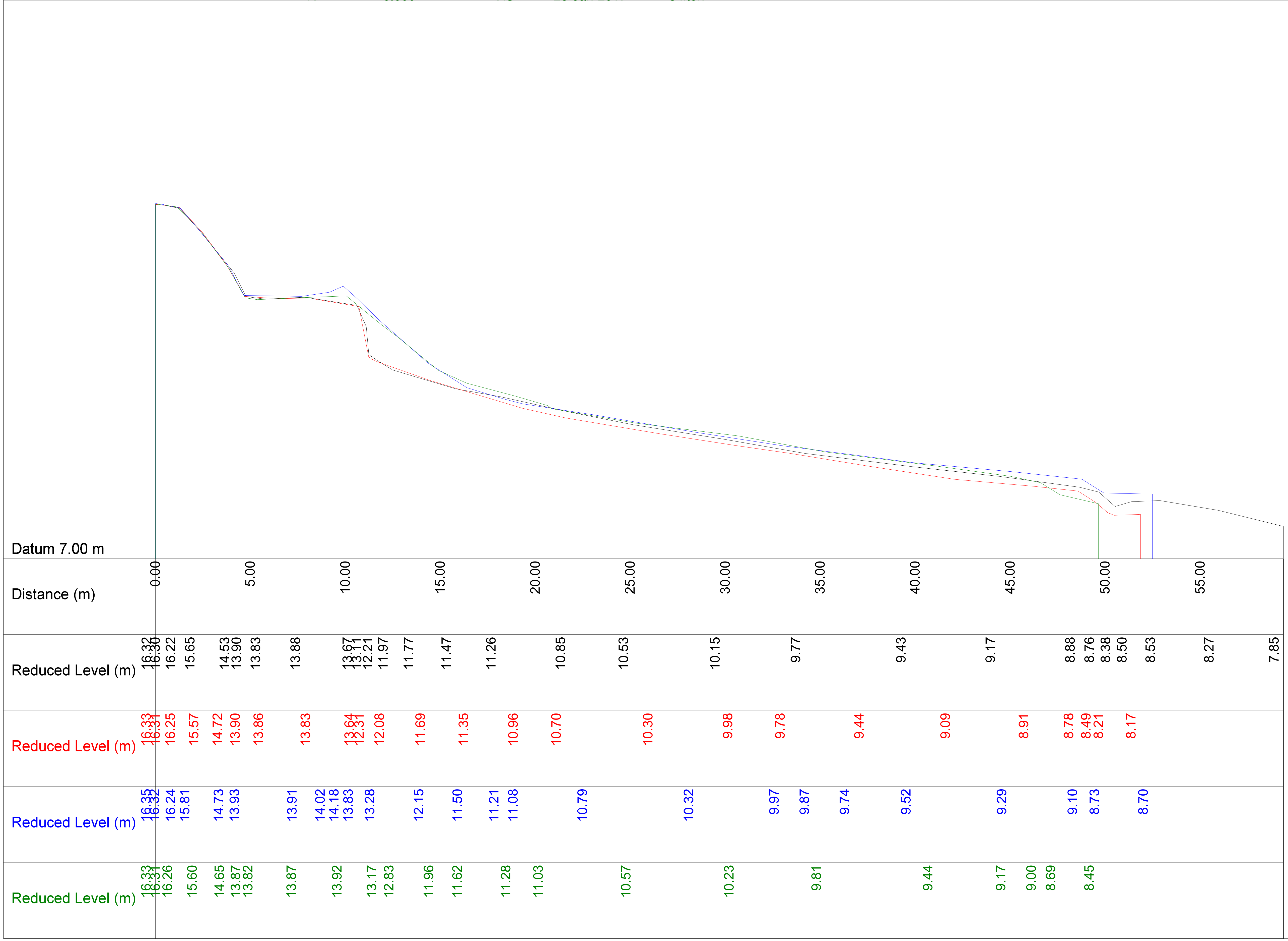
V 1 : 100



Site Name : Clifton Beach Rd Monitoring XS

Site Number : HB1

XS ID	Distance	Type	Survey Date	Local Name
HB1	0.000	XS	03-Oct-2017	Clifton Acess Rd
HB1	0.000	XS	26-Jul-2017	CLIFTON MOTOR CAMP
HB1	0.000	XS	23-Mar-2017	CLIFTON MOTOR CAMP
HB1	0.000	XS	23-Jan-2017	CLIFTON MOTOR CAMP

03-Oct-2017 04:08 p.m.

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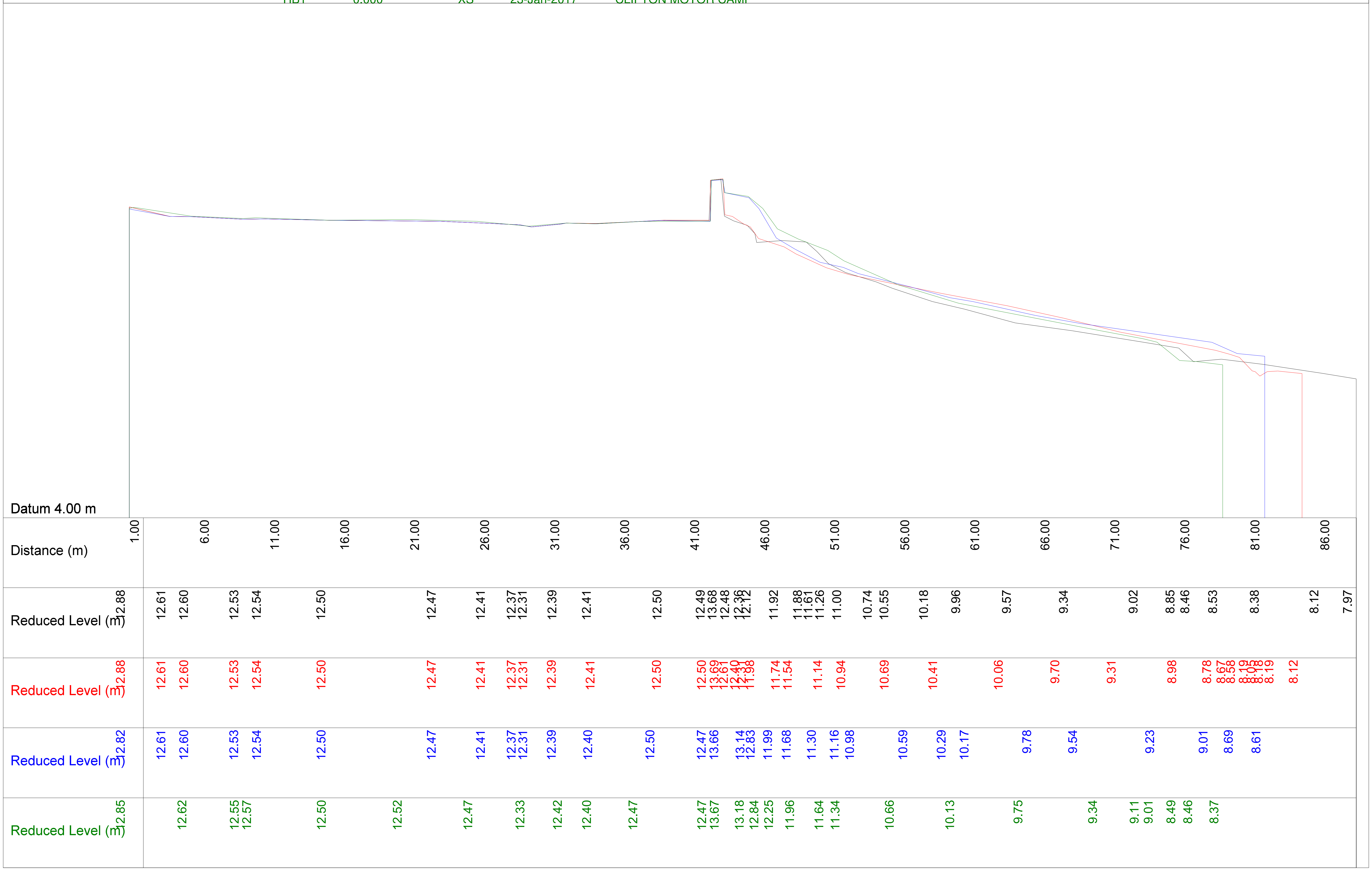
V 1 : 100



ATTACHMENT 2

Memorandum from Les Glock to John on Condition of Existing Revetment

HASTINGS DISTRICT COUNCIL

HASTINGS DISTRICT COUNCIL
207 Lyndon Road East
Hastings 4122
Private Bag 9002
Hastings 4156

Phone 06 871 5000
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TE KAUNIHERA O HERETAUNGA

MEMORANDUM

File Ref PRJ16-16-0091

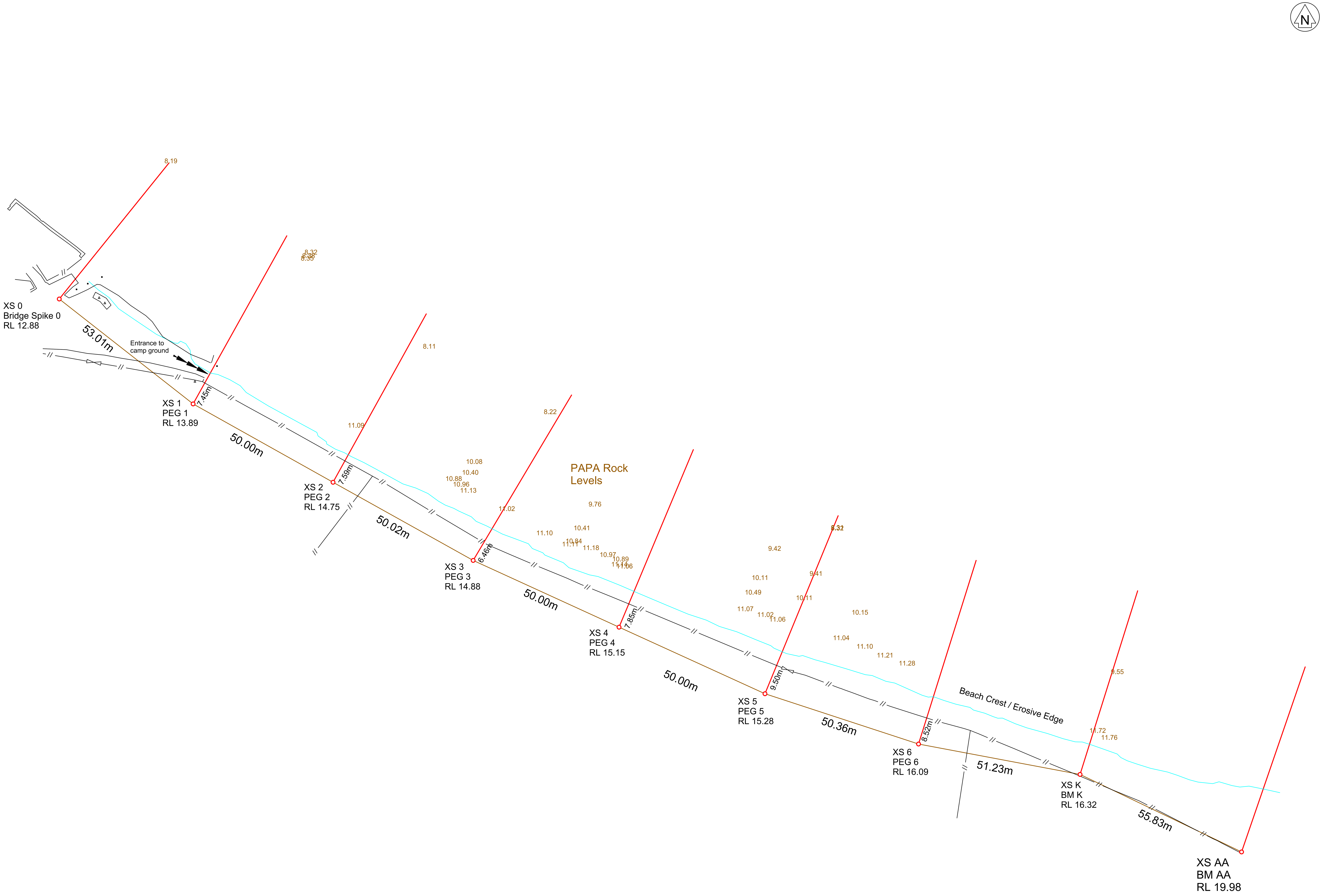
To:	John O'Shaughnessy
From:	**Les Glock**
Copy to:	Janeen Kydd-Smith, Stephen Priestley
Date:	31 October 2017
Subject:	Condition of existing Clifton Revetment

Further to our phone discussion today with Stephen Priestley of Beca Consultants, I can confirm that myself and Ray Berkett have on a number of occasions inspected the existing revetment. We have found that the structure has remained sound with no movement, dislodgement or fracturing of the limestone rocks.

Transportation Operations Advisor
lesg@hdc.govt.nz

ATTACHMENT 3

Zorn Figure showing papa rock levels



NOTES:

- Refer to Spreadsheet: "Clifton Camp Access Way Excursion Distance" for Excursion Distances to Erosive Edge
- Distance from Peg to Fence Shown
- Levels on PAPA taken where exposed
- Additional Levels taken on XS line when found by digging

Survey 20 18-10-2017
Clifton Beach
Papa Rocks Plan

DATE	:	Oct 2017
SCALE	:	1:600 @ A1
DRAWN BY	:	A.E
JOB NO.	:	13DNM
PLAN NO.	:	13DNM-20-Papa-1

ZORN SURVEYING Ltd
9 Severn Street, Pandora, Napier
PO Box 1006 Napier
Phone 06 835 2360
Web www.zornsurveying.co.nz
Email aaron@zornsurveying.co.nz

ATTACHMENT 4

Revised Beca Engineering Assessment Report (November 2017)

www.beca.com

Report

Clifton Beach: Engineering Assessment

Prepared for Hastings District Council

Prepared by Beca Limited

November 2017

Fisherman on Clifton Beach, Looking North, 2007. Credit Google Earth

Revision History

Revision Nº	Prepared By	Description	Date
1	**Evan Walters**	Draft	30 June 2017
2	Evan Walters	For Resource Consent	11 July 2017
3	Stephen Priestley	Revised dwgs for Section 92 response	3 November 2017

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Evan Walters**		November 2017
Reviewed by	Stephen Priestley		November 2017
Approved by	**Stephen Priestley**		November 2017
on behalf of	Beca Limited		

Executive Summary

Clifton beach, located in the southern end of New Zealand's Hawke Bay, has been subject to long term shoreline retreat. The shoreline retreat has encroached upon an access roadway which leads to a campground at the road's easternmost end. As this campsite and access road is valued by the local community, efforts to protect it have been undertaken.

Although a short section of revetment was constructed in 2013 to protect the campsite access, it does not protect the entire stretch of roadway. This has let the shoreline to continue eroding and threatening the access roadway.

This report evaluates the coastal processes at Clifton and reviews various options to protect the roadway. Hastings District Council preferred option is to extend the existing revetment by 400m to protect the coastal roadway.

This report also presents the preliminary engineering design of the revetment. The engineering design takes into consideration many environmental factors including a design water level, wave conditions, climate change, and wave overtopping. The revetment will comprise 2 layers of 1.0m diameter limestone rock at a slope of 1(vertical):2 (horizontal).

The report assesses the potential environmental effects of the revetment on the coastal processes. This is based on modelling the wave environment and longshore sediment movement (see Appendix D). No updrift adverse effects are likely. Although the revetment will impound approximately 600m^3/year of gravel, any down drift effects on the western end will be similar to the historical shoreline in the medium to long term. In the short term (less than 10 years), however, the adverse effects are considered to be moderate, having slightly more erosion than with the historical shoreline. In the medium to long term the adverse effects are considered to be minor.

Local erosional cutting in of the downdrift coastline is likely be experienced and will potentially need to be managed.

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1 Introduction

1.1 Background

Clifton Beach, located in the southern end of New Zealand's Hawke's Bay, has been subject to long term shoreline retreat. This shoreline retreat has encroached upon an access roadway which leads to a campground at the road's easternmost end. Although a small portion of this roadway was protected in 2013 by a rock revetment, the road is still in jeopardy. Its resource consent expires August 31st 2018

Clifton is the southernmost township along Hawke Bay in New Zealand. Clifton road ends at a campground location at its easternmost point. To access the campground, an access road runs along the beach for a half kilometer. The exact project location can be found in Figure 1.3.

The Hastings District Council (HDC) is applying to the Hawkes Bay Regional Council (HBRC) for a longer section of permanent protection works. The existing resource consent expires August 31st 2018. These works, covering a reach length of 400m, will provide protection to the road. This report reviews the options and describes preliminary design of the proposed coastal protection works in order to accompany the resource consent application.

Figure 1.1: Clifton, New Zealand, demarked by the red maker

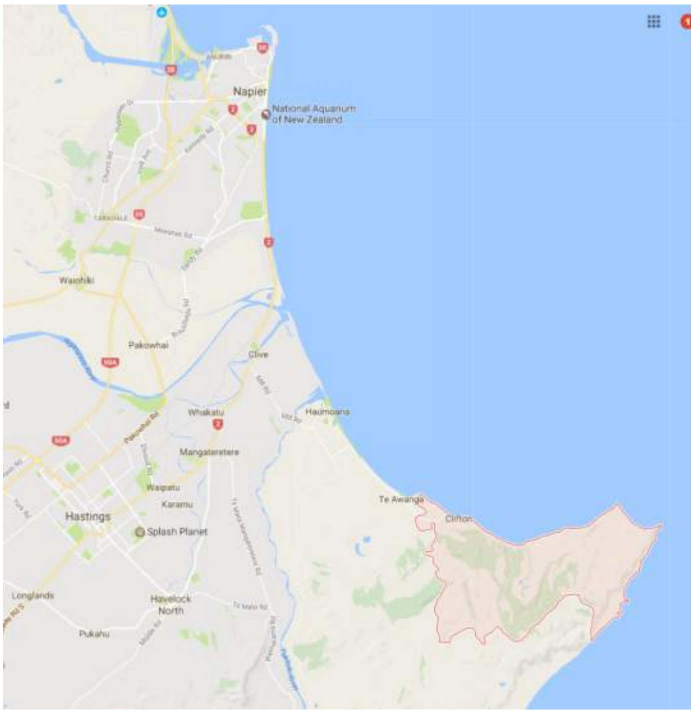

Figure 1.2: Closer up view of Clifton, red outline demarking the township limits

Figure 1.3: Exact Project Location demarked by red markings

1.2 Issues

The shoreline at Clifton is retreating such that the road is at risk. With little room left, options have been considered to protect the road which minimize adverse effects on the environment. Although studies have been done in the past for the Te Awanga and Haumoana area (Komar 2014, Environmental Management Services 2009), a study for Clifton beach has not been carried out in the past. This report represents a specific assessment for Clifton beach.

1.3 Purpose of the Report

The Hastings District Council (HDC) is preparing a resource consent application detailing a longer section of permanent protection works. This report considers and describes various options. From all the options considered, HDC chose a longer revetment as the preferred option. This report specifically addresses the coastal processes and engineering design issues and the potential adverse environmental effects on the surrounding area. It also presents a preliminary design for a 400m revetment extension.

2 Existing Environment

2.1 Topography and Bathymetry

The land levels and water depths at Clifton beach and the surrounding area has strong relief. Due to New Zealand's location near the interface of two tectonic plates, vertical cliff faces and large sediment deposits can be found throughout the region. Cape Kidnappers, a headland extending 8 kilometres eastwards, is part of this cliff system. West of Cape Kidnappers, where the cliff faces and hills stop, is a small flat area where Clifton was founded. Although this area is relatively flat, many reef systems extend offshore. These reef systems can influence the local wave climate by diffracting waves around the reefs and other underwater obstacles.

To better understand the area, bathymetric surveys were taken. This data was obtained from the Hawke's Bay Regional Council. Figure 2.1 below includes the results of the bathymetric survey which extended 1km offshore. Using SWAN (Simulating WAves Nearshore) the offshore wave climate was transformed into the beach nearshore using the bathymetric data. This bathymetric grid is illustrated in figure 2.2.

