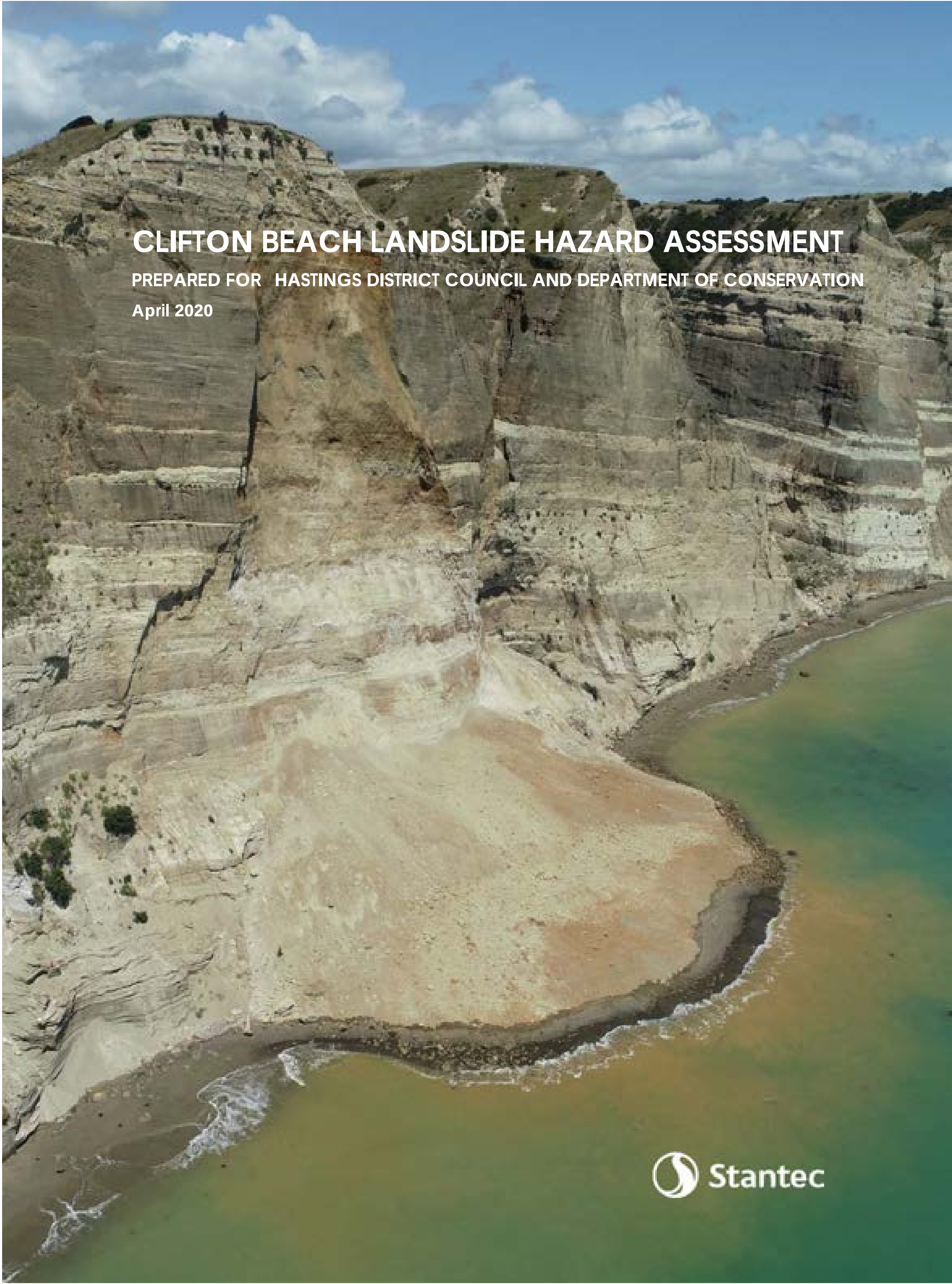
CLIFTON BEACH LANDSLIDE HAZARD ASSESSMENT

PREPARED FOR HASTINGS DISTRICT COUNCIL AND DEPARTMENT OF CONSERVATION

April 2020



Stantec

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REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
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A	Nov 19	Draft	MS	GM		JD
B	Dec 19	Final for review	MS	GM		JD
C	Dec 19	Final	MS	GM	DP	JD
D	Apr 20	Update to hazard assessment	MS			JD

Executive Summary

Introduction

Stantec New Zealand (Stantec) has been commissioned by Hastings District Council (HDC) and the Department of Conservation (DOC) to assist with a Quantitative Risk Assessment (QRA) of landslide hazard at Clifton Beach, Hawke's Bay. The key objective of the QRA is to calculate the potential for loss of life (PLOL) to a variety of beach users due to landslide hazards, so this can be assessed against the HDC/DOC selected tolerable risk criteria.

The QRA is delivered in two parts, as follows:

- Hazard assessment - completed by Stantec. The findings of the assessment are summarised in this report.
- Risk calculation – completed by GNS. To be reported separately.

Why complete a QRA?

HDC councilors voted at a public meeting on the 5 March 2019 to undertake a QRA for the site. It is being completed following the 23 January 2019 Cape Kidnappers Landslide (CKL), which injured two tourists who were present on Clifton Beach at the time. The QRA was recommended by Stantec to HDC as:

- No previous landslide risk assessment has been completed (be it qualitative or quantitative). Landslide hazard exists along most of the beach from Clifton to Cape Kidnappers. This hazard is evident from the number of reported incidents and near misses along Clifton Beach.
- Whatever the risk, the overall risk was increasing. This was mainly due to the increasing number of beach users. For this reason, reliance on precedence over the last 50 years or so is not a sound argument for the landslide risk as being acceptable (i.e. no one has died before).
- There is the potential for multiple injuries or fatalities to occur.
- It is possible that the landslide risk may be somewhat higher than most beach users 'expect' or may be prepared to 'accept', particularly tourists who access the beach.

QRAs are judged standard practice when assessing the PLOL, both in New Zealand and overseas, due to natural hazards. This is as the calculated risk can be more readily assessed against tolerable risk criteria.

Overall QRA Methodology

The only hazard considered as part of the QRA is landsliding, and the only element at risk being considered is people. Other elements at risk, such as infrastructure and the environment, are not considered. The key beach user groups are:

- General public – locals and tourists, which are largely those completing the Cape Kidnappers Walking Track, administered by DOC.
- Guided public – passengers of Gannet Beach Adventures (GBA), which access the beach via tractor and trailer.
- Employees:
    - Employees of GBA – it is expected that an employee of GBA is probably the individual most at risk, due to the time they spend on the beach.
    - HDC and DOC employees and their subcontractors.

The methodology applied for the QRA is that documented in the Australian Geomechanics Society Guidelines on Landslide Risk Management (2007), which is that commonly applied for landslide hazard QRA's in New Zealand. The QRA methodology is also judged consistent with the AS/NZ IS0 31000:2009 Risk Management, the DOC Visitor Risk Management Standard Operating Procedure (SOP) DOC-2852133 and the Health and Safety at Work Act (2015). Both individual and societal risk has been calculated.

Risk Calculation

The risk calculation used to assess the PLOL as part of the overall QRA is:

$$\mathbf{P_{LOL} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}}$$

Where:

P_{LOL} = The risk to an individual beach user, expressed as the probability of loss of life

$P_{(H)}$ = The probability of landsliding

$P_{(S:H)}$ = The probability if a landslide occurs that it impacts a location a beach user may occupy (i.e. the beach)

$P_{(T:S)}$ = The temporal spatial probability of the beach user, which is a beach user being in the location when the landslide occurs

$V_{(D:T)}$ = The vulnerability of the individual given impact from the landslide

Each parameter in the risk calculation is assigned a value of between 0 and 1. A probability of 0 being impossible and 1 being certain. A value of 0.5 represents an 'even chance' (i.e. 50%). Natural hazard probabilities and the associated risk are typically 'low' when compared to other risks people are exposed to. Due to the low probabilities, scientific conventions are commonly used instead of decimals or percentages for expressing likelihood and risk. When using scientific convention, it is important to note that each change in value is one order of magnitude, that is, 10 times more or less likely.

Site Considerations

Some of the unique considerations for the QRA based upon site characteristics are:

- Little is known about past landsliding.
- Landslide hazard is from coastal cliffs, which commonly display a high frequency of landsliding.
- The length and height of the cliffs. This provides many potential landslide source areas.
- Beach users are itinerant and spend a low proportion of their time on their beach. Beach usage is generally very seasonal. Most beach users access the site between September and May. Beach access is very restricted by environmental conditions. Access can occur two hours or so either side of low tide. And because of the timing of tides, access is not possible every day of the year.
- The probability of landslides impacting the beach is very high, due to the high and steep cliffs and the narrow 'beach' at the very base of the cliffs that people occupy.

Landslide Characteristics

Several landslide mechanisms exist, but rockfalls are the key mechanism which 'control' the risk at the site. They occur the most frequently and have the highest consequence. Rockfalls can be distinguished in those of very small (<10m^3) to moderate size (>10, <100 m^3) and those of large (>100m^3, <,1,000 m^3) to very large size (>1,000 m^3) for risk management.

- Very small to moderate rockfalls – likely to impact the upper half of the beach and up to ten metres along the beach. May cause injury or fatalities to an individual or a small-sized group.
- Large to very large rockfalls - can be termed rock avalanches. Likely to spatially impact the entire beach from the base of the cliff to the sea. Likely to spatially impact tens to a few hundred metres along the beach. May cause injury/fatality to an individual up to a large-sized group.

The key considerations for rockfalls at the site are:

- They commonly occur with little or no warning. They are difficult to monitor.
- They are very rapid to extremely rapid, meaning evacuation may not be possible.
- Rockfalls have a short runout distance, from steep cliffs, and are very likely to impact the beach.
- Beach users being struck by rockfall typically have a very high vulnerability.

- They do not always have an obvious ‘trigger’, such as heavy rainfall. Many previous rock avalanches, such as the CKL, appear to have no obvious trigger. This makes risk management more difficult.
- The overall geomorphic process causing landsliding at the site is coastal erosion at the base of the cliffs, which over-steepens the slope. Landsliding occurs as the slope attempts to find a more stable angle. This process was demonstrated by the CKL.

Hazard Assessment Findings

The key findings of this hazard assessment are:

- Probability of landsliding - is judged high, compared to most ‘typical’ sites. This is as the site comprises coastal cliffs, which are actively eroding.
  - The assessed annualised non-earthquake induced landslide frequency by volume class are summarised in Table ES-1.
  - The likelihood of earthquake-induced landslides is to be calculated by GNS as part of their work.
  - The assessed frequency of non-earthquake triggered and earthquake triggered landslides should be combined to determine the overall probability of landsliding in the risk calculation.

Table ES-1: Relationship between different probability descriptors

<table>
<tr><th rowspan="2">Date Source</th><th colspan="5">Volume Class</th></tr>
<tr><th>Very small (<10 m^3)</th><th>Small (10 to 100 m^3)</th><th>Moderate (100 to 1,000 m^3)</th><th>Large (1,000 to 10,000 m^3)</th><th>Very Large (>10,000 m^3)</th></tr>
<tr><td>Anecdotal (newspaper only)</td><td colspan="4">N/A</td><td>0.06</td></tr>
<tr><td>GBA information</td><td colspan="4">N/A</td><td>0.2</td></tr>
<tr><td>Aerial imagery review</td><td colspan="3">N/A</td><td>2</td><td>0.5</td></tr>
<tr><td>LiDAR 2003 to 2012</td><td colspan="3">N/A</td><td>2</td><td>0.4</td></tr>
<tr><td>LiDAR 2012 to UAV 2019 (Flight 1)</td><td colspan="3">N/A</td><td>1</td><td>0.4</td></tr>
<tr><td rowspan="2">UAV 2019 (Flight 1) to UAV 2019 (Flight 2)</td><td>180 (min)</td><td>150 (min)</td><td>48</td><td>12</td><td>3</td></tr>
<tr><td>770 (max)</td><td>190 (max)</td><td colspan="3">N/A</td></tr>
<tr><td>Adopted</td><td>800</td><td>200</td><td>50</td><td>12</td><td>3</td></tr>
</table>

- Spatial impact of landsliding – is also judged high, compared to most ‘typical’ sites. This is as the cliffs are typically very high and steep, with the beach at the very base of the cliffs.
  - It is almost certain that large to very large landslides will spatially impact the beach, irrespective of where they occur. They are also likely to spatially impact the entire beach from the base of the cliff to the MLWS.
  - The spatial impact of very small to moderate volume rockfalls is much harder to assess based upon precedence and this is when the landslide source area and slope characteristics below the source area become much more critical. It is not feasible to model all the possible scenarios based upon source area height and cliff shape. In many locations, due to the very steep cliffs, it is judged almost certain even very small to moderate rockfalls would spatially impact the beach. What is important, is that these rockfalls are much less likely to spatially impact the entire beach.
  - Overall, at the base of the cliff, the probability of spatial impact is very high, but is likely to be much less at the MLWS for example. The challenge with this is beach users could be in any part of the beach, as there is no defined track on which they would be.
  - The ratio of source area width to rockfall deposit width appears to be in the range of 1.5 to 2 for large to very large rockfalls, with the CKL calculated as 1.7. This ratio will be different for smaller volume landslides.

- Temporal spatial probability of beach users – as beach users are itinerant and spend a short time on the beach, their exposure is relatively low. This is the key aspect that reduces the risk at the site.
- Vulnerability of a beach user if struck – is judged high, compared to most 'typical' sites. This is as rockfalls travel fast and may hit beach users directly from above.

Risk Calculation

GNS was commissioned by HDC and DOC to carry out a quantified landslide risk analysis in the study area, adopting the results from the hazard assessment contained in this report. The findings of the risk analysis are to be reported separately.

Risk Context

As context for helping HDC and DOC in establishing tolerable risk criteria and for decision-making purposes:

- A balance is required to be achieved between protecting people from the hazard (and the decisions of others) and enabling them to live as they wish.
- Beach users are undertaking a recreational activity in accessing the beach and they can choose whether to access the beach or not. Employees having to access the beach as part of their employment duties also have some degree of choice. Beach users decide if the risk of accessing the beach is worth the benefit gained (i.e. risk vs reward). 'Imposed risk', where people have no or little choice but to accept the risk and have limited control over it, is not a key consideration in this instance.
- By accessing the outdoors for recreational purposes, people inherently 'expect' and 'accept' some risk and probably more risk than 'normal'.
- It is difficult to apply a 'one tolerable risk criteria' fits all approach for decision-making. This is as each beach user group, and individuals within each group, likely have very different levels of risk they expect and are willing to accept.

Risk Management Approach

One approach to risk management could be in allowing beach users to access the beach should they wish to do so. This could only be considered with risk management per AS/NZ ISO 31000:2009 risk management framework. Key aspects of this would be:

- The estimated risk is communicated to all beach users. It is contextualised against other everyday recreational risks that people can understand. Beach users make their own risk-informed decision whether accessing the beach for the benefit they gain is worth the risk involved.
- Risks are managed with an ALARP approach, consistent with the Health and Safety at Work Act (2015) and other instances where societal risk is a key consideration.

Risk Management Requirements

The overall QRA has 'established the context' and is a 'risk assessment' as per the requirements of AS/NZ IS0 31000:2009. A separate assessment is required to confirm the requirements to address the other key areas of the AS/NZ IS0 31000:2009 risk management framework. Specifically:

- 'Risk treatment'
- 'Monitoring and review'
- 'Communication and consultation'.

This hazard assessment represents the starting point for landslide hazard risk management at Clifton Beach. The findings of this report and that of the associated GNS report should be reviewed on an annual basis, as more information is acquired to more reliably assign parameters to the risk calculation.

Abbreviations

AGS	Australian Geomechanics Society
AIFR	Annual Individual Fatality Risk
ALARP	As Low As Reasonably Practicable
ANCOLD	Australian National Committee on Large Dams
CCC	Christchurch City Council
CKL	Cape Kidnappers Landslide (23 January 2019)
DEM	Digital Elevation Model
DOC	Department of Conservation
GBA	Gannet Beach Adventures
GNS	GNS Science
GSD	Ground Sample Distance
HBRC	Hawke's Bay Regional Council
HDC	Hastings District Council
HSWA	Health and Safety at Work Act 2015
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
pga	Peak ground acceleration
P_{LOL}	Annual Probability of Loss of Life
$P_{(H)}$	Probability of a landslide occurring
$P_{(S:H)}$	Probability of spatial impact
$P_{(T:S)}$	Temporal spatial probability
QRA	Quantitative Risk Assessment
RPT	Risk Per Trip
SOP	Standard Operating Procedure
TAC	Tongariro Alpine Crossing
TNP	Tongariro National Park
UAV	Unmanned Aerial Vehicle

Hastings District Council and Department of Conservation

Clifton Beach Landslide Hazard Assessment

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1. Introduction

1.1 Project Background

Stantec New Zealand (Stantec) has been commissioned by Hastings District Council (HDC) and the Department of Conservation (DOC) to assist with a Quantitative Risk Assessment (QRA) of landslide hazard at Clifton Beach, Hawke's Bay.

The key objective of the QRA is to calculate the potential for loss of life (PLOL) to a variety of beach users due to landslide hazards, so this can be assessed against the HDC/DOC selected tolerable risk criteria. The work has been undertaken per the Stantec proposal dated 12 June 2019 (Rev C).

The QRA is to be delivered in two parts, as follows:

- Hazard assessment - completed by Stantec. The findings of this are summarised in this report.
- Risk calculation – completed by GNS. To be reported separately.

1.2 Why complete a QRA?

HDC councilors voted at a public meeting on the 5 March 2019 to undertake a QRA for the site. The QRA is being completed following the 23 January 2019 Cape Kidnappers Landslide (CKL), which injured two tourists who were present on Clifton Beach at the time.

The QRA was recommended by Stantec (2019), who were engaged by HDC to act as their technical advisor for the CKL, as:

- Landslide hazard is not restricted to the immediate CKL location only. Landslide hazard exists along most of the beach from Clifton to Cape Kidnappers. This hazard is evident from the number of reported incidents and near misses along Clifton Beach.
- No previous landslide risk assessment has been completed (be it qualitative or quantitative).
- Although the risk before the CKL occurred was unquantified and was still unquantified at the time of the public meeting, the overall risk was increasing. This is mainly due to the increasing number of beach users.
- For this reason, reliance on precedence over the last 50 years or so is not a sound argument for the pre-CKL risk, or the current risk, being acceptable (i.e. no one has been killed before).
- Depending on the characteristics of landsliding and other circumstances, there is the potential for multiple injuries or fatalities to occur.
- Low likelihood landslides are not a necessity to cause an injury or a fatality at the site. Even small volume rockfalls, of less than 1m^3, could cause an injury or a fatality when the site characteristics are considered. This includes the high and steep cliffs and the potential for people to be at the very base of the cliffs, due to the narrow 'beach'.
- It was considered that the landslide risk may be somewhat higher than most beach users 'expect' or may be prepared to 'accept'.

QRA's are judged standard practice when assessing the PLOL, both in New Zealand and overseas. QRA's are preferred to qualitative and semi-quantitative risk assessments as the calculated risk can be more readily assessed against tolerable risk criteria.

1.3 QRA Objectives

1.3.1 Overall QRA

The key objectives of the overall QRA are to:

- Calculate the PLOL for a variety of beach users[1]
- Calculate the annual societal risk
- Suggest tolerable risk criteria that could be applied for decision making.

The outputs of the QRA will be used by HDC and DOC for decision-making with regards to public access of the site. The specific geographic locations which are included in the QRA are:

- Clifton Beach, between Clifton Motor Camp (Stanley's Point) and Cape Kidnappers. Considered a legal road and within the district of HDC.
- DOC land at Cape Kidnappers and the section of private property on which the DOC walkway to Cape Kidnappers is located.

These locations are collectively referred to as 'the site' in this document. Gullies extending away from the beach have not been specifically considered. The only hazard being considered as part of the QRA is landsliding. Other site hazards are not considered[2]. Only direct landslide hazard is considered (i.e. people being struck by a landslide). Indirect consequences of landsliding are not considered.

The landslide hazard is largely from 'inundation' (i.e. beach users being struck from above). There are some locations of the site however where beach users may be located directly on the landslide, this is restricted to the DOC land at Cape Kidnappers and the section of private property on which the DOC walkway is located.

1.3.2 Stantec Hazard Assessment

The objectives of this hazard assessment report are to identify:

- Landslide types (mechanisms) and locations
- Landslide volumes and their frequency
- How far the landslide debris may travel down the slope
- The temporal and spatial probability of beach users to landslide hazard
- Their vulnerability in the event of being struck by landslide debris.

The report is arranged as follows, structured by the above objectives of the hazard assessment:

- Section 2 – the framework for the overall QRA as context to this report
- Section 3 – the key site characteristics relevant to this hazard assessment
- Section 4 – a summary of general landslide characteristics at the site
- Section 5 – the assessed probability of landsliding (by different volume)
- Section 6 – the assessed probability of spatial impact of landsliding (i.e. hitting the beach if it occurs)
- Section 7 – the assessed temporal and spatial probability of different beach users to landslide hazards (i.e. how much time they spend on the beach in the hazard area)
- Section 8 – the assessed vulnerability of different beach users in the event of being struck by landsliding
- Section 9 – a summary of risk control measures, based upon a previous Stantec report

[1] The term 'beach user' is used in this document, as qualitatively this is where the highest risk seems to be present. It is noted however that some 'beach users' will also access DOC land, away from the beach.
[2] Such as drowning.

- Section 10 – a summary of risk criteria and risk context, based upon a previous Stantec report
- Section 11 – conclusions and guidance
- Section 12 – key references cited in this report
- Section 13 – limitations.

A glossary is provided as Appendix A of key risk and landslide terms used in this report. Appendix B provides a summary of landslide classification and characteristics, as further context to the overall QRA.

1.3.3 GNS Risk Calculation

GNS was commissioned by HDC and DOC to carry out a quantified landslide risk analysis in the study area shown in Figure 3-1 of this report, adopting the results from the hazard assessment contained in this report.

The risk will be calculated for cliff collapse hazards triggered by:

- earthquakes; and
- non-earthquake events.

The quantitative landslide risk analysis will be based on risk-estimation methods that follow appropriate parts of the Australian Geomechanics Society framework for landslide risk management (Australian Geomechanics Society, 2007). It provides risk estimates suitable for use under SA/SNZ ISO1000: 2009.

The risk analysis will quantify the risk, in this case the loss of life, to staff (working for the tourist operator) and visitors from cliff collapse hazards in the study area. The risk metrics adopted will be the annual individual fatality risk and the individual fatality risk per visit due to impact or inundation by debris. Calculation of aggregate risk per trip and other risk metrics derived from it will also be estimated.

The uncertainties relating to the parameters used in the risk analysis, and their impact on the risk estimates, will also be quantified to give some indication of the accuracy of the risk analysis results.

The risk analysis will also quantify the societal risk (i.e. the probability of multiple fatality events occurring) in the form of an F/N curve for both tourists who walk, or take a commercial tour to the Gannet colony.

2. QRA Framework

The following subsections summarise the methodology of the overall QRA as context to this hazard assessment.

2.1 Elements at Risk

The only element at risk considered by the QRA is people. Other elements at risk, such as infrastructure, property and the environment, are not considered.

The key beach users are:

- General public:
  - Locals
  - Tourists – largely those completing the Cape Kidnappers Walking Track, which is administered by DOC.
- Guided public[3] – passengers of Gannet Beach Adventures (GBA), which access the beach via tractor and trailer. GBA is a concessionaire of DOC, to access Cape Kidnappers as part of their trip.
- Employees:
  - Employees of GBA – it is expected that an employee of GBA is probably the individual most at risk, due to the time they spend on the beach and are exposed to landslide hazard.
  - HDC and DOC employees, together with their subcontractors.

2.2 QRA Process

The methodology applied for the QRA is that presented within AGS (2007). This is the most widely applied methodology in NZ and Australia for landslide QRA's. The overall process of the QRA is shown in Figure 2-1, together with how this report fits within the overall process.

AS/NZ IS0 31000:2009 is a New Zealand standard providing 'guiding principles, a generic framework and a process for managing risk'. The overall risk management framework AS/NZ IS0 31000:2009 is summarised in Figure 2-2. It is considered that the adopted QRA methodology is in general accordance with this standard.

The QRA methodology is also judged consistent with the DOC framework for visitor risk management (VRM) on public conservation land, which is documented in SOP DOC-2852133 (Figure 2-3).

[3] The risk to passengers and employees of Gannet Safaris Overland, who access DOC land at Cape Kidnappers, are not being specifically considered as part of the overall QRA.

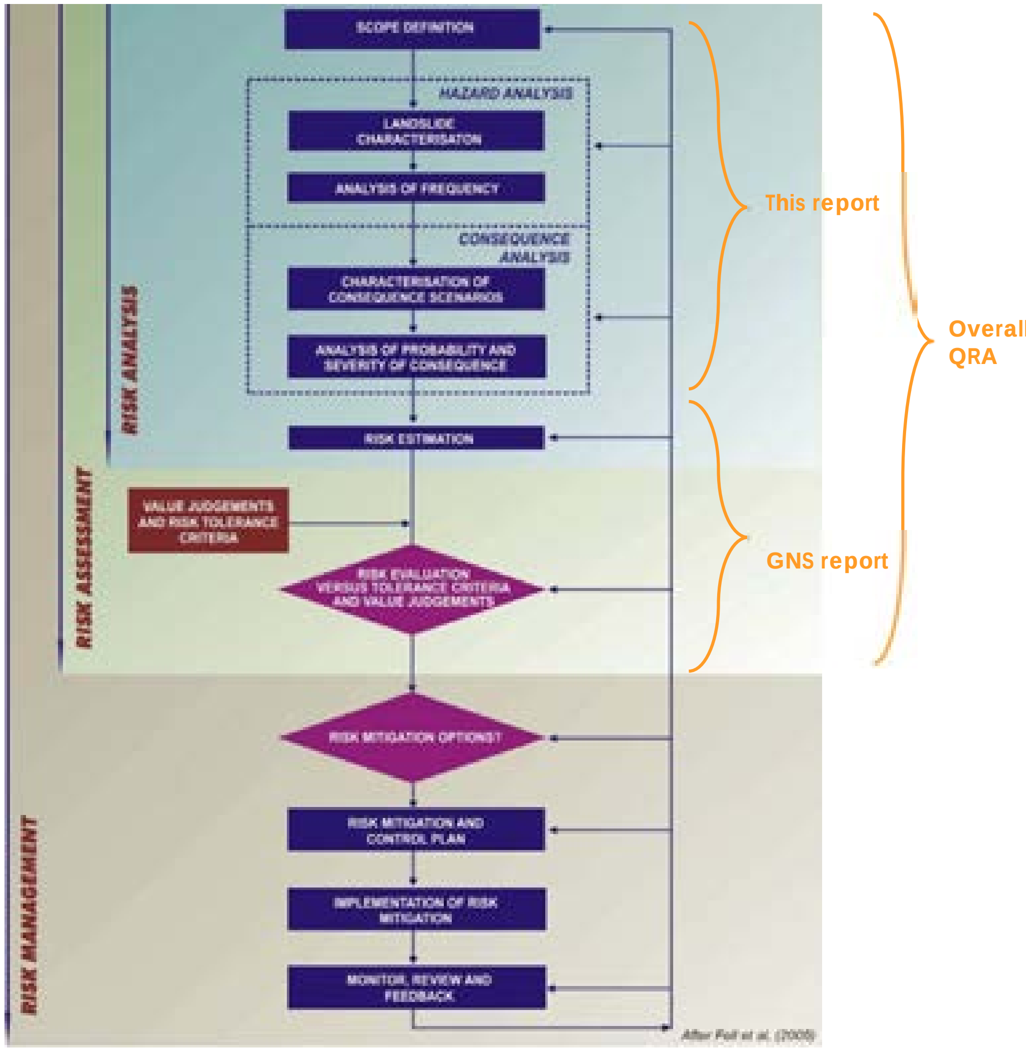


Figure 2-1: Overall QRA process (from AGS 2007)

Figure 2-2: AS/NZ ISO 31000:2009 Risk Management Framework

Figure 2-3: DOC framework for risk management

2.3 Acceptable vs Tolerable Risk

Key definitions relevant to the overall QRA and establishing relevant criteria for decision-making:

- **Acceptable risks** – are those which everyone is prepared to accept. Action to further reduce the risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort.
- **Tolerable risks** – are those within a range that society can live with to secure certain benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced if practicable.