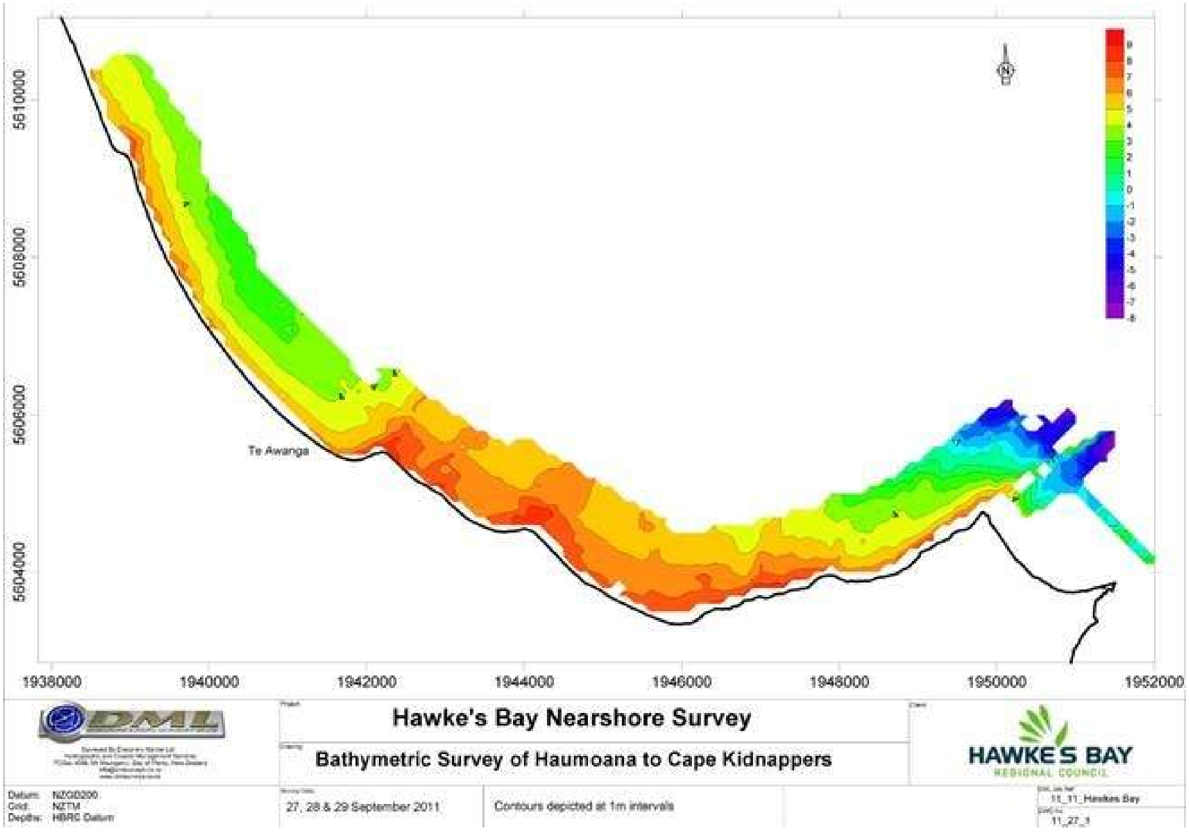

Figure 2.1: Sidescan sonar survey offshore of Clifton Beach, elevations in meters

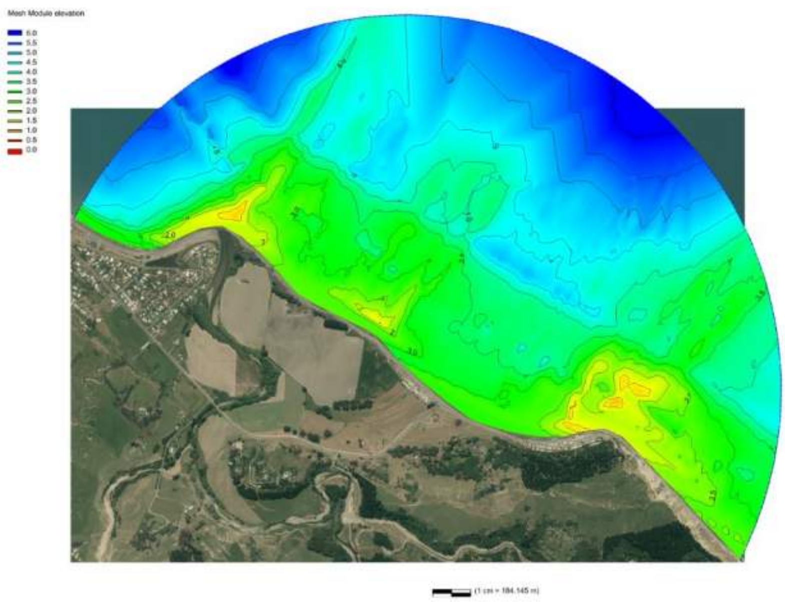

Figure 2.2: SWAN Model Bathymetry, showing reef systems

In addition to the bathymetric survey, beach profile surveys dating back to 1972 have been recorded, as discussed in section 2.6. These beach profile surveys show that the beach system has few bars with a beach face of 8% slope in places. This slope varies along the coastline depending on reefs and proximity to the cliff faces eastward of the project location.

2.2 Geology

The beach at Clifton is a gravel beach mainly derived from greywacke rock. Gradation curves of the sediment can be found appended to this report. Due to the steep beach slope, the beach is reflective and very little cross shore gravel movement is experienced. During fair weather sand accumulates on the beach, which later disappears during inclement weather. Similarly the beach flattens during fair weather and steepens during inclement weather.

In 1931 an earthquake caused the landform along the coast to lower by about 1.0m, however at the Clifton beach site itself the exact lowering amount is unknown. This lowering caused the coastal system to be out of equilibrium, probably contributing to the problems experienced today.

Below mean sea level (MSL), bedrock “Papa” rock is commonly found. This rock, forming the cliff formation, was deposited on the sea floor about 15 million years ago. At the cliff faces, this rock can erode and is highly susceptible to erosion and landslides during heavy rainfall (Komar, Harris, 2014).

2.3 Tides and Water Levels

Tidal levels in Hawke Bay are given in Table 1 (LINZ, 2015). Storm surges during low pressure events could raise the tide levels by some 0.2m. In extreme events, storm surges may increase tide levels by 0.8m. The local datum at RL 10.0m is at about mean sea level (MSL). Levels referred to in this report are in terms of the local datum.

Table 2.1: Tide Levels

Tide State	Chart Datum (m)	Local Datum (m)
HAT	2.0	11.1
MHWS	1.8	10.9
MHWN	1.5	10.6
MSL	0.9	10.0
MLWN	0.4	9.5
MLWS	0.1	9.2
LAT-Chart Datum	0.0	9.1

2.4 Wave Climate

The site is an open coast site which is exposed to swells which propagate across the Pacific Ocean as well as wind generated waves. Hindcast wave data (MetOcean Solutions, Ltd.) was used to produce the wave climate as illustrated in the wave roses below. The hindcast wave data covers a range of 37 years and encompasses significant events such as cyclones and major storms in addition to routine events. This hindcast wave data was calculated at the coordinate 177.005E, 39.630S which is 1km offshore at a depth of 4-5m relative to MSL. From the wave roses, it is evident that the majority of the waves propagate from a very tight range between 50 and 65 degrees clockwise from North.

For extreme wave conditions, MetOcean Solutions (2011) reported the 10 year return period significant wave in 10m of water depth as 4.6m and the 100 year return period significant wave as 5.4m. The mean wave period is about 10s. Although transformed from oceanic conditions, these waves represent high energy wave conditions.

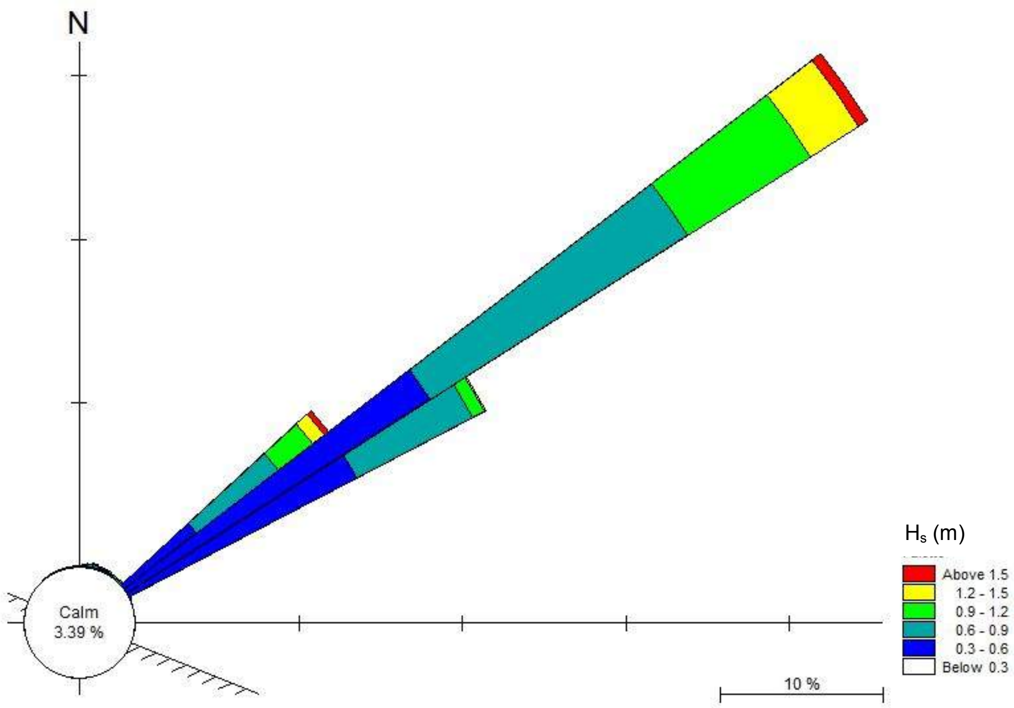

Figure 2.3: Wave Rose of Hindcast Wave Data at 177.005E, 39.630S, 5 degree bins, height in meters

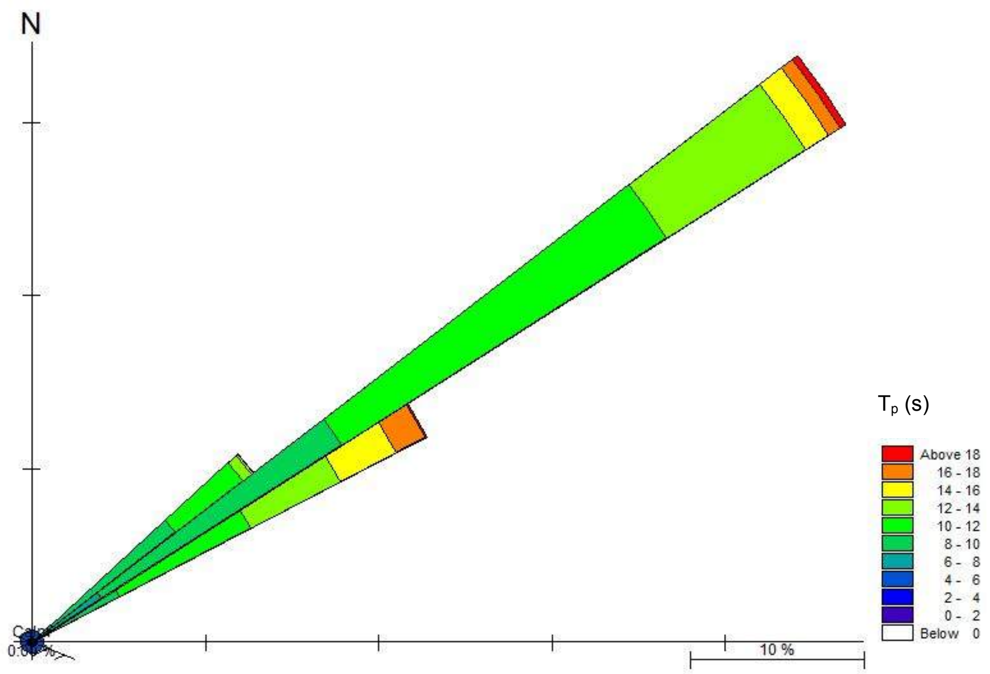

Figure 2.4: Wave Rose of Hindcast Wave Data at 177.005E, 39.630S, 5 degree bins, period in seconds

2.5 Currents

According to previous studies (Ridgeway, 1962) where drift-cards were used to determine currents along Clifton, Clifton beach has a small magnitude longshore current of 0.2 knots to the west.

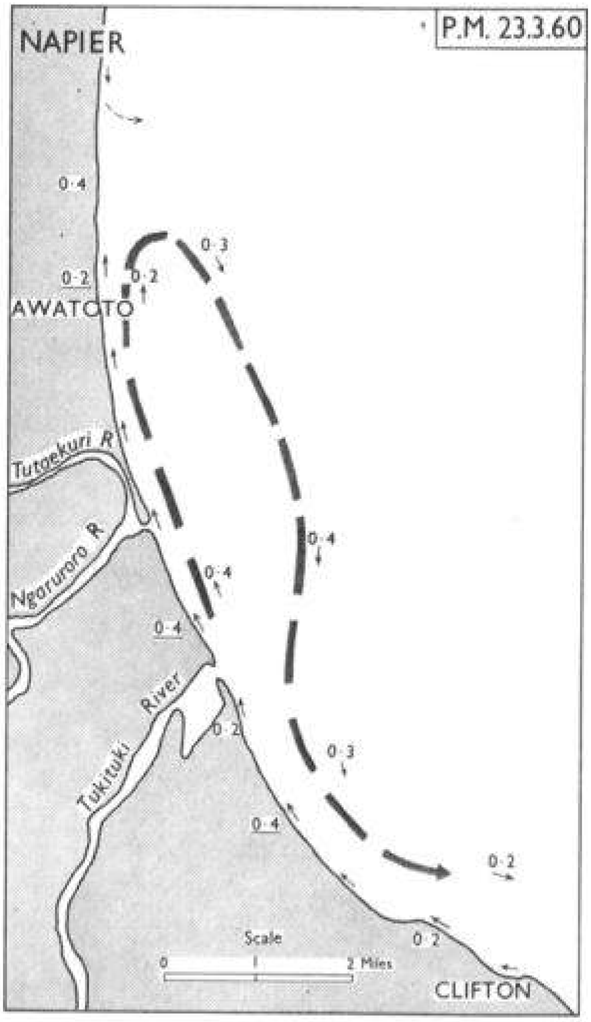

FIG. 9—Generalised movements, P.M., 23 March 1960. Broad arrow shows general movement of dye spots. Average rate (knots) shown alongside. Small arrows along coastline show drift-card movements. Predicted rates of longshore drift are underlined. Estimated rates from drift card returns also shown (not underlined).

Figure 2.5: Nearshore Currents in Hawke Bay

2.6 Sediment Transport

In 2005, Professor Paul Komar published a report which detailed the sediment transport rates for the various littoral cells of Hawke Bay. Clifton is located in the Haumoana littoral cell which extends from Cape Kidnappers to the Port of Napier. Despite the 18,000m^3/year sediment source from Cape Kidnappers erosion, Komar determined that Haumoana littoral cell has a net sediment loss of 45,000m^3/year. The westerly sediment transport is primarily due to a westerly drift from incoming swells and waves from the North-Easterly direction.

Although anecdotal knowledge is that during calm weather sand is deposited on the beach, whereas during storms it is transported offshore, there is very little information on the cross shore sediment transport rates at Clifton Beach.

Beach profile data at HB1 has been periodically taken at Clifton beach since 1972. The location of this profile, labelled below as BM1 Clifton, can be seen in Figure 2.6. Figures 2.7 and 2.8 show the results of the beach profile monitoring. Most notably from these results, the beach profile has retreated 32m since 1972 (i.e. 0.69m/year).

Figure 2.6: HB1 (labeled BM1 Clifton) Cross section profile location, Clifton, New Zealand. Image obtained from the Hawke's Bay Regional Council

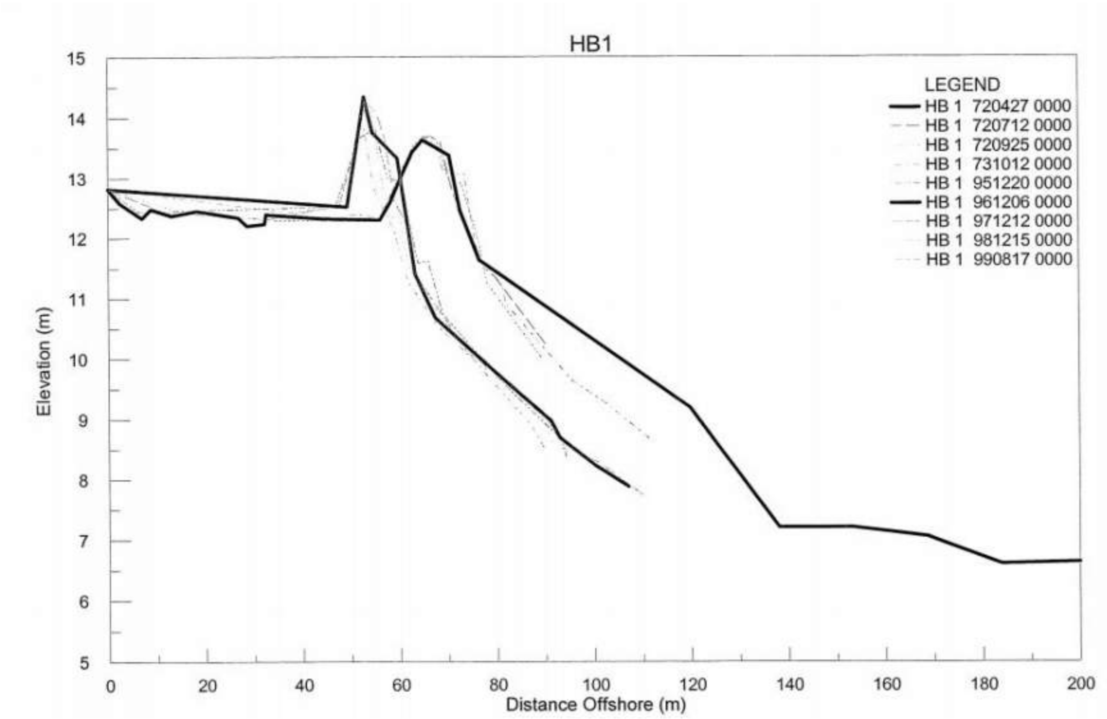

Figure 2.7: HB1 Profile Surveys, 1972-1999

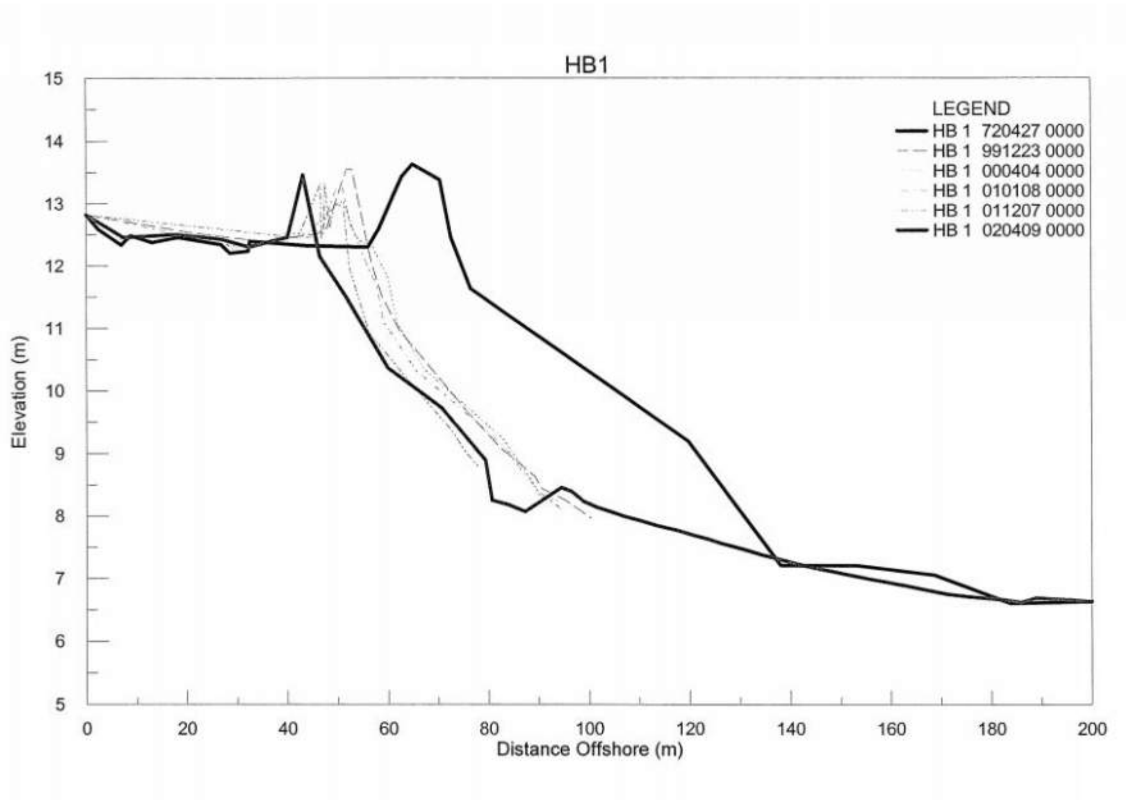

Figure 2.8: HB1 Profile Surveys, 1999-2002, and 1972

HB1 TOTAL REPORT
Profile Volume Report
Contour Level: **11 m**

Profile	Date	Vol (cu.m/m)	Distance (m)	Difference (m)	Cum. Diff (m)
HB1	27/04/1972	120.269	87.67	0	0
HB1	12/07/1972	70.994	82.97	-4.7	-4.7
HB1	25/09/1972	70.795	80.28	-2.69	-7.39
HB1	12/10/1973	51.978	81.72	1.44	-5.95
HB1	20/12/1995	107.472	68.01	-13.71	-19.66
HB1	06/12/1996	114.573	65.55	-2.46	-22.12
HB1	12/12/1997	103.756	66.58	1.03	-21.09
HB1	15/12/1998	101.136	66.06	-0.52	-21.61
HB1	17/08/1999	101.273	64.07	-1.99	-23.6
HB1	23/12/1999	94.668	62.05	-2.02	-25.62
HB1	04/04/2000	89.883	62.38	0.33	-25.29
HB1	08/01/2001	88.453	59.94	-2.44	-27.73
HB1	07/12/2001	89.327	56	-3.94	-31.67
HB1	09/04/2002	76.036	55.34	-0.66	-32.33

Descriptive Statistics	
Mean	-2.486923077
Standard Error	1.06339646
Median	-2.02
Mode	#N/A
Standard Deviation	3.834130463
Sample Variance	14.70055641
Kurtosis	6.519365947
Skewness	-2.249140712
Range	15.15
Minimum	-13.71
Maximum	1.44
Sum	-32.33
Count	13
Confidence Level(95.0%)	2.316941811
Trend (m/year)	-0.748
r squared	0.915

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.95675719
R Square	0.91538432
Adjusted R Square	0.90769199
Standard Error	2.79215192
Observations	13

	Coefficients	*Standard Erroi*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	49.2030968	6.45226167	7.62571318	1.02712E-05	35.00175747	63.40443621	35.00175747	63.40443621
X Variable 1	-0.0020487	0.00018781	-10.9086915	3.07979E-07	-0.00246208	-0.001635365	-0.002462084	-0.001635365

FREQUENCY ANALYSIS

				Observed		Normal
				Number	Frequency	Frequency
<-3sd	-14.0			0	0.0%	0.5%
>-3sd &<-2sd	-14.0	to	-10.2	1	7.7%	2.0%
>-2sd &<-1sd	-10.2	to	-6.3	0	0.0%	13.5%
>-1sd &< mean	-6.32	to	-2.49	3	23.1%	34.0%
>mean & <1sd	-2.49	to	1.35	8	61.5%	34.0%
>1sd &<2sd	1.35	to	5.18	1	7.7%	13.5%
>2sd &<3sd	5.18	to	9.02	0	0.0%	2.0%
>3sd	9.02			0	0.0%	0.5%
				13		

Figure 2.9: HB1 Profile Statistics

2.7 Natural hazards

Clifton Beach is subject to natural hazards including sea storms, tsunamis, earthquakes, cliff/ landslides, and flooding. Each of these natural hazards can change the physical environment. Sea storms can produce an increased water level as high as 0.8m and displace sediment in the cross shore direction. During these events waves overtop the coastal structures, disrupting access and vehicular traffic.

2.8 Existing Infrastructure

Over time the small settlement at Clifton has developed a carpark, beach access ramp at camp No. 1, access road, and campsite along the coast. The condition of each of these entities varies, but has overall fared well. A vertical wall protection structure exists to the east of the beach access ramp which produces a high level of wave reflection, with only minor dissipation from tyres in front of the wall. This wave reflection aids clearing of sediment from the boat ramp.

The beach between Camp No.1 and Camp No. 2 is in an erosional state. This erosion has resulted in the relocation of the access road three times between 2009 and 2013. To protect the road and access to the campsite, an 80m long revetment was installed in 2013. This revetment has stopped the retreating shoreline, but is insufficient for a long term result as continued erosion is experienced along the western end of the access road.

Camp No 1 has some existing protection from adverse sea condition due to the vertical wall at the boat ramp, the beach, and the 80m revetment.

3 Evaluation of Options

3.1 Purpose of Coastal Protection Works

Since shoreline retreat continues to jeopardize the existing infrastructure at Clifton Beach, implementation of coastal protection or management options was considered necessary in order to maintain the integrity of existing assets. Although coastal protection works will protect assets, in some cases it is more beneficial to re-establish assets elsewhere. The following options were assessed as potential solutions to maintain access to Clifton Beach.

3.2 Option Descriptions

3.2.1 Do nothing

In some cases, a recommendation of doing nothing can be reached on the basis of predicted future characteristics of the coastal ecosystem. Given this area's record of shoreline retreat dating back over more than 40 years, the characteristics of the area are not predicted to change in the near future, and the area will continue to erode over time. This also can be reinforced by the photos below, as well as the beach profile survey graphs in section 2.6.

Figure 3.1: Photo, circa 1912

Figure 3.2: Clifton beach aerial photo, 2009

The do nothing option would entail continued erosion of the beach to the road, and compliance with the existing consent for the revetment. This consent would result in the existing revetment being removed by August 31st 2018. According to the Coastal Processes report (2017), removal of the existing revetment would cause erosion at the campsite's entrance, which would later result in that beach access ramp and campground buildings being redundant.

3.2.2 Minimum Response with Extending Consent

The Joint Coastal Strategy, initiated in 2014, is a cross-council approach to identifying and responding to coastal hazards along the Hawke Bay coast. It is being developed in four key stages:

1. Define the Problem
2. Framework for Decisions
3. Develop Responses
4. Respond

Although stages one and two are complete, stage three is underway. Stage three involves development of coastal hazard plans for specific coastal areas to respond to the identified risks. Stage three is expected to be complete by the end of 2017. Afterwards, stage four is anticipated to be ongoing for several years.

It is possible to apply for an extension of the existing revetment's resource consent duration beyond August 31st, 2018, until an agreed way forward in line with the Joint Coastal Strategy has been determined. Doing so would require maintenance of the existing revetment and likely allow the erosion to further encroach on private land where the road is unprotected.

3.2.3 Inland Road Relocation

Although extending the resource consent of the existing revetment will protect the campsite entrance, the access roadway will soon be lost unless something is done to keep the access route open. One solution is to relocate the road further inland, as has been done before.

In 2003, Tonkin and Taylor released a report which included set back lines for various places along the Hawke Bay coast. These set back lines act as recommended lines where assets should be relocated behind to preserve their integrity. Specifically at Clifton beach, a setback of 60m was advised for the year 2060, and a setback of 100m by 2100. See Appendix C.

However, due to the location it is difficult to reposition the road inland on its eastern side. Although it is possible to tunnel through the cliffs to the campsite, this is a very risky and expensive option which will not be cost effective.

Since the beach and roadway are already very close to the private property lines, any further landward movement will breach these property lines. Figure 3.3 illustrates property lines overlain on an aerial image. Necessary coordination and approval from the landowners will be required if this solution is chosen. However, since the landowners have indicated to Council an unwillingness to provide further land for this purpose in the future, beyond the small encroachment already agreed, this option would be difficult to deploy.

Figure 3.3: Aerial Image of property lines along Clifton Road, Existing road in white, Cliff line in Green

3.2.4 Campground Relocation

Relocation of the camp No1 to an area near camp No 2 is a viable option. To have the same level of amenity, however, the boat ramp would need to be relocated. Relocating the ramp would introduce additional risk in Council owning and operating a boat ramp in an exposed location.

3.2.5 Managed Retreat

The 2009 report by Environmental Management Services Ltd studied the Te Awanga – Haumoana and Clifton area of coastline. The report details a cost analysis of staged retreat options as well as construction of a groyne field. Due to uncertainties in the performance of the groyne field along with its high costs, the report recommends staged retreat as the better option for the area.

It is important to note that the 2009 report studied a larger area than the campsite access road. With specific consideration of the road, if it were relocated inland there would be property issues and the difficulties of road relocation discussed in section 3.2.3.

3.2.6 Nourishment and Planting

This option, sometimes referred to “soft” or “passive” protection, would entail maintaining the existing beach front by importing sediment compatible with the existing beach sediment, and placing it on the beachfront. This sediment would increase the amount of beach width. As time goes on, the newly placed sediment would enter the littoral system and be lost. Options like this typically have high maintenance costs, but maintain the existing aesthetics of the area.

Dune planting is a very good option in many cases due to its aesthetics and use of natural resources to solve coastal problems. Planting can go hand-in-hand with nourishment. It uses the roots of the plants to hold sediment in place, potentially resisting natural erosion. This solution can extend the lifetime of a nourishment project. Solutions like these require dunes to be constructed if there are no existing dunes. Furthermore, dune planting requires room for the plants as well as time for the plants to establish themselves. Considering that there is little space between the road and the water line at Clifton, there is insufficient space for this option without acquiring private land.

Both nourishment and planting would be at risk of not providing protection during extreme sea storm conditions.

3.2.7 Groynes and Nourishment

In the 2009 Environmental Management Services report, groynes were assessed as an option for the Clifton to Te Awanga- Haumoana reach of coastline. Although the cost of the option over the project lifespan was $18.5 million (2009 NPV), the analysis was for many more groynes than would be necessary to protect the roadway. An individual groyne would cost about $1.8 million (2009 NPV) to construct, and have annual maintenance costs of about $8,500 (2009 NPV) according to the report. It is predicted that 3-4 groynes would effectively protect the access roadway. It is uncertain how these groynes would affect the downdrift area.

Groyne fields, although a viable solution, do have potentially adverse aesthetic value and would reduce the amenity value of the beach. The local community and tourist companies may well oppose the construction of a groyne field due to the potential loss of access.

Groynes cause accumulation on the updrift side of the groyne, but encourage downdrift erosion. To minimize the downdrift erosive effects, they are used in series. Another way to remedy the downdrift effect is to nourish the beach between the groynes. With very little room left between the water line and the existing roadway, nourishment between the groynes would be required. This nourishment would increase the project costs.

Figure 3.4: Groyne Field example, Australia

3.2.8 Offshore Breakwaters

Offshore breakwaters function by dissipating the wave energy impacting a shoreline and reducing the longshore transport behind them. With slower transport rates, the beach sediment is able to accumulate behind the breakwaters and widen the beach. In some cases, the beach behind the breakwater can accrete so much that it touches the breakwater forming a tombolo. A tombolo significantly reduces the longshore sediment transport behind the breakwater thereby depleting downdrift sediment supply.

Figure 3.5: Offshore breakwaters example

Since breakwaters are in deeper water, they are substantial structures and costly to construct.

3.2.9 Sheet Pile Wall

Due to the space limitations at the site, a sheet pile wall could effectively protect the roadway. However, a vertical sheet pile wall will reflect waves, providing little energy dissipation. These reflected waves have the potential to cause adverse effects elsewhere.

3.2.10 Revetment

Revetments have been implemented in the past at Clifton to protect the roadway. The existing revetment installed in 2013 covers a length of 80m and protects the campsite entrance and toilet block structure. This revetment, made from local limestone, has successfully held the coastline in position. However, the revetment's extent has been insufficient to cover the entire reach of shoreline which is eroding to the roadway, so a longer revetment has been considered.

There are various revetment options available. These include a short length which would minimally protect the roadway, a long length revetment to protect the entire roadway, a buried revetment, a low crested revetment, and a high crested revetment.

A short length revetment would only protect part of the road access way.

Buried revetments are typically covered with compatible beach sediment. The advantage of a buried revetment is that it would preserve the aesthetic value of the beach and protect the road. However, to be effective, the road would need to be located behind the buried wall to offer proper protection.

Low crested revetments are commonly used in benign wave climates. A crest height of at least RL 15.0m is necessary to prevent the revetment from being damaged during storms. Furthermore, a crest height at RL 15.0m matches the existing ground level and would help key into the roadway on the landward side. A low crested revetment, however, is subject to more overtopping and probable damage to the structure due to its low amount of freeboard.

It is considered that a 400m long, RL 15.0m high crested revetment is required to protect the remaining access roadway.

3.3 Preferred Option

Of all the above options, Council looked at two of the options in some detail. Option 1 was to move Camp No1 to Camp No 2 and Option 2 was to extend the revetment. Council eventually selected the 400m long revetment option because:

- Camp No 2 is in a flood zone and land would need to be purchased.
- A new boat ramp would need to be built at Camp No 2. This had a number of issues. Council would be taking on extra health and safety risk for the ramp (which it doesn't have now) and may need to build a breakwater around it to make it safe. That would potentially affect the coast processes more than the revetment.
- The revetment was more cost effective, overall.

4 Revetment Design

4.1 Description

The revetment design detailed in this section would extend from the existing revetment's western end 400m to the west until the road turns away from the shoreline. There is a beach access ramp where the road turns away from the shoreline. Preliminary design drawings can be found in Appendix B.

4.2 Design Considerations

4.2.1 Design Water Levels

Taking the water levels in section 2.3 into consideration and knowing that the proposed revetment structure will experience depth limited wave conditions. The design still water level of RL 12.0m is based on:

- MHWS RL 10.9m
- Storm surge 0.8m
- Sea level rise (SLR) 0.3m

4.2.2 Design Wave Conditions

The base of the wall will extend from RL 11.0m. This results in a depth of water of 1.0m and a design wave height of 1.2m. A design mean wave period of 10s was adopted, although wave periods up to 16s were considered.

Local limestone boulders are proposed to be used to form the revetment works. The ability of limestone boulders to resist the design wave will depend on many factors. The main factors are the rock integrity and its density, the level of acceptable damage, the revetment slope and level of permeability. Assuming a limestone boulder density of 2.2 t/m^3 and a slope of 1:2 (which would be the maximum slope) it was found that:

- For a 2 layer system with an underlayer and minimal damage, the D_{50} would need to be about 1000mm. The underlayer would have a D_{50} of 400mm. With a geotextile between the native and rock material, an impermeable barrier was assumed.
- Using the Van der Meer equation for rock armour design in shallow water, the following parameters were assumed: S_d=2, P=0.1, N=3000.
- The crest level of the revetment should be set at RL 15.0m and be at least 3 D_{50} wide. (i.e. about 3m wide). Overtopping is discussed in Section 4.2.4. Some scouring of the road and grass areas could be expected during extreme sea storms.
- The toe of the revetment will be subject to scour and should have a buried toe with a width of twice the design wave height (i.e. about 2m). It is known that there is "papa" rock at around MSL and this has been assumed over 50% of its length. This will require a key toe detail to minimise loss of revetment rock.
- For the 80m length of rock wall in place, it is recommended that another layer of 1.0m rock be placed over the sloping revetment to improve its integrity for long term application.
- The limestone rock armour will require on-going monitoring and maintenance.

4.2.3 Climate Change Considerations

Considering the design life of the structure, an appropriate allowance for sea level rise is the 0.3m which would cover about 30-50 years of structure life. The New Zealand Coastal Policy Statement requires consideration of SLR over 100 years which approximately equates to about 1.0m. The approach here is to monitor SLR and if it exceeds 0.3m then the revetment would have another layer of rock to protect it for a more elevated design water level and wave run-up.

4.2.4 Overtopping

The maximum allowable overtopping rate for no revetment damage is approximately 50 litres/s per metre of revetment or 200 litres/s per metre if the crest is protected according to the UK Environment Agency (1999) and CIRIA/CUR (2007). Given the design wave height of 1.2m, the design wave period of 10s, and the dimensions of the proposed revetment the overtopping rate was calculated to be 44 litres/s per metre on the seaward side of the revetment crest. For design wave period of 16s, and the dimensions of the proposed revetment the overtopping rate was calculated to be 200 litres/s per metre. At these overtopping rates the revetment would not be damaged.

The overtopping rate on the landward crest side would range from 4 to 15 L/s/m. CIRIA/CUR (2007) states that this rate of overtopping would produce dangerous conditions for vehicles travelling on the road behind the revetment. It is advised that appropriate signage be installed to advise road users about dangerous road conditions during storms.

4.2.5 Tsunami

Power (2013) gives the 100 year and 500 year return period tsunami with wave heights of 4.2 and 7.0m respectively. The revetment is not designed as a protection structure to guard against such tsunami. Revetment damage can be expected in an extreme tsunami events.

Clifton is in a tsunami evacuation zone, and extreme tsunami events will be a serious civil defence issue.

4.3 Revetment Geometry

4.3.1 Spatial Extent

The spatial extent of the revetment stretches 400m from the western end of the existing revetment to where the road turns away from the coastline in front of the Clifton Café. The revetment will roughly be parallel to the RL 11.0m contour at its toe, and be roughly 15m wide at its typical cross section. It will key in with the beach access ramp and road at its westernmost end.

4.3.2 Levels

To allow for the overtopping rates above, the revetment crest elevation was set to RL 15.0m. This elevation is low enough to allow for overtopping during storms without damaging the revetment. Towards the western end of the revetment, the crest elevation is RL 14.4m to aid the transition with the adjacent beach area.

From the crest towards the coastline, the revetment side slopes down to the toe at RL 11.0m and the existing road lowers at a slope of 1:2. This toe is at the same approximate level as MHWS. Thus, the revetment toe will be visible. Since the toe of the revetment will tie in with the hard Papa rock or have a buried toe, scour effects are not anticipated.

The new concrete beach access ramp will tie into the hard papa rock at a level of RL 9.8m. It is designed so that some beach material will wash up onto the base area of the ramp. The top of the ramp will tie in with the road at a level of RL 13.2m. The ramp slope at 1:7 is to facilitate vehicle access.

Refer to the drawings in Appendix B for revetment and road levels which tie into existing ground levels.

4.3.3 Rock

Limestone is readily available from nearby quarries and so it will be used to construct the revetment. Limestone is not a durable material but has been used to construct revetments in the past. To ensure that the wave environment will minimally dislodge the armour stone, the average rock size has been determined to be 1m diameter. If a smaller rock size were used, displacement of the armour stone can be expected. Additionally, the rock will be angular to facilitate interlocking and discourage armour stone from being dislodged from the revetment. A typical armour thickness is twice the equivalent cubic diameter (CEM 2008), hence the revetment will be 1.8m thick.

4.4 Revetment Construction

The revetment's construction is expected to take approximately 4 months. Access to the site will be via Clifton road. The project will require excavation of the foreshore and mudstone to form a sound base upon which the revetment can be built. As necessary, sand may be used to form a compacted subgrade. The excavation will take place as the tidal conditions allow.

Geotextile fabric and filter layer rock armour will then be laid on top. The rock armour will be stacked to provide for adequate inter-locking. Rock armour placement will be done from the foreshore, however the upper portion of the rock armour may be completed from the access road.

The revetment construction will take place progressively. The revetment will be constructed in 5-15m long segments to minimise risk of foundation exposure.

Rock will be inspected for various factors including cleanliness, quality, size conformity, etc. at the quarry rather than the construction site to reduce disturbances. The materials will then be transported by trucks to the construction site and used immediately. Overall about 9000 m^3 of rock required. Assuming an average truck load of $10m^3$ per truck, the project will require 900 truckloads (about 15 trucks per day on average).

Lastly, it is best for the works to be completed outside of the main summer holiday period and Easter to avoid high use periods. Works will be undertaken between the hours of 7:00am and 7:00pm, Monday to Friday, tide permitting. All construction will be undertaken to comply with the Construction Noise Standard NZS6803:1999 to avoid adversely affecting residents of neighbouring dwellings.

4.5 Revetment Maintenance

Although the revetment is expected to last 20 years before any significant maintenance would be necessary, the actual design life of the structure is dependent on the level of maintenance and the frequency of significant storms. With proper maintenance, a design life of 50 may be achievable.

Regular annual inspections as well as inspections after significant storms occurring during high tide are recommended for the structure. These inspections may find that periodic replacement of dislodged rocks may be necessary.

The beach may require periodic renourishment. This is due to the impoundment of about $850m^3$/year of sediment which will probably be evidenced as a local down drift erosional lee effect. Of the $850m^3$/year impoundment, it is estimated that $600m^3$/year will be impounded gravel. It is recommended that an allowance of up to $1000m^3$/year be made with the actual amount determined through site monitoring.

The timing of the replenishment will be determined by 6 monthly monitoring (or after sea storms) with the aim of placing it within two months of exceeding a threshold level. It would be preferable for replenishment to take place in winter. This replenishment provision is mitigation for the wall and not for long term erosion.

The renourishment material will be sourced to have a similar sized material as the existing beach gravel. It will be delivered to site by truck and dumped on the beach. A small blade machine will then be used to spread the material to make up the deficient caused by the downdrift erosion. Some overfilling of the deficient should be allowed for.

5 Environmental Effects of Revetment

In general, revetments hold the shoreline at a constant point and prevent future shoreline retreat. On the seaward side of the revetment, some scour and erosional effects could potentially be experienced. Scour effects are expected to be minimal for this project because the revetment toe will generally tie in with the hard Papa rock or be buried.

The revetment armour slope is designed to dissipate wave energy and minimize reflection so the wave environment will be similar. Since the revetment runs along the shoreline, nearshore currents will also remain unchanged.

According to the results of the coastal process modelling (Appendix D), the revetment extension will have no effects up drift to the east due to it tying in with the existing revetment.