Acceptable risks are commonly one order of magnitude lower than tolerable risks.

Tolerable risks are recommended to be used for the overall QRA, as they are most typically used for landslide risk management.

A further important concept is that of '**imposed risk**'. Imposed risks are those that people don't have an option but to accept and they typically have limited control over the risk. An example would be people living downstream of a dam, with the hazard being dam failure. For these reasons, 'imposed risks' commonly have a lower risk acceptance criterion compared to those risks where people have some choice and control of the risk. In this instance of landslide hazard on Clifton Beach, the hazard is pre-existing, and people can choose whether they wish to enter the hazard location or not. Therefore, imposed risk is not a key consideration[4].

[4] There are some instances where this may be applicable, however. Such as the head of household deciding to access the beach, on behalf of their family.

2.4 Risk Calculation

The risk calculation being used as part of the overall QRA to assess the PLOL is:

$$\mathbf{P_{LOL} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}}$$

Where:

$\mathbf{P_{LOL}}$ = The risk to an individual beach user, expressed as the probability of loss of life.

$\mathbf{P_{(H)}}$ = The annual probability of landsliding. This parameter is assigned based upon a combination of:

- Historical landsliding – what has happened in the past
- Future landsliding – what might happen in the future, when factors such as landslide triggers are considered.

$\mathbf{P_{(S:H)}}$ = The probability that if the landslide occurs, it impacts a location a beach user may occupy. This parameter is usually assigned based upon a combination of:

- Empirical relationships of landslide failure paths/trajectories
- Numerical modelling of landslide failure paths/trajectories.

$\mathbf{P_{(T:S)}}$ = The temporal spatial probability of the beach user, that is the probability a beach user will be in the location when the landslide occurs. This parameter is assigned based upon an understanding of visitor numbers and characteristics. Consideration of whether a beach user may evacuate is also included.

$\mathbf{V_{(D:T)}}$ = The vulnerability of the individual given impact from the landslide. This parameter is usually assigned based upon published literature.

The risk calculation is shown graphically as Figure 2-4.

Each parameter in the risk calculation is assigned a value of between 0 and 1, a probability of 0 being impossible and 1 being certain. A value of 0.5 represents a neutral or an ‘even chance’.

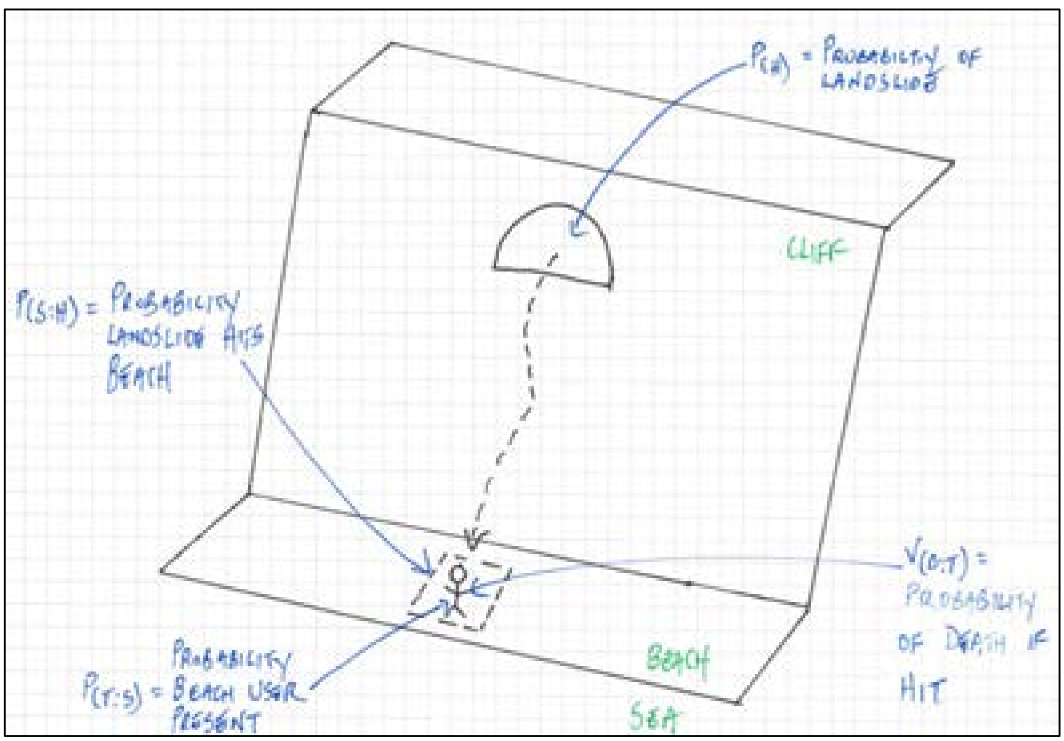


Figure 2-4: Graphical summary of risk calculation being used by the overall QRA

When assigning the probabilities for the hazard components, we have applied a 'best estimate' scenario as recommended by ANCOLD (2003)[5]. This is what we believe is most likely to occur.

2.5 Probability

Each of the parameters of the risk calculation need to be met for a fatality to occur. This concept is demonstrated by Reason's Swiss Cheese Model, as depicted in Figure 2-5. As further explanation to Figure 2-5:

- Yellow line – a landslide has occurred, but it does not hit the beach. It does not matter if beach users are on the beach. Death due to the landslide is not possible.
- Red line – a landslide has occurred, it hits the beach, a beach user is present at that location when it hits, the landslide impact is sufficient to cause death.

As each step or parameter is not certain, each has a probability assigned to it. As you move through each of the steps, the cumulative probability reduces.

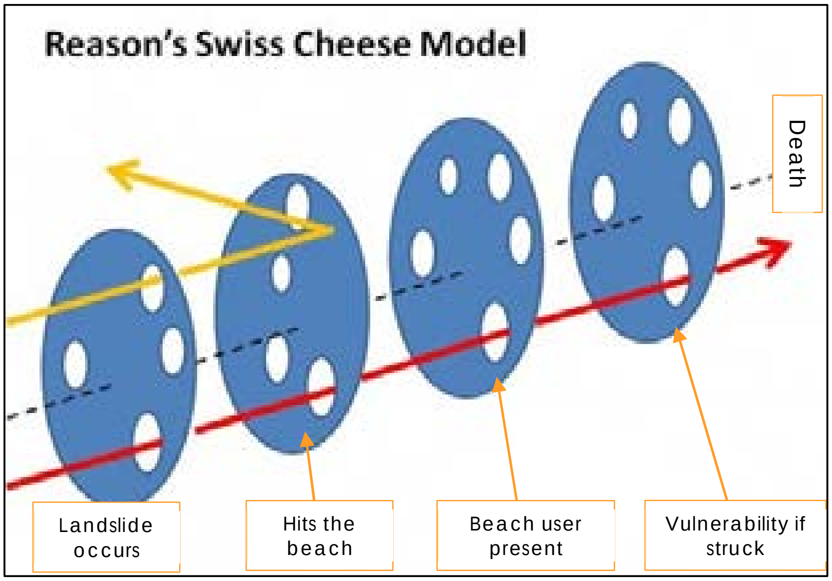


Figure 2-5: Reason's swiss cheese model for accident causation

Natural hazard probabilities and the associated risk are typically 'low' when compared to other hazards people are exposed to. This is as the occurrence of natural hazards is relatively low, they may only occur every few hundred years or thousand years for example. For this reason, it is not uncommon for calculated risks from QRA to have an uncertainty in the order of one order of magnitude (i.e. ten times higher or lower than the 'best estimate').

Probabilities calculated by the QRA are also 'low' as beach users are itinerant. They spend only a very small portion of their time on the beach. For example, a tourist may only make the trip once in their lifetime. Due to the low probabilities typically derived by landslide QRAs, scientific conventions are commonly used instead of decimals for expressing likelihood and risk.

Table 2-1 shows a comparison of different probability descriptors for reader understanding. Highlighted on the figure is the range of probabilities commonly relevant for natural hazard QRA's. It can be seen that probabilities are commonly less than 1 in 1,000. This can be difficult for people to understand, as they do not happen often within their lifetime or are unlikely to happen in their lifetime. Also shown in Table 2-1 are some example 'everyday' and 'recreational' risks for reader context. It is noted that these example risks are approximated only, and some are lifetime risks while others are per participation/activity.

[5] Sometimes referred to as a 'maximum reasonable outcome'.

As further context to these probabilities, risks higher than 10^{-4} are commonly considered unacceptable. When using scientific convention, it is important to note that each change in value is one order of magnitude. That is, 10 times more or less likely.

Table 2-1: Relationship between different probability descriptors

Ratio	Decimal	Scientific	Percentage	Everyday risks	Recreational risks
1 in 1	1	1 or 1E+00	100 %		
1 in 10	0.1	10^{-1} or 1E+01	10 %		Base jumping
1 in 100	0.01	10^{-2} or 1E+02	1 %		Motor racing
1 in 1,000	0.001	10^{-3} or 1E+03	0.1 %	Cancer, heart disease	Climbing Mt Cook, hang gliding
1 in 10,000	0.0001	10^{-4} or 1E+04	0.01 %	Driving – all, falls	Rock climbing
1 in 100,000	0.00001	10^{-5} or 1E+05	0.001%	Drowning, suffocation	White water rafting, scuba diving
1 in 1,000,000	0.000001	10^{-6} or 1E+06	0.0001%	Average NZ natural hazard risk	Jetboating, parachute jump, fishing, skiing
1 in 10,000,000	0.0000001	10^{-7} or 1E+07	0.00001%	Struck by lightning	Soccer, netball
1 in 100,000,000	0.00000001	10^{-8} or 1E+08	0.000001%	Commercial air travel	Golf, cricket

2.6 Key QRA Context

Key context for the QRA are:

- No risk assessment of any form has been completed previously.
- There is limited pre-existing information to help assign values to the parameters in the risk calculation. For example, no records of past landsliding are available.
- In accessing the beach, beach users choose if the risk of accessing the beach is worth the experience (reward) gained.
- Until this point, it appears many beach users have assumed the risk is acceptable. For example:
  - Tourists completing the Cape Kidnappers Walking Track may have assumed that if the walk is being promoted by the DOC, then the risk is acceptable
  - Passengers of GBA may have as assumed that if the trips were being run, then the risk was acceptable.
- Each of the beach user groups, and individuals within each beach user group, are probably exposed to different levels of risk (and significant variation of risk). This is due to factors including:
  - How much time they spend on the beach within the hazard area
  - Their different levels of hazard awareness and the ability to evacuate in the event of landsliding
  - Their vulnerability in the event of being struck, depending on whether they are on foot, in a vehicle, etc.
- Each of the beach user groups probably has different tolerable risk levels and there is likely significant variation of tolerable risk between the groups.

Other relevant unique characteristics of the site relevant to the hazard assessment are:

- The length of the site - approximately 9.5 km. The cliffs are also very high, up to 120 m or so. In essence, landslide source areas could occur throughout this length.
- The site characteristics are different throughout the access route. This means hazard and risk also vary.
- Beach users are itinerant and spend a low proportion of their time on the beach. On this basis, their temporal spatial exposure to landslide hazard is very low.

- Beach usage is very seasonal, except for locals and employees of HDC and DOC. Most beach users access the site between September and May.
- Beach access is restricted by environmental conditions, with access only possible two hours or so either side of low tide. Due to the timing of tides, access is not possible every day throughout the year.
- Landslide hazard is from coastal cliffs. Coastal cliffs commonly display a high occurrence of landsliding. This is particularly true at the site, for several reasons discussed later in this report.
- The probability of landslides impacting the locations accessed by beach users is very high, this is due to the high, steep cliffs and the narrow 'beach' at the very base of the cliffs.

2.7 Previous Incidents

Three instances of beach users being struck by a landslide are known:

- 23 Jan 2019 – CKL, two tourists injured
- 5 March 1988 - two tourists injured
- 1 February 1973 – one man injured, two men evacuated the area, damage to tractors and trailers of GBA.

There are no known instances of:

- Beach users on foot being directly struck/inundated by a rockfall that is falling or bouncing. Evidence indicates also that people struck to this point have been when the rockfall deposited has transitioned to a flow/slide after impacting the beach.
- Beach users in a vehicle being struck by rockfall.
- A GBA tractor or trailer unit being struck by rockfall with passengers.

In terms of providing some context to the number of previous incidents and what the risk may be:

- GBA:
  - Have operated for 67 years and have carried more than 500,000 passengers. Recent history shows around 12,000 passengers per annum.
  - The main driver for GBA has likely made more than around 2,000 trips.
- The number of tourists who have accessed the beach is not reliably known. Recent history shows around 15,000 per annum per but the actual number may have been somewhat higher than this for various reasons. The number is likely more than 100,000 in the last 50 years say.
- The number of times locals have accessed the beach is not known. But, if it were assumed five locals access the beach on average each day, then around 100,000 visits have been made by locals in the last 50 years say.

3. Site Characteristics

The following subsections briefly summarise the setting of the site, relevant to this assessment. Reference is made to Appendix C for plans, elevations, and sections of the site.

3.1 Location and Access

The location of the site is shown in Figure 3-1, together with key locations referenced in this report. Figure 3-2 shows the area around Cape Kidnappers in greater detail.

Key comments about the location and access of the site are:

- Access for all beach users to the site occurs from Stanley's Point
- Access for all beach users occurs as a return trip
- Dependent on the beach user, the length of the beach accessed, and the method of access may vary. This can be summarised as:
  - General public:
    - Locals – variable locations. Accessed on foot or by vehicle (bike, motorbike, quad, and car).
    - Tourists – return trip to Cape Kidnappers. Accessed on foot.
  - Guided public – return trip to Cape Kidnappers. Accessed on a trailer towed by a tractor.
  - Employees:
    - GBA – return trip to Cape Kidnappers, accessed on a tractor. Employees also access other areas of the beach during the season to complete maintenance works on the access route.
    - HDC and their subcontractors - return trip to Cape Kidnappers. Accessed on foot or by vehicle.
    - DOC employees – overland vehicle access to Cape Kidnappers. Do not typically access the beach.

For the purposes of surveying during the hazard assessment, we have divided the beach into nine 'sectors'. These sectors were developed solely to aid the systematic survey of the beach. They do not represent sectors of varying hazards or risks. The location of the surveying sectors is shown in Figure 3-3 and Figure 3-4.

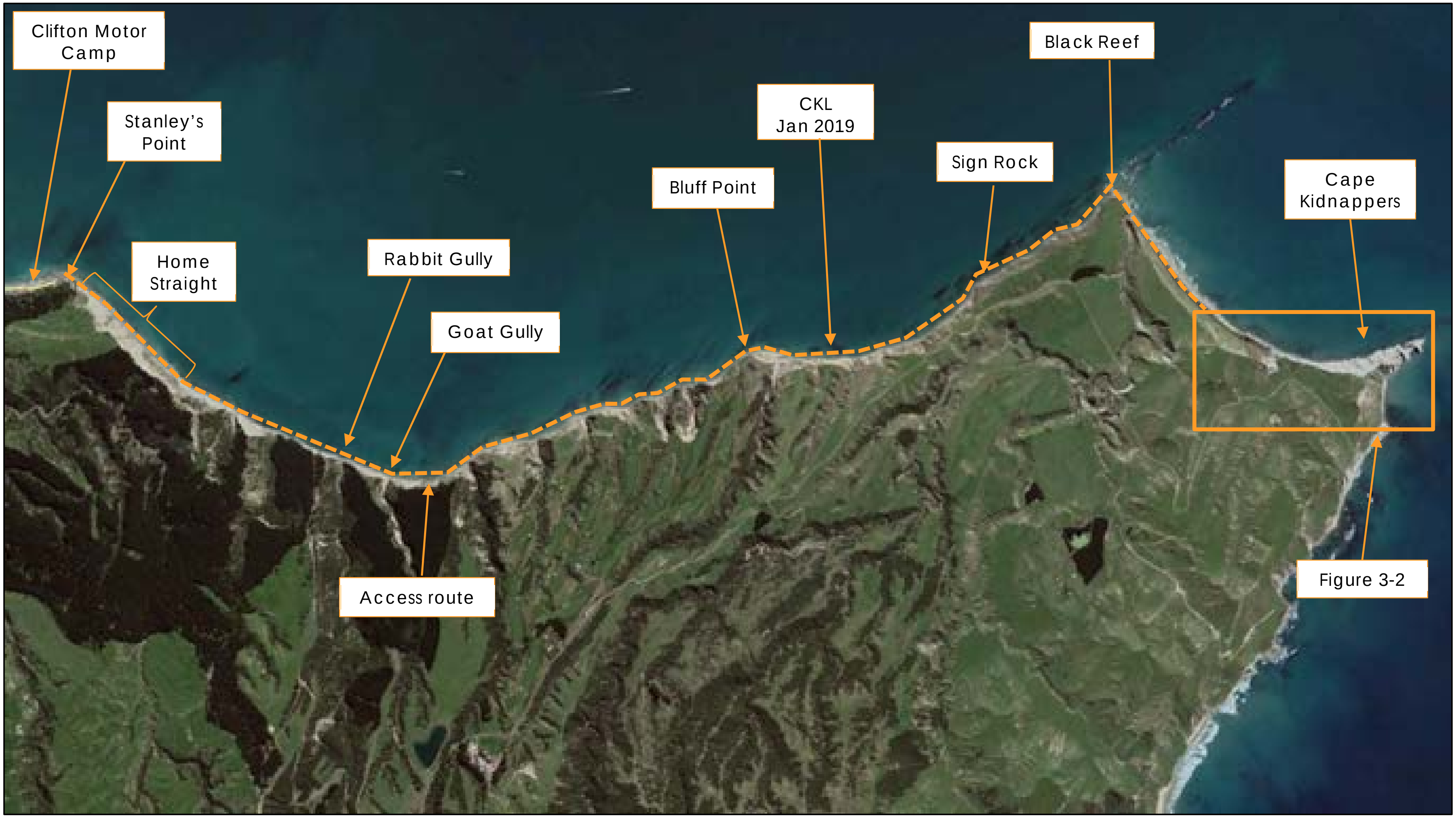


Figure 3-1: Site location

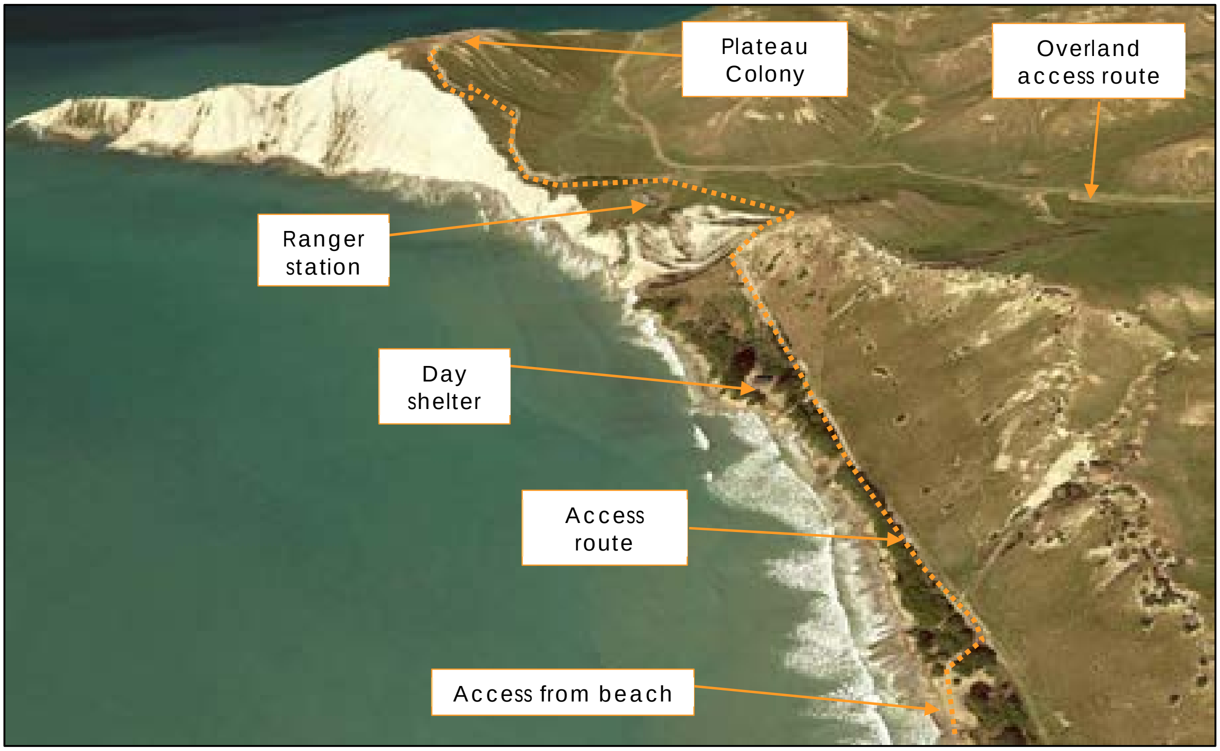


Figure 3-2: Oblique view of Cape Kidnappers looking SE

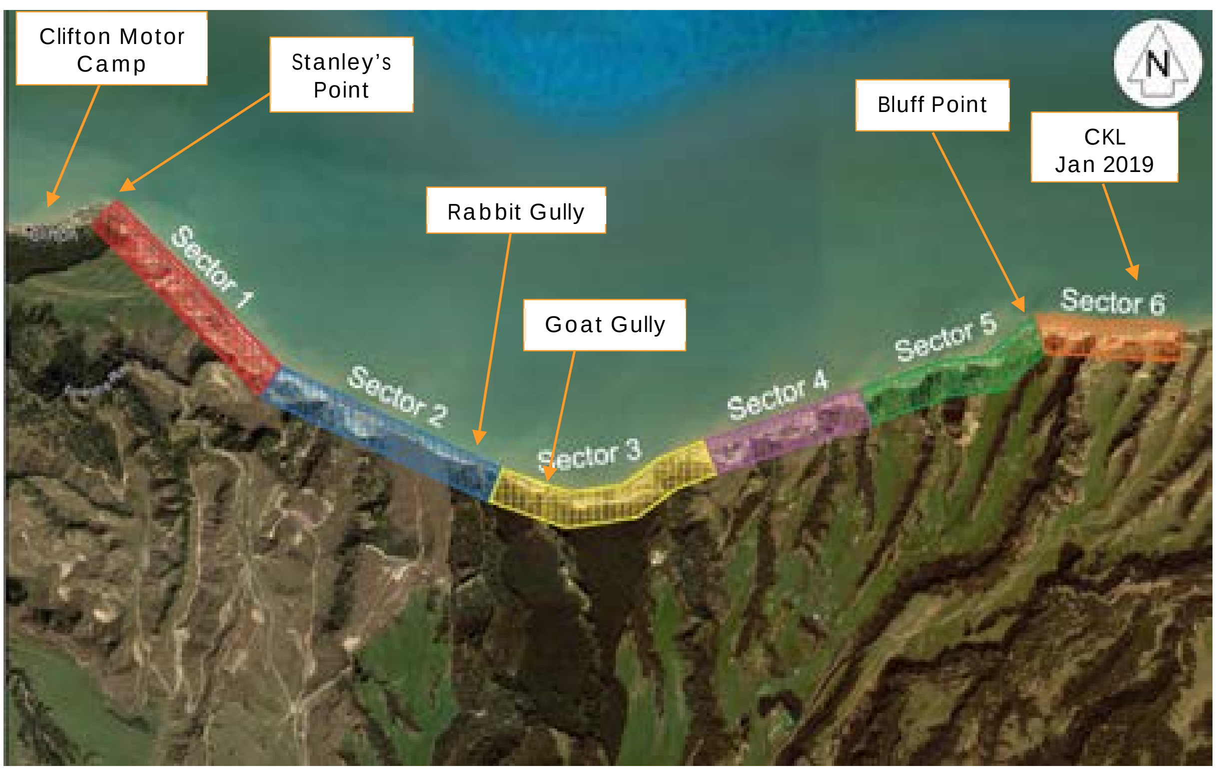


Figure 3-3: Surveying Sectors 1 to 6 locations

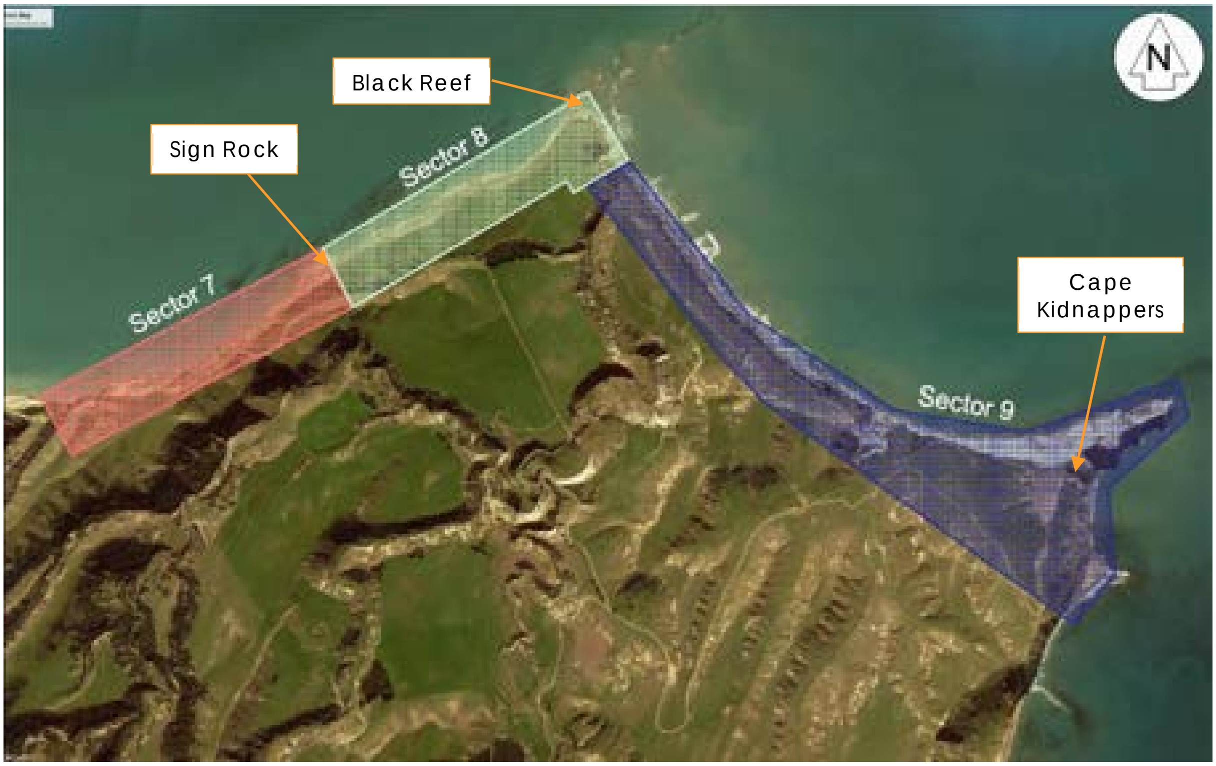


Figure 3-4: Surveying Sectors 7 to 9 locations

Access along the beach generally occurs within the foreshore (Figure 3-5). The foreshore is considered a legal road and within the district of HDC. The foreshore is defined as the area between the Mean Low Water Spring (MLWS) and the Mean High Water Spring (MHWS), as shown in Figure 3-6. On this basis, beach access is restricted by tides. Access is only feasible two hours or so either side of low tide.

Other key comments with about beach access are:

- There is typically no or limited backshore
- Even at low tide, beach access can still be impacted by waves
- The width of the foreshore is variable, dependent on its characteristics.

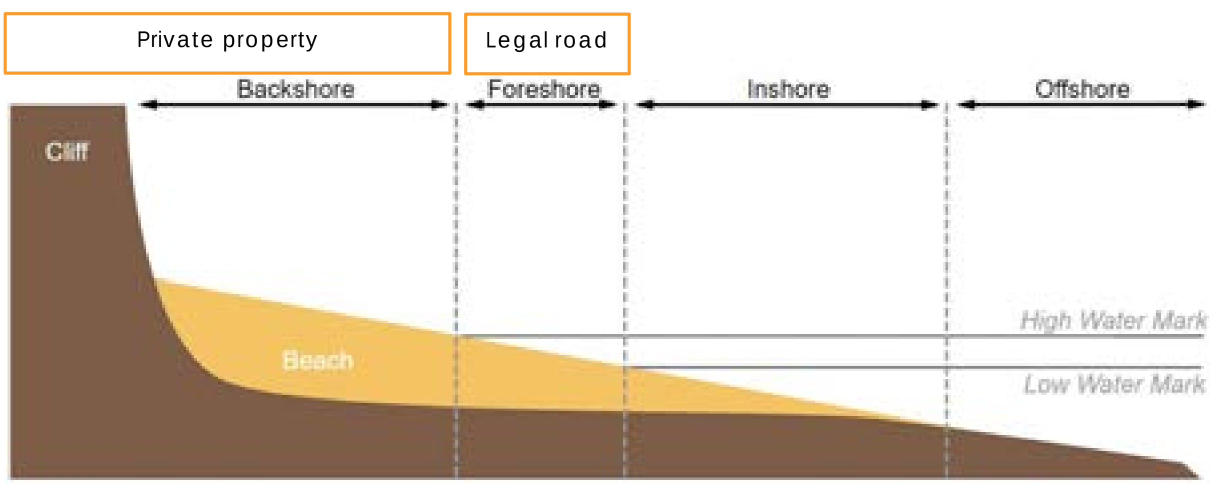


Figure 3-5: Coastal zones

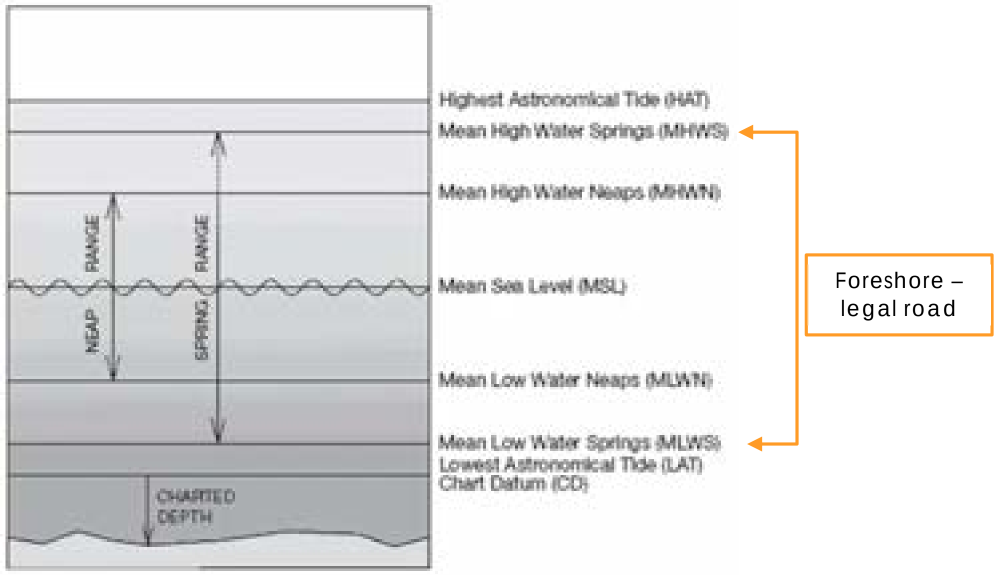


Figure 3-6: Definitions of tidal terms

To provide some context, Figure 3-7 shows an oblique view looking west at the CKL location. It shows the narrow foreshore at the very base of the cliffs which provides access along the beach, and the limited backshore that is present. This is important for the QRA as it means, in the event of landsliding from the cliffs, it is very likely to impact the location where beach users occupy (i.e. the foreshore).

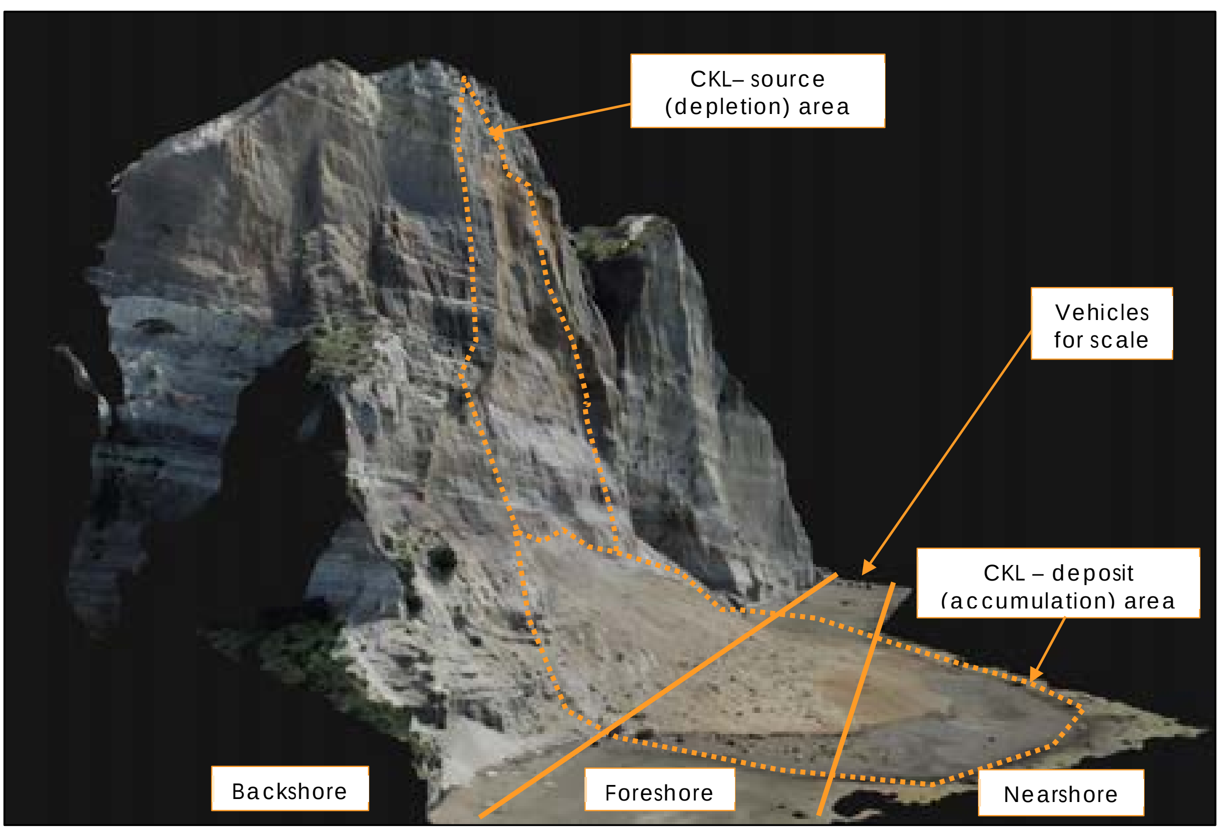


Figure 3-7: Sector 6 - schematic cliff section at the CKL location

3.2 Geological

The published geological map for the site is shown in Figure 3-8. The key geological features are (youngest to oldest):

- Q5b – these deposits are mapped on top of the cliffs and represent old marine benches. They are described as 'beach deposits of sand, silt, mud, gravel; commonly containing loess, palaeosols, and tephra' and are shown to be between 128,000 and 71,000 years old.
- eQp – Kidnappers Group – is shown to form the cliffs from Stanley's Point to Black Reef. These deposits are described as 'basal fossiliferous sandstone overlain by conglomerate, sandstone, carbonaceous mudstone, tephra, and ignimbrite'. These deposits are assessed to be between 1.8 million and 425,00 years old.
- Pmz – shown to outcrop east of Black reef to Cape Kidnappers and south of Cape Kidnappers. These deposits are described as 'Early Pliocene massive calcareous and fossiliferous mudstone with minor interbedded sandstone at Cape Kidnappers'. Their age is shown as between 5.32 and 3.6 million years old.

The bedding within the cliffs is shown on the published geological map to dip towards the northwest at 8° to 15°. Due to the east-west strike of the cliff, this equates to obliquely out of slope. Two un-named active faults are present 500 m west of the landslide location. The New Zealand Active Fault Database (https://data.gns.cri.nz/af/) does not contain any information for these active faults (such as the sense of movement, Recurrence Interval, age of last rupture etc.). The map indicates the mapped fault locations vary from 'accurate' to 'approximate', with the easternmost fault showing the eastern side is downthrown. These faults are not discussed further in this report.

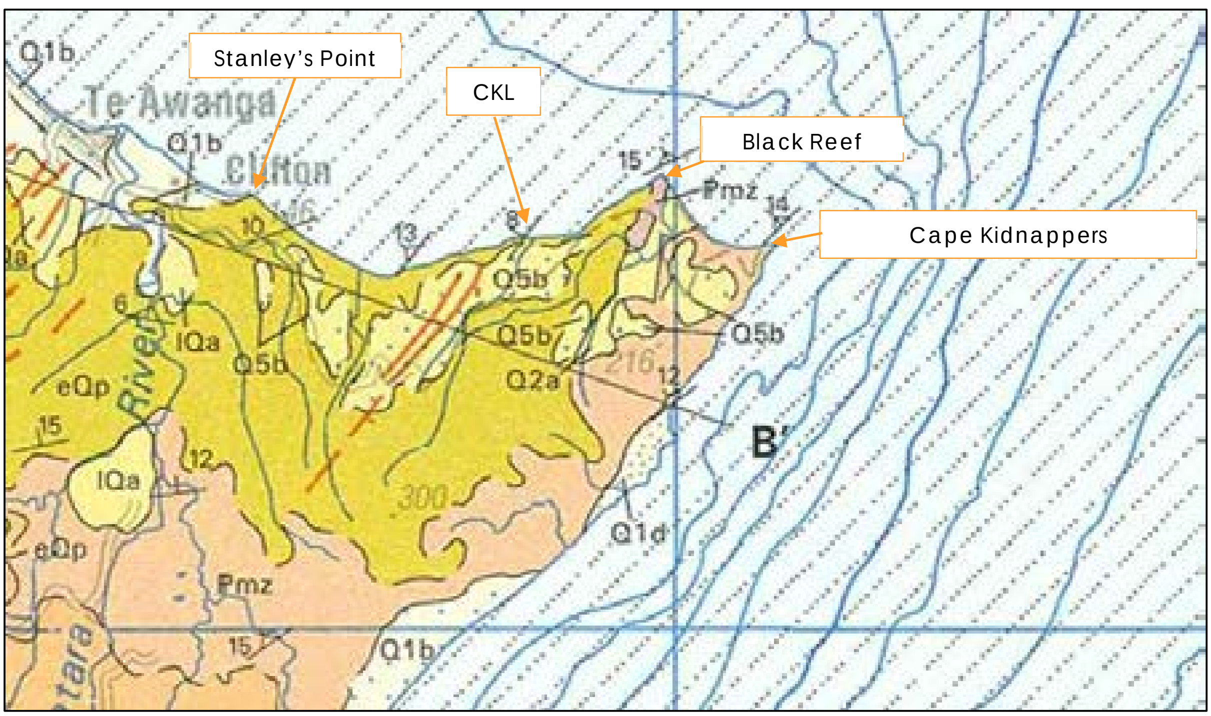


Figure 3-8: Published geological map (Lee et al. 2011)

Further detail on the geology of the site is provided in Beu & Grant-Taylor (1975). An elevation showing the geology of the cliffs between Black Reef and Stanley's Point is presented as Figure 3-9. The cliff-forming materials are shown to get geologically older from Clifton to Black Reef. Bedding is shown to be flatter at Black Reef, steepening towards Stanley's Point. Several faults are shown on the elevation, largely west of Bluff Point.

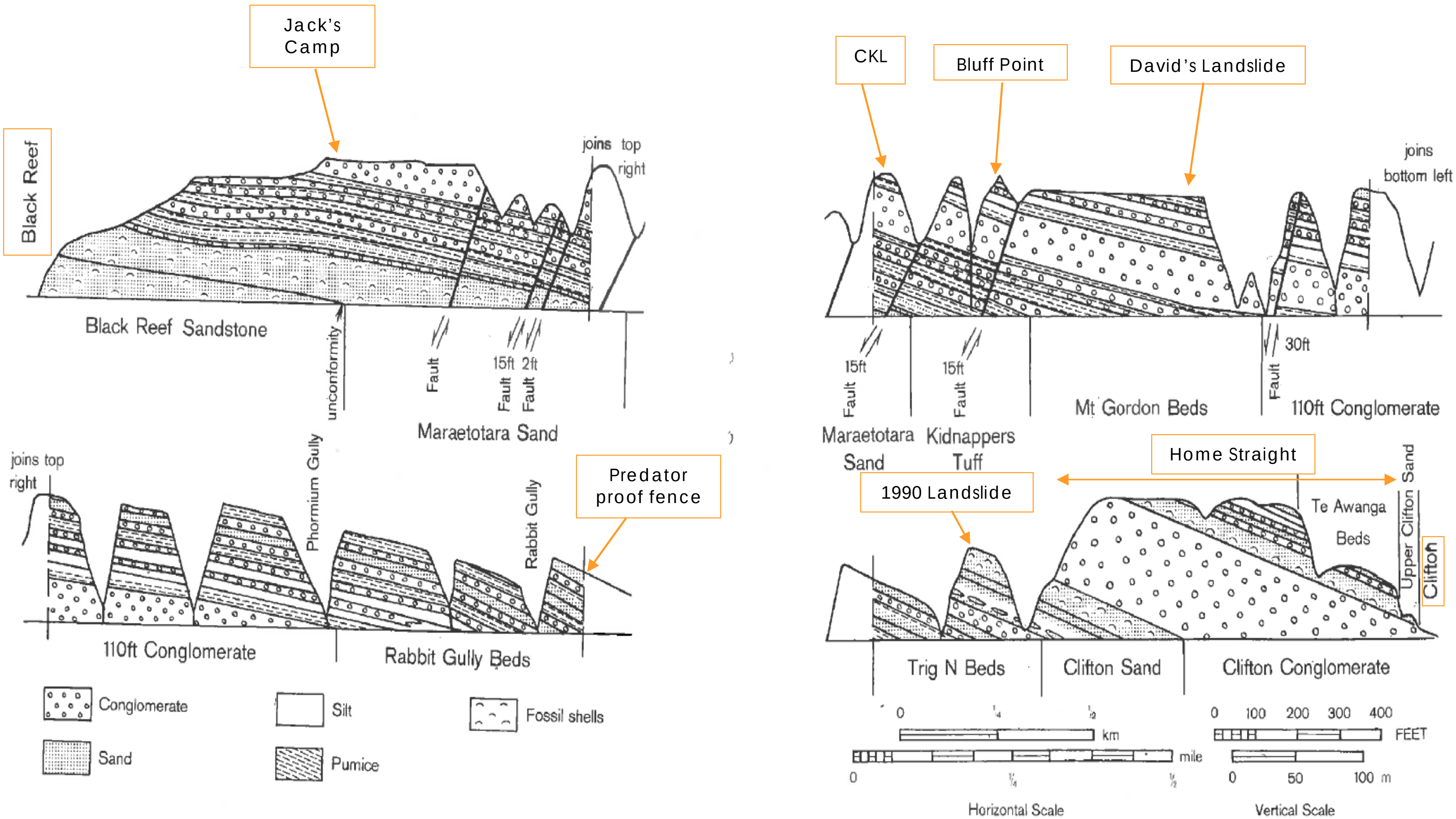


Figure 3-9: Geology of the cliffs between Black Reef and Stanley's Point (from Beu & Grant-Taylor (1975))

Although not shown on the published geological map, modern beach deposits are present at the base of the cliffs. Alluvium is also present within and adjacent to the main creeks.

Debris from previous landsliding is present on the beach and over lower cliff areas (Figure 3-10).

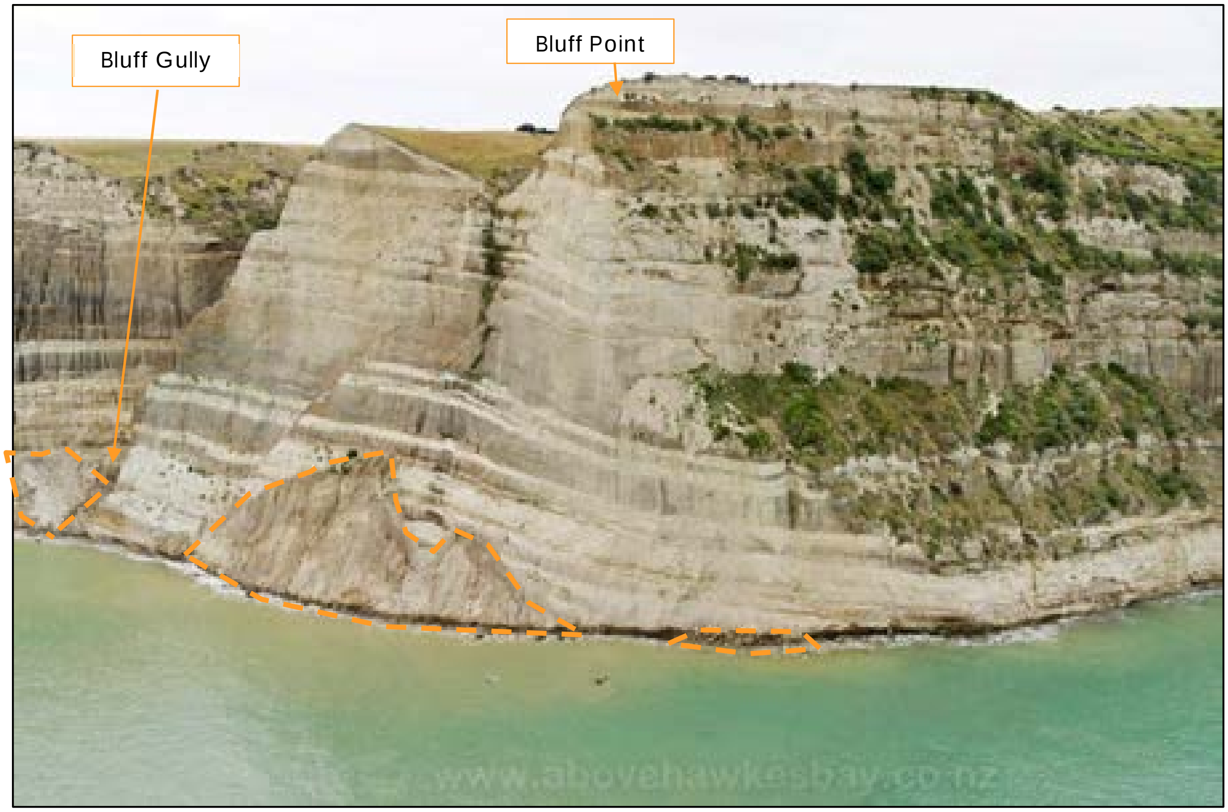


Figure 3-10: Sector 6 - example of historic rockfall deposits from previous landsliding at Bluff Point

3.3 Geotechnical

There is no existing information available to geotechnically characterise cliff-forming materials.

In summary, the cliff-forming materials can be summarised as being interbedded 'soft rocks' and except for bedding, relatively 'massive' and free from rock defects such as joints. This means that their behaviour will be controlled largely by the intact strength of the material, as opposed to the strength of joints in the rock, which typically controls the behaviour (and stability) of 'hard rocks'. This was shown by the CKL, where failure appeared to occur largely through intact material.

Bedding is typically not important for the stability of the cliffs, as it does not dip out of the slope. There are some instances where bedding is important for the stability of the cliffs, where it appears to form the surface of rupture for large, deep-seated, translational slides. These landslides are less important for the hazard assessment, for the reasons discussed later.

Locally, there is evidence that rock mass defects are important and kinematically feasible failure mechanisms exist.

3.4 Physiographic

As the site comprises 9.5 km of coastline, the physiographic characteristics vary throughout the site. Understanding these changes is important for the hazard assessment For this report, we have divided the site into several 'domains' of similar physiographic characteristics, as shown in Figure 3-11.

The domains can be summarised as follows:

- Domain A:
  - CH 0 (Stanley's Point) to CH1700.
  - Comprised of the geologically youngest materials.
  - Strike broadly NW-SE.
  - Subvertical cliffs, up to around 15 0 m high. Mostly continuous cliff face.
  - Free from vegetation, with much evidence for historic landsliding.
  - A small beach or backshore is present in this location. The beach is steep, which means there is a limited foreshore.
  - No significant reefs present in the nearshore.
- Domain B:
  - CH 1700 to CH2500.
  - Strike broadly WNW-ESE.
  - Subvertical cliffs, up to around 70 m high, so lower height. The cliff face is discontinuous, being broken by several deeply incised creeks such as those at Rabbit Gully and Goat Gully.
  - Cliffs are generally free from vegetation, with much evidence for historic landsliding.
  - A small beach or backshore is present in this location. The beach is steep, which means there is a limited foreshore.
  - No significant reefs present in the nearshore.
- Domain C:
  - CH2500 to 5500.
  - Strike broadly ENE-WSW.
  - Subvertical cliffs, up to around 120 m high. The cliff face is largely continuous but is broken by several deeply incised creeks. Many hanging gullies also present.
  - No beach or backshore. A larger foreshore exists at this location.
  - Cliffs are variably vegetated, with much evidence for historic landsliding.
  - Reefs typically present in the nearshore, although some exceptions such as near the CKL location.
- Domain D:
  - CH5500 to 7100.
  - Strike broadly NE-SW.
  - Cliffs, up to around 120 m high, decreasing in height towards the east (Black Reef). The cliff face is largely continuous, with only hanging gullies present. The lower part of the cliff is formed from geologically older materials.
  - Slope angles are typically 60° to 75°.
  - Cliffs are typically vegetated, with some evidence for historic landsliding.
  - No beach or backshore. A larger foreshore exists at this location.

  - Significant reefs present at this location.
- Domain E:
  - CH7100 to 8200.
  - Strike NW-SE.
  - Significant beach or backshore.
  - Slope heights up to around 100 m, but slope angles typically around 45°. Vegetated. Slopes are continuous, being broken by one creek.
  - Significant reefs present at this location.
- Domain F:
  - CH8200 to 10000.
  - Variable strike.
  - Slopes from around 40 m in height up to around 100 m, variable angles. Continuous cliffs.
  - Slopes typically free from vegetation.
  - Reefs typically present in the nearshore, although there are some exceptions.

As detailed above, several surface water features dissect the site. The surface water features can be broadly divided into those with larger catchments, which have incised down to sea level at the coast. Examples include Rabbit Gully, Goat Gully, Bluff Gully and Black Reef Gully. They have catchments of up to around 15 km^2 and appear to show some flow year-round. These surface water features may be subject to debris flow hazard (refer Section 4).

Smaller surface water features are not as deeply incised and appear to be ephemeral and meet the coast as hanging gullies. When flowing, they appear as waterfalls on the cliffs. They have smaller catchments and are therefore not as deeply incised.

Some key comments about the physiography of the site and its importance for the QRA:

- The cliffs are typically high and largely continuous throughout the site, providing large potential source areas for landsliding.
- As the cliffs are typically very steep and the beach access is at the toe of the cliff, there is a limited travel distance for landsliding.
- The reefs are important for understanding the rate of erosion (and therefore landsliding). Sections of the cliffs which are free from vegetation and show evidence for historical landsliding, commonly have no nearshore reefs. The opposite of this also appears true.
- Sections of the cliffs where there is a distinct backshore or beach are not exposed to costal erosion as much as those where there is no backshore or beach.
- Swells from the N or NE are likely those most important for coastal erosion.

Figure 3-11: Physiographic 'domains' of the site

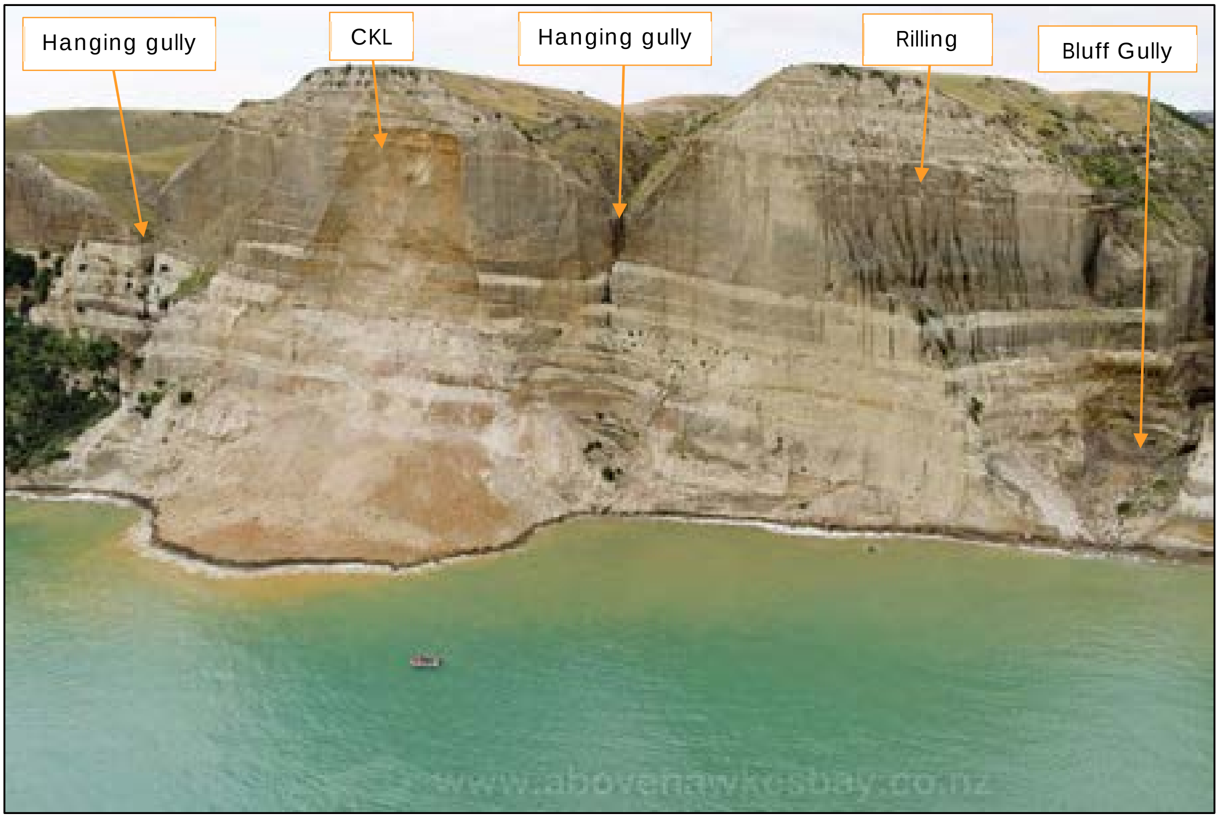


Figure 3-12: Sector 6 - example of surface water features

3.5 Other

The following subsections briefly discuss the setting of the site, relative to other factors likely important for this hazard assessment. Specifically, factors that may 'trigger' or 'cause' landsliding. Further information on landslide triggers and causes is provided later in this report.