Due to the hardening of the coastline, the revetment will impound approximately 600m^3/year of gravel, not making it available to the littoral system. This impoundment loss will slightly increase over time due to sea level rise.

Down drift effects on the western end will vary over time. In the short term (less than 10 years), the adverse effects will be moderate, having slightly more erosion than the historical shoreline retreat. In the medium term (20-30 years), the erosion rate will be similar to the historical shoreline retreat. Therefore the medium to long term adverse effects are considered to be minor.

Although the model results don't show an increase in the shoreline retreat, a local erosional cutting in of the coastline will likely be experienced and potentially need to be managed.

Construction of the proposed revetment will provide a much larger level of protection for the existing infrastructure. The revetment will locally hold the coastline stable

6 Conclusions

The environment at Clifton beach is complex due to a variety of factors including waves, tides, currents, wind and its local geology. Over time, that environment has become conducive to an eroding shoreline which over the years has become to a hazard to infrastructure along the beach.

Although a short revetment has been put in place to protect Camp No 1 access, its influence is insufficient to protect the entire roadway. There are various options which can protect the rest of the roadway. Extending the revetment is considered by Council as the best way forward.

The report assesses the potential environmental effects of the revetment on the coastal processes. This is based on modelling the wave environment and longshore sediment movement (see Appendix D). No updrift adverse effects are likely. Although the revetment will impound approximately 600m^3/year of gravel, any down drift effects on the western end will be similar to the historical shoreline in the medium to long term. In the short term (less than 10 years), however, the adverse effects are considered to be moderate, having slightly more erosion than with the historical shoreline. In the medium to long term the adverse effects are considered to be minor.

Local erosional cutting in of the downdrift coastline is likely be experienced and will probably need to be managed.

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Appendices

Appendix A

Gradation Curves

Appendix B

Engineering Drawings

Appendix C

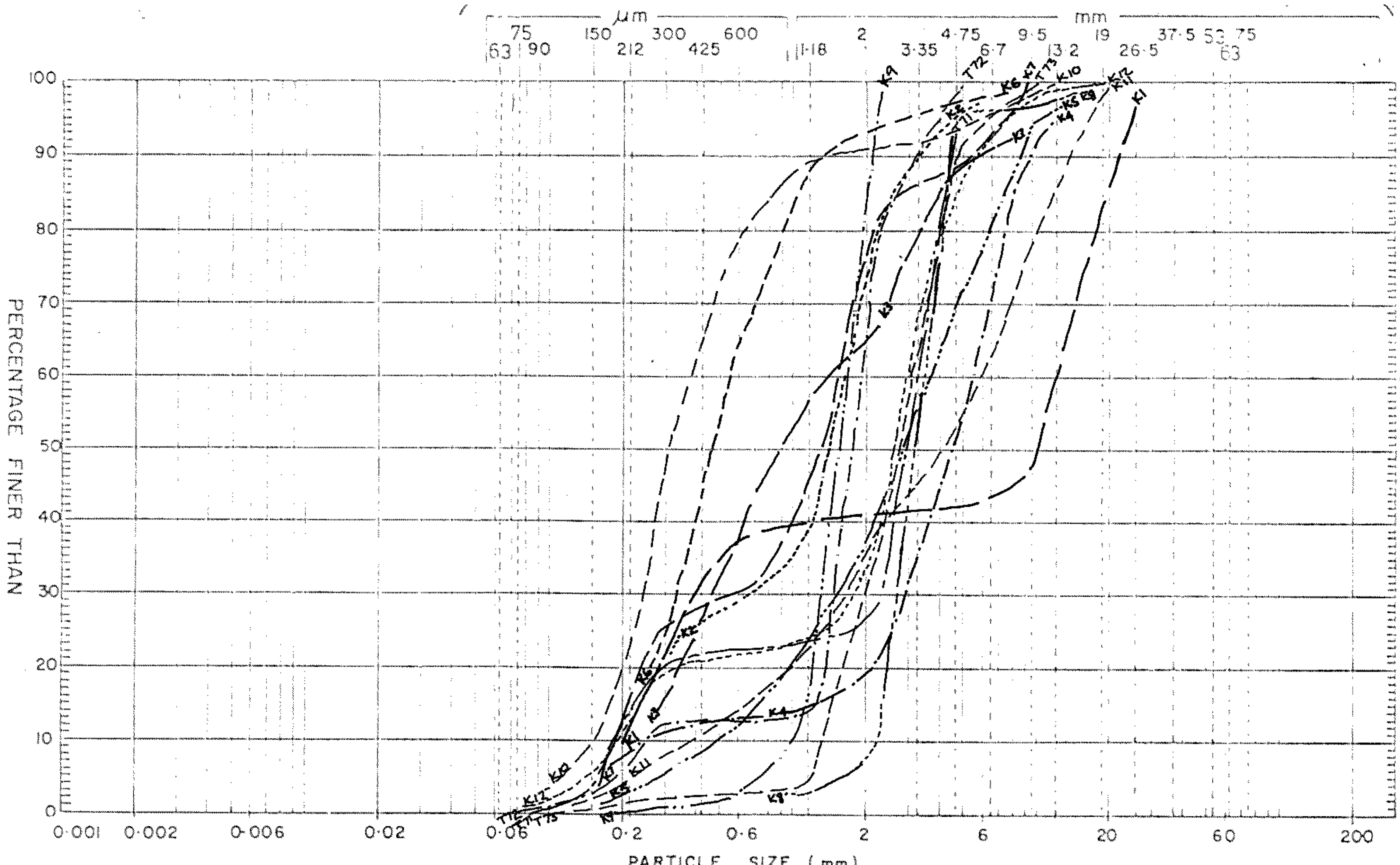
Setback Lines

Appendix D

Coastal Processes Assessment

Appendix A

Gradation Curves



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	V. COARSE
		SILT			SAND			GRAVEL		

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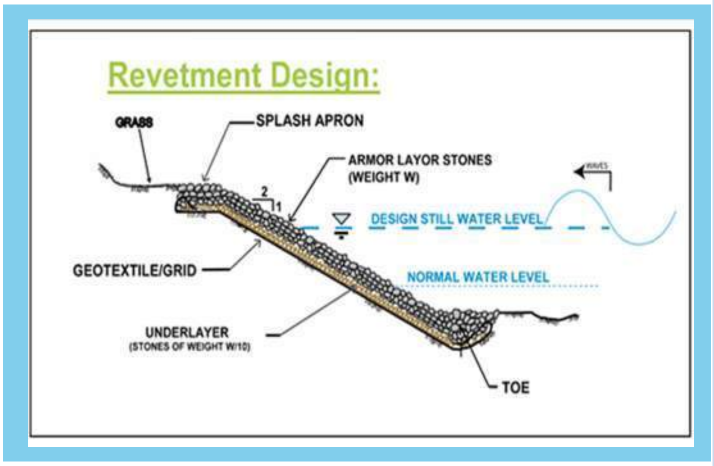
	LOCATION: K Series T71-73, 82	~~WET SIEVED~~, DRY SIEVED, ~~PIPETTE, HYDROMETER~~	DATE: 1/85
		REMARKS	CHECKED BY:
	DEPTH: R.L. 11·00m.		DATE:

Fig. 14 CHART FOR RECORDING PARTICLE SIZE DISTRIBUTION

Appendix B

Engineering Drawings



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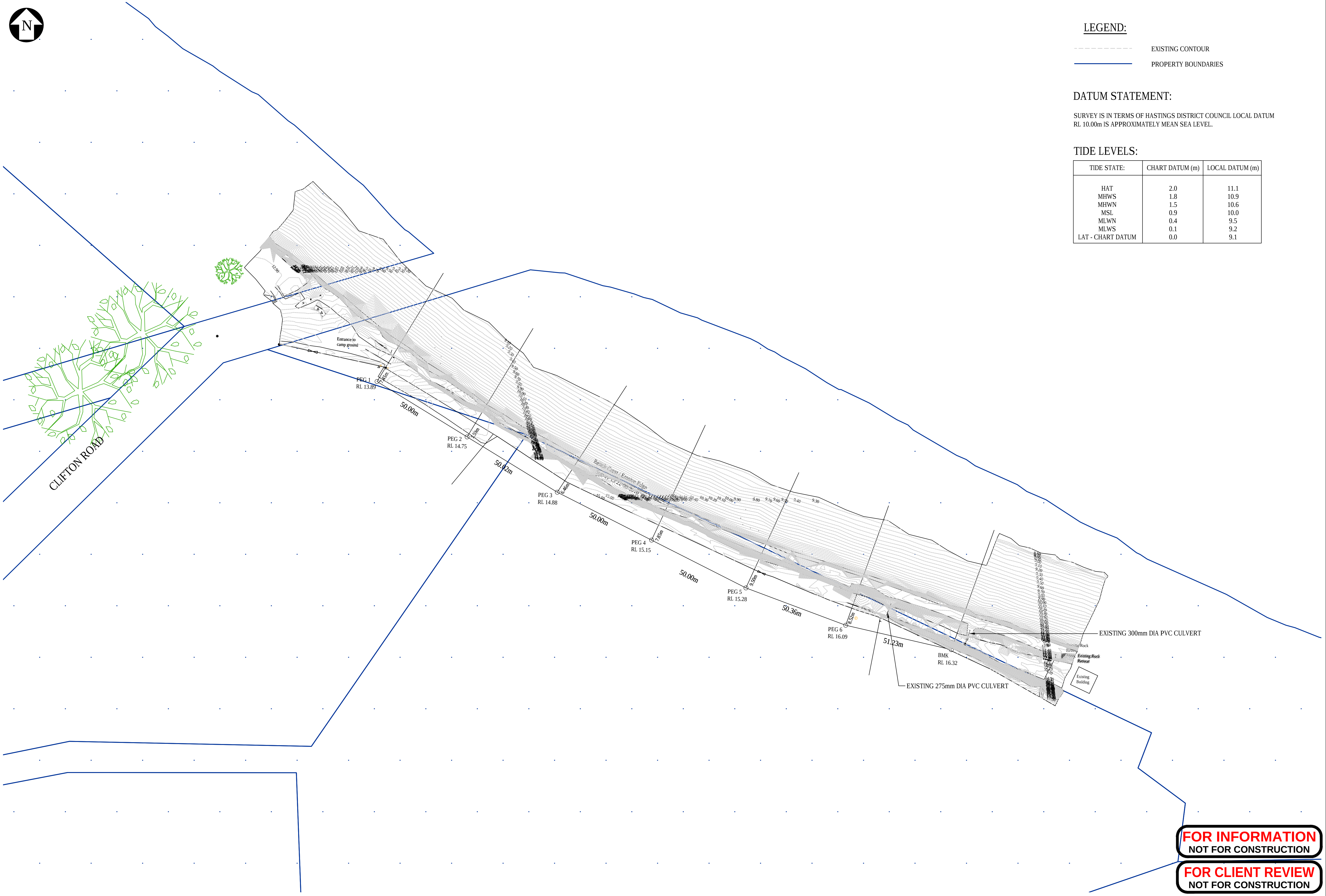

LEGEND:

EXISTING CONTOUR

PROPERTY BOUNDARIES

DATUM STATEMENT:

SURVEY IS IN TERMS OF HASTINGS DISTRICT COUNCIL LOCAL DATUM
RL 10.00m IS APPROXIMATELY MEAN SEA LEVEL.

TIDE LEVELS:

TIDE STATE:	CHART DATUM (m)	LOCAL DATUM (m)
HAT	2.0	11.1
MHWS	1.8	10.9
MHWN	1.5	10.6
MSL	0.9	10.0
MLWN	0.4	9.5
MLWS	0.1	9.2
LAT - CHART DATUM	0.0	9.1

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FOR CLIENT REVIEW
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No.	Revision	By	Chk	Appd	Date
A	ISSUED FOR CLIENT REVIEW	KWN	EW	SP	21.04.17

Drawing Originator: Beca

Original Scale (A1) | Reduced Scale (A3) | Design | Drawn | Dwg Verifier | Dwg Check | Approved For Construction* | Date

* Refer to Revision 1 for Original Signature

Client: HASTINGS DISTRICT COUNCIL

Project: CLIFTON REVETMENT

Title: EXISTING LAYOUT PLAN (CONTOURS)

Discipline: CIVIL ENGINEERING

Drawing No. 3233367-CA-K001

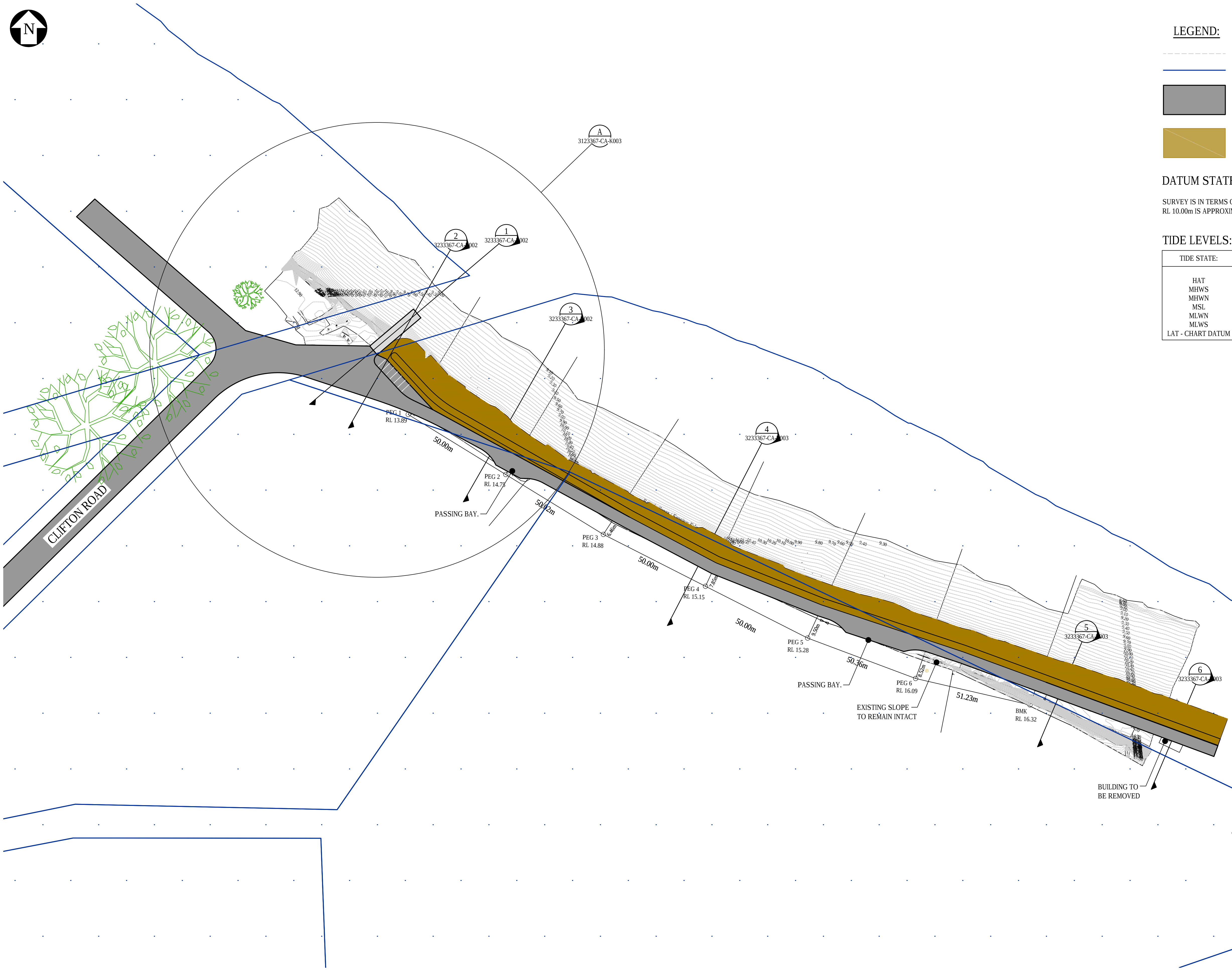
Rev. A

Document No. 3233367-CA-K001.DWG

DO NOT SCALE

IF IN DOUBT ASK.

Drawing Plotted: 03 Jul 2017 1:42 p.m.



LEGEND:

- EXISTING CONTOUR
- PROPERTY BOUNDARIES
- ROAD
- PROPOSED REVETMENT

DATUM STATEMENT:

SURVEY IS IN TERMS OF HASTINGS DISTRICT COUNCIL LOCAL DATUM
RL 10.00m IS APPROXIMATELY MEAN SEA LEVEL.

TIDE LEVELS:

TIDE STATE:	CHART DATUM (m)	LOCAL DATUM (m)
HAT	2.0	11.1
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MSL	0.9	10.0
MLWN	0.4	9.5
MLWS	0.1	9.2
LAT - CHART DATUM	0.0	9.1

FOR INFORMATION
NOT FOR CONSTRUCTION

FOR CLIENT REVIEW
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	BOAT RAMP AMENDED	KWN	EW	SP	03.07.17
A	ISSUED FOR CLIENT REVIEW	KWN	EW	SP	21.04.17

Drawing Originator: Beca

Original Scale (A1) 1:800
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Drawn	KWN	06.04.17
Dwg Verifier	SJP	13.04.17
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Project: CLIFTON REVETMENT

Title: PROPOSED OVERALL LAYOUT PLAN

Discipline: CIVIL ENGINEERING

Drawing No. 3233367-CA-K002 Rev. B

Document No. 3233367-CA-K002.DWG

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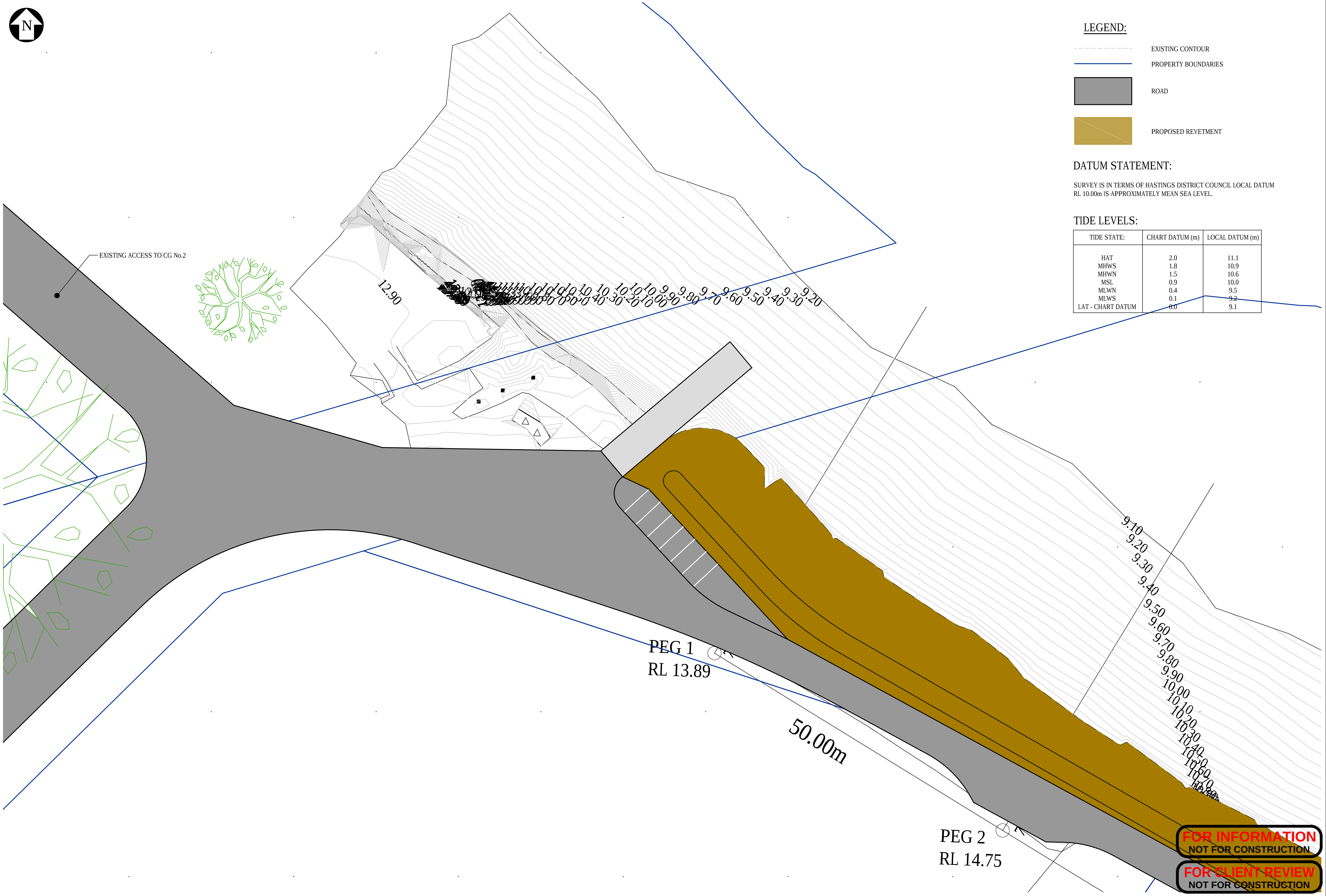

LEGEND:

- EXISTING CONTOUR
- PROPERTY BOUNDARIES
- ROAD
- PROPOSED REVETMENT

DATUM STATEMENT:

SURVEY IS IN TERMS OF HASTINGS DISTRICT COUNCIL LOCAL DATUM
RL 10.00m IS APPROXIMATELY MEAN SEA LEVEL.