3.5.1 Seismic

Relative to most other parts of New Zealand, the site would be described as being of higher relative seismic hazard. Calculated horizontal Peak Ground Accelerations' (PGA's) for various return periods are shown in Table 3-1, assuming Site Class B (rock), as per the NZTA Bridge Manual (2018, magnitude unweighted). Topographic amplification will be significant, considering the height and slope angle of the cliff. GNS (2014) observed amplification factors of 2.5 for horizontal motions and 3 for vertical motions in the Port Hills, Christchurch.

It is noted that these seismic hazard values are time independent. They do not make consideration if movement along a fault is 'overdue'. Yet this is important for understanding risk.

Table 3-1: Unweighted peak ground accelerations for various return periods

Unweighted PGA's – Site Class B					
Site	Return period (years)				
	25	100	500	1,000	2,500
Hastings	0.08	0.15	0.31	0.40	0.55
Associated Mw	6.0	6.25	6.5	6.75	7.0

Significant landsliding would be expected from the cliffs under higher return periods (above say a 500 AEP). There is limited information available to reliably assess the past performance of the cliffs under earthquake loading. Anecdotally:

- 1931 Hawkes Bay (Napier) Earthquake – M7.8, no records pertaining to landslides available. MM8 to MM9 shaking was estimated at Clifton and Cape Kidnappers which should have been sufficiently strong to generate landsliding (Dowrick 1998). It is not unsurprising landsliding was not referenced at the time, as no infrastructure would have been impacted and significant loss of life and damage occurred in Hawke's Bay.
- 1904 Cape Turnagain Earthquake – M7.0 to M7, thought to have generated MM7 shaking at Clifton and Cape Kidnappers (Downes 2006). Downes notes:
  - 'However, most landslides seem to have been small, except those from the coastal cliffs from Clifton to Cape Kidnappers'.
  - 'A more probable source of a tsunami at Mohaka would be the large earthquake-induced coastal landslides from the cliffs at Cape Kidnappers'.
- Anecdotally, it is understood some localised landsliding has occurred in the last few years under 'moderate' to 'strong' shaking.

The cliff-forming materials are not judged as susceptible to liquefaction and associated effects.

An active fault is mapped 500 m west of the CKL location. No information is presented for this fault in the database, such as its last activity or Recurrence Interval.

3.5.2 Climate

Relative to most other parts of New Zealand, the site would be described as being of lower relative rainfall. Figure 3-13 shows the median annual total rainfall to be between 700 and 800 mm for the site. Rainfall is likely a key trigger of landsliding at the site. Significant landsliding occurred at the site due to the April 2011 rainfall event.

The median annual average wind speeds for the site are between 3 to 4 m/s (approximately 11 to 14 km/hr). Wind may be a trigger for very small landslides, due to the dislodgement of small rocks.

Temperature changes on the cliff face may be important, with the cliff aspect being generally northerly and receiving all day sun. The cliff-forming materials may be subject to loss of strength upon warming/cooling, with similar effects due to wetting/drying. Freeze-thaw is unlikely to be important.

Climate change is an important consideration.

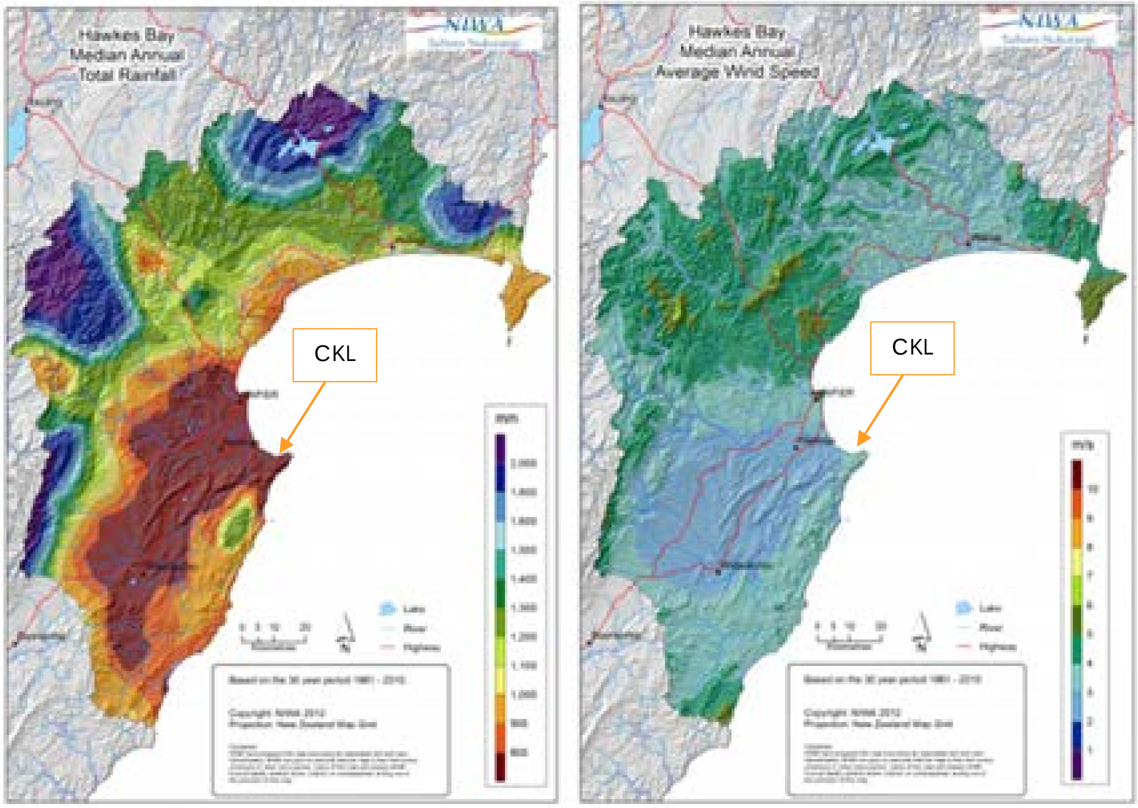


Figure 3-13: Key climate information (from NIWA)

3.5.3 Coastal Processes

Understanding coastal erosion is likely critical for the stability of the cliffs. The controlling geomorphic process for landsliding appears to be coastal erosion at the toe of the slope (Figure 3-14), over-steepening it, leading to retrogressive instability as the slope looks to form a stable slope[6].

Coastal processes are also important for understanding historical landsliding at the site. This is as landslide debris on the foreshore will be impacted by coastal erosion (so not identified or its characteristics not reliably identified).

It is understood there has been no previous study at the site assessing coastal processes and specifically, rates of coastal erosion.

The direction of sediment transport (littoral or longshore drift) at the site is to the west and then north. Sediment size decreases with the littoral drift. Erosion from 'Cape Kidnappers' has been calculated by others previously to provide an estimated sediment volume of 18,000m^3/year (T&T 2016) to the sediment budget. This is presumably an averaged value for the entire stretch of coastline from Cape Kidnappers to Clifton.

The fetch length, the distance over which the wind can blow over the surface of the sea, from northerly and north-easterly winds is 50 km and 65 km respectively.

Wave refraction due to Black Reef will be important for wave characteristics. Increasing sea level and intensity of storms (and associated wave heights) are important considerations in the future for coastal erosion.

[6] This process was observed at the CKL location in the days and years previous to Jan 2019.

Figure 3-14: Sector 5 - an example of recent landsliding triggered by erosion at the toe of the slope

3.5.4 Other

Sheet and rill erosion have occurred to the cliff faces and provide a useful indication of the relative ages of the cliffs (Figure 3-12). Human influence on slopes is a common trigger or cause of landsliding. This is not a key consideration for most of the site. Locally, there are some locations where this is important, however (Figure 3-15).

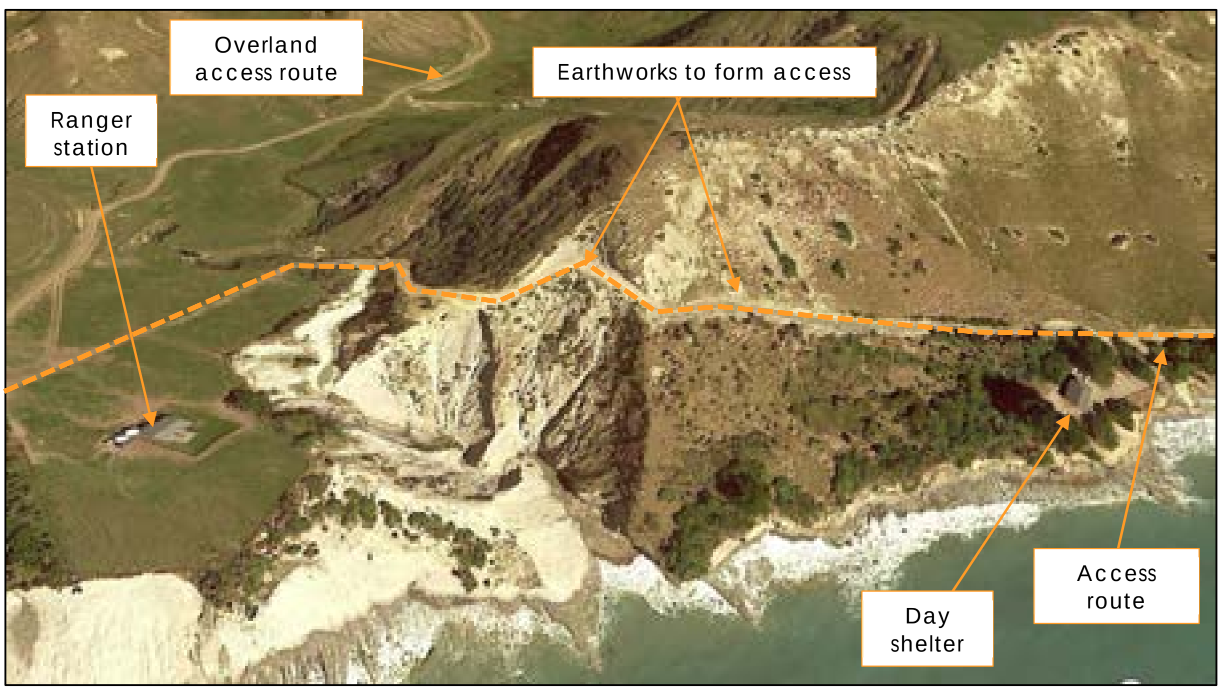


Figure 3-15: Sector 9 - An example of where human influence on slopes may be important for future landsliding

4. Landslide Characteristics

The following subsections summarise the key characteristics of landslides at the site. Reference is made to Appendix A for a landslide glossary and Appendix B for background information to landslides.

4.1 Introduction

A 'landslide' is defined as 'the movement of a mass of rock soil down a slope under the effects of gravity'. A basic introduction to landslide characteristics is provided below, as it is important for understanding landslide hazards and the associated risk. Reference is made to Appendix B for further information. Landslide definitions used in this report are as presented by Cruden & Varnes (1996). This is the most widely used landslide classification in general practice.

Landslides are classified as per the movement type (failure mechanism) and the characteristics of the pre-failure material, as shown in the simplified figure below (Figure 4-1). Their rate of movement is also described as part of their classification, as shown in Figure 4-2 and Figure 4-3. Their rate of movement is important for understanding the associated risk.

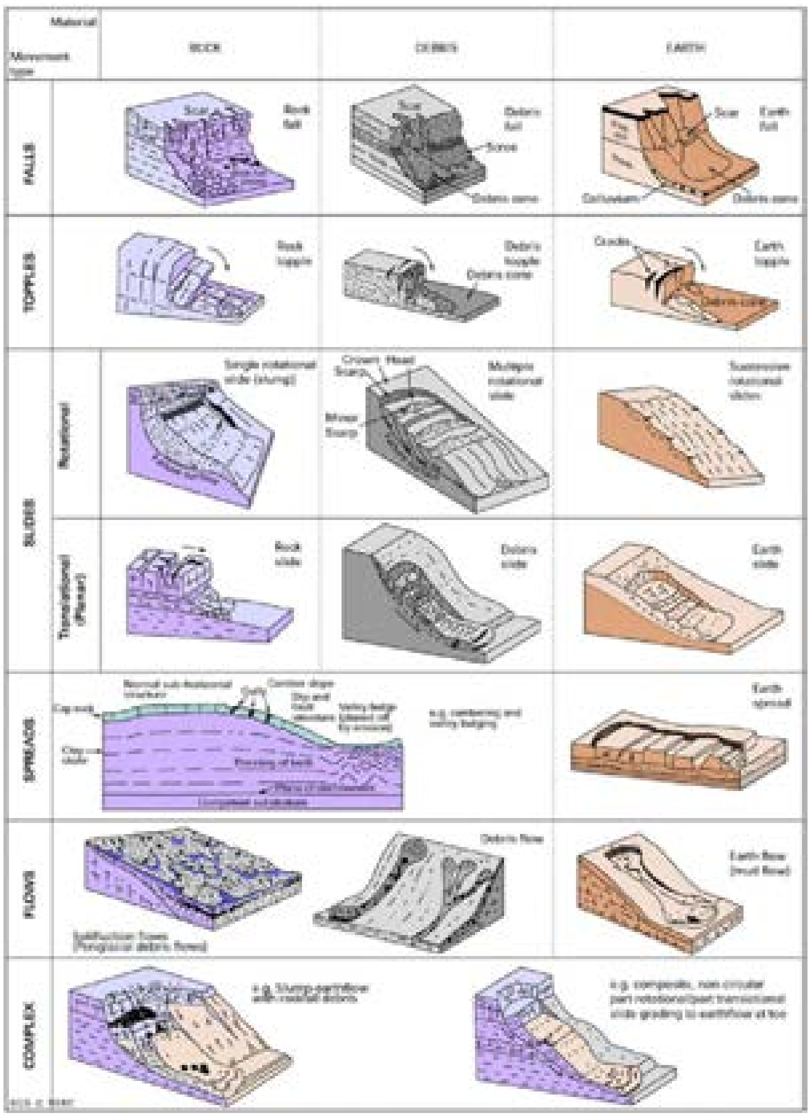


Figure 4-1: Landslide classification (from Cruden & Varnes 1996)

Velocity Class	Description	Velocity (mm/sec)	Typical Velocity	Probable Destructive Significance
7	Extremely Rapid			Catastrophe of major violence; buildings destroyed by impact of displaced material; many deaths; escape unlikely
		5×10^3	5 m/sec	
6	Very Rapid			Some lives lost; velocity too great to permit all persons to escape
		5×10^1	3 m/min	
5	Rapid			Escape evacuation possible; structures; possessions, and equipment destroyed
		5×10^{-1}	1.8 m/hr	
4	Moderate			Some temporary and insensitive structures can be temporarily maintained
		5×10^{-3}	13 m/month	
3	Slow			Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
		5×10^{-5}	1.6 m/year	
2	Very Slow			Some permanent structures undamaged by movement
		5×10^{-7}	15 mm/year	
1	Extremely SLOW			Imperceptible without instruments; construction POSSIBLE WITH PRECAUTIONS

Figure 4-2: Landslide velocities (from Cruden & Varnes 1996)

Activity

State	Distribution	Style
Active	Advancing	Complex
Reactivated	Retrogressive	Composite
Suspended	Widening	Multiple
Inactive	Enlarging	Successive
Dormant	Confined	Single
Abandoned	Diminishing	
Stabilised	Moving	
Relict		

Figure 4-3: Other landslide descriptive terms (from Cruden & Varnes 1996)

To avoid ambiguity:

- 'Rock' is defined as 'a hard or firm mass that was intact in its natural place before the initiation of movement'.
- 'Soil' is defined as 'an aggregate of solid particles, generally of minerals or rocks, that either was transported or was formed by the weathering of rock in place. Gases or liquids filling the pores of the soil form part of the soil'. 'Soil' can be divided into:
  - 'Earth', where '80% or more of the soil particles are less than 2 mm, the upper limit of sand-sized particles'.
  - 'Debris', where '20% to 80% of the particles are larger than 2 mm, and the remainder are less than 2 mm'.

4.2 Landslide Magnitude and Frequency

The magnitude (or volume) of the landslide is important in understanding risk. This is as the magnitude of the landslide will be one control over the location to which it travels and lands (i.e. spatially impacts). That is, which part of the 'beach' will be impacted. It is also important for the vulnerability of the beach users in the event of being struck by a landslide.

For this assessment, landslides have been qualitatively differentiated in magnitude as:

- **Very small** - <10 m^3. Likely to spatially impact the very base of the cliffs only. Likely to spatially impact up to a few metres along the beach (width). May cause injury/fatality to an individual.

- **Small** – 10 m^3 to 100 m^3. Likely to spatially impact the very base of the cliffs only. Likely to spatially impact up to a few metres along the beach (width). May cause injury/fatality to an individual.
- **Moderate** – 100 m^3 to 1,000 m^3. Likely to spatially impact the upper part of the beach. Likely to spatially impact from a few metres to tens of metres along the beach (width). May cause injury/fatality to an individual or up to a small-sized group.
- **Large** – 1,000 m^3 to 10,000 m^3. Likely to spatially impact the entire beach. Likely to spatially impact many tens of metres along the beach (width). May cause injury/fatality to an individual or up to a moderate-sized group.
- **Very large** – greater than 10,000 m^3. Likely to spatially impact the entire beach. Likely to spatially impact from many tens of metres up to a couple of hundred metres along the beach (width). May cause injury/fatality to an individual or up to a large-sized group.

The frequency of landsliding typically increases with decreasing magnitude or volume. 'Small' landslides are the most likely to occur and very large landslides are the least likely to occur. Landslide magnitude/frequency relationships have not been previously developed for the site and are not currently reliably known.

As context to the above, the 23 January 2019 CKL had a source area volume of around 25,000 m^3. The deposit was 125 m wide along the beach and extended up to 75 m from the base of the cliff into the nearshore (does not include boulder roll and fly-rock).

Based upon slope height and likely failure mechanisms, It is expected a maximum credible landslide volume of around 100,000 m^3 likely exists. This is consistent with evidence from historical landsliding at the site.

4.3 Triggers

A landslide 'trigger' is commonly defined as a single event that initiated the movement, typically an external stimulus, which causes an immediate or near-immediate response. As no previous investigations have been completed, landslide triggers at Clifton Beach are not well known. Key triggers of landsliding along Clifton Beach are likely to be:

- Sea erosion
- Earthquake shaking
- Rainfall (more likely for very small to moderate-sized landslides)
- Wind (more likely for very small to small landslides).

4.4 Causes

Landslide 'causes' are considered as factors that make a slope vulnerable to failure (i.e. predisposed). There can be one or several causes. The causes can either be internal to the landslide or external factors. They are typically divided into four key categories:

- Geological – such as low strength materials, presence of weaker layers, kinematically feasible failure mechanisms due to unfavourable geological structures, materials which lose strength on exposure, etc
- Hydrogeological – such as groundwater levels and pressures
- Geomorphological – such as erosion and weathering
- Anthropogenic (i.e. human activities) – such as slope modification or deforestation.

One of the primary 'causes' of landsliding is expected to be coastal erosion at the toe of the cliffs, as mentioned previously.

The landslide causes along Clifton Beach are not reliably known. Changes in temperature and moisture content are likely important. Some of the cliff forming materials appear to lose strength on exposure (i.e., slaking). Rock mass defects also appear to be locally important, providing kinematically feasible failures.

Anecdotally, GBA advise than many large to very large landslides have occurred during summer. This is suggestive that changes in temperature and moisture content, together with their associated effects, are a key cause of landsliding. Short to medium term changes in climatic conditions could be important for landsliding and the associated risk.

4.5 Landslide Bulking Factors

The displaced mass of the landslide can be a different volume compared to the undisplaced mass from which it comes. The monitoring of the CKL has shown a bulking factor between 1.1 and 1.3 from source area volume to deposit volume. This needs to be considered in assessing risk.

In addition to volume, bulking can also be considered with the width of the rockfall deposit relative to the width of the source area. For the CKL, the ratio of the source area width to rockfall deposit width was around 1.7.

4.6 Key Failure Mechanisms

4.6.1 Falls and Topples

The main landslide hazard along Clifton Beach appears to be from 'falls' and 'topples'. The displaced material is 'rock'. A rockfall is typically defined as (from MBIE 2016):

- A very rapid to extremely rapid slope movement in which material is detached from a steep slope and descends by falling, bouncing, rolling or sliding
- It typically relates to the fall of individual or several rock blocks, where there is little interaction between the individual blocks. It is a continuum however, and can include falls of many thousands of blocks
- It can involve gravel-size particles up to large rock masses.

A rock topple is like a rock fall, except that forward rotation occurs around an axis, at or near the base of the source area. For this assessment, falls and topples have been grouped together under the term 'rockfall'.

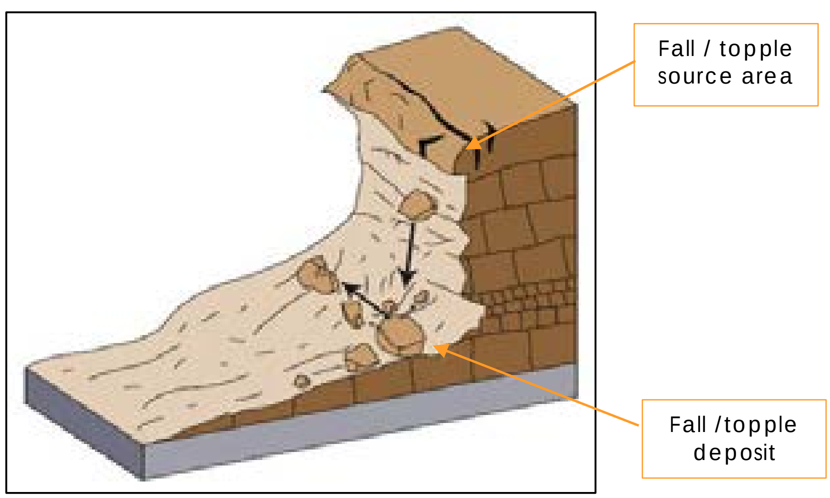


Figure 4-4: Schematic of a fall and topple – with key terms used in this report

The type of movement of a rockfall from its source area will be dependent on the location-specific characteristics of the cliff. The typical movement types of 'small' to 'moderate' rockfalls are shown in Figure 4-5 (sliding is not shown but can also occur). Considering the typical cliff angles, falling and bouncing are judged as the most likely movement types down the slope.

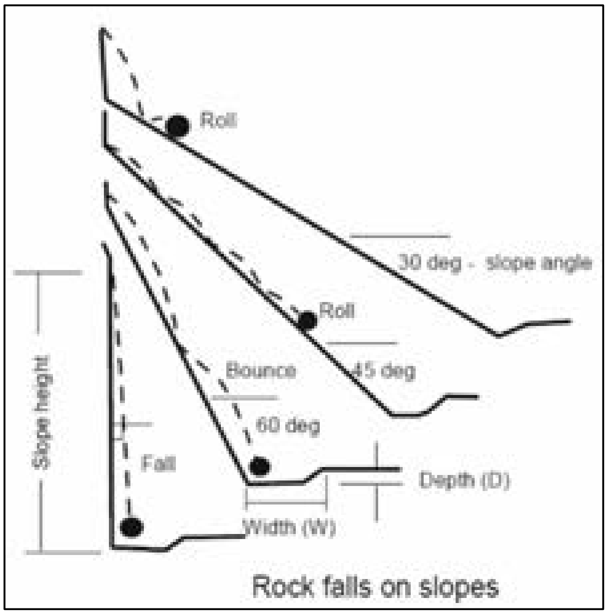


Figure 4-5: Rockfall movement types down a slope (sliding not shown)

Key comments about small to moderate-sized rockfalls:

- They commonly occur with little or no warning.
- They are very rapid to extremely rapid, meaning evacuation may not be possible.
- Based upon the cliff shape, rockfalls have a short runout distance to the area they spatially impact. Because of the cliff shape and as they are falling or bouncing, understanding their trajectory is relatively straightforward compared to some sites.
- People being struck by rockfall in the open typically have a very high vulnerability.
- Rockfalls from steep cliffs can be difficult to identify from aerial imagery and other survey methods such as LiDAR (i.e. top-down).
- Evidence can be easily removed by erosion or missed for other factors (such as vegetation, removal).
- Repeat rockfalls at the same location can be difficult to distinguish, yet this is critical for understanding risk.
- They are less likely to be reported (or remembered) than larger volume landslides as they are commonly of lower consequence. They wouldn't block beach access for example.
- They usually occur at a higher frequency than other landslide mechanisms.
- They likely have more potential triggers than some other landslide mechanisms. For example, small rockfalls can be triggered by wind, root jacking by vegetation, wetting/drying, cooling/heating, etc. in addition to the triggers for larger landslides.

An example of a small and a moderate-sized rockfall is provided in Figure 4-6. A small rockfall spatially impacted the middle of the beach and this originated from high on the cliff. Behind this, a moderate-sized rockfall can be seen immediately against the base of the cliff, with the source area readily apparent above it.

Figure 4-6: Sector 6 - example of rockfall deposits on the beach, west of the CKL

It is expected that 'large' to 'very large' rockfalls will behave differently due to the interaction of the many blocks. The CKL of the 23 January 2019 was at the upper end of the rockfall magnitude 'continuum' for example (refer Figure 3-12). Similar failures as a result of the 2011 Christchurch Earthquake were commonly referred to as 'cliff collapse' and are termed 'rock avalanches' elsewhere in New Zealand and overseas. These larger rockfalls may show other mechanisms of movement on impacting the beach, such as a flow. This appears to have been indicated by the failure imagery of the CKL. There are many examples along the beach of deposits from historic rock avalanches.

Key comments about the risk posed by large to very large rockfalls (rock avalanches):

- They are more likely to have precursory instability than small to moderate rockfalls, but typically show less indications of movement than some other mechanisms.
- They are very rapid to extremely rapid, meaning evacuation may not be possible.
- Based upon the cliff shape, they have a short runout distance to the area they spatially impact. Because of the cliff shape, understanding their trajectory is relatively straightforward compared to some sites.
- People being struck directly by a rockfall typically have a very high vulnerability.
- They are easier to distinguish from aerial imagery and LiDAR, due to their size.
- Evidence is less easily removed and more likely to be preserved.
- They are likely to be reported (or remembered) as they are commonly of higher consequence, such as impeding or blocking access to the beach.
- They can occur as a series of events over a short period but this cannot always be identified. This was demonstrated by the CKL, with monitoring showing several phases of landsliding over several weeks. Yet, without this knowledge and based upon inspection of the rockfall deposit alone, it would likely be interpreted as a single landsliding event.
- They usually occur at a lower frequency than smaller volume landslide mechanisms.

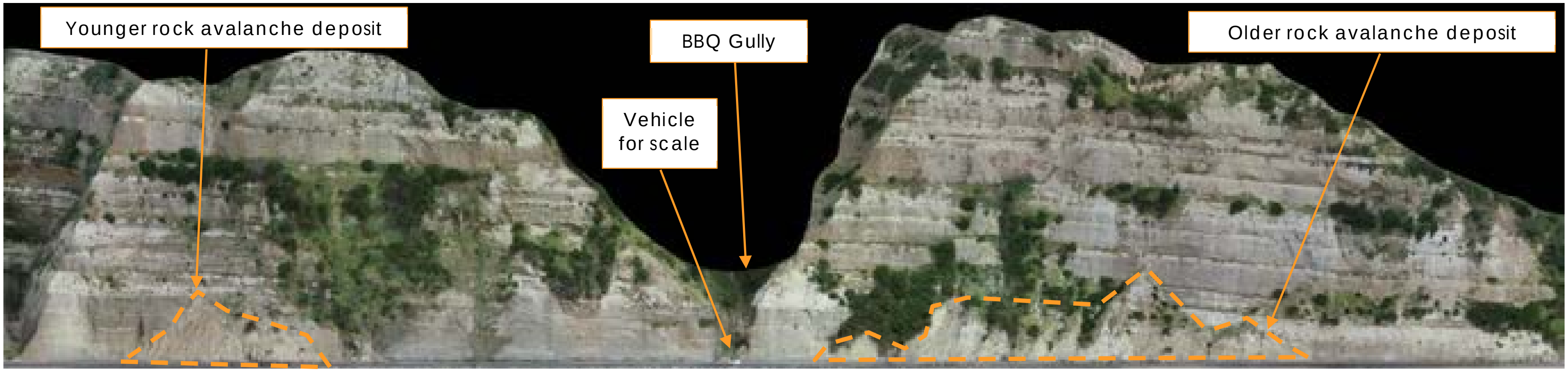


Figure 4-7: Sector 5 - Examples of rock avalanche deposits

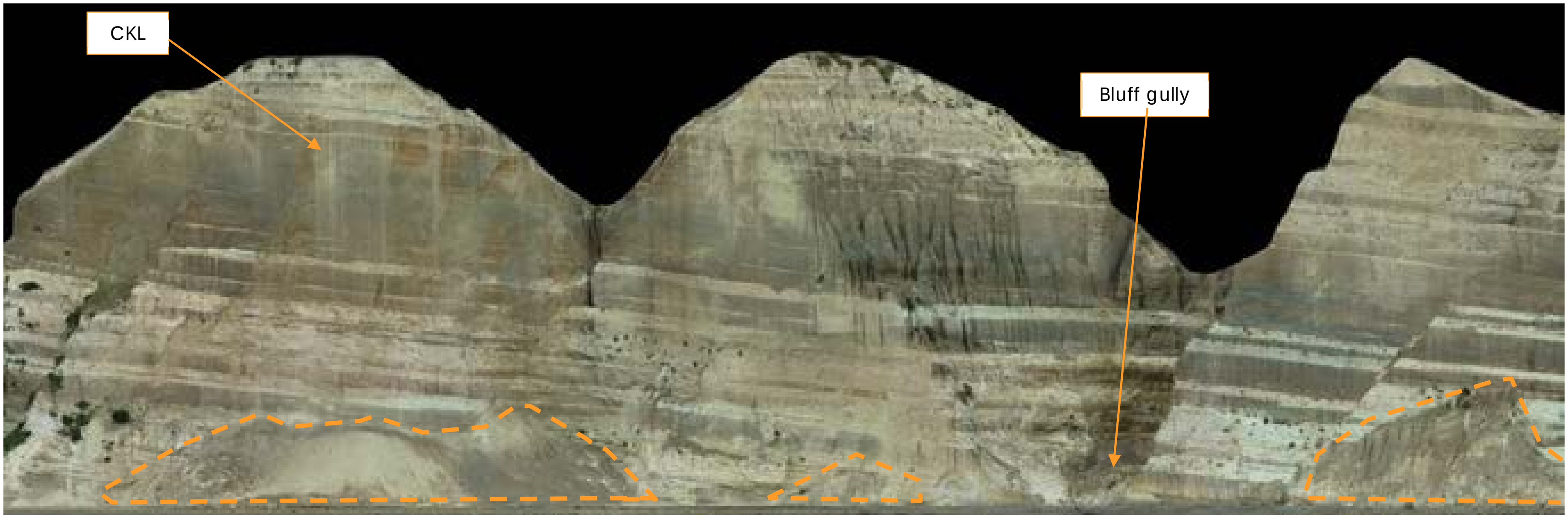


Figure 4-8: Sector 6 - examples of rock avalanche deposits

4.6.2 Slides

The second most prevalent landslide failure mechanism along Clifton Beach appears to be 'slides'. A good example is the Clifton Motor Camp Landslide, located at Stanley's Point (Figure 4-9). This comprises a translational rockslide, with the surface of rupture occurring on bedding (i.e. a dipslope landslide). The landslide appears to have an area of around 0.3 km^2, with a failure surface around 20 m below ground level. It has a volume of around 7 MCM. The landslide is likely many thousands or tens of thousands of years old and extremely slowly moving. It is of limited importance for the hazard assessment for this reason.

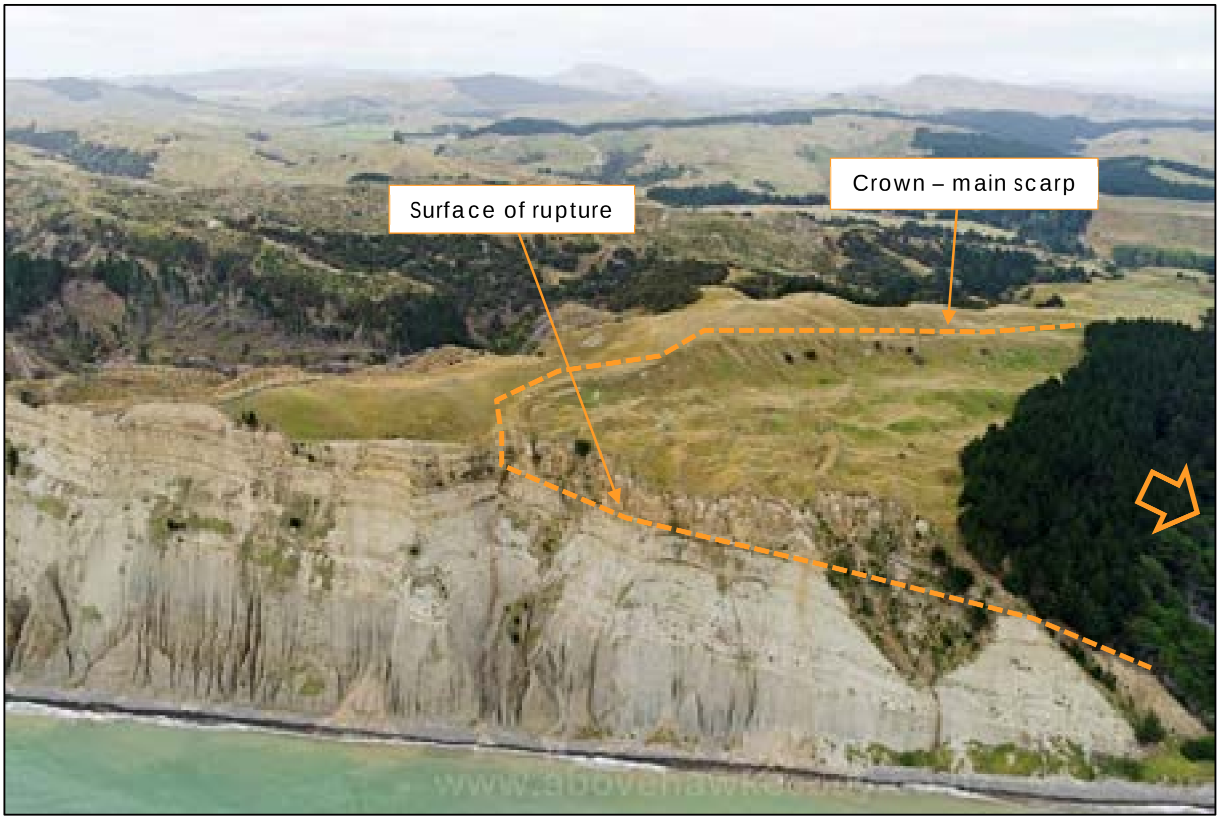


Figure 4-9: Sector 1 - A large deep-seated landslide, where the surface of rupture appears to be along bedding

In addition to the above, slides also appear to occur in existing landslide debris (i.e. its remobilisation). A good example of this is the 1990 Landslide. The landslide debris shows remobilisation following heavy rainfall or coastal erosion. These landslides would be considered 'debris slides'.

Slides also occur in soil and weathered rock. Good examples are those observed at Cape Kidnappers as a result of the April 2011 rainfall event (Figure 4-10). These are shallow translational or rotational slides in soil. Mainly open-slope landslides, they do not appear to have shown significant channelization and transition to debris flows (refer below).[7] It is expected that the access track was impacted by this shallow landsliding (refer to Figure 4-10). They appear to have been of very small to moderate volume typically. Significant shallow landsliding on the cliffs and inland was generated by the 2011 rainfall event. It is possible similar landslides would be generated by earthquake shaking.

The risk posed by slides to beach users is judged less than that of rockfalls as:

- They appear to occur less frequently
- Slides commonly display indications of instability before occurring. This may allow evacuation
- They are typically slower-moving, and so evacuation is more likely possible

[7] Similar landsliding occurred near Clifton Motor Camp

- Beach user vulnerability in the event of being impacted by a slide is typically lower than rockfalls.

For these reasons, they have not been considered in detail as part of the QRA.

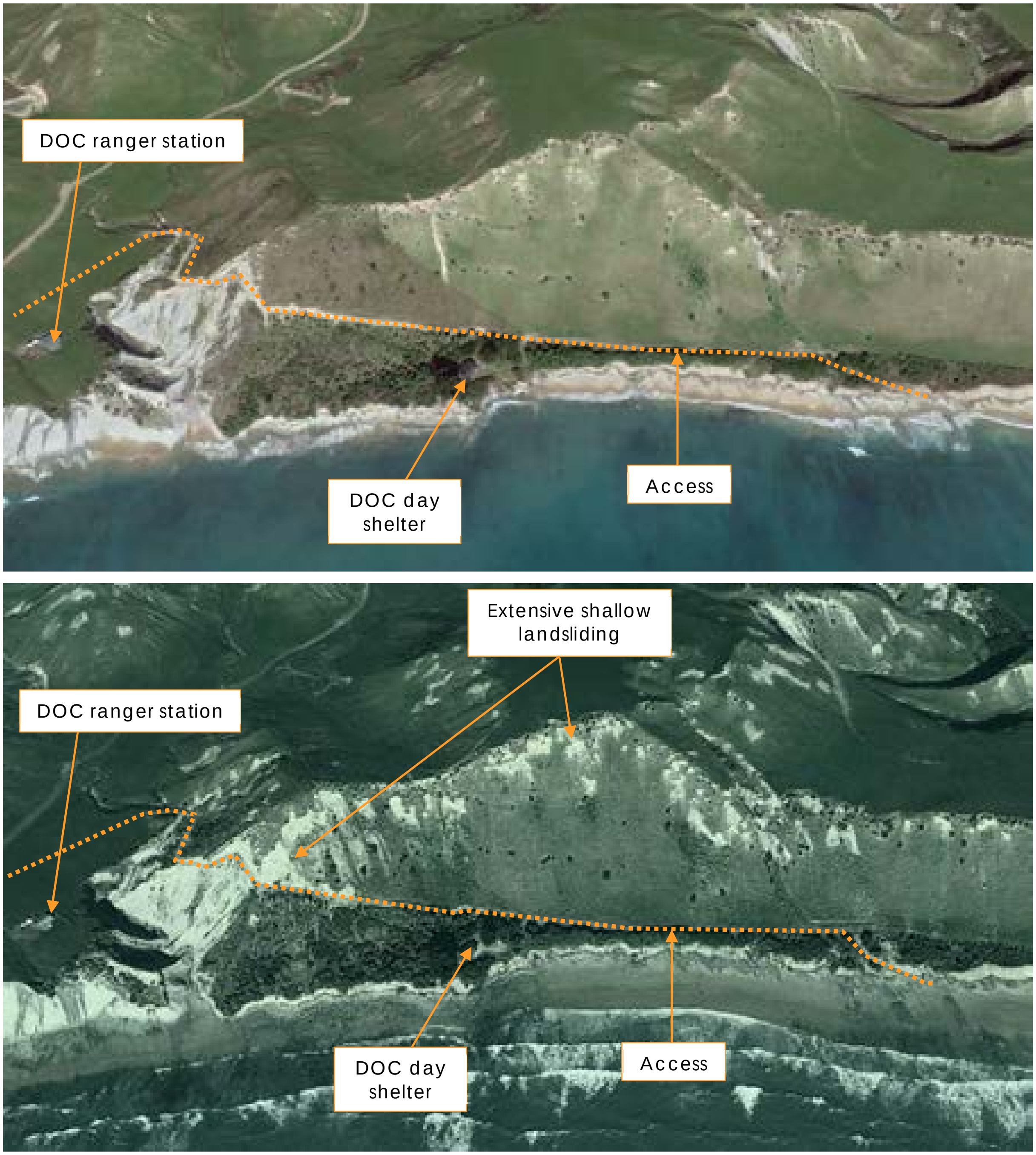


Figure 4-10: Sector 9 - Imagery from 2009 (top) and 2012 (bottom) – showing the landsliding generated from the 2011 rainfall event

4.6.3 Flows

Debris flows occur due to significant rainfall and are very rapid to extremely rapid. They originate from open-slope landslides entering channels/creeks, or due to the remobilisation of creek bed materials. The smaller gullies at the site likely have insufficient catchment area to consistently generate debris flows. Anecdotally, and based upon visual inspection observations, channelized debris flows appear to occur in the larger gullies at the site. The gullies include Rabbit Gully, Goat Gully, Flax Gully, BBQ Gully, Bluff Gully and Black Reef Gully. Debris flows may also occur at Cape Kidnappers, although no notable debris flows appear to have occurred in 2011. It is possible a debris flow may have occurred near to the access with the beach (Figure 4-11).

Figure 4-11: Sector 9 - Imagery from 2009 (top) and 2012 (bottom) – possible debris flows due to the 2011 rainfall event

The risk posed by debris flows is judged much less than by rockfalls as:

- They appear to occur less frequently
- The hazard area is much smaller, being confined generally to gullies only
- Debris flows can often be heard and evacuation may be possible
- They are most likely to occur during or immediately following very heavy rainfall, when beach users are unlikely to be on the beach.

For these reasons, they have not been considered in detail as part of this hazard assessment.

5. Probability of Landsliding

The following subsections summarise the information used to assign the probability of landsliding in the risk calculation. The information can be broadly summarised into two groups:

1. **Precedence - historical landsliding**. Those information sources which help us understand what historical landsliding has occurred previously at the site and is largely factual. This precedence helps informs predictions for the future. Key information sources are usually landslide inventories, site observation, review of aerial imagery and anecdotal information.
2. **Prediction - future Landsliding** – those information sources which predict the probability of landsliding in the future. As they are prediction-based, there is uncertainty associated with them. This is important if the rate of assessed historical landsliding is judged not to be a reliable indication of likely future landsliding. Examples would be if key landsliding triggering events have not occurred in the recent history of the effects of climate change.

5.1 Precedence

5.1.1 Anecdotal Information

For this assessment, anecdotal information has been collated on past landslides. Anecdotal records of landslides cover the period of the last 50 years or so. The main sources of anecdotal information have been newspaper articles and records from GBA. Landslides identified from anecdotal sources are presented on Drawings C130 to C133.

Excluding the January 2019 CKL and subsequent landsliding, two previous landslides are reported in the press where people were injured. These articles are presented in Figure 5-1 and

Figure 5-2. These two landslides can be summarised as:

- March 5 1988 – at the CKL location:
  - Two tourists injured, on foot, location on the beach not known.
  - Struck by very large rock avalanche, as it was of sufficient size to block the beach. It appears the rock avalanche had struck the beach and was transitioning to a flow.
  - They both suffered lower-body injuries. They do not appear to have been struck above the waist.
  - Significant precursory rockfalls were observed, including immediately before the main landslide, yet the tourists did not appear to evacuate.
- 1 February 1973 – around 500 m from Stanley's Point (?):
  - One man injured; two men evacuated. Damage to tractors and trailers of GBA. The men appear to have been clearing landslide debris on the beach from recent landslides.
  - One man was struck by a very large rock avalanche, which was sufficient to block the beach and extend into the sea. The man was partially buried. The other two men appear to have evacuated by going into the sea.

There is one instance of a very large landslide being reported in the press which did not cause injury, due to the loss of gannet nesting areas (September 2018). Although not reviewed in detail as part of this hazard assessment, it is understood social media documents many landslides to have occurred over the last 20 years or so also.

Around 20 landslides have been advised by GBA. Hazard maps provided by GBA to help inform this report are presented as Appendix D. GBA advise:

- Very large rockfalls occur on average, around every 5 years
- Large rockfalls occur, on average, several times a year
- Very small to moderate-sized rockfalls happen at a very high frequency
- Many landslides occur with no definitive trigger
- The CKL is one of the largest recent landslides. The 2004 Bluff Point landslide was likely larger, maybe up to 1.5 times the volume.

Rocks sweep pair into sea

Hero dives to rescue

By NORM DAKEN

A Swiss tourist was described as a hero after he dived into the sea near Cape Kidnappers yesterday to rescue two young women with broken legs who had been hit by a cliff-face rockfall.

The women, believed to be tourists from Belgium, both had badly broken legs when 26-year-old Marco Caviola reached them in the surf.

They were subsequently taken from the beach, about half-way between Clifton and Cape Kidnappers, by helicopter to the Hastings hospital.

The women are Pascale Guittic, 21, and Anita Vangaerd, 25, who were described by a hospital spokesman today to be "not so well" in a general ward.

The incident began at about 12.30pm yesterday with several small groups walking out toward the gannet colony in wet weather.

Mr Caviola said he and his 24-year-old girlfriend Sonja Stalder were on the walk and were about 200 metres behind the two young women when he saw "little pieces of the cliff" coming down near the women.

The two women stood still, apparently thinking there was no danger after those pieces finished falling.

"Suddenly a big piece fell down," said Mr Caviola.

He lost sight of the two women when it hit the beach, and a few seconds later he saw them in the surf.

By this time he had been joined by a Dutch couple who had been a short distance further back.

Mr Caviola said he swam out in the sea to get to the two women.

He saw they each had a leg badly broken, the wounds open and bleeding about 10cm above the ankle.

Mr Caviola said he asked the Dutch couple to go back and get help and he, with girlfriend Sonja, continued to help the two injured women out of the water.

Small pieces continued to fall down the cliff-face, he said.

"We tried to get them to a safer place."

Mr Caviola said he feared another large rockfall.

Soon afterward, two tractors came along the beach, the driver using a walkie-talkie to call for a helicopter rescue. By that time the two injured women were lapsing into unconsciousness, said Mr Caviola.

Mr Neil Burden, who operates tractor-and-trailer safari trips along the beach to the gannets, said he always carried the walkie-talkie radios.

"He's a hero," said Mr Burden, describing Mr Caviola's actions of diving into the sea to rescue the two injured women.

"They would otherwise have drowned," he said.

When the two Dutch people met him there was a language problem, until he found a person among the 14 on his trip who could speak German.

Learning of the accident details, Mr Burden said the tourist trip was abandoned and the tractors went to the scene.

He quickly realised that a helicopter was necessary as the only practical way to get the two women treated and transported to hospital.

"If we couldn't get a helicopter we could have put them on our trailers but we did not want to do that," he said.

Ambulance officers and a doctor treated the two women and they were landed in the grounds of the Hastings hospital at 1.40pm.

Mr Burden said that when he returned to his tour party at the Clifton Motor Camp those involved chatted with Mr Caviola and then in a quick fund-raising effort gave him $31 to pass on to the two injured women.

He plans to return at low tide later today to try and find the pack one of the pair lost.

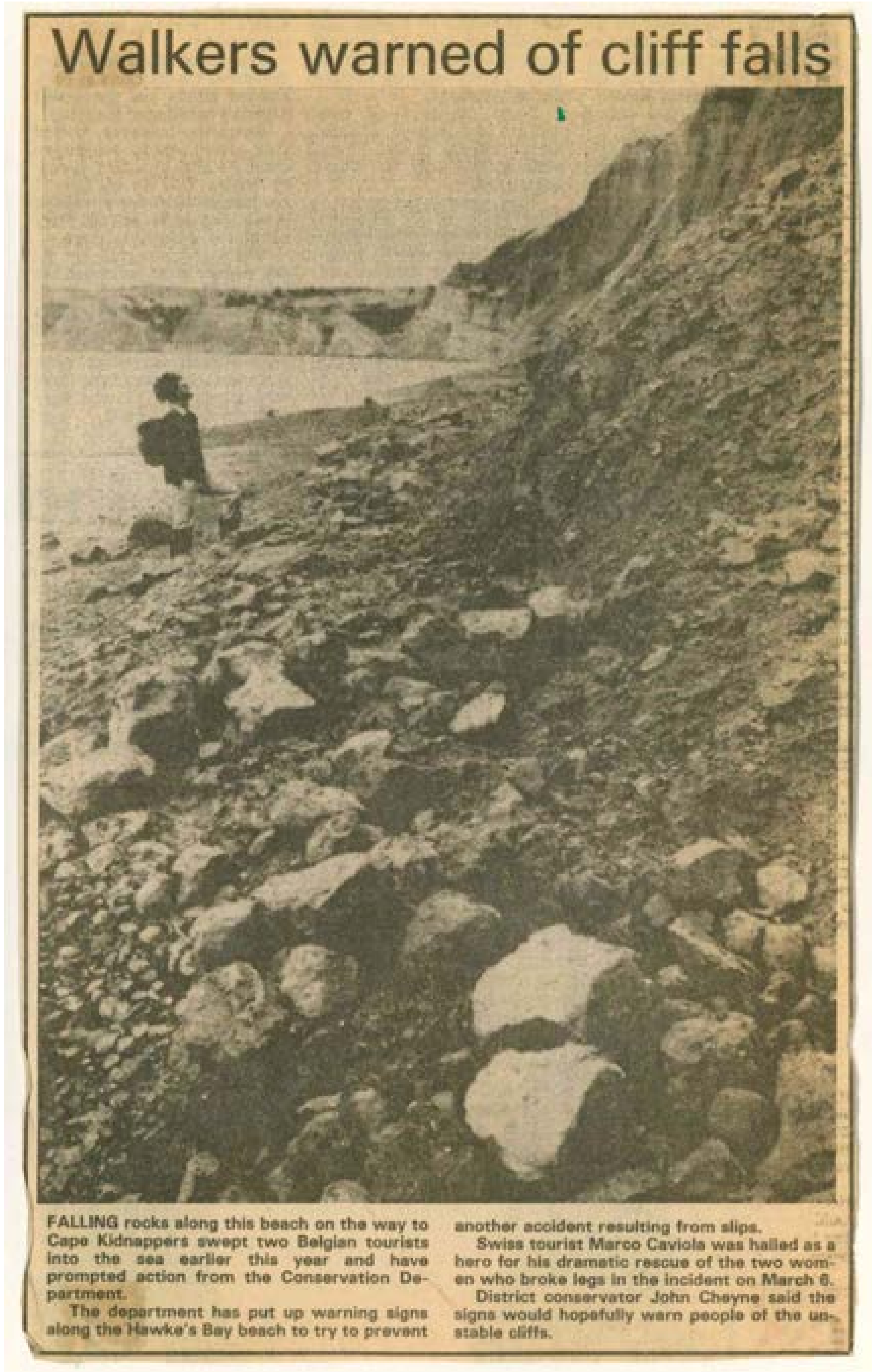
Mr Burden said the cliff-face was unstable and rockfalls were regular events.

• Upgrading of the track and facilities leading to the gannet colony at Cape Kidnappers is due to begin around June and will cost about $18,000, according to the Department of Conservation.

The District Conservator, Mr John Cheyne, said the upgrading is expected to be completed by the next gannet season and will make access to the colony easier and more enjoyable.

The upgrading will include improving the condition of the track and steps, which get slippery in wet weather, and a new footbridge. Safety [illegible] and additional seating will be [illegible] on the steeper parts of the track, Mr Cheyne. The low fence [illegible] surrounds the colony will also be [illegible] proved, he said.

Annual Swiss Army training helped in the dramatic rescue yesterday by Mr Marco Caviola, pictured with his girlfriend Sonja Stalder.



Walkers warned of cliff falls

FALLING rocks along this beach on the way to Cape Kidnappers swept two Belgian tourists into the sea earlier this year and have prompted action from the Conservation Department.

The department has put up warning signs along the Hawke's Bay beach to try to prevent another accident resulting from slips.

Swiss tourist Marco Caviola was hailed as a hero for his dramatic rescue of the two women who broke legs in the incident on March 6.

District conservator John Cheyne said the signs would hopefully warn people of the unstable cliffs.

Figure 5-1: Newspaper articles from 5 March 1988 landslide

Trio dive into sea for safety

Three men swam for their lives when two landslides crashed down on to the beach about half a mile from Clifton yesterday afternoon.

Landslide crushes beach-buggies

Always a danger of slips

Above: Rocks and rubble crash down a cliff face on the beach route to Cape Kidnappers yesterday. Below it was a truck and two beach-buggies which had been taking excursionists to the cape.

Right: When the dust settled the beach was blocked, two [illegible] were crushed and the truck and one tractor were in the sea. So also were three men who dived in and swam away from the crumbling cliff.

Below: The truck was flung for a chain past the tractor as the pressure of falling rock pushed them into the sea.

Figure 5-2: Newspaper article from 1 February 1973 landslide

Key limitations with anecdotal information are:

- Landslides reported in the press are likely to only be those causing injury or obvious consequences.
- GBA is likely only to recall large to very large rockfalls, as these impact their business. These are landslides of enough size to impede or block access along the beach.
- They do not indicate the frequency of very small to moderate-sized landslides.

5.1.2 Historic Aerial Imagery

We have reviewed freely available aerial historic imagery to inform an assessment of past landsliding at the site. The historic imagery can be broadly divided into two main groups:

- Pre-2008 – available on Retro Lens. This imagery is of lower resolution. Imagery is available since 1948, but there are large time gaps and imagery is commonly not available for much of the site. They have not proved useful in identifying landslides pre-2008.
- Post-2008 - available on Google Earth. Generally, of higher resolution and more useful for assessing landsliding at the site. Imagery is available on at least an annual basis since 2012. Imagery is available for all of the site. Due to scale, it is likely large to very large rockfalls can be identified from a review of historic imagery only.

Landslides discernible on aerial imagery post-2008 are shown on Drawings C130 to C133. Key observations are:

- Around 30 large to very large landslides appear to have occurred since 2008. This equates to around 1.5 a year on average
- Around 50% of these landslides have occurred in Sectors 1 and 2. The high rate of landslides at this location appears related to higher levels of coastal erosion, and the absence of nearshore reefs
- The remaining landslides are evenly distributed through Sectors 3 to 8. An example is shown in Figure 5-3
- Only one large to very large landslide appears to have occurred in Sector 9
- Many very small to moderate landslides have occurred since 2009. The 2011 rainfall event triggered significant shallow landsliding of the cliffs. This is particularly obvious in Sectors 7, 8 and 9. Figure 5-4 is an example of these small to moderate landslides.