TIDE LEVELS:

TIDE STATE:	CHART DATUM (m)	LOCAL DATUM (m)
HAT	2.0	11.1
MHWS	1.8	10.9
MHWN	1.5	10.6
MSL	0.9	10.0
MLWN	0.4	9.5
MLWS	0.1	9.2
LAT - CHART DATUM	0.0	9.1

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No.	Revision	By	Chk	Appd	Date
B	BOAT RAMP AMENDED	KWN	EW	SP	03.07.17
A	ISSUED FOR CLIENT REVIEW	KWN	EW	SP	21.04.17

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Dsg Verifier	SJP	13.04.17	
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Client: HASTINGS DISTRICT COUNCIL

Project: CLIFTON REVETMENT

Title: PROPOSED LAYOUT PLAN

Discipline: CIVIL ENGINEERING

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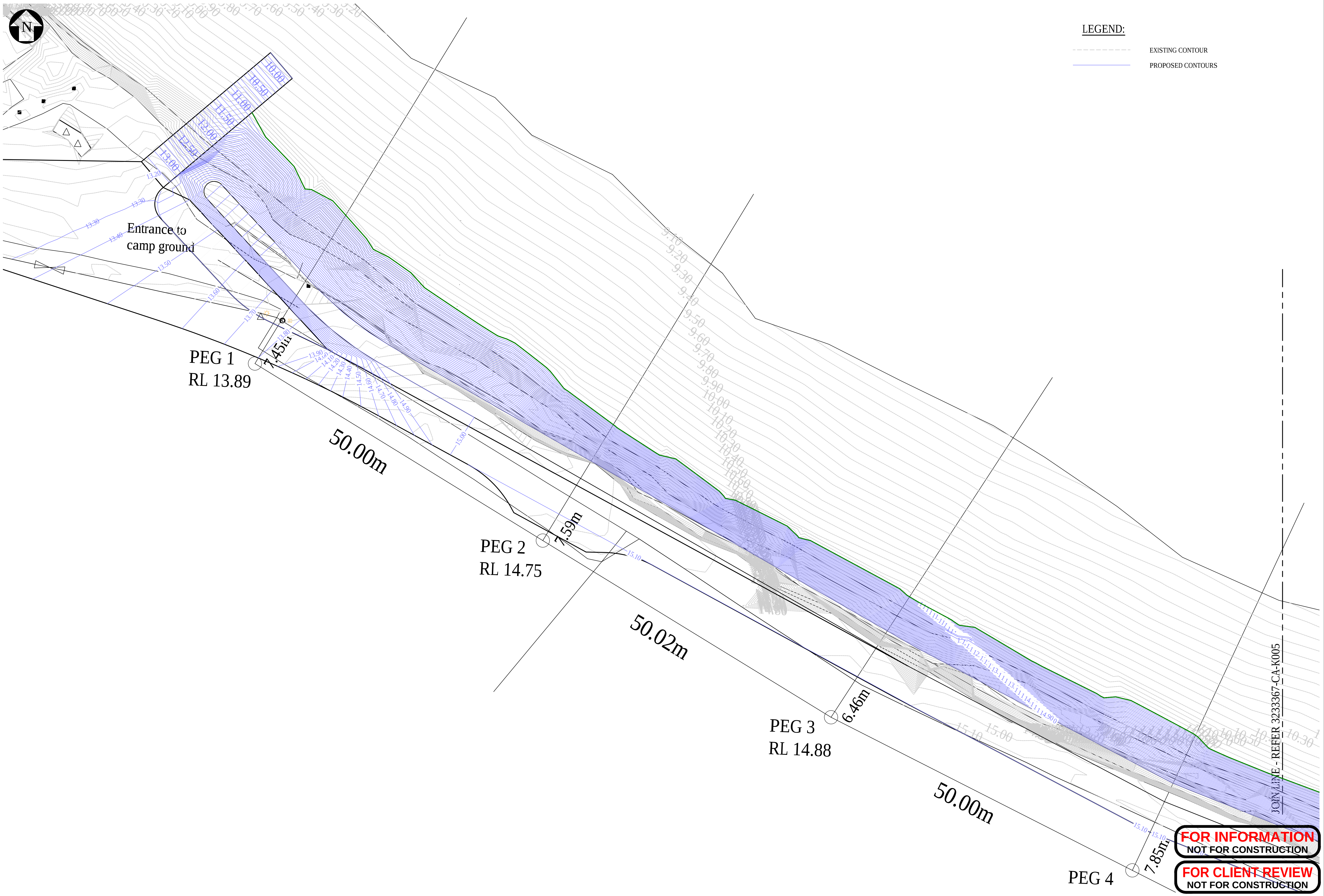

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A	ISSUED FOR CLIENT REVIEW	KWN	EW	SP	21.04.17

Drawing Originator: Beca

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Design	SJP	04.04.17
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Dsg Verifier	SJP	13.04.17
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Client: HASTINGS DISTRICT COUNCIL

Project: CLIFTON REVETMENT

Title: EXISTING AND PROPOSED CONTOUR PLAN SHEET 1 OF 2

Discipline: CIVIL ENGINEERING

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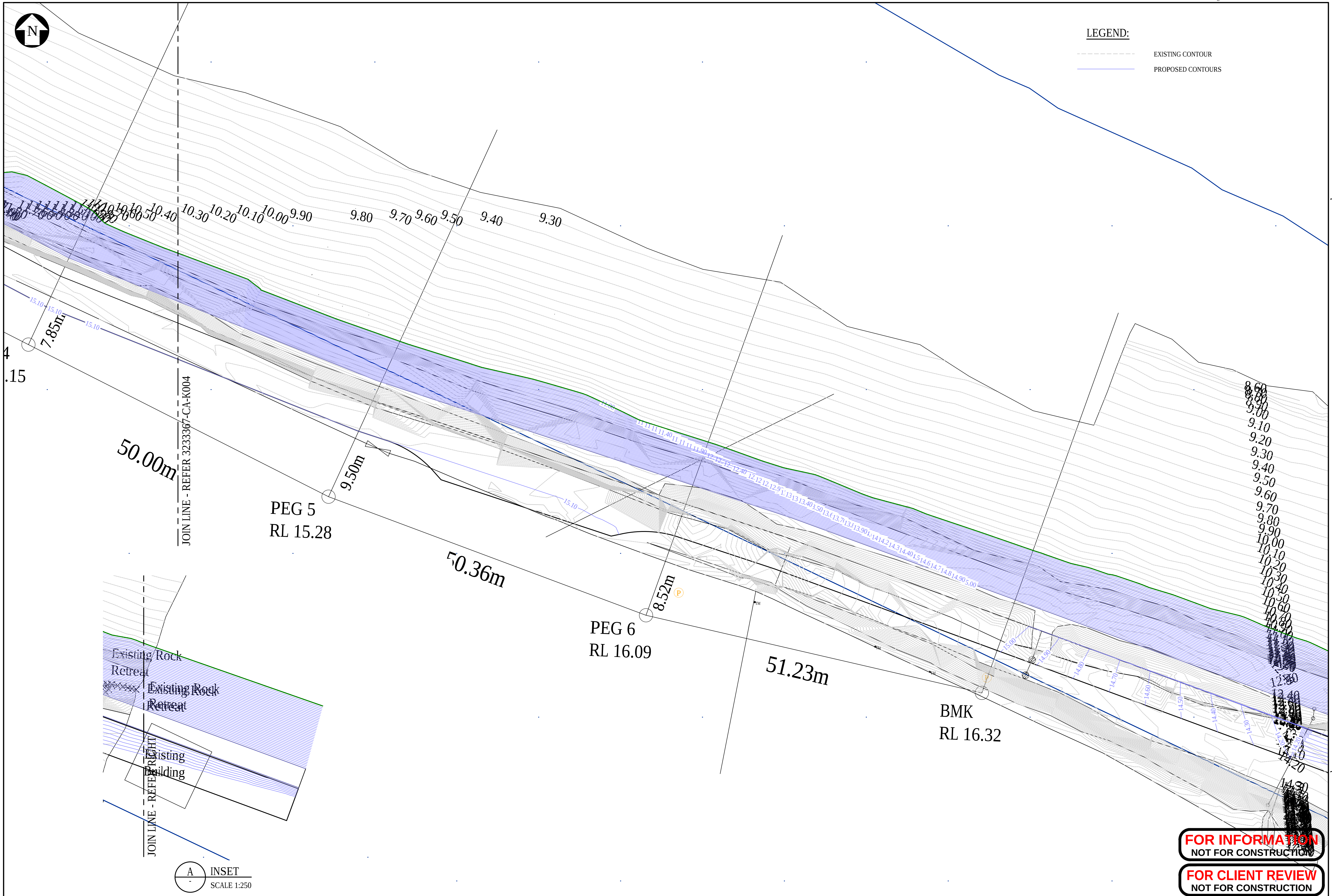

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A	ISSUED FOR CLIENT REVIEW	KWN	EW	SP	21.04.17

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Reduced Scale (A3) 1:500	Dsg Verifier	SJP	13.04.17
	Dwg Check		

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Project: CLIFTON REVETMENT

Title: EXISTING AND PROPOSED CONTOUR PLAN SHEET 2 OF 2

Discipline: CIVIL ENGINEERING

Drawing No. 3233367-CA-K005

Rev. B

Document No. 3233367-CA-K005.DWG

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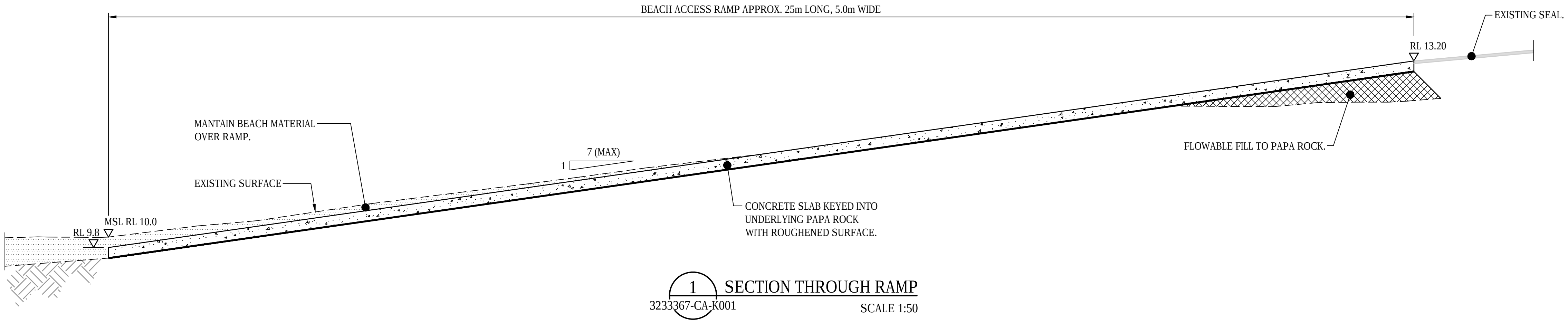

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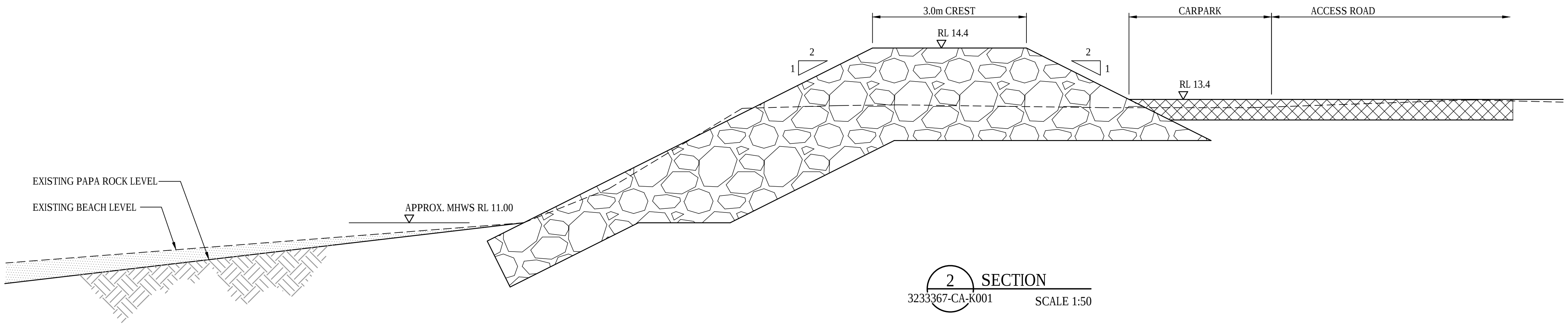

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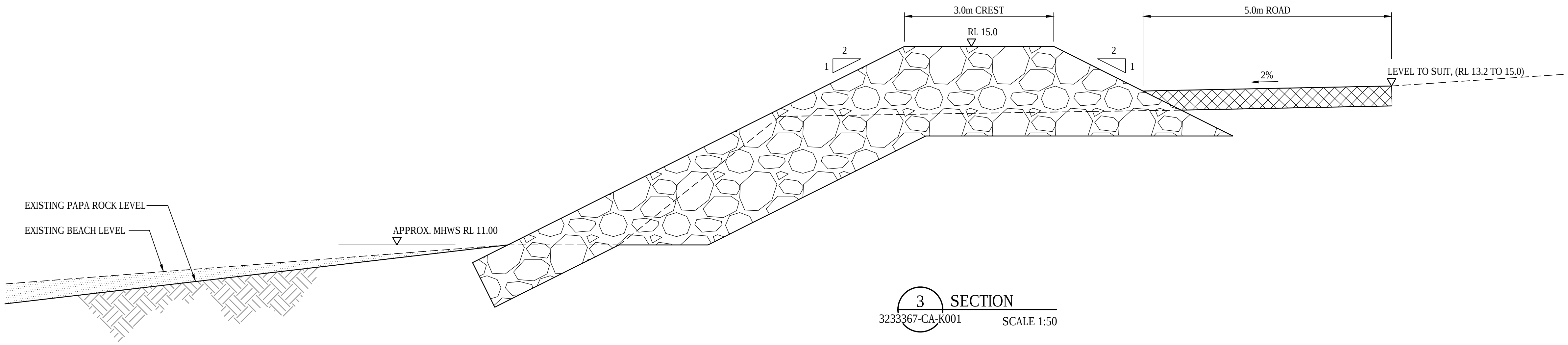

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Project: CLIFTON REVETMENT

Title: TYPICAL CROSS SECTIONS SHEET 1 OF 2

Discipline: CIVIL ENGINEERING

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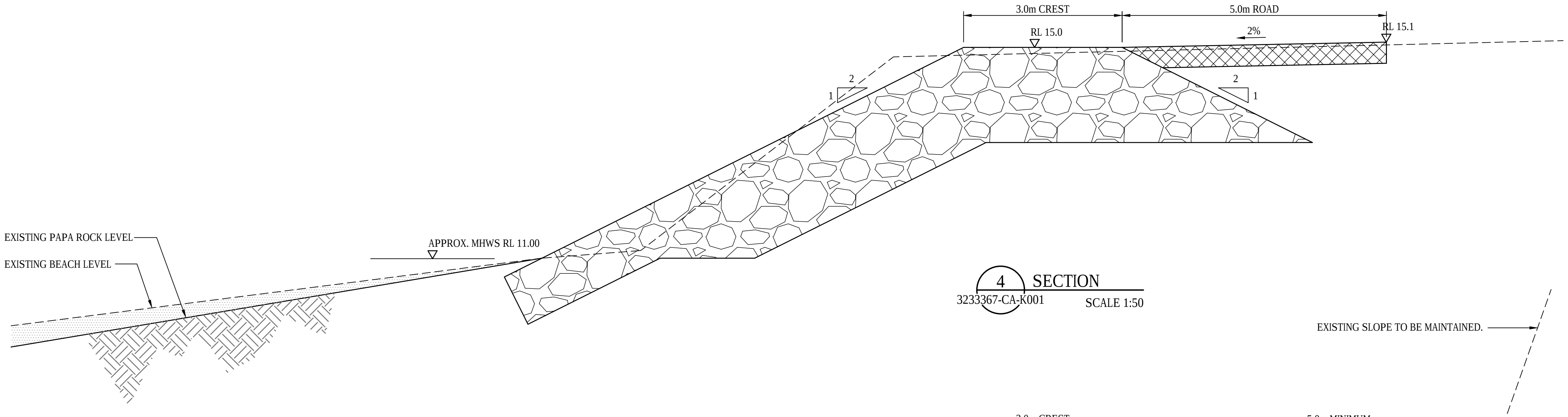
Document No. 3233367-CA-K006.DWG



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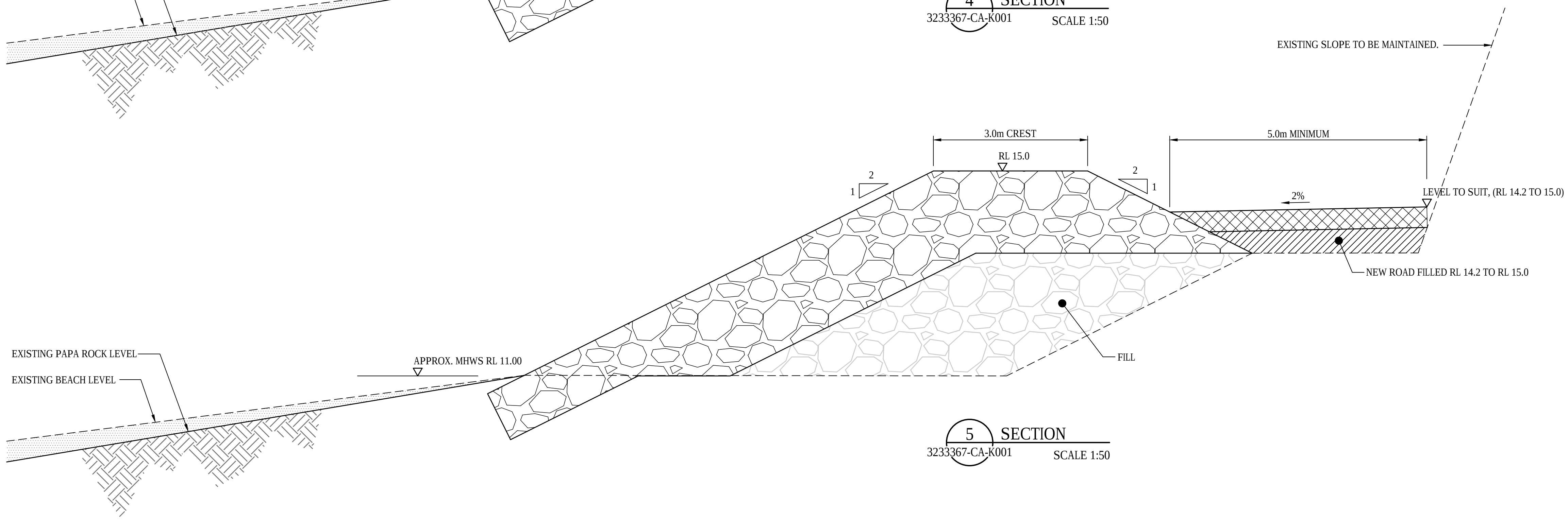

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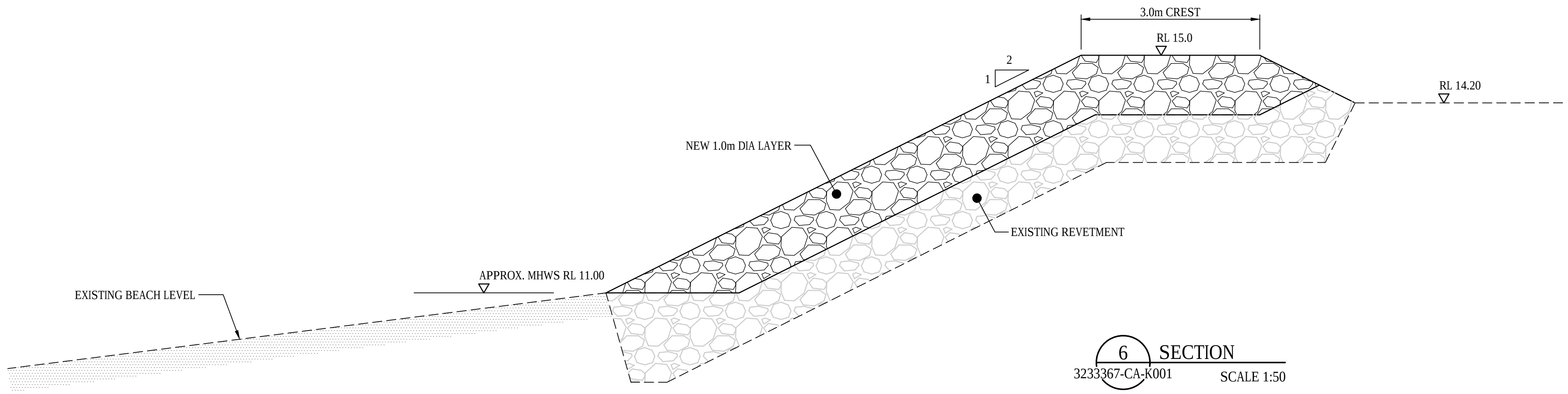