5.1.3 Survey Information

5.1.3.1 2003 LiDAR vs 2012 LiDAR

We have compared LiDAR information provided by HBRC from 2003 to 2012. The purpose of the comparison of the two sets of LiDAR surveys was to identify changes in the ground surface level. Where ground levels have gone down, this has been interpreted to represent erosion/loss. Where ground contours have gone up, this has been interpreted to represent deposition/accumulation.

The following LiDAR data was provided:

- 2003 – Sectors 1 to 3 only, 2 m point grid
- 2012 – all the project area. 0.5 m point grid.

The original coordinate system was New Zealand Transverse Mercator 2000. The original height datum was Hawke's Bay Local Authority Datum 1972 (MSL+10m). A coordinate transformation was carried out using 12d (v14.0C2d) to transform the data to the Hawke's Bay 2000 Circuit. A height adjustment of -10.235m was applied to translate the heights to New Zealand Vertical Datum 2016. The original capture and survey methods are not known. Basic translations have been applied to this data. This data has not been checked against any control points.

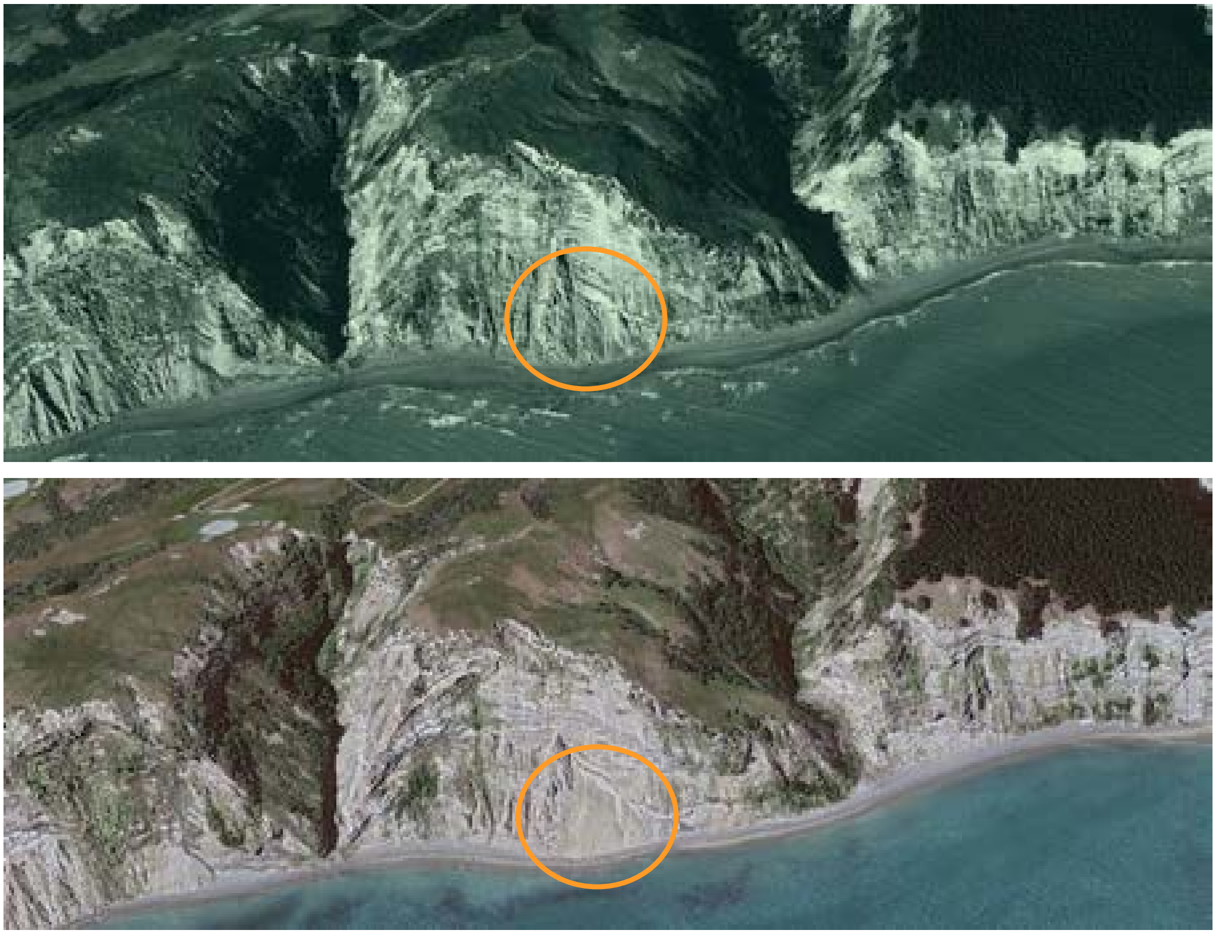


Figure 5-3: Sector 4 - example of a very large rock avalanche identified from historic imagery, Sept 2012 (top) and Nov 2012 (bottom)

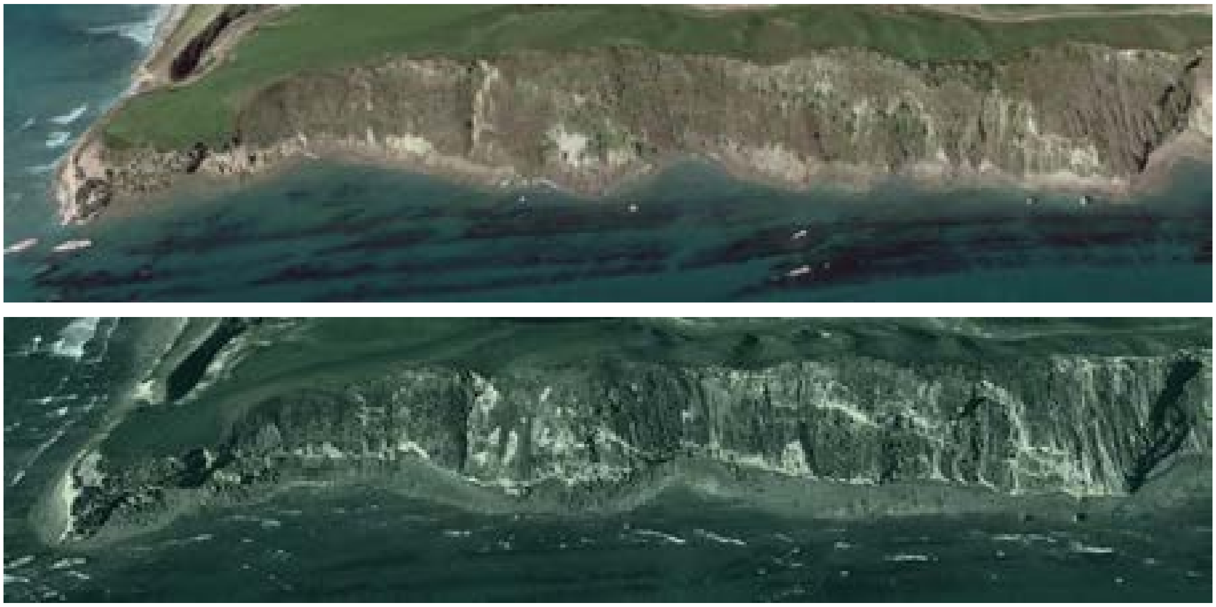


Figure 5-4: Sector 8 - Imagery from 2009 (above) and 2012 (bottom) - shallow landsliding between Jack's Camp and Black Reef due to the 2011 rainfall event

The results of this comparison are shown in Figure 5-5 (erosion/loss) and Figure 5-6 (deposition/accumulation). The key conclusions of this comparison of available LiDAR data are:

- Around 10 large to very large landslides are evident
- Key areas of landsliding are:
  - The area between Papa Point and Mog's Rock
  - Further landsliding at the 1990 Landslide location
  - Landsliding of the low height cliff at the location of the predator-proof fence
  - A landslide on the eastern side of Goat Gully
  - Home Straight.
- A good correlation with the landslides identified from anecdotal information and aerial imagery review is obtained
- A good correlation with the hazard maps prepared by GBA is obtained.

5.1.3.2 2012 LiDAR vs 2019 Photogrammetry (Flight 1)

We have compared 2012 LiDAR information provided by HBRC with the UAV photogrammetry obtained by Stantec (Flight 1, completed March to April 2019). The UAV photogrammetry was collected in Hawkes Bay 2000 Circuit and heights to New Zealand Vertical Datum 2016. The photogrammetry obtained accuracies in the order of 0.01 to 0.02 m, with a Ground Sample Distance (GSD) of between 2.0 and 2.75 cm/px.

As with the LiDAR comparison detailed above, the purpose of the comparison was to identify changes in the ground surface level. Where ground levels have gone down, this has been interpreted to represent erosion/loss. Where ground levels have gone up, this has been interpreted to represent deposition/accumulation. The same limitations apply to that described above.

The results of this comparison are shown in Figure 5-7 (erosion/loss) and Figure 5-8 (deposition/accumulation). More detailed figures are presented as Appendix E. The key conclusions of this comparison can be summarised as:

- Around 10 large to very large landslides appear to have occurred over the period (between the 2012 and 2019 LiDAR surveys)
- Several of the landslides occurred at the same locations as those identified between 2003 and 2012
- Good consistency was achieved between the identified landslides and those from anecdotal information, historical imagery review and the GBA hazard maps
- The active erosion of historic rockfall deposits is evident at several locations.

5.1.3.3 Limitations

Key limitations of this assessment of precedent landsliding at the site based upon the above two comparisons are:

- It is likely only large to very large rockfalls are represented in the record. It does not help assess the locations and rates of very small to moderate-sized rockfalls.
- Progressive landsliding at the same location may be missed.
- Coastal process may remove geomorphic evidence of the rockfall deposit.
- Source areas are difficult to identify, as the cliffs are very steep. Cliff losses are hard to identify, unless they resulted in the retrogression of the cliff-top, due to the data acquisition method of LiDAR. On this basis, rockfalls deposits are the key piece of evidence used.
- The influence of coastal processes and other aspects, such as vegetation growth, on interpreting the results.
- The landsliding representing a snapshot in time. Its representativeness needs to be considered, especially against the occurrence of likely triggering events, etc.

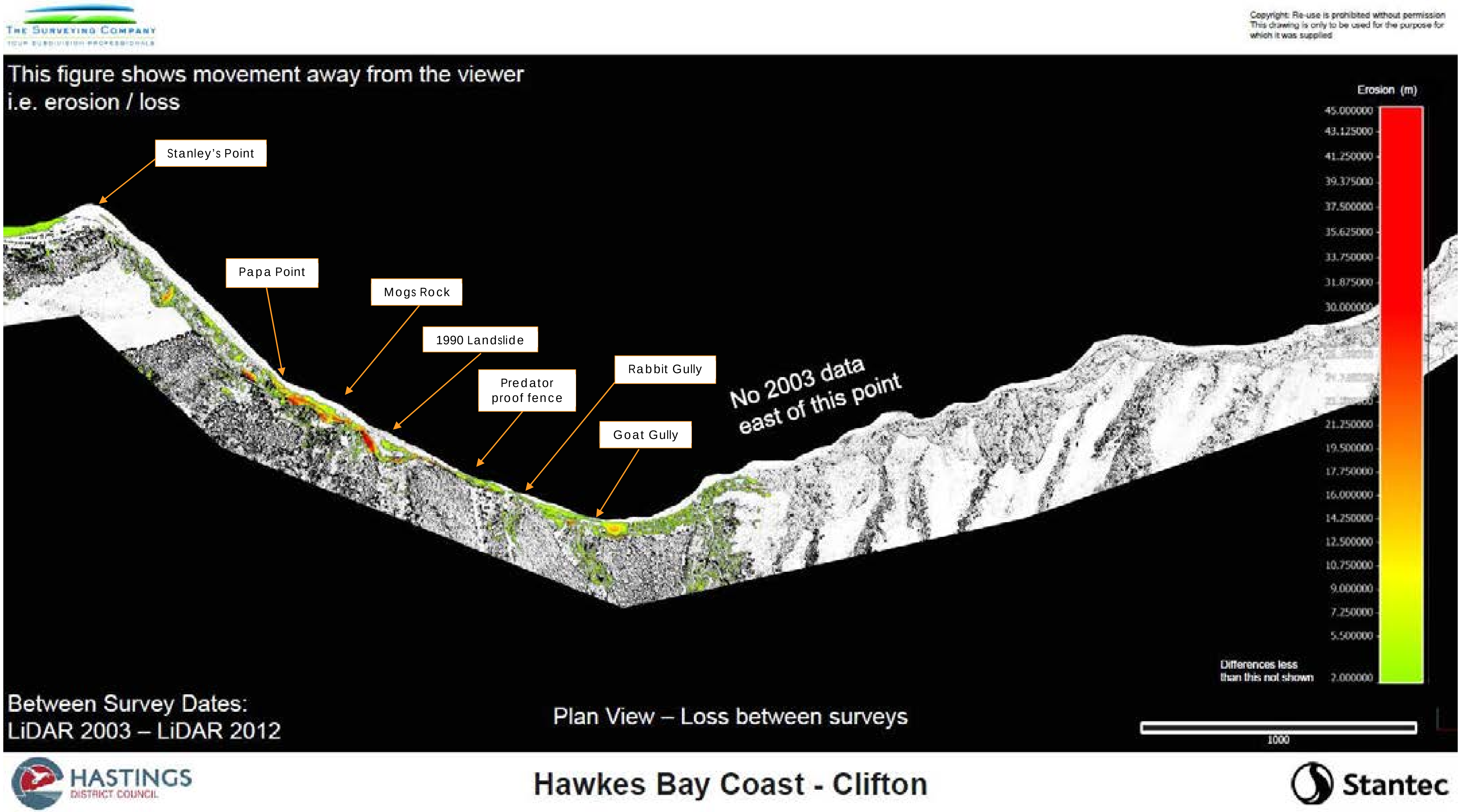


Figure 5-5: Comparison of LiDAR from 2003 to 2012 – movement away from the viewer – erosion/loss (Sectors 1 to 3)

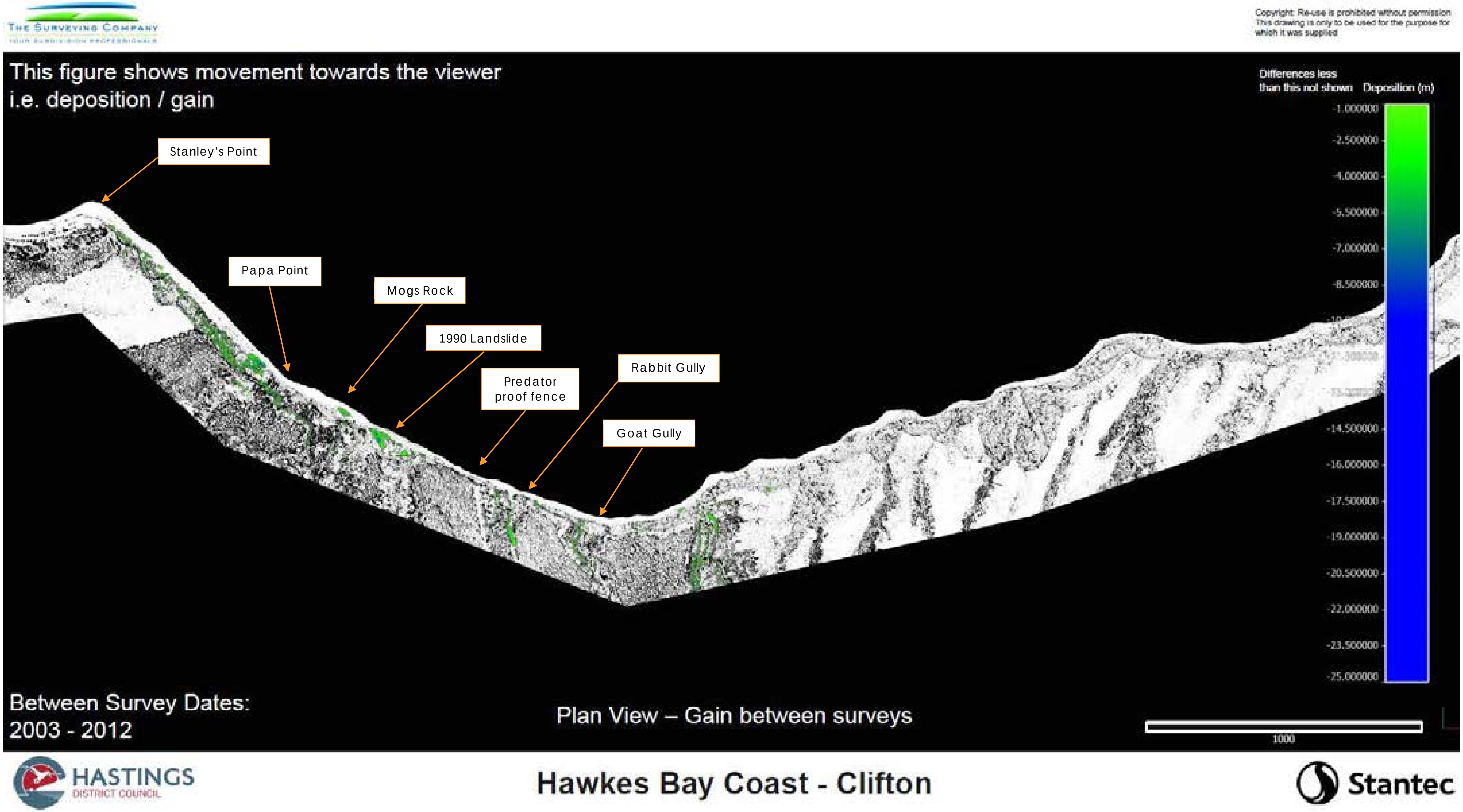


Figure 5-6: Comparison of LiDAR from 2003 to 2012 – movement towards the viewer – deposition

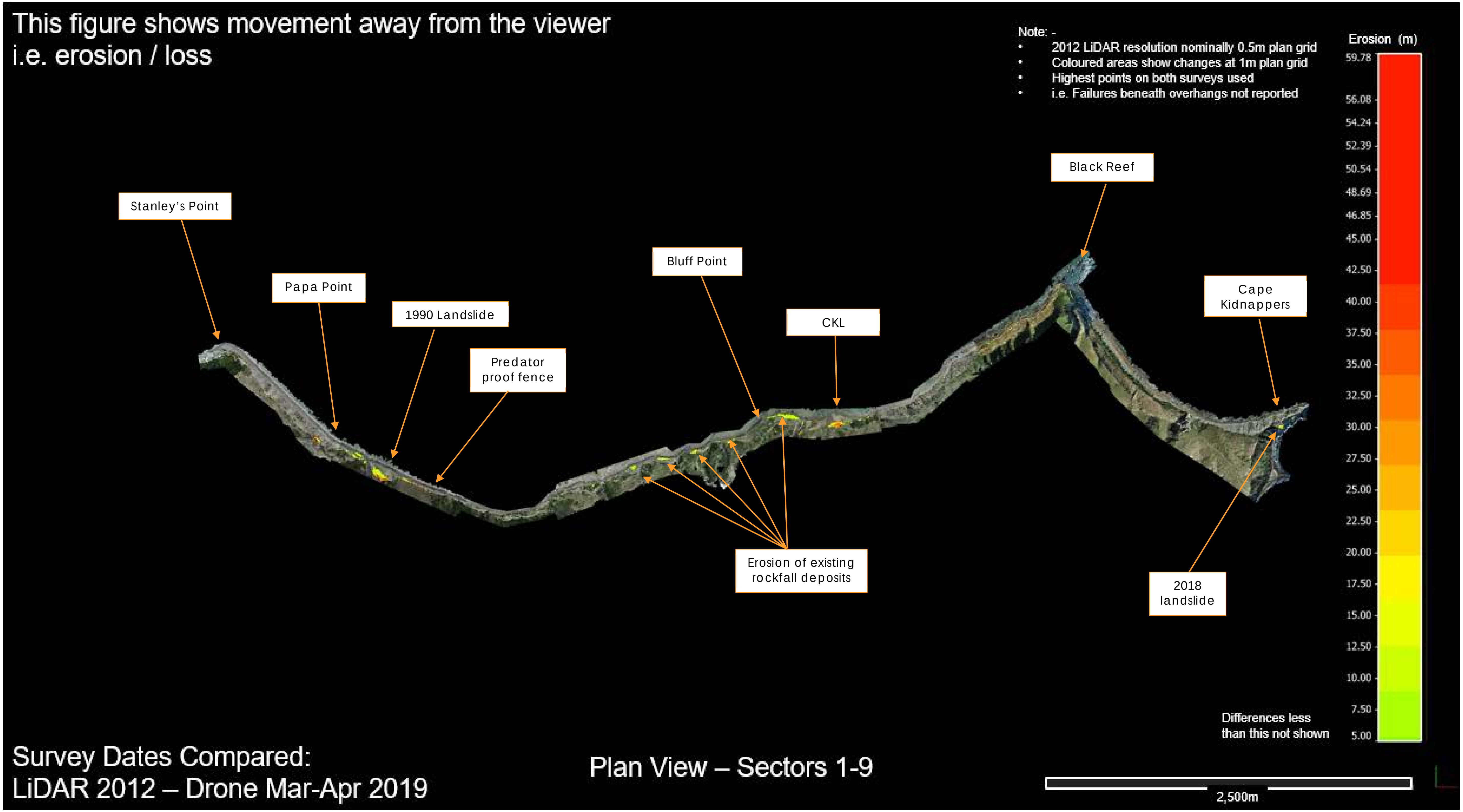


Figure 5-7: Comparison of 2012 LiDAR with 2019 photogrammetry - movement away from the viewer – erosion/loss

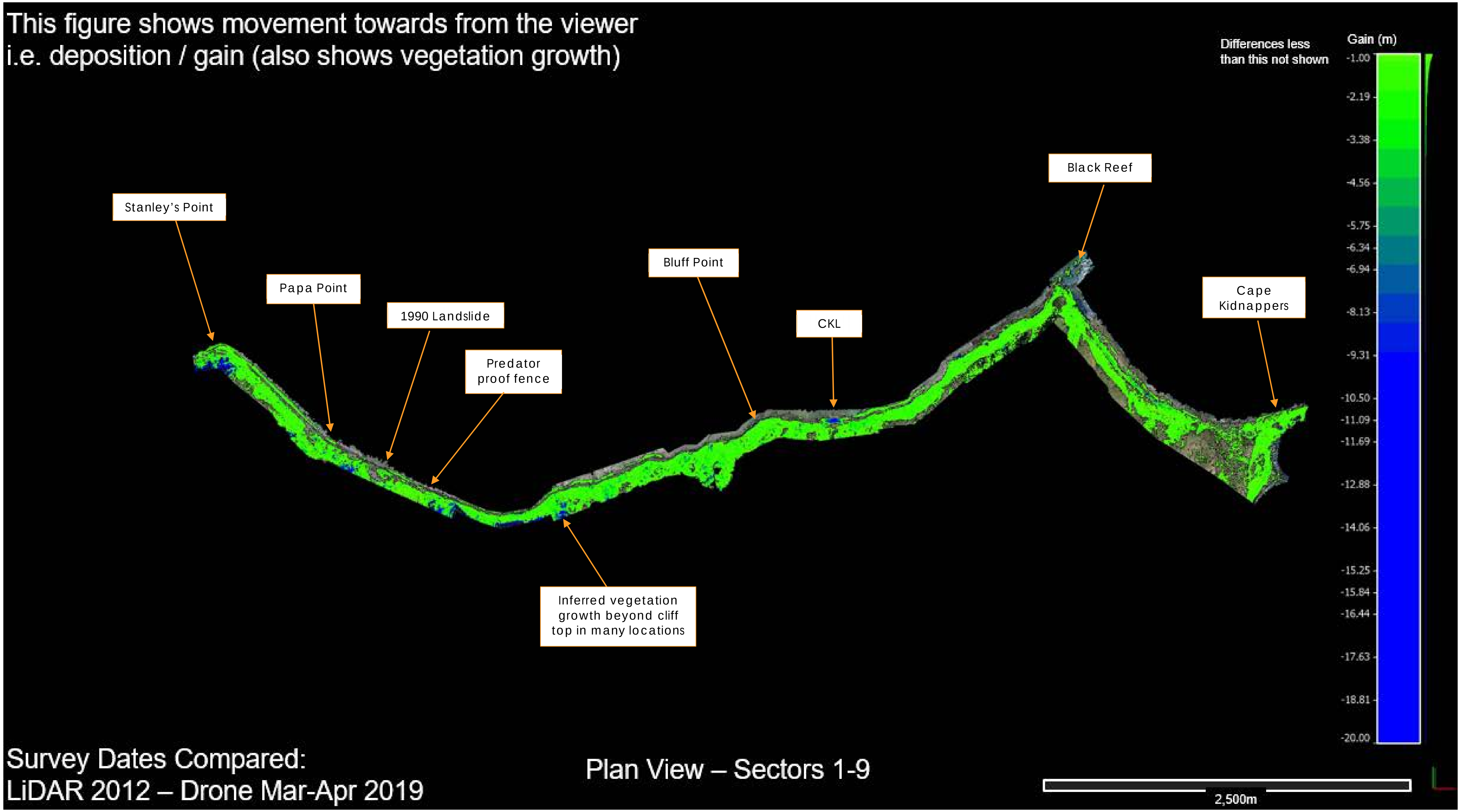


Figure 5-8: Comparison of 2012 LiDAR with 2019 photogrammetry - movement towards the viewer – deposition

5.1.3.4 2019 Photogrammetry (Flight 1) vs 2019 Photogrammetry (Flight 2)

A second UAV photogrammetry survey was completed by Stantec between July and September 2019 (Flight 2), 4 to 5 months after completing the initial survey (Flight 1)[8]. The methods were consistent with those described above for Flight 1. The advantage of completing the second UAV photogrammetry survey was to:

- Allow comparison of two high-resolution survey data sets, meaning very small to moderate-sized rockfall could be identified
- The photogrammetry captured data for the cliff faces, allowing better interpretation of source areas and volumes
- The period between surveys, 4 to 5 months, means:
  - Less influence from geomorphic processes such as coastal erosion and deposition
  - Less 'noise' is present in the data, as vegetation growth etc is not a key consideration for a short period
  - Multiple landslides at the same location are less likely to be missed.

Figures comparing the two UAV photogrammetry surveys are attached as Appendix E. An example of the output is provided in Figure 5-9. The results of the comparison are tabulated below in Table 5-1.

Table 5-1: Landslides recorded by UAV photogrammetry comparison (approx. 4 to 5 month period)

Sector	Very small (<10 m³)	Small (10 to 100 m³)	Moderate (100 to 1,000 m³)	Large (1,000 to 10,000 m³)	Very large (>10,000 m³)
1	6	2	2	1	
2	11	3	5		
3	4	8	2	1	1 (Flax Gully)
4	4	5			
5	8	3		1 (Pigeon Holes)	
6	6	4	2	2*	
7	10	6		1	
8	2	2	4		
9	9	14	1		
Total	60	47	16	6 (4)	1

*This could be judged as not being representative of the 'normal' background rate of landsliding, as it was continued landsliding at the CKL following the 23 January 2019 landslide.

Some key conclusions of this comparison can be summarised as[9]:

- Very small landslides – 60 were recorded over the period, which equates to approximately 180 a year
- Small landslides – 47 were recorded over the period, which equates to approximately 150 a year
- Moderate landslides – 16 were recorded over the period, which equates to approximately 45 a year
- Large landslides - 4 were recorded over the period (excluding those at the CKL location), which equates to approximately 12 a year
- Very large landslides – 1 was recorded over the performance period, which equates to approximately 3 a year
- The reduction in landsliding frequency with increasing volume appears evident in the data.

[8] Flight 1 was completed for Sector 6 on the 20 March 2019. This is after the 23 January 2019 CKL and the multiple subsequent landslides. They are not included in the data presented. One very large and three large landslides were shown by monitoring to have occurred between 21 January 2019 and 20 March 2019.

[9] This does not consider what triggers of landslides may have occurred, cause effects such as seasons (survey period is over winter).

The survey period is very short and is very unlikely to be representative of 'typical' background landsliding at the site. Surveying is required over a longer period to make this more reliable.

On this basis, we have not developed a volume magnitude frequency curve for the site. Typical 'rules of thumb' do appear in the data, with large landslides around 10 times less likely than very small to small landslides, with very large landslides around ten times less likely again.

Other observations from the UAV photogrammetry survey can be summarised as:

- The geomorphic process of coastal erosion at the base of the cliffs, over-steepening the slope, is readily apparent in the data (i.e. retrogressing up the slope)
- Some of the landslides were recorded at locations of historic landsliding
- Some of the landslides were recorded at locations away from identified historic landslides
- The DOC land at Cape Kidnappers and the private property on which access is also located is at a much lower landslide risk than the access to the site (i.e. the beach).

5.2 Prediction

5.2.1 Numerical Analysis

We have not completed a numerical analysis of cliff stability. It is not realistic given the size of the site to assess each section of the cliffs and determine their probability of failure.

There is no information available to reliably assign material parameters for analysis. Back analysis would yield material parameters which would show landsliding under unusual and extreme loading conditions.

5.2.2 Trigger Assessment

5.2.2.1 Earthquake Triggers

Anecdotal information confirms earthquake-induced landsliding has occurred previously at the site and this appears to have been significant in at least the 1904 Cape Turnagain earthquake.

Earthquake shaking is expected to be a key trigger of landsliding at the site. This is as the cliffs are very high and steep. The cliffs are also judged to be in a metastable condition due to ongoing coastal erosion. This means:

- Earthquake-induced landsliding is likely to be extensive under higher ground shaking
- Even small ground shaking may be sufficient to trigger some landsliding
- Site characteristics may mean some topographic amplification would occur.

When assessing the likelihood and volumes, methods commonly used include landslide source area to volume scaling (Figure 5-10), landslide frequency to source area scaling (Figure 5-11) and the development of landslide regression models. Much of these methods are based upon empirical relationships with landsliding observed in past-earthquakes. For some sites, this is judged appropriate and likely to yield reliable results.

What is of further relevance is the comparison with observations from rock avalanches (cliff collapse) in the Port Hills in the Canterbury Earthquakes. Many coastal and inland cliffs suffered from collapse, these were very step (>65°) and typically up to 60 m high, but locally up to 100 m high. The inland cliffs are not subject to coastal erosion and have not been for some time, which is important for their stability before the earthquake. Observations appear to show:

- No instances of significant cliff collapse occurred below 0.2 g
- Some cliff collapses occurred from 0.2 up to around 0.4 g
- Many cliff collapses occurred above 0.4 g.

The earthquake triggered landslide risk cannot be significantly reduced with risk management. This is as earthquakes just happen. The risk can be reduced following an earthquake however by risk management, when a period of increased landsliding may occur (in association with aftershocks). Obviously, should there be a significant foreshock, the same rule would apply to the mainshock.

The likelihood of earthquake-induced landslides are to be calculated by GNS as part of their work.

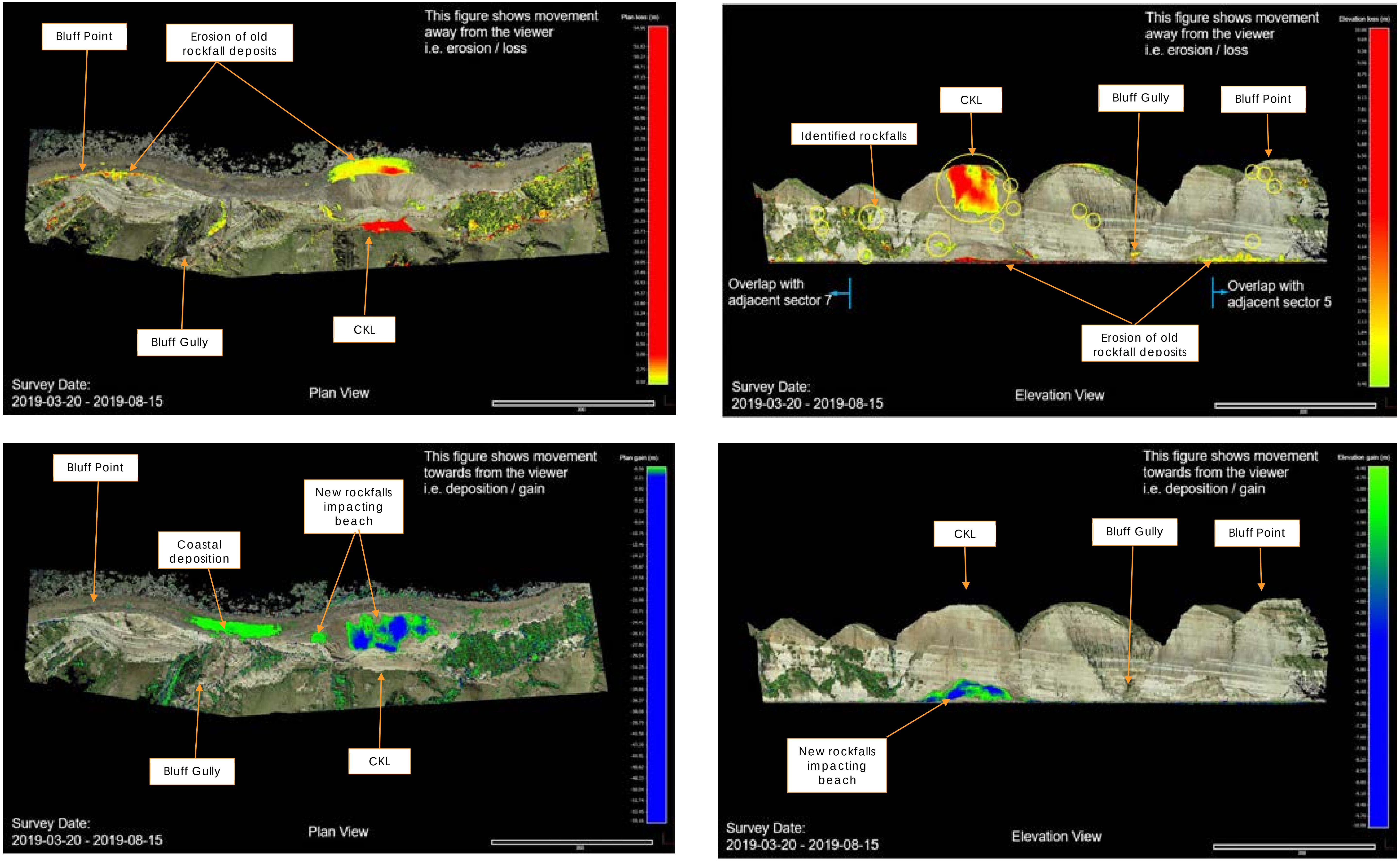


Figure 5-9: Example of UAV photogrammetry comparison for Sector 6 - plan views at left (erosion /losses top, deposition/accumulation bottom) and elevations at right (erosion /losses top, deposition/accumulation bottom

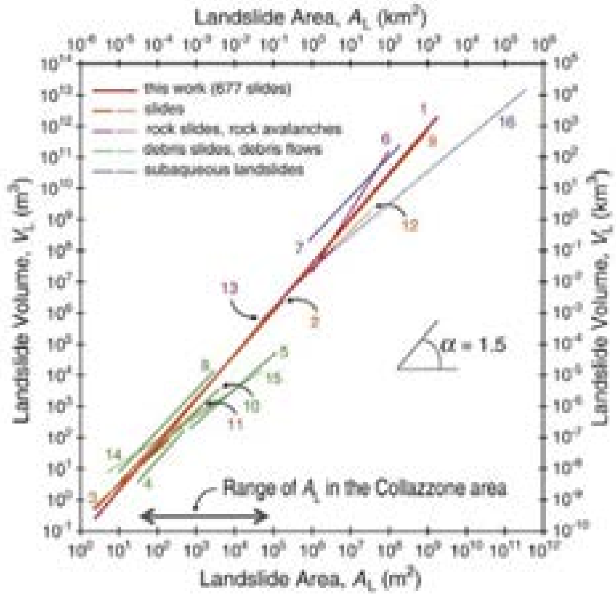


Figure 5-10: Empirical relationships between landslide source area and volume (from Guzetti et al. 2009)

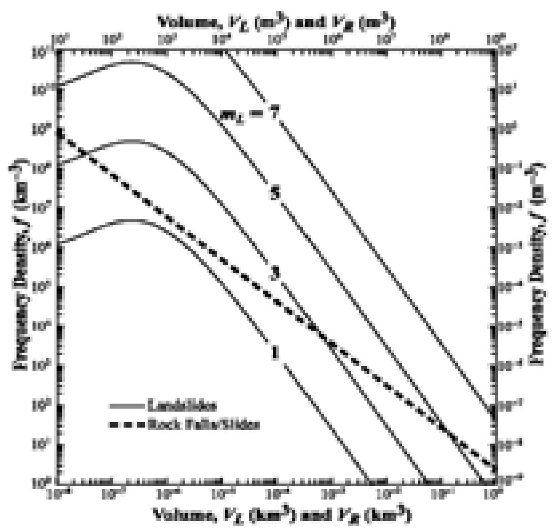


Figure 5-11: Empirical relationships between landslide frequency and source area (from Malamud et al 2004)

5.2.2.2 Rainfall

Although rainfall is likely to be a key trigger of landsliding at the site, it has not been considered in detail in this report. This is as rainfall-induced landslides occur either during or immediately following heavy rainfall. Beach users are very unlikely to be on the beach at that time and it does not significantly influence the risk. This is especially the case when the current risk control measures are considered.

5.2.3 Climate Change

No reliable assessments of the possible future effects of climate change have been completed for the project area. On this basis, a detailed assessment of the effects of climate change on the landslide risk has not been completed as part of this hazard assessment. Possible future effects of climate change may include:

- Increasing sea levels:
  - This reduces the effective width of the foreshore and the MWHS will be closer to the base of the cliffs. Beach users are more likely to be in the locations spatially impacted by landslides, where they would have a higher vulnerability (i.e. the very base of the cliffs).
  - More erosion may occur at the base of the cliffs, causing increased rates of landsliding.
- More intense storms – with larger waves and associated erosion, and heavier/more prolonged rainfall. These are two possible triggers of landslides. Increased rates of landsliding could occur.

There are no obvious reasons why climate change would decrease the rate of landsliding from what it is currently. On this basis, it can be assumed the risks would only increase in the future. The rate of which would be dependent on the rate of impacts of climate change. It is expected this increase is likely to be negligible in the short to medium term (the next 5 years say).

5.3 Summary

Based upon the above information, the calculated frequency of non-earthquake triggered landsliding for Clifton Beach is summarised in Table 5-2 to Table 5-3 This represents a high rate of landsliding, consistent with actively eroding coastal cliffs. This is largely based upon a short monitoring period, however.

It is not feasible at this stage of the study of the site to define and assign annual probabilities of landsliding to specific ‘source areas’. The information has shown landsliding occurs throughout the project area from the cliffs, not just at specific source areas.

It is clear from the data that some locations currently display higher rates of landsliding than others. Many of these locations are those which have shown evidence of historic landsliding. These locations appear to be those subject to the highest rates of coastal erosion and have no or limited protection from nearshore reefs. Locations that have shown no previous landsliding historically are highly unlikely to be ‘stable’. They are best described as ‘metastable’. Coastal erosion and landsliding is still happening, albeit at a slower rate than some other locations. They cannot be excluded as potential source areas.

It is expected significant landsliding would occur at the site, including large to very large landslides under earthquake shaking (i.e. many would be expected to occur). The likelihood of earthquake-induced landslides is to be calculated by GNS as part of their work. The assessed frequency of non-earthquake-triggered and earthquake-triggered landslides should be combined to determine the overall probability of landsliding in the risk calculation.

Table 5-2: Approximated raw landslide frequency data (non-earthquake)

Date Source	Volume Class Very small (<10 m³)	Small (10 to 100 m³)	Moderate (100 to 1,000 m³)	Large (1,000 to 10,000 m³)	Very Large (>10,000 m³)
Anecdotal (newspaper only)	N/A			3 landslide/50 years	
GBA information	Daily	Daily	Weekly to monthly	Several/yr	5 yearly
Aerial imagery review	N/A			30/11 years	
LiDAR 2003 to 2012	N/A			10/9 years	
LiDAR 2012 to UAV 2019 (Flight 1)	N/A			10/7 years	
UAV 2019 (Flight 1) to UAV 2019 (Flight 2)	60/4 months	47/4 months	16/4 months	4/4 months	1/4 months

Table 5-3: Annualised landslide frequency (non-earthquake)

Date Source	Volume Class Very small (<10 m³)	Small (10 to 100 m³)	Moderate (100 to 1,000 m³)	Large (1,000 to 10,000 m³)	Very Large (>10,000 m³)
Anecdotal (newspaper only)	N/A				0.06
GBA information	N/A				0.2
Aerial imagery review	N/A			2	0.5
LiDAR 2003 to 2012	N/A			2	0.4
LiDAR 2012 to UAV 2019 (Flight 1)	N/A			1	0.4
UAV 2019 (Flight 1) to UAV 2019 (Flight 2)	180 (min)	150 (min)	48	12	3
	770 (max)	190 (max)	N/A		
Adopted*	**800**	**200**	**50**	**12**	**3**

*Upper bound values conservatively assumed

6. Probability of Spatial Impact

6.1 Introduction

The probability of spatial impact is, in the event of a landslide occurring, the probability it will impact a location a beach user may occupy (i.e. the beach). The probability of spatial impact has been assessed by information that can be broadly divided into two groups:

- Precedence – based upon direct observation of past landslides at the sites
- Prediction – based upon empirical methods, or numerical modelling, of where landslides may spatially impact.

Some of the considerations for the probability of spatial impact are shown in Figure 6-1.

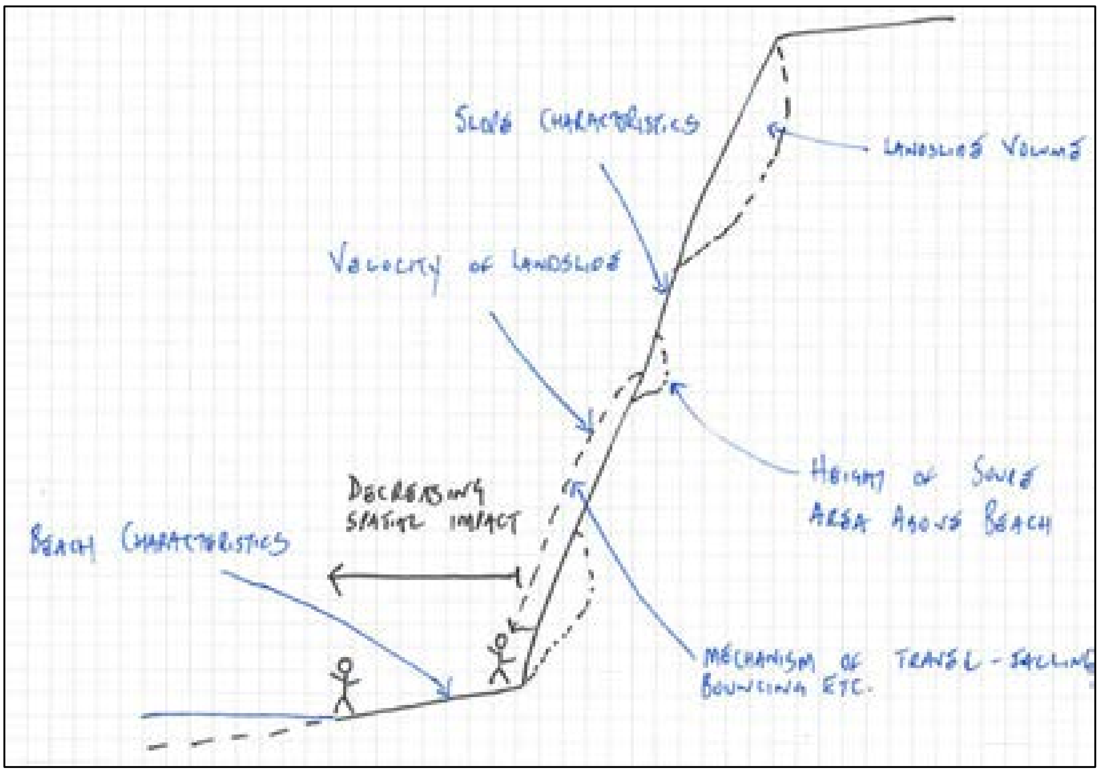


Figure 6-1: Some considerations for the probability of spatial impact

A key challenge of the QRA is that beach users can occupy any part of the beach, which is up to say 30 m wide in some locations. They are not following a set path, except for DOC land at Cape Kidnappers. This is critical when the probability of spatial impact is assessed, as it will be very different the further away from the cliff a beach user is present (particularly so for small to moderate volume landslides).

It is obvious for Clifton Beach that the probability of spatial impact is generally very high. For example, a rockfall from the cliff at the CKL will have a probability of a spatial impact of 1, as it is certain it will hit the beach. This is irrespective of whether the landslide source area is low or high on the cliff. In some other locations the cliff is much less steep. In these locations, the probability of spatial impact on the beach will vary depending on the location of the landslide source area. This concept is shown in Figure 6-2.

The following subsections summarise how the probability of spatial impact has been assessed as part of this hazard assessment.

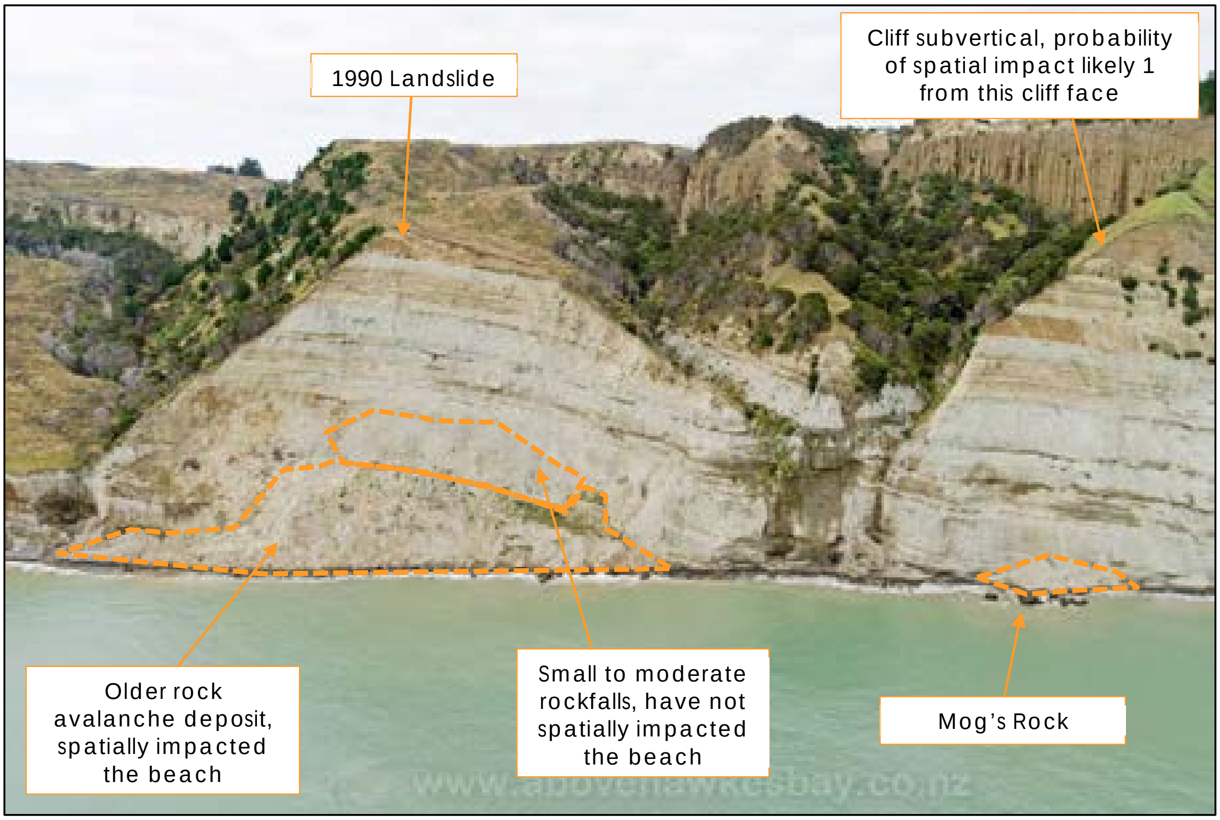


Figure 6-2: Sector 2 - examples of the probability of spatial impact

6.2 Precedence

Site observation and anecdotal information show that large to very large landslides almost certainly spatially impact the beach. They also typically spatially impact the entire beach, from the base of the cliffs to beyond the MLWS. This is not to say all the landslide volume spatially impacts the beach, however.

This was demonstrated during monitoring by the Pigeon Holes Landslide, as shown in Figure 6-3. The landslide was around 3,000 m3 in source volume (i.e. a large landslide) and its source area was around mid-height on the cliff (around 75 m). It spatially impacted the entire beach, and some of the rockfall deposit did not make it to the beach, and was deposited on the cliff face.

The CKL extended around 75 m from the base of the cliff, around 50% of which was beyond the MLWS. The 1981 landslide at the CKL location was assessed to have extended 90 m from the base of the cliff at the time.

The spatial impact of very small to moderate rockfalls is much harder to assess based upon precedence, and this is when the landslide source area and slope characteristics below the source area become much more critical. This is both:

- Do the rockfalls spatial impact the beach?
- Which part of the beach do they impact? Is it mainly the upper part of the beach only, at the base of the cliffs?

It is likely evidence for very small to moderate landslides is missed. The rockfall deposit would be quickly removed by coastal processes.

Comparison of the UAV photogrammetry does show:

- Most very small to moderate landslides spatially impact the beach when the cliffs are very steep. It is typically the upper part of the beach to be impacted only, however.
- Where the cliffs are less steep, most very small to moderate landslides do not spatially impact the beach.

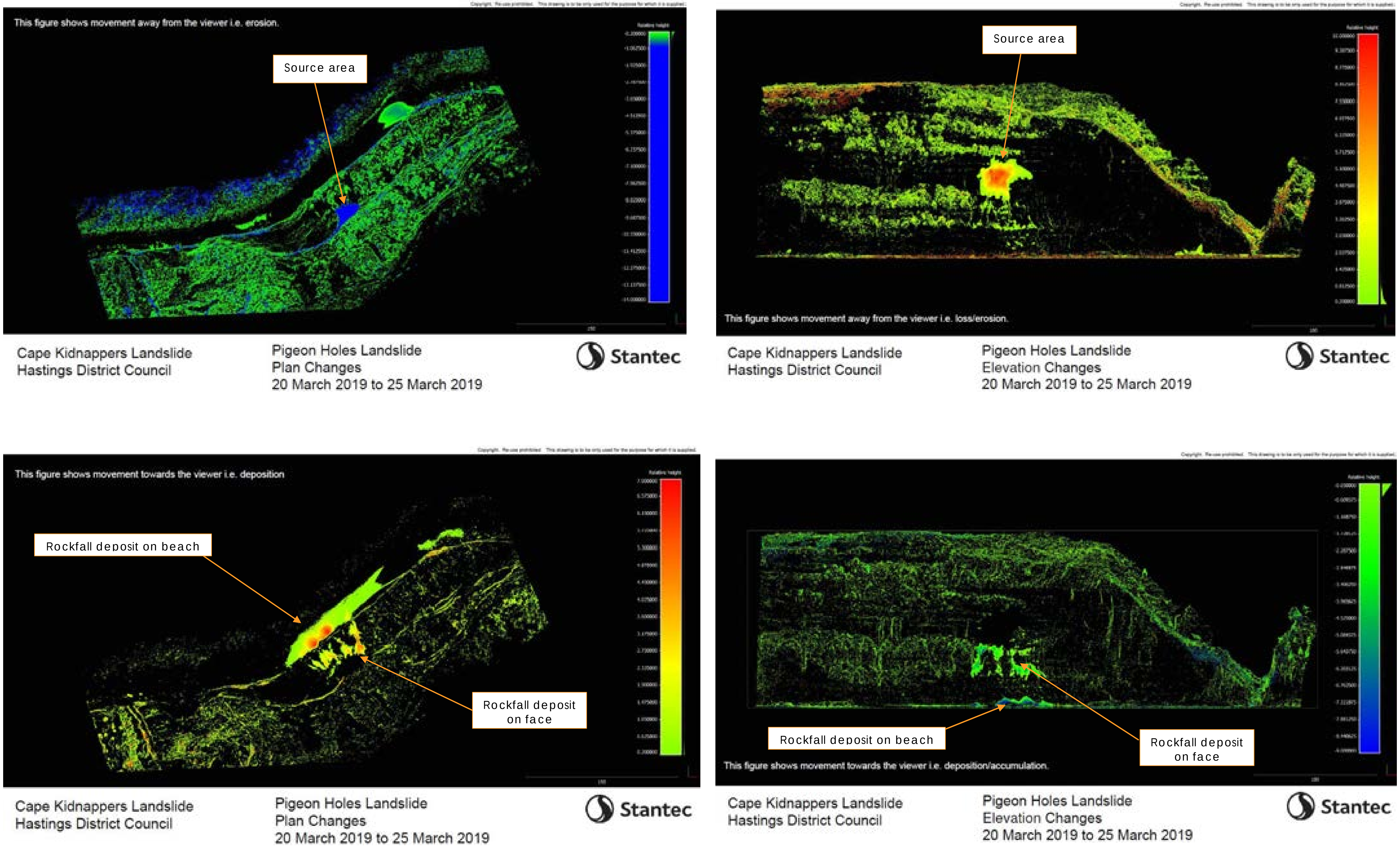


Figure 6-3: Pigeon Holes Landslide (3,000 m3) – plan and elevation losses and gains

6.3 Prediction

6.3.1 Large to Very Large Rockfalls (Rock Avalanches)

Empirical methods of assessing rockfall runout are based upon relationships of slope height and angle. A commonly applied method for rock avalanches is that of the Fahrboschung angle (Heim 1932), sometimes known as the travel angle, which is a line of a horizontal plane from the top of a rockfall source area to the stopping part of the rock (Figure 6-4). The line assumes no topographical effects, so it is the direct path of the rockfall. Overseas studies by others showed Fahrboschung angles of 28.5° (100%) and 32° (95%).

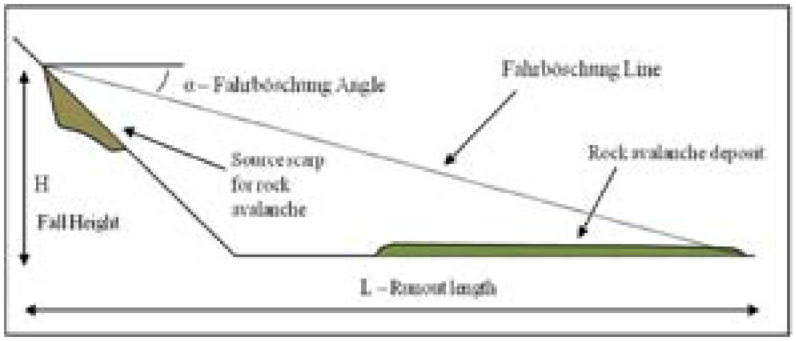


Figure 6-4: Fahrboschung angle (from Heim 1932)

Others have assessed relationships between rock avalanche volume and slope height/runout length overseas (Davidson 2011, unpublished thesis). The data is presented in Figure 6-5. Data is for large rock avalanches, and landslides at Clifton Beach are more likely to be at the lower end of the volumes presented. Volumes are also deposited volumes, not source area volumes. The CKL rock avalanche is plotted for context. This figure shows an obvious best fit line through, which is judged most reliable between around 10^{-6} and 10^{-9} say.