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Project: CLIFTON REVETMENT

Title: TYPICAL CROSS SECTIONS SHEET 2 OF 2

Discipline: CIVIL ENGINEERING

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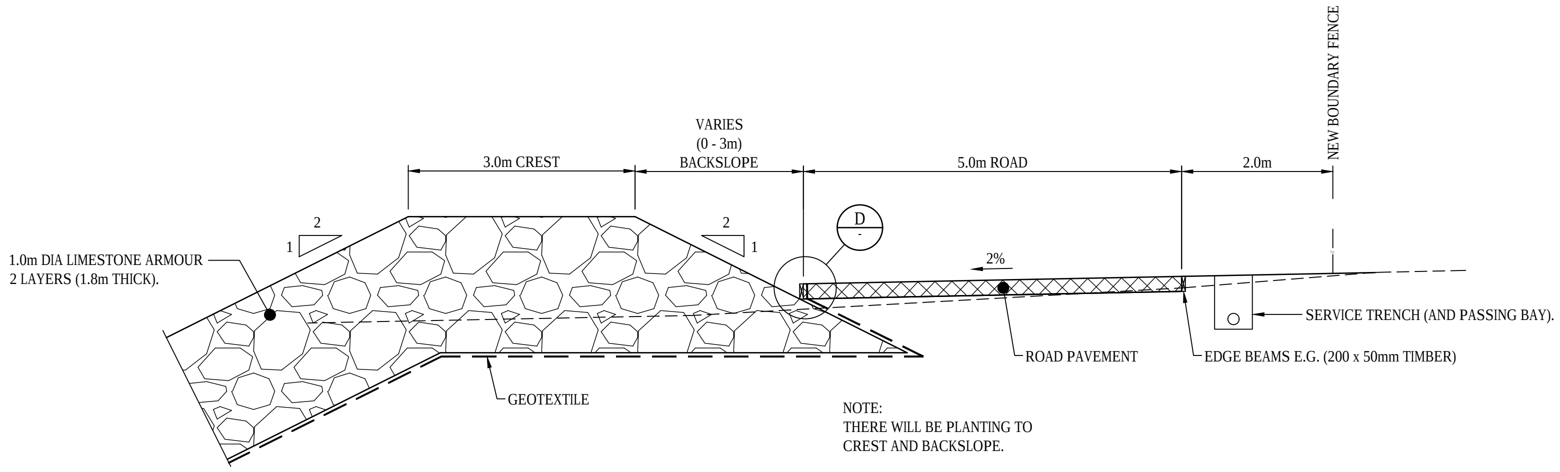
Document No. 3233367-CA-K007.DWG



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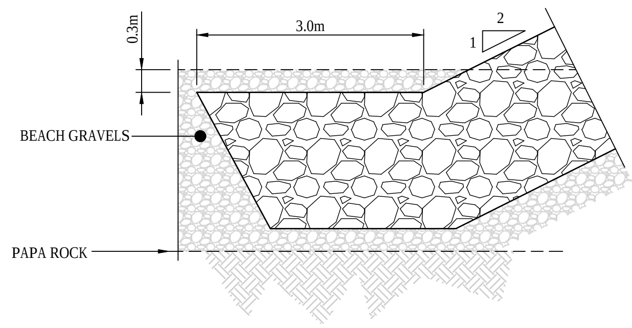

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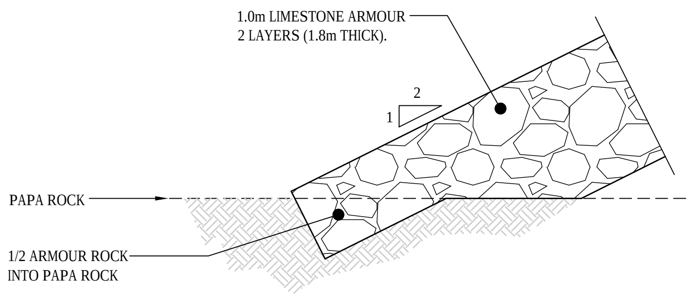

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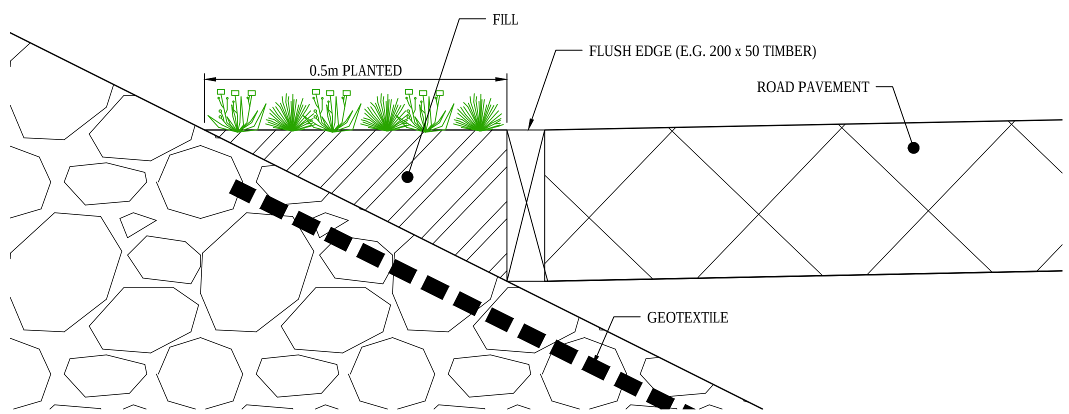

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A	ISSUED FOR CLIENT REVIEW	KWN	EW	SP	21.04.17

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Design	SJP	05.04.17	Approved For Construction*
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Project: CLIFTON REVETMENT

Title: TYPICAL DETAILS

Discipline: CIVIL ENGINEERING

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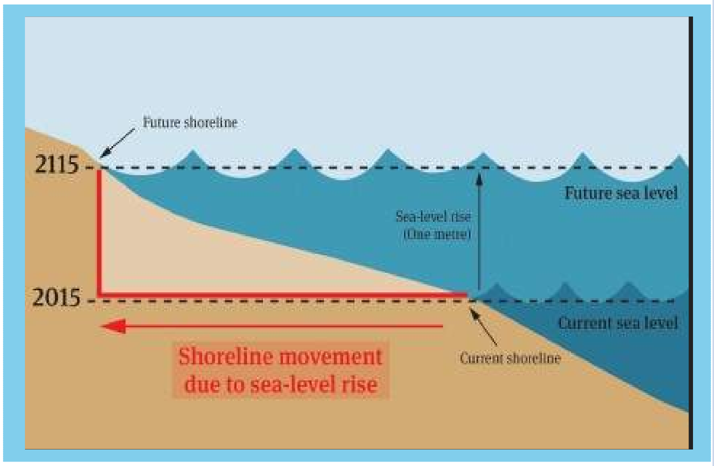
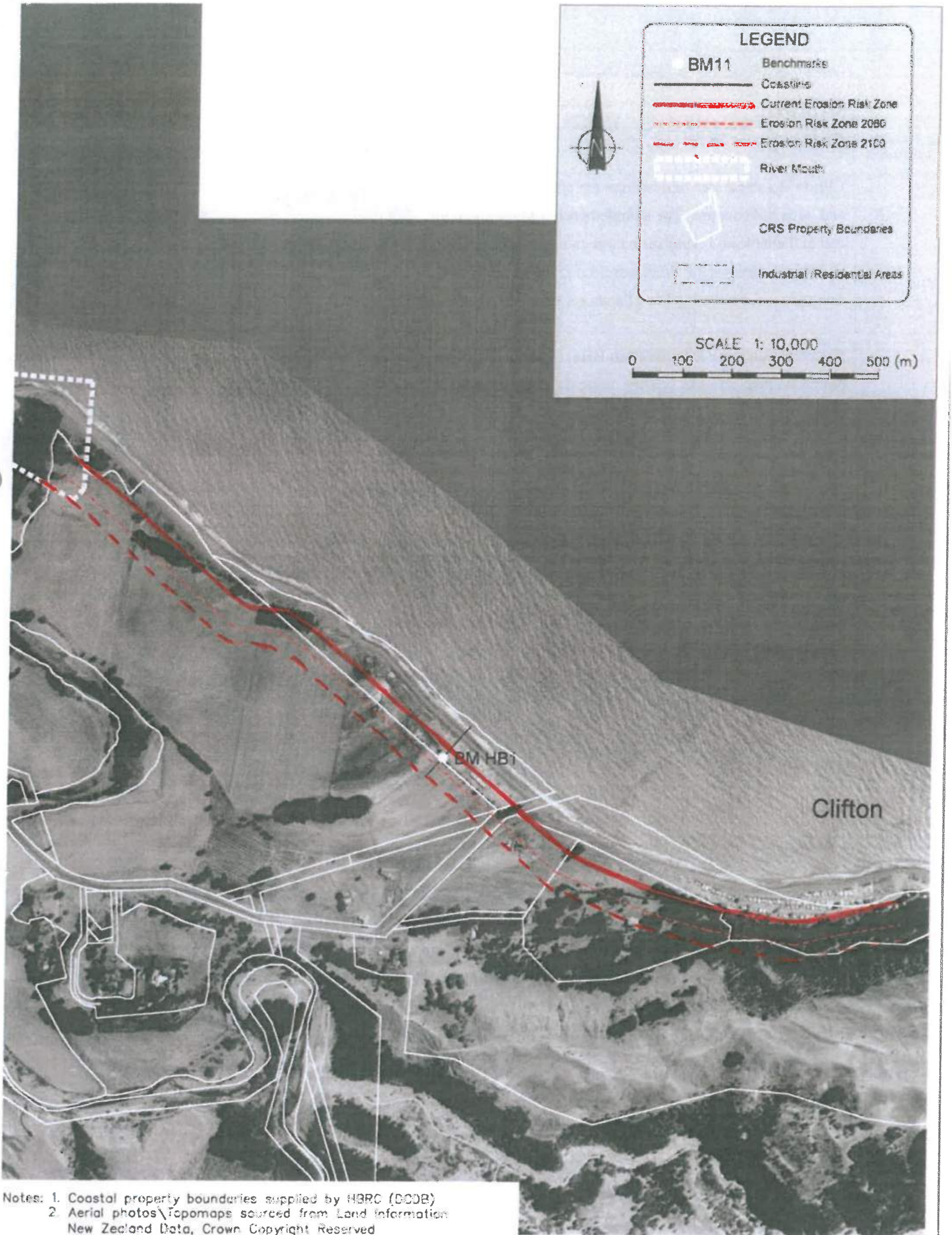
Rev.: B

Document No. 3233367-CA-K008.DWG

Appendix C

Setback Lines





Notes: 1. Coastal property boundaries supplied by HBRC (DCDB)
2. Aerial photos\Topomaps sourced from Land Information New Zealand Data, Crown Copyright Reserved

Tonkin & Taylor
Environmental & Engineering Consultants
Auckland, Hamilton, Christchurch, Nelson, Wellington, Whangarei

DRAWN	BKD	Sep.03
DRAFTING CHECKED		
APPROVED		
CADFILE	L:\205 14\205 14-F7	
SCALES (AT A4 SIZE)	1: 10 000	
PROJECT No.	205 14	

HAWKES BAY REGIONAL COUNCIL
REGIONAL COASTAL HAZARD ASSESSMENT
HAZARD ZONE DEFINITIONS
Clifton

FIG. No. Figure 7.11 REV 1

Clifton

Setting

Clifton is a small area of development bound by the coast and steep hill country. The shingle beach is at the southern end of the bay and is subject to large rates of erosion based on historic survey data. Main assets at risk include the camp ground, access road and the motor camp.

Shoreline trends are inferred from HB1. A range of ad-hoc protection measures can be seen along the coast including tipped rubble and construction debris.

Hazard Description

CERZ	30.0 m
ERZ 2060	45 m
ERZ 2100	31 m
Total Erosion Zone width	107 m
Sea Inundation level (CERZ)	14.9 m
Sea Inundation level landward of CERZ	13.5 m

Potential Risk

Likelihood	Consequence	Risk
Unlikely	Catastrophic	Extreme
Possible	Catastrophic	Extreme
Likely	Catastrophic	Extreme
Certain	Major	Extreme

Uncertainties

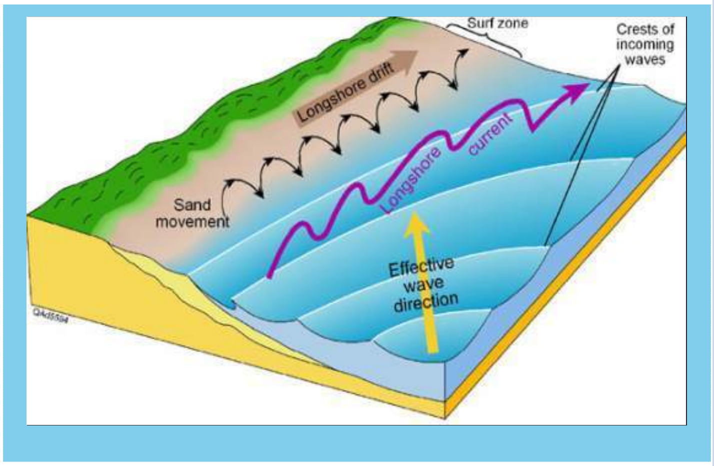
Uncertainties over future climate change impacts

Recommendations

- No new council infrastructure or new private development to be located within the CERZ
- Consider removal/relocation of camp ground and replacement of failing coastal protection structures with beach replenishment or managed retreat
- All new private development within remaining Erosion Hazard Zone to be relocatable and above inundation levels or be provided with flood protection bund subject to confirmation of no adverse effect on catchment flooding.
- No further modification of land designation permitted in currently non-residential zoned land within hazard zones
- Monitor shoreline change

Appendix D

Coastal Processes Assessment



Proposal

Clifton Beach: Coastal Processes Assessment

Prepared for Hastings District Council

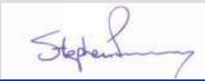
Prepared by Beca Limited

November 2017

Revision History

Revision Nº	Prepared By	Description	Date
0	**Evan Walters**	Preliminary Draft	15/05/2017
1	**Evan Walters**	For Resource Consent	11/07/2017
2	**Connon Andrews**	Updated for Section 92	01/11/2017

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Evan Walters**		01/11/2017
Reviewed by	**Connon Andrews**		01/11/2017
Approved by	**Stephen Priestley**		01/11/2017
on behalf of	Beca Limited		

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1 Introduction

1.1 Background

The southern extent of Clifton Beach has been experiencing ongoing coastal erosion that is threatening Clifton Road and a camp No. 1 near Cape Kidnappers. Historically, Clifton Road been relocated landward on several occasions in response to coastal erosion to maintain access.

To afford coastal protection Hastings District Council (HDC) constructed an 80m revetment in 2013 to protect the campsite entrance and toilet block (refer to Figure 1.1). The revetment resource consent expires on August 31st 2018. Despite these efforts, the shoreline has continued to retreat and threatens other areas of the access road.

To address the coastal erosion HDC is preparing a resource consent application to retain the existing revetment and to extend it further westward by 400m along the access road. This report provides an assessment of the potential effects on coastal processes from the proposed revetment.

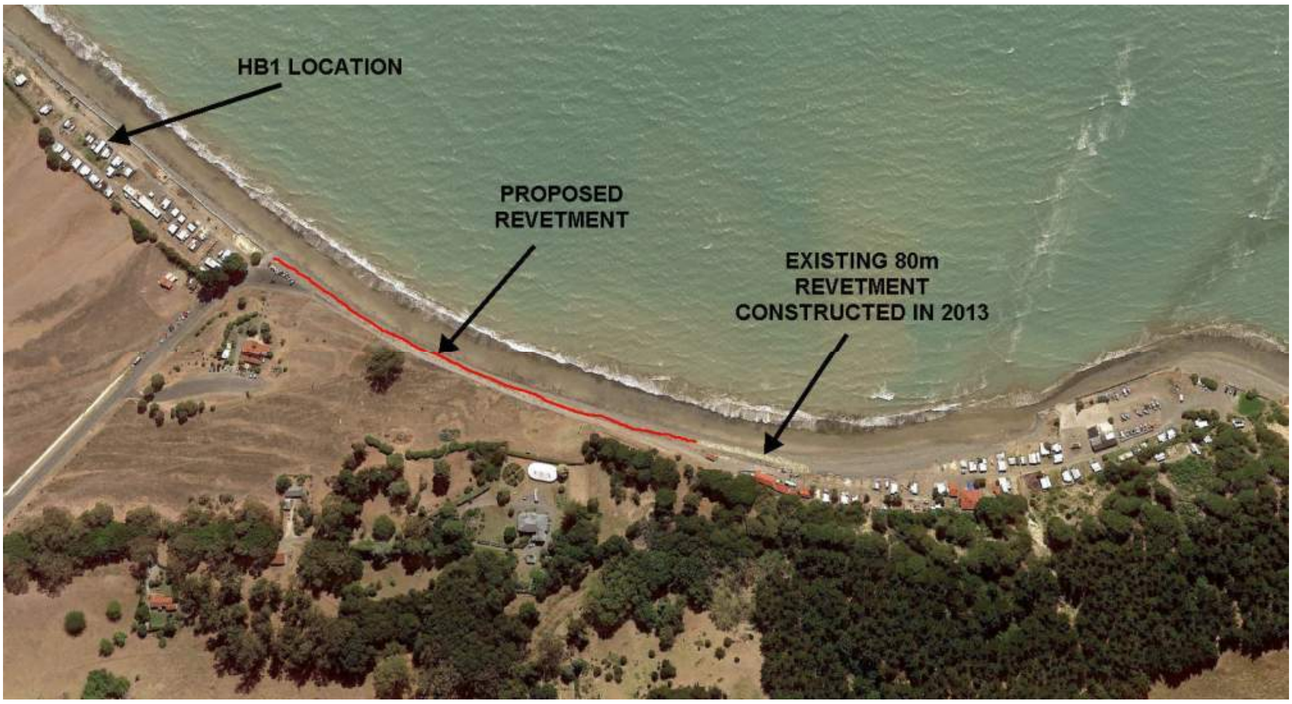

Figure 1.1: Project Location

1.2 Methods

The most noticeable potential effects of revetment structures is a change to the coastline planform, either by erosion or accretion. Therefore, the focus of this coastal process assessment has been on longshore sediment transport. This requires a sound understanding of the wave climate at the beach and the characteristics of the sediment such as sediment size and supply rates.

To investigate the proposed revetment's effects on the local environment; it is first necessary to compile all existing information on the local environment. This information includes geotechnical information, wind, wave and current data, aerial graphics, and bathymetric survey data. Available information is summarized in Section 2.0 of this report.

The offshore bathymetry along the Clifton Beach shoreline is complex comprising of reefs and rock outcrops which have a significant effect on wave transformation and the shoreline morphology. To resolve the nearshore wave climate SWAN (Simulating WAves Nearshore) was employed to provide time series wave data at 32 locations along the shoreline. Next, this data was used in Littoral Processes FM a DHI coastal longshore transport model to simulate longshore transport and shoreline evolution. The potential effects from the proposed engineering works are assessed within Littoral Processes FM and are presented in Section 3 of this report.

1.3 Limitations

The potential effects from the implementation of a revetment has been assessed via numerical techniques and available data. The simulation of waves and sediment transport processes is complex and numerical modelling is one method used to quantify these processes. The accuracy of numerical models to simulate coastal processes is model dependent and a function of model physics, model assumptions and available data. For this assessment the SWAN and LITPACK models have been adopted, both have been validated for shallow water wave transformation and simulation of gravel transport. However, these models all have inherent limitations and range of applicability. While the uncertainties have been addressed through the coastal process assessment it is important to recognize that the model results are estimates and the model limitations, such as 1d definition of sediment transport processes in LITPACK, needs to be considered when defining physical effects.

The assessments are also dependent on input data, such as:

- The coastal processes assessment is reliant on the offshore wave data provided by Metocean Solutions Ltd.
- The modelling is reliant on the available bathymetric data.
- The modelling has been calibrated to a digitised vegetation line derived from ortho-corrected aerial photographs. There is inherent errors in ortho-correction and definition of the vegetation line particularly with older aerial photographs.

While there are uncertainties in the model assumptions and inputs, a model calibration and validation process has been completed to measured long term trends.

2 Project Information and Simulation Inputs

2.1 Previous Studies

2.1.1 Komar Report (March 2014)

This comprehensive report summarizes environmental information along the entire Hawke's Bay coast. It covers topics such as sea level rise, past earthquakes, wave climate, and extreme water levels. Most importantly for this report, it also includes sediment budget calculations.

Information from this report was used as input to the Littoral Processes FM model. The report states that "In this budget it is seen that the Tukituki River and the erosion of Cape Kidnappers combine to contribute an estimated 46,000 m^3/year of gravel to this cell, while loses amount to a total of -91,000 m^3/year, the result being that the budget's balance is significantly "in the red" with a net annual loss of -45,000 m^3/year, indicating that on average the Haumoana Cell's shoreline has experienced erosion over the decades". For this study, Komar reports that 18,000 m^3/year of littoral supply is available at Clifton.

2.1.2 T&T Report (April 2008)

The Tonkin and Taylor report details the erosion risk at the various beaches along Hawke's Bay. Most relevant to this report, it discusses historical trends for Clifton beach. It states that although historical erosion rates for the HB1 cross shore profile are higher between 1973 to 1995 than the rates after 1995, the overall average erosion rate is 0.69m/year (1973 to 2008).

2.1.3 Environmental Management Services Ltd. (April 2009)

This report evaluates the advantages and disadvantages of several options to solve the erosion problems at Te Awanga, Haumoana, and Clifton Beaches. Within its sediment budget section, it states that the net 'loss' of gravel from Te Awanga – Haumoana and Clifton beaches is estimated to be 48,800 cubic metres per year, 11,600 cubic metres being at Clifton Beach. It then goes on to evaluate various options to solve the beach erosion. Specifically, it dismisses a seawall revetment as a solution calling it too expensive, and proposes constructing a groyne field in the area. It rules out a beach nourishment solution due to the availability of gravel in the area.

The recommendation provided in the report is a staged retreat approach due to the high cost of a groyne field ($17.4 million net present value in the first 20 years, $18.5 million over 60 years) and uncertainty of constructing groynes in the area. Although expensive, it must be noted that the extent of the 2009 study is for a larger area than this assessment. A groynes project at Clifton beach would be less expensive than the cited numbers above.

2.2 Existing Information

2.2.1 Tides and Water Levels

Astronomical tide levels for the Port of Napier, which are considered applicable for Clifton Beach are presented in Table 2.1. Levels are presented in both Chart Datum (CD) and relative to the local Hawkes Bay MSL datum (RL).

Table 2.1: Tide and Water Levels for Napier, New Zealand

	Level (m CD)	Level (m RL)
MHWS	1.89	10.97
MHWN	1.49	10.57
MSL	0.95	10.03
MLWN	0.39	9.47
MLWS	0.04	9.12

Source: LINZ Standard Ports

2.2.2 Geotechnical Information

The backshore comprises of alluvial deposits (silt, sand and gravel) which is underlain by papa basement rock. The papa basement rock is exposed at various locations along the shoreline in the form of hard headlands, exposed outcrops in the intertidal beach area and as submerged reefs. The papa rock is generally located at an elevation of RL 10.0m and is considered hard and does not erode at any noticeable rate.

The beach material comprises of mixed sand gravel with coarser sediment at the upper beach levels. Sediment gradation curve for this location (labelled K1) is presented in Appendix A of the Engineering Assessment Report. Based on the gradation data and anecdotal information, the average sediment size used in the model is 20mm.

2.2.3 Bathymetric Information

2.2.3.1 Side scan Data

Side scan sonar data was provided by the HBRC (refer to Figure 2.1). The data extends approximately 1km offshore to a depth of RL 8.0 at the nearshore.

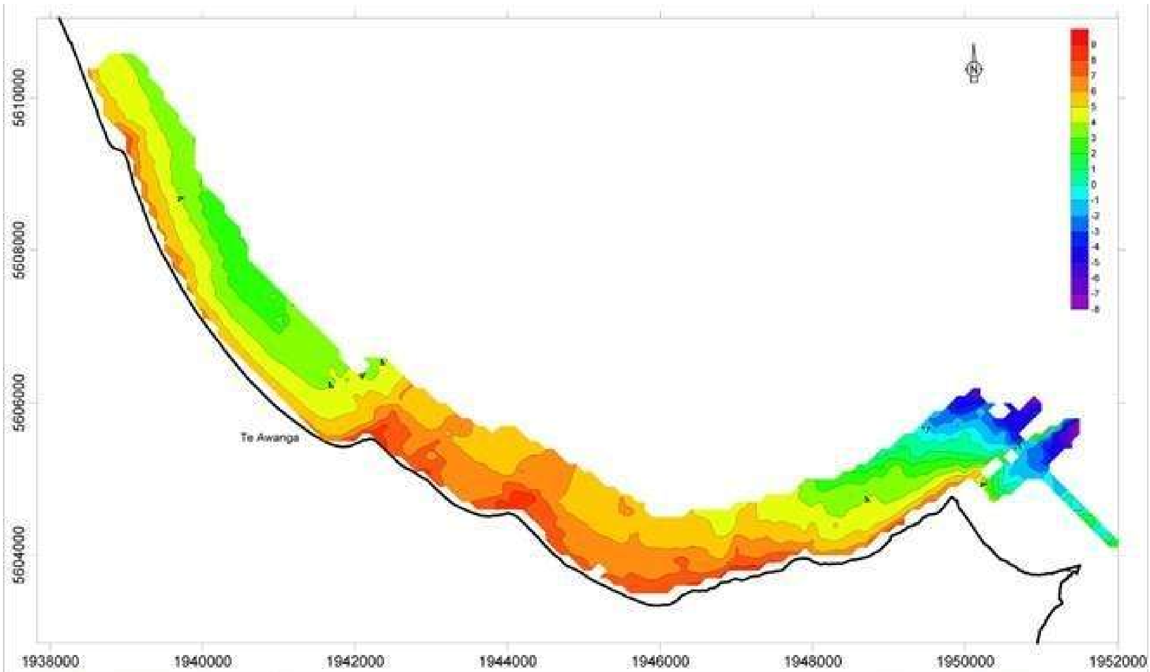

Figure 2.1: Side scan sonar survey offshore of Clifton Beach, elevations in metres

2.2.3.2 Beach Profile Survey, HB1

HBRC has been keeping records of beach profiles since 1972. The closest monitoring location to the project is called HB1 (refer to Figure 1.1). The data of these records were used in the 2008 Tonkin and Taylor report which produced a shoreline retreat rate of 0.69m/year. Beach profile data is presented in Figures 2.7 and 2.8 of the Engineering Assessment Report.

2.2.3.3 Zorn Surveying Survey

A survey of the backshore and intertidal area was provided by Zorn Surveying for the project area. This data was combined with the side scan sonar data and some extrapolation allowed for an accurate portrayal of the beach and nearshore area. Figure 2.2 presents the various bathymetric data scatter sets. The red circled area represents the nearshore extents of the Zorn Survey, the blue highlighted area is the extrapolated data set, and the other scatter data represents the side scan sonar data.

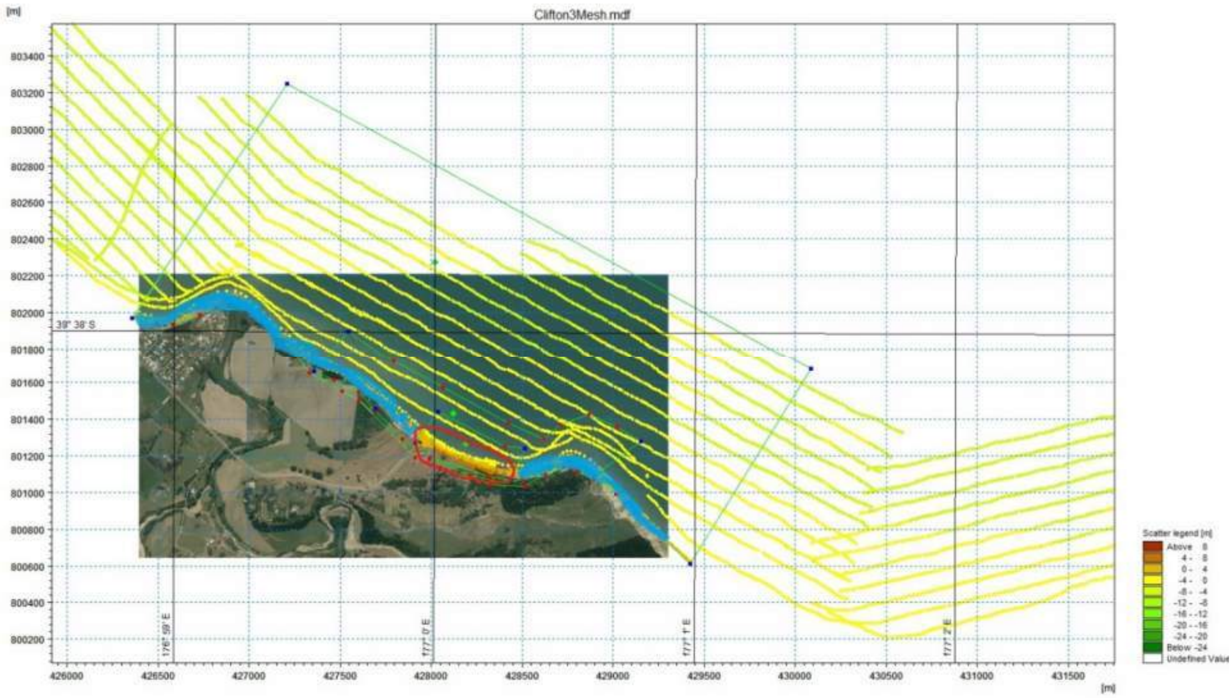

Figure 2.2: Bathymetric Data Sets

2.3 Procured Information and Assumptions

2.3.1 Wave Data

Accurate wave data is one of the most important drivers of the coastal model. This is because the wave data input directly influences the way that the sediment is forced to move in the model. MetOcean Solutions Ltd keeps a SWAN wave hindcast model for all of New Zealand at a 0.005 degree resolution. The dataset spans a timeframe of 37 years from January 1st 1979 to December 31st 2015. The advantage of using a large dataset is that all significant events such as cyclones, storms, etc. will average out over time.

Regionally the wave climate within Hawkes Bay is influenced by Cape Kidnappers via wave sheltering. According to the Metocean hindcast the mean significant wave height in the vicinity of Cape Kidnappers and the Clifton area ranges between 1.00 to 1.25m and decreases to 0.75 to 1.00m north of the Tukituki River. While it is expected that wave sheltering afforded by Cape Kidnappers is likely to influence the Clifton area, due to the limited shoreline length of the study area the potential decrease in offshore wave energy throughout the study area is considered negligible. Accordingly, the wave climate at the location 177.005E, 39.630S which has a seabed level of RL 5.9m and located approximately 1km offshore of the study area is considered to the representative of the study area.

MetOcean Solutions Ltd provided Significant Wave Heights (H_s), wave periods, and mean wave directions at 3 hour intervals for the time frame. H_s and Peak Wave Period (T_p) wave roses for the 37 year dataset are presented in Figures 2.3 and 2.4 respectively. From the wave rose, it is evident that the majority of the waves come from the North Easterly direction in a very tight range between 50 and 65 degrees. The average H_s and T_p over the data set is 0.67m and 10.4s respectively.

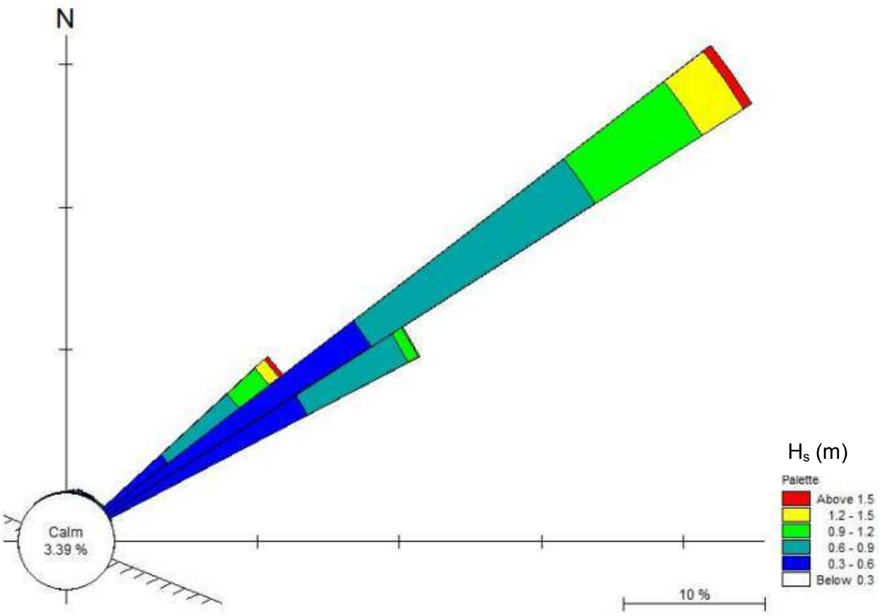

Figure 2.3: Wave Rose of Hindcast Wave Data at 177.005E, 39.630S, 5 degree bins, height in metres

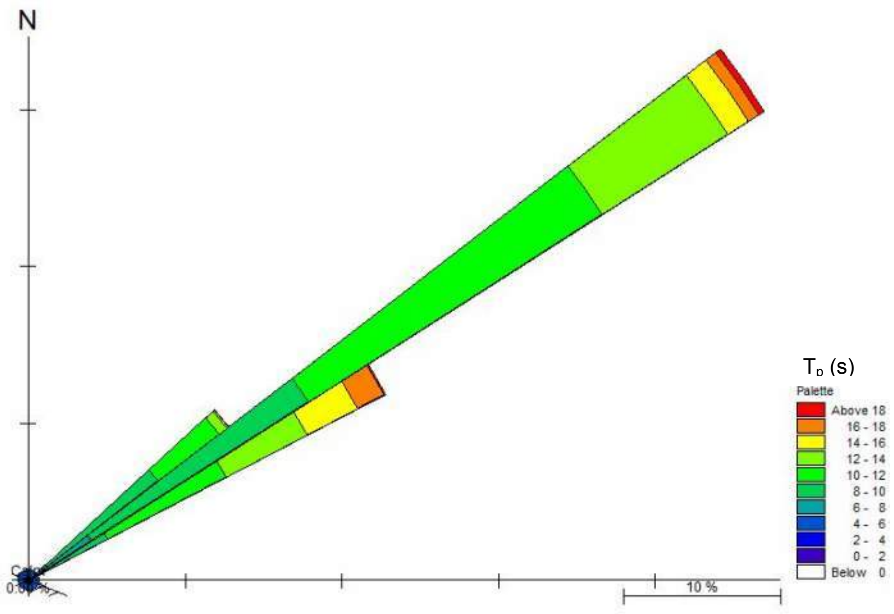

Figure 2.4: Wave Rose of Hindcast Wave Data at 177.005E, 39.630S, 5 degree bins, period in seconds

2.3.2 Depth of Closure

Depth of closure is an important concept used in coastal engineering. It is a theoretical depth along a cross shore beach profile where sediment transport is very small or non-existent. This depth varies dependent on wave height wave period, and sediment grain size. Beaches with larger sediment sizes have smaller depths of closure because larger sediment isn't as easily influenced by wave action than smaller sediment. Since Clifton beach is a gravel beach, its depth of closure is small due to the large sediment size. After calibration, the depth of closure varied along the coastline, but in general the depth of closure used was RL 8.3 (1.7m below MSL).

3 Modelling

3.1 Wave Modelling

The offshore bathymetry along the Clifton Beach shoreline is complex comprising of reefs and rock outcrops which have a significant effect on wave transformation and the shoreline morphology. To resolve the nearshore wave climate SWAN (Simulating WAves Nearshore) was employed to provide time series wave data along the shoreline.

3.1.1 SWAN Wave Model Brief Description

SWAN (Simulating WAves Nearshore) is a 3rd generation spectral wave model for obtaining realistic estimates of wave parameters in coastal areas, lakes, and estuaries from given wind, bottom, and current conditions. The model is developed at Delft University of Technology.

For this project, SWAN was used to transform the wave data provided by MetOcean Solutions Ltd to the closure depth (RL 8.3m).

3.1.2 SWAN Wave Modelling

The model domain and bathymetry is presented in Figure 3.1. A flexible mesh was compiled utilizing the composite bathymetric dataset (refer to Figure 2.3). The Metocean Ltd time series dataset which consisted of 3 hourly data from January 1st 1979 to December 31st 2015 was adopted on the seaward boundary.

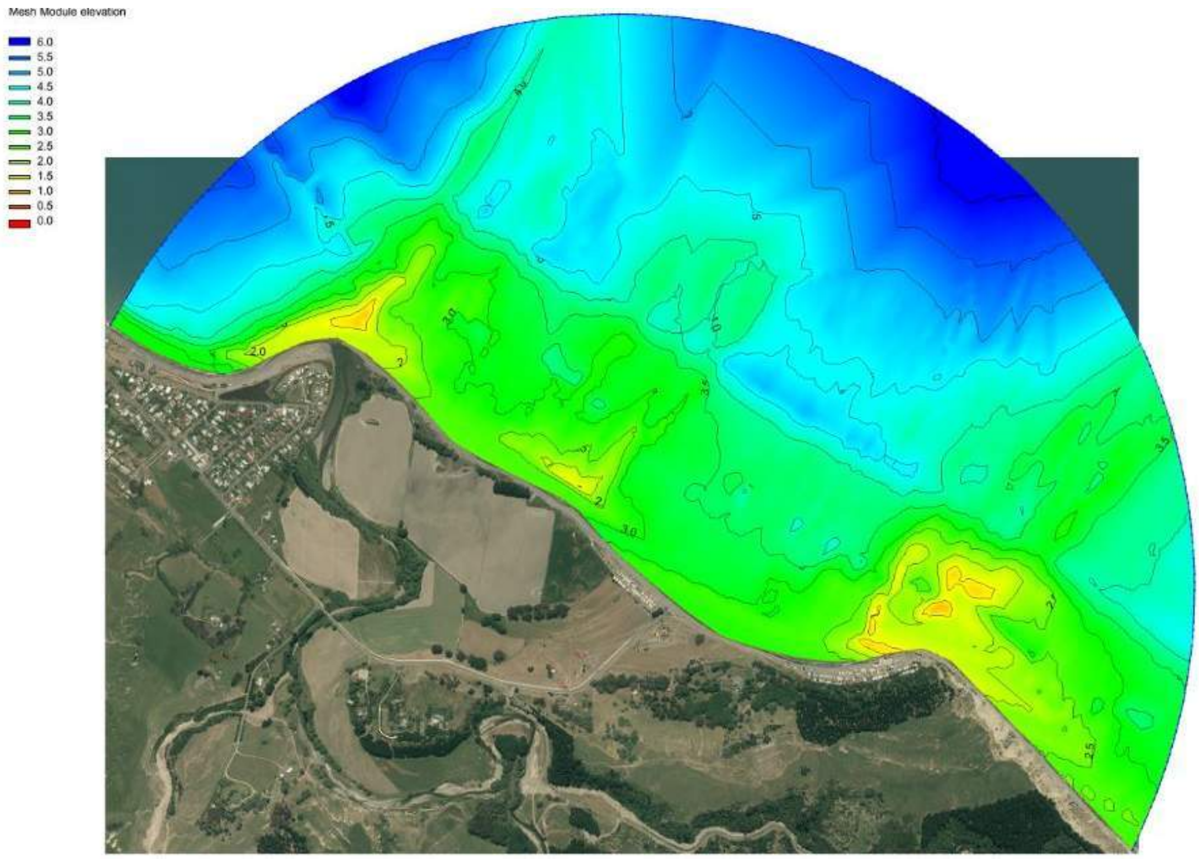

Figure 3.1: SWAN Model Bathymetry, showing reef systems

The model was simulated in third generation non-stationary mode at a 3-hourly time steps allowing for the following processes:

- Exponential wind growth (Komen, 1984)
- Quadruplets (Hasselmann *et at.*, 1985)
- White capping (Komen, 1984)
- Triads (Eldeberky, 1996)
- Bottom friction (JONSWAP, 1973)
- Water level generated from Port of Napier tidal constituents

Time series data at approximately RL 8.0 was generated along the coastline for the full dataset (refer to Figure 3.2 locations). The data was subsequently converted to a profile series for the use in Littoral Processes FM.

Figure 3.2 SWAN Wave model output locations

3.2 Longshore Sediment Transport

3.2.1 Littoral Processes FM Brief Model Description

Littoral Processes FM (Flexible Mesh) was chosen for this study because of its ability to simulate non-cohesive sediment transport, particularly for gravel beaches.

Littoral Processes FM is a modelling system published by the Danish Hydraulics Institute (DHI) that simulates non-cohesive sediment transport along a quasi-stationary coastline. It is a powerful tool for sediment budgets and simulating long term shoreline evolution.

Within Littoral Processes FM are four models. The transport in point model calculates non-cohesive sediment transport in one or several points. The littoral drift model calculates the longshore transport for one or several cross-shore profiles. The littoral drift table generation model uses similar methods to the littoral drift model, but produces outputs which can be used in the coastline evolution model. Lastly, the coastline evolution model calculates coastline movements with respect to a straight baseline. It has the ability to have simulate various coastal structures such as revetments, offshore breakwaters, jetties, and groynes.

3.2.2 Littoral Processes FM Simulation Domain

For longshore sediment transport modelling it is important to extend the model past geomorphic features that can affect or control the movement of sediment. Accordingly, a model was developed that extended 3.5 km from the west of the Maraetotara River to east of the headland that accommodates Camp No. 1 (refer to Figure 3.2). Figure 3.2 not only represents the model domain, but also depicts the model baseline in Red, along with the cross shore profile.

For the model domain a grid resolution of 20 m was adopted, which was required to resolve the key geomorphic controls and structures.

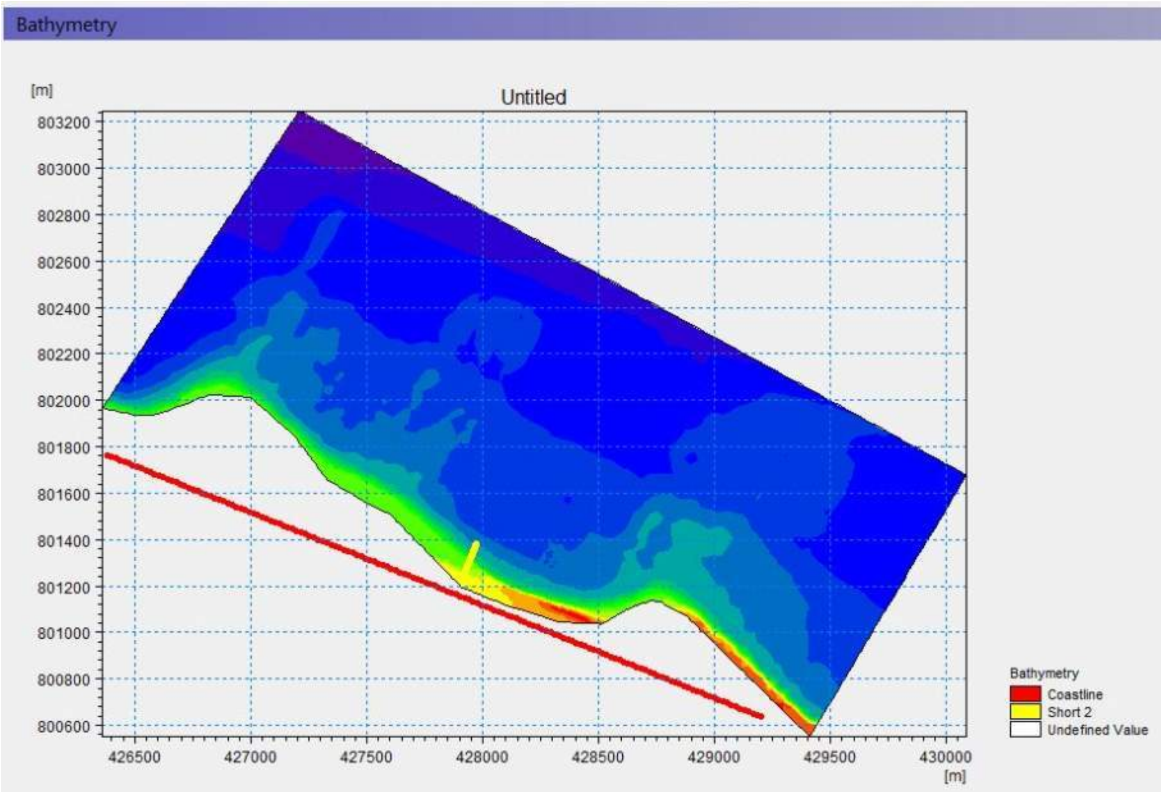

Figure 3.2: Simulation Domain with project Baseline and 5 Cross sections

3.2.3 Simulation Time Range

To provide for the most accurate results over time and most efficient use of the wave data set, the time settings of the model were set to run from January 1st, 1979 through December 31st, 2015 in three hour time step intervals.

3.2.4 Coastal Structure Locations

Figure 3.3 presents the extent and location of the existing (red) and proposed (cyan) revetments.

Figure 3.3: Hard point and Revetment Positions (red) and proposed revetment (cyan)

3.2.5 Sources and Sinks

3.2.5.1 Cape Kidnappers Erosion Source

Following Komar (2014) which estimated that erosion from Cape Kidnappers to the south of the project area represents a sediment source coming from the east. In the Littoral Processes FM model, this sediment source was included as 18,000 m^3/year.

3.2.5.2 Maraetotara River

Te Awanga – Haumoana Coastal Erosion: Review and Recommendations is a report released in 2009 by Environmental Management Services Ltd. which is available on the HBRC's website. This report details the various sediment inputs including the Maraetotara River. The report states that "[although] some gravel deposits [exist] in deep water off the mouth of the Maraetotara River… their contribution to the beach, if any, is unknown and assumed to be negligible.". This statement is also reinforced in *The Hawke's Bay Littoral Cells: Processes, Erosion Problems and Management Strategies* which states that "with its small watershed and discharges, the Maraetotara River reaching the shore at Te Awanga is considered to be insignificant". Hence, in the Littoral Processes FM model the Maraetotara River was not included as a sediment source.

3.3 Calibration and Simulations

3.3.1 Methods

The simulation set up discussed in Section 3.2 was run through the Littoral Processes FM model. The model was initially set up to simulate what would happen if the revetment constructed in 2013 was not there. This case was called the "no protection case" and was used to calibrate the model. After the model was calibrated, two more cases were developed to compare the environmental effects of the proposed revetment to the existing situation. These cases are discussed in more detail in Section 3.4.

3.3.2 Historical Retreat

Historical shoreline movement was assessed by comparison of historic aerial photography. Aerial photographs from 1963, 1980 and 2009 were sourced and rectified to enable comparison. Vegetation lines were digitized and used for comparison to obtain erosion/accretion rates. Figures 3.4 and 3.5 represent the vegetation lines with different base photographs.

Measured shoreline movement and annual rates were calculated for simulation cells 39, 64, 76, 83, and 99 as shown in Figures 3.4 and 3.5 and are presented in Table 3.1.

Table 3.1: Shoreline Retreat Calibration Rates

Cell	Measured 29 year Shoreline Retreat (m)	Retreat Rate (m/year)	Cell Description
39	4	0.13	About ½ km East from Maraetotara River
64	15	0.51	Outcrop point
76	20	0.69	HB1
83	15	0.51	Road Turnoff
99	15	0.51	Inside the Project Area

3.3.3 Scenarios

As part of the calibration and production process the following scenarios were simulated:

- Scenario 1 - No Protection Scenario: A simulation which *excludes* the existing 80m revetment installed in 2013, but includes a hard point to the east of Camp No.1 to simulate the existing protection and the cliff line.
- Scenario 2 - Existing Condition Scenario: Same as Scenario 1 but includes the 80m revetment installed in 2013.
- Scenario 3 – Proposed Revetment Scenario: Same as Scenario 2 but includes the proposed revetment.

With these three runs, an accurate depiction of the coastal environment was modeled, and the results are presented in Section 3.4.

3.3.4 Calibration

Shoreline retreat rates were calculated and compared to the target values as presented in Table 3.2. Unless protected by a revetment, all of the measured cells exhibited shoreline retreat except for Cell 39 which showed minor accretion. The model describes the annual rates well and replicates the larger scale morphodynamics, particular with the salient feature adjacent cell 64.

Table 3.2: Shoreline Retreat and Target Shoreline Retreat Comparison

Case	Cell 39	Cell 64	Cell 76	Cell 83	Cell 99
37 Year Shoreline Retreat Target Value	0.0m	-19.1m	-25.5m	-19.1m	-19.1m
No Protection Case	+0.6m	-21.1m	-26.1m	-21.4m	-28.2m
Existing Conditions Case	+0.6m	-21.2m	-25.7m	-18.4m	-7.2m
Proposed Case	+0.6m	-21.5m	-24.5m	0m*	0m *

*Revetment holds shoreline in place

Figure 3.4: Historical shoreline movement – Base photograph 1963, 1980 vegetation line (green) and 2009 vegetation line (red)

Figure 3.5: Historical shoreline movement – Base photograph 2009, 1980 vegetation line (green) and 2009 vegetation line (red)

3.4 Results

3.4.1 Longshore Transport Statistics

The longshore transport rates in the study area vary depending on the location along the study area. With each different location, the transport rates are influenced by the angle of the shoreline and the incident wave angle. In areas with high oblique angles such as the shoreline adjacent to Camp No. 2 high sediment transport rates are expected, whereas in areas where waves approach the coast close to the shoreline normal transport rates are close to zero. Simulated annual gravel transport rates varied from 2000m^3/year to 14,000m^3/year in the westerly direction. Sediment transport rates in the vicinity of the proposed revetment were calculated to be 11,000m^3/year, markedly higher compared to down drift rates indicating an erosive trend.

3.4.2 Scenario 1: No Protection Case

The shoreline retreat rates for this case were consistent with the measured aerial photo values with negligible change west of the central salient and erosion rates of 0.70 m/year at HB1 (refer to Figure 3.8). However, cell 99 (area of the proposed revetment) experienced approximately 9m of erosion more than the observed. This translates to an enhanced retreat rate of 0.76m/year compared to a target retreat rate of 0.52m/year.

The rate of erosion adjacent to cell 99 is a function of the position of the eastern geomorphic control point. In this simulation the control point is the hard lined tip of the Camp No.1 headland. It was assumed that no coastal protection structures were implemented fronting Camp No. 1 and that the back shore are was fully erodible. The results show that without the ad hoc erosion protection measures fronting Camp No.1 the camp ground is particularly susceptible to erosion. Furthermore, the downstream effects of an eroding shoreline are likely to result in increased erosion rates through to the central salient as the shoreline continues to establish equilibrium.

3.4.3 Scenario 2: Existing Conditions Case

The shoreline retreat rates for this case were consistent with the measured aerial photos with negligible change west of the central salient and erosion rates of 0.68 m/year at HB1 (refer to Figure 3.9). The results show that the erosion rates down drift of the revetment constructed in 2013 have decreased compared to Scenario 1. The decreased erosion rate is attributed to the revetment providing a fixed control point which terminates at a point where the shoreline angle relative to the incident wave angle is less oblique than that directly to its east, leading to lower transport rates.

Typically, revetments cause a local down drift erosional effect, however simulating revetment's effects were beyond the capabilities of the model. It is expected that the shoreline retreat rates would be higher if local down drift effects were included in the model.

3.4.4 Scenario 3: Proposed Case

This simulation includes the proposed 400m revetment extension (refer to Figures 3.10 and 3.11). The revetment extension holds the shoreline in place at cells 83 and 99, so no shoreline retreat was simulated at these locations. Cell 76, representing HB1, approximately 200m down drift of the proposed revetment has similar retreat rates to the existing Scenario 1 and 2 with shoreline retreat of 0.67m/year. Decadal changes to erosion rates are presented in Table 3.3 for HB1. The results show that while the proposed revetment protects Clifton Road the shoreline adjacent to Camp No. 2 is likely to continue to erode. While the rate of change is low, the introduction of the revetment is expected to increase erosion at the northern end of the revetment in the short term and revert to erosion rates consistent with the historical observations in the medium term (20 to 30 years).

Table 3.3 – Decadal changes to average erosion rates at HB1

	Existing Conditions (m/year)	Proposed Case (m/year)
10 years	0.67	0.97
20 years	0.71	0.79
30 years	0.68	0.67

3.5 Discussion

The longshore sediment transport modelling has demonstrated that the erosion potential of the Camp No.1 headland is high and the erosion potential decreases to the west as the shore normal becomes more perpendicular to the incident wave direction.

The geomorphic controls of the Camp No.1 headland, the central offshore reef west of Camp No.2 and the Maraetotara River are the main features that control shoreline evolution. The results show that the central salient feature in the lee of the offshore reef acts as the western control for the shoreline to the east extending to Camp No.1. Accordingly, the headland and the 2013 revetment acts as the western control.

The modelling has shown that the implementation of the 2013 revetment transferred the control point eastwards to a location where the sediment transport potential is lower. Accordingly, this reduced the erosion potential in the area of the proposed revetment. The results have shown that the do nothing scenario will result in continued erosion of the shoreline fronting Clifton Road, albeit at a slightly lower rate (0.2m/year compared to 0.5m/year).

Extending the revetment eastwards further moves the eastern shoreline control point to a location on the shoreline where the shore normal is more aligned to the incident wave direction. Accordingly, the shoreline in this location adopts a crenulate shape with the down drift control being the central salient. As shown in the modelling the shoreline immediately west of the revetment has an initial higher erosion rate compared to existing in the first decade as the shoreline attempts to establish equilibrium and reverts to erosion rates consistent with historical measurements thereafter. The increased erosion rate is expected to decrease over time as the shoreline approaches equilibrium. Furthermore, local lee side erosion effects from the revetment, which are not resolved in the modelling, are likely to locally exacerbate erosion at the terminal end of the revetment.

Observed long term erosion rates have included effects from sea level rise. Potential future shoreline retreat has been assessed by T&T (2004) to be 6.4m and 9.6m by 2060 and 2100 respectively. This translates to an erosion rate of approximately 0.1m/year. In order to quantify the potential wave energy effects from sea level rise over the expected lifetime of the revetment (30 years) the SWAN model was rerun over a 3 year period assuming a 0.15m and 0.30m increase in water level. The results in the form of Wave Energy Flux which is often taken a being directly proportional to sediment transport potential and H_s exceedance are presented in Figures 3.6 and 3.7 for SWAN model output point 20 (Refer to Figure 3.2).

The wave energy flux calculated at the approximate closure depth increases by 4% and 8% for sea level increases of 0.15m and 0.30m respectively. These increases are proportional to sea level increase with lower sea level rises resulting in lower fluxes (and vice versa). In comparison H_s is less affected with P50% and P90% increases over the 30 year timeframe (0.30 m SLR) of approximately 2% (0.02m).

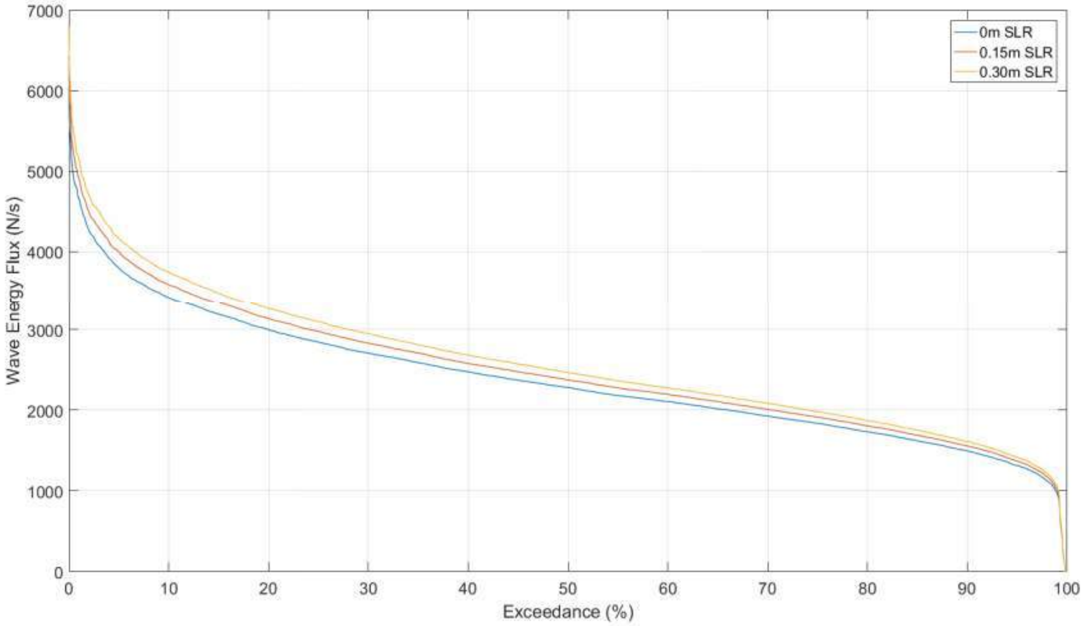

Figure 3.6 – Wave Energy Flux Exceedance at SWAN model output Pt 20

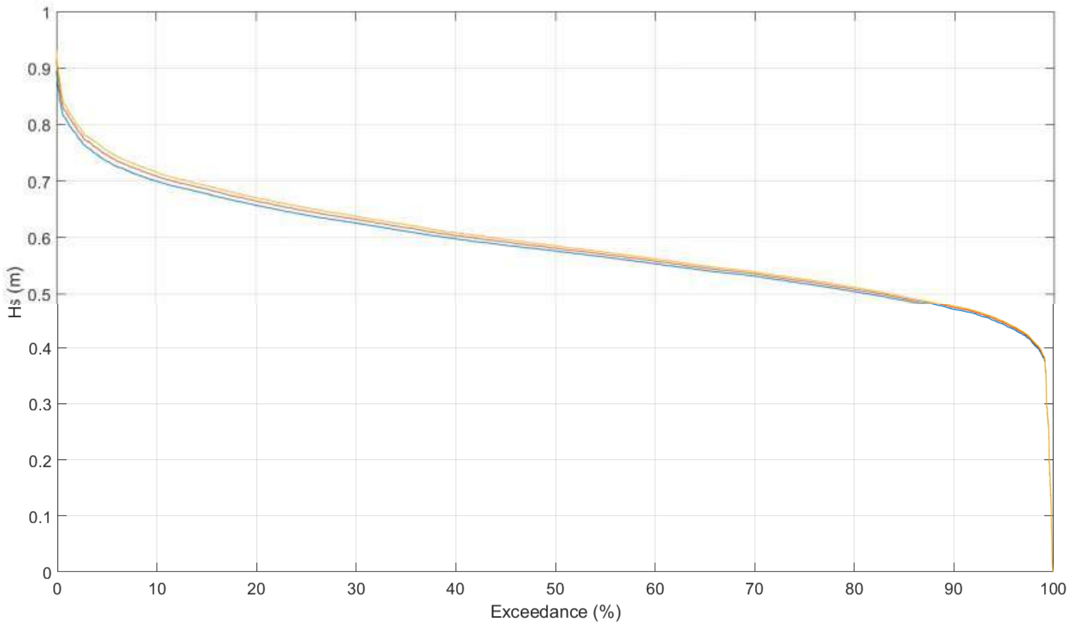

Figure 3.7 – Hs Exceedance at SWAN model output Pt 20

The implementation of the revetment is not expected to modify the expected trends of shoreline retreat apart from holding the line in the vicinity of the revetment. It is noted that the revetment will reduce the amount of sediment that can be utilized for the surrounding shoreline to establish equilibrium as sea levels increase. It is estimated that the likely reduction is in the order of 500 to 1000m^3 per year which is approximately 5% of the net regional input to the Clifton sediment cell.

Figure 3.8: Coastline Evolution, No Protection Case (Scenario 1)

Figure 3.9: Coastline Evolution, Existing Conditions Case (Scenario 2)

Figure 3.10: Coastline Evolution, Proposed Conditions Case (Scenario 3)

Figure 3.11: Shoreline evolution - Existing and Proposed Revetment Cases at Campground 1

4 Conclusions

The results of the numerical modelling have shown the following:

- The wave climate along the Clifton Beach is complex due to offshore reefs which result in varying incident wave angles which in turn dictates longshore sediment transport rates.
- Shoreline evolution is strongly dependent on reefs and outcrops at the mouth of the Maraetoetara River, north of Camp No. 2 (Cell 64) and the hard edged headland that includes Camp No. 1.
- The shoreline fronting Clifton Road has high erosion potential as the shoreline continues to adjust to the incident wave climate. The existing revetments have formed control points which has compartmentalised the shoreline erosion and resulted in down drift erosion.
- While the proposed revetment protects Clifton Road the shoreline adjacent to Camp No. 2 is likely to continue to erode. While the rate of change is low, the introduction of the revetment is expected to increase erosion at the northern end of the revetment in the short term and revert to erosion rates consistent with the historical observations in the medium term (20 to 30 years).
- The modelling indicates that the proposed revetment is not likely to influence the shoreline north of Cell 64, which is controlled by an offshore reef.
- Modelling is not capable of depicting any local down drift erosion, a regular feature on the leeward side of the revetment. However, it must be assumed that this feature will occur.
- The revetment will not influence the effects of future sea level rise on down drift coastlines.