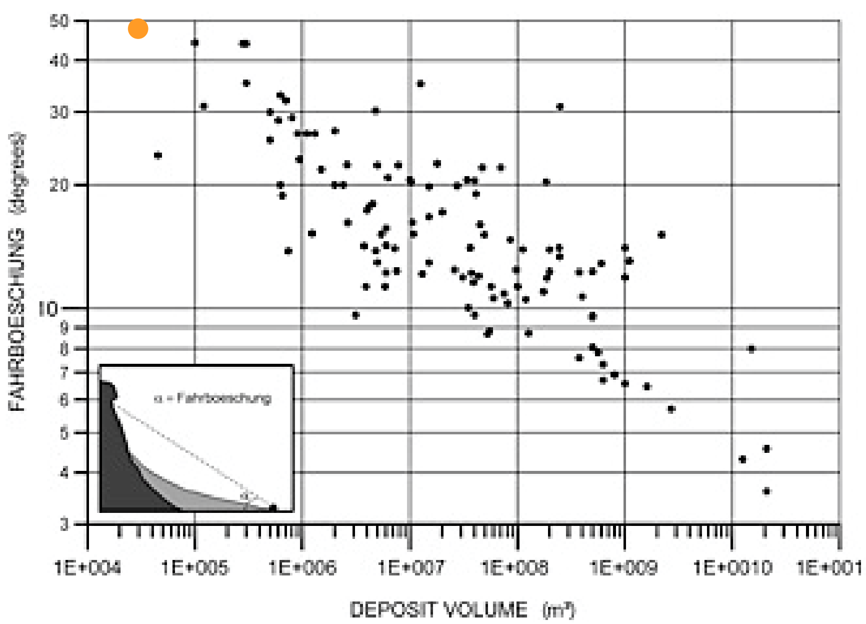


Figure 6-5: Fahrboschung angle for rock avalanches (from Davidson 2011)

Massey et al (2012) also presented relationships between the Fahrboschung angle and rockfall volume. Key results are presented in Figure 6-6, with rock avalanche data at left and rockfall data at right. The volumes presented in the data are judged comparable to those likely to occur. There are some key differences however in geology and topography etc. which should be considered when this data is considered. The CKL had a failure volume of 25,000 and an H/L ratio of around 1.7[10]. The Pigeon Holes Landslide had a failure volume of 3,000 m3 and an H/L ratio of around 2. This data is generally consistent with that presented.

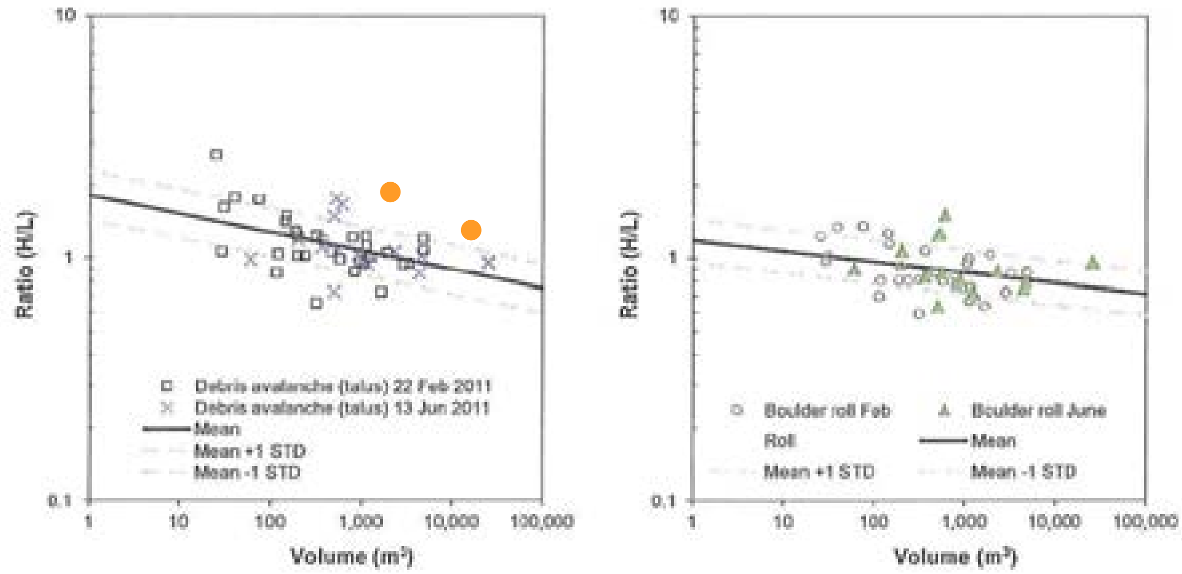


Figure 6-6: Relationship between Fahrboschung angle and rockfall volume (Massey et al 2012)

Further detail about Fahrboschung angles from Massey et al (2012) is presented as Figure 6-7. Data is presented for the extent of the main rockfall deposit (debris avalanche angle), together with associated boulders and fly rock which extended beyond the main rockfall deposit. Massey et al (2012) used an overall Fahrboschung angle of 31° for assessing life-safety risks in the Port Hills.

	Debris avalanche angle (°)	Boulder roll angle (°)	Fly rock angle (°)
Mean	47	41	41
Minimum	33	33	31
Standard deviation	±6.6	±6.0	±6.4
Standard deviation (±) of mean	±0.9	±0.8	±1.6
95% confidence limit	±1.7	±1.6	±2.9
95% limit	46	40	38
Degrees of freedom	49	48	17

Figure 6-7: Fahrboschung angles for rock avalanche deposits, and their associated boulder rolls and fly rock (Massey et al 2012)

The above information shows that for rock avalanches, the Fahrboschung angle may range from 30° up to 50°, noting that these angles are from the horizontal.

In applying any Fahrboschung angle at the site, it is noted:

- The cliffs have very variable height and slope angles

[10] It is hard to reliably define the Fahrboschung angle at Clifton Beach, as for most rock avalanches, the rockfall deposit enters the nearshore and is partially submerged

- The source area for the rock avalanche could occur from various heights on the cliff.

Irrespective of these factors and which Fahrboschung angle is applied, it is clear in the majority of instances the beach will be spatially impacted and a probability of spatial impact of 1 could be assumed. This is supported by precedence, with many instances of rock avalanches deposits present on the beach. For these reasons, we have not completed the numerical modelling of rock avalanche runout.

6.3.2 Small to Moderate Rockfalls

It is not feasible to model all the possible scenarios based upon source area height and cliff shape to determine the probability of spatial impact of very small to moderate-sized rockfalls.

6.4 Summary

It is judged almost certain that large to very large landslides will spatially impact the beach, irrespective of where they occur. They are also likely to spatially impact the entire beach from the base of the cliff to the MLWS. This is purely a function of site characteristics (high and very steep cliffs, with the beach at the very base of the cliffs) and the landslide volume.

The spatial impact of very small to moderate rockfalls is much harder to assess based upon precedence, and this is when the landslide source area and slope characteristics below the source area become much more critical. It is not feasible to model all the possible scenarios based upon source area height and cliff shape. In many locations, due to the very steep cliffs, it is judged almost certain that even very small to moderate rockfalls would spatially impact the beach. What is important is that these rockfalls are much less likely to spatially impact the entire beach. At the base of the cliff, the probability of spatial impact is very high, but is likely to be much less at the MLWS for example. The challenge with this is beach users could be in any part of the beach, as there is no defined track on which they would be.

Another important aspect is how the width of the rockfall deposit compares to the width of the source area. Monitoring of the CKL showed the rockfall deposit was around 1.7 times the source area width.

A key risk control could be in encouraging beach users to stay as far away from the base of the cliffs as feasible.

7. Temporal Spatial Probability of Beach Users

7.1 Introduction

The temporal spatial probability is the amount of time a beach user spends in the landslide hazard area (i.e. on the beach). Beach users are itinerant and therefore their temporal spatial probabilities are low. This is as:

- Most of the time, beach users are not on the beach and exposed to landslide hazard
- Beach users may be on the beach when a landslide occurs but is much more likely they will be in another part of the beach and not the one spatially impacted by the landslide.

The following subsections provide commentary about the temporal spatial probability of the key beach user groups.

7.2 Beach User Characteristics

The temporal spatial probability of beach users is summarised as:

- General public:
  - Locals:
    - Are likely the beach user group with the most variability in their temporal spatial exposure. Some may access the beach frequently, almost daily, while others will be much less frequent. They also access the beach in different ways.
    - We have assumed a local will access the beach once a week, for a period of 2 hrs each visit. This equates to 52 trips a year, or 104 hours per year. This equates to 2.3% of the year (or 2.37×10^{-2}). We have further assumed their time is evenly spread across the beach length.
  - Tourists:
    - DOC advises allowance for 5 hrs for the return trip, which includes time at Cape Kidnappers and other stops. This equates to around 0.5 % of the year (or 5.7×10^{-4}).
    - The walking time to Cape Kidnappers is 1 hr 45 mins for the average person from Stanley's Point. So, 3.5 hrs total on the beach (or 3.9×10^{-4}). We have assumed this time is evenly distributed along the beach length.
    - Although the risk metric being used is RPT, it is noted than most walkers would likely make the trip once a year. On this basis, the RPT is also similar to their AIFR.
- Guided public – passengers of GBA:
  - Trips occur 2 hrs either side of low tide.
  - A trip takes 1 hr 15 mins to the access to the DOC land, with short stops along the way. The return trip takes around 1 hr, with a 10 min stop at Black Reef. Passengers are given around 2 hrs at Cape Kidnappers.
  - This gives a total trip duration of 4 hrs. This equates to 17% of the day (or 4.5×10^{-4} of the year).
  - Of these 4 hrs, 2 hrs are assumed on the 'beach' and 2 hrs at Cape Kidnappers. For the QRA, it can be assumed the time on the beach is evenly distributed throughout the beach length. This equates to less than 10% of the day on the beach itself (or 2.2×10^{-4}).
  - The tractors drive at an average speed of 10 km/hr, with a maximum speed of 20 km/hr.
  - Although the risk metric being used is RPT, it is noted than most passengers would only make the trip once a year (and for many, once in their lifetime). On this basis, the RPT is also similar to their AIFR.

- Employees:
  - Employees of GBA:
    - GBA schedule approximately 200 trips per year. Of these, 10 to 15 are typically lost to weather/beach conditions. We have assumed 190 trips per year. This equates to trips on days around 50% of the year. It has been conservatively assumed one driver drives a tractor every day. We have assumed 2 hrs per trip on the beach per trip, with the remainder of the time at Cape Kidnappers. This equates to 760 hrs of the year, or less than 10% (or 8.6×10^{-2}).
    - In addition, drivers spend some time on the beach during the season undertaking access maintenance. This commonly equates to two to three times per month. We have assumed 3 days per month, for 6 months of the year, with 4 hrs each maintenance period (i.e. 2 hrs either side of low tide). The locations are variable, so we have assumed this time is evenly distributed on the beach. This equates to 72 hrs of the year, or less than 1% (or 8.2×10^{-3}).
    - The temporal spatial exposure of the driver is a combination of the two. This equates to 832 hrs of the year, or 9.5% of the year (or 9.4×10^{-2}).
    - We have assumed the employee does not access the beach outside of work.
  - HDC and DOC employees, together with their subcontractors:
    - DOC employees - access Cape Kidnappers via the overland track and not the beach. It has been assumed they visit Cape Kidnappers once a fortnight and spend 4 hrs on-site each visit, evenly distributed throughout the area. This equates to 104 hrs of the year or around 4.5% (or 4.7×10^{-2}). We have further assumed they do not access the beach outside of work.
    - For HDC staff and their subcontractors - we have assumed they access the beach once a fortnight, 4 hrs each trip. This equates to 104 hrs of the year, or around 1% of the year (or 1.19×10^{-2}). We have assumed their time is easily distributed along the beach. We have further assumed they do not access the beach outside of work.

The assumed driver from GBA is the individual most at risk. The individual most at risk is often used for individual risk-based decision making.

7.3 Possibility of Evacuation

AGS (2007) recommends that the possibility of evacuation in the event of landsliding is considered under the assigned temporal spatial probability. Evacuation may be possible in the event of landsliding if:

- Beach users may see precursory signs of landsliding, such as rockfalls
- People may see or hear the landslide occurring or travelling towards the beach.

The ability of beach users to evacuate is dependent on several factors such as:

- Their hazard awareness - which will be very different between different beach user groups
- The characteristics of the landslide – such as the location it occurs on the cliff, its volume, the length of its runout and its velocity
- Their physical ability to do so
- If they are on foot or in/on a vehicle.

Generally, people on a landslide (i.e. the ground beneath them) are more likely to evacuate than those below a landslide who are inundated from above. This is as they are much likely to see and heed warnings signs.

Factors which make evacuation more likely at the site are:

- Recent rockfall deposits on the beach are obvious to most beach users
- There are good sight distances - the cliffs can be seen
- There is somewhere a beach user can evacuate to - it is feasible to move either way on the beach to avoid a landslide

- At Cape Kidnappers, if beach users are on the landslide (i.e. on top of a cliff), seeing warning signs of landsliding is much more likely.

Factors which make evacuation less likely at the site area:

- Rockfalls velocities are very to extremely rapid
- Rockfalls have been shown to occur previously with no warning signs
- Large to very large volume failures occur (i.e. rock avalanches)
- Many beach users, mainly tourists, likely have a low hazard awareness.

It is also important to note that for some beach users, the ability to individually evacuate is not possible. This would apply to passengers in vehicles for example. In these instances, these beach users rely on the decisions and actions of others for evacuation.

In terms of precedence at the site, it is noted:

- Five people are known to have been struck by landsliding previously. In the three instances of beach users being struck by landsliding (5 people total):
  - Four were tourists, one was a local
  - In all three instances, smaller rockfalls occurred before a larger landslide and rockfall deposits were present on the beach
  - In one of the instances, the smaller rockfalls were directly observed and the beach users still did not evacuate the area
  - When the large to very large landslide then occurred (i.e. rock avalanches), a full evacuation was not possible, and the beach users were struck.
- Other beach users, who are locals and have a good familiarity with the site, anecdotally advise they have evacuated a location at the time of a landsliding occurring and avoided being struck.
- A GBA vehicle stopped before the CKL due to the presence of rockfall deposits on the beach. It could be argued that GBA hazard awareness meant they were not struck by the CKL and this would be considered 'evacuation'.
- Two tourists were nearly struck by further landsliding at the CKL on the 2 February 2019. The specifics of this are not reliably known, but it is understood they evacuated the area and believe they would have been struck if they had not done so.

This information, combined with information from the DOC about visitor groups and their characteristics, is suggestive that:

- General public:
  - Locals - likely have a higher hazard awareness, more likely to identify or heed warning signs, would have a higher probability of evacuation. Possibly significantly so when assigning the temporal spatial exposure, up to one order of magnitude say.
  - Tourists – likely have a low hazard awareness, may not identify or heed warning signs, would have a lower probability of evacuation.
- Guided public – passengers of GBA will not have the option of individual evacuation. They would rely on the decisions and actions of the GBA employee. Refer below.
- Employees:
  - Employees of GBA – likely have a higher hazard awareness, more likely to identify or heed warning signs, would have a higher probability of evacuation. Possibly significantly so when assigning the temporal spatial exposure, up to one order of magnitude say.
  - HDC and DOC employees, together with their subcontractors - likely have a higher hazard awareness, more likely to identify or heed warning signs, would have a higher probability of evacuation. Possibly significantly so when assigning the temporal spatial exposure, up to one order of magnitude say.

8. Vulnerability of Beach Users

8.1 Introduction

The vulnerability of a beach user describes the likely consequence in the event of them being struck by a landslide:

- A probability of 1 means death is certain.
- A value of 0 would mean death is impossible.

Key factors which will influence the vulnerability of beach users in the event of landsliding will include (refer Figure 8-2):

- Their location on the beach in the event of an impact. People at the base of the cliff will have a higher vulnerability than those at the MLWS
- How they are accessing the beach – on foot, in a car etc
- The volume and velocity of the landslide – the bigger the volume and the higher the velocity, the higher the vulnerability
- Where on the body they are struck by the landslide, and if they are buried
- Their age, health etc.

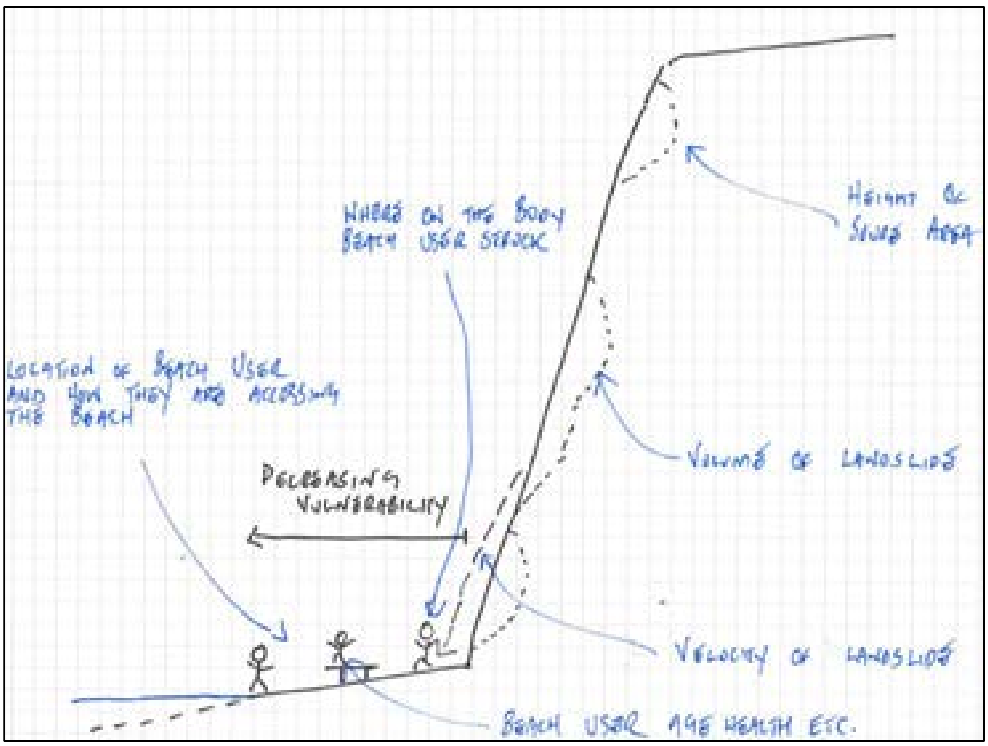


Figure 8-1: Considerations for the vulnerability of beach users

Whether people would evacuate in the event of landsliding is not considered by the vulnerability parameter. Evacuation is considered under the temporal spatial probability parameter of the risk calculation (as per AGS 2007).

The following subsections discuss the findings of an assessment of likely vulnerability, based upon a review of published information only. The assessment of vulnerability is very subjective and there is relatively limited published information.

8.2 Precedence

The only reliably known instances of beach users being struck by landslides are:

- Jan 23 2019 – CKL:
    - Two tourists, on foot, walking at the downslope side of the beach
    - Struck by very large rock avalanche, it appears the rock avalanche had struck the beach and was transitioning to a flow
    - They both suffered lower-body injuries. They do not appear to have been struck above the waist.
- March 5 1988 – near CKL location:
    - Two tourists, on foot, location on the beach not known
    - Struck by very large rock avalanche, as it was of sufficient size to block the beach. It appears the rock avalanche had struck the beach and was transitioning to a flow
    - They both suffered lower-body injuries. They do not appear to have been struck above the waist.
- 1 February 1973 – around 500 m from Stanley's Point:
    - One man injured; two men evacuated. Damage to tractors and trailers of GBA
    - Appear to have been clearing landslide debris from recent landslides. Struck by a very large rock avalanche, which was sufficient to block the beach and extend into the sea.

There are no known instances of:

- Beach users on foot being directly struck/inundated by a rockfall
- Beach users in a vehicle being struck by rockfall
- GBA tractor or trailer unit being struck by rockfall with passengers.

8.3 Published Vulnerability Values

Vulnerability values from AGS (2007) are presented in Figure 8-2. The specifics of the landslides considered are not known and so the values should be considered approximates only.

Case	Range in Data	Recommended Value	Comments
Person in Open Space			
If struck by a rockfall	0.1 – 0.7	0.5	May be injured but unlikely to cause death
If buried by debris	0.8 – 1.0	1.0	Death by asphyxia almost certain
If not buried	0.1 – 0.5	0.1	High chance of survival
Persons in a Vehicle			
If the vehicle is buried/crushed	0.9 – 1.0	1.0	Death is almost certain
If the vehicle is damaged only	0 – 0.3	0.3	High chance of survival

Order of magnitude of landslide crossing road (m^3)	Rockfalls from Scarborough Cliff	
	Landslide hits car	Car hits landslide
0.03	0.05	0.006
0.3	0.1	0.002
3	0.3	0.03
30	0.7	0.03
300	1	0.03
3,000	1	0.03

Figure 8-2: Vulnerability probabilities from AGS (2007)

8.4 Summary

Based on precedence and published information, it is summarised that:

- Beach users in the open being struck by rockfalls likely have a variable vulnerability:
  - If struck on their heads, their vulnerability will be very high
  - If they are fully buried, their vulnerability will be very high
  - If they are not struck on their heads and are not fully buried, they have a high chance of survival (the previous instances of people being struck by landslides would be in this category).
- Beach users in a vehicle being struck by rockfalls likely also have a variable vulnerability:
  - People on motorbikes or quad bikes will have a similar vulnerability to people of foot and similar rules apply.
    - If struck on their heads, their vulnerability will be very high
    - If they are fully buried, their vulnerability will be very high
    - If they are not struck on their heads and are not fully buried, they have a high chance of survival.
  - People inside vehicles will have a lower vulnerability compared to those people on foot. This is as the vehicle may provide some protection.
    - If the vehicle is damaged only, they have a high chance of survival
    - If the vehicle is buried or crushed, they have a high chance of death.
  - People on a trailer may have similar vulnerabilities, or slightly lower, than people on motorbikes or quads.

9. Risk Control Measures

9.1 Summary of Control Measures

Clifton Beach was re-opened for public access on the 5 June 2019. The beach was reopened with interim risk management measures in place. Reference is made to Stantec (2019) for a more detailed description of the interim risk management.

The currently applied interim risk management can be described as 'non-engineered' measures (Figure 9-1). 'Engineered' risk management for landslides are commonly grouped as either 'stabilisation' or 'protection'. Stabilisation and protection were not considered reasonably practicable at the site when its characteristics were considered (Stantec 2019).

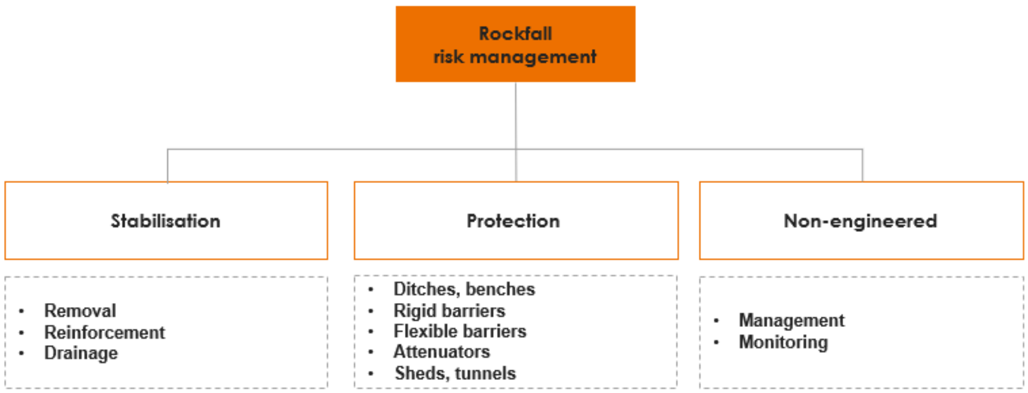


Figure 9-1: Relevant interim risk management options for this assessment

Non-engineered risk management is usually aimed at reducing the temporal spatial probability of people to landslide hazards. Specifically, reducing the time they spend in the hazard area or reducing the likelihood that they will be in the hazard area should a landslide occur (i.e. warnings, evacuation, closure when landslide most likely to occur).

The interim risk management can be summarised as:

- Procedural:
  - Development of a safety plan for HDC staff and subcontractors, including PPE requirements.
  - The use of Kaitiaki to provide information to beach users on landslide hazard and risk. The intent being they were somewhat 'risk-informed'.
  - Development of an operations manual, which detailed:
    - Requirements for active monitoring – via inspection, survey etc.
    - Requirements for proactive and retrospective beach closure, when the likelihood of landsliding was judged higher than 'normal'. This was based upon an assessment of likely landslide triggers.
  - Access to Cape Kidnappers has been closed. For this reason, GBA have not been operating.
  - Promotion of the Cape Kidnappers Walking Track was removed as much as possible.
  - Development of incident and emergency response plans.
- Educational risk management:
  - The use of signs and information boards
  - Pamphlets
  - Other media communications.

- Other:
  - Installation of CCTV camera at Stanley's Point, to assess beach users.

9.2 Beach Usage

Beach visitor numbers are presented in Table 9-1 during the period on the applied interim risk management. The data is judged to be incomplete. The data is also representative of the off-season. Key observations from a review of this data are:

- Approximately 50% of people chose not to access the beach, following review of the signage, information boards and information provided by Kaitiaki.
- It appears locals continued to access the beach. Around 25% to 50% of locals accessing the beach appeared to use vehicles.
- Increasing beach users are apparent from October 2019 data.
- The number of people discouraged from accessing the beach, who didn't go to Stanley's Point, is not known. No previous visitor data from earlier years are available for comparison. So, the overall reduction in visitor numbers would be somewhat more than 50%.

Table 9-1: Clifton Beach users – May to October 2019 (incomplete data)

Month	Accessed Beach		Did not Access Beach	
	Foot	Vehicle	Foot	Vehicle
May	69	23	71	0
June	55	37	64	3
July	92	44	34	2
August	52	49	55	0
September	81	55	42	1
October	114	68	113	6

Other key comments about the period of applied interim risk management:

- Beach closure was implemented twice. Once due to earthquake shaking (no landsliding reported) and once due to a large sea (some landsliding occurred).
- There was no 'landslide emergency', defined as a landslide occurring and directly impacting a beach user(s).
- There was one 'landslide incident', defined as a landslide occurring and resulting in a near-miss with a beach user(s).

9.3 Risk Reduction Obtained

It is very difficult to reliably quantify the risk reduction obtained by the applied interim risk management. Overall comments are:

- Should an individual access the beach while it is open, but not access the beach when it is closed, then the risk to an individual would be somewhat reduced.
- Should an individual continue to access the beach during a closure, then the risk to an individual remains largely unchanged even with the interim risk management in place. It is understood that the DOC commonly observe an 80% to 90% adherence to signage at their sites.
- The individual most at risk has been changed and this level of risk has likely been reduced. It is expected an employee of GBA was previously the individual most at risk, and they have not been operating.
- The societal risk has been significantly reduced, both due to less general public accessing the beach and as GBA has not been operating. The GBA operation is critical for societal risk.

Key limitations of the applied interim risk management are:

- The probability of landsliding is not reduced.
- The probability of spatial impact of a landslide on the beach, where beach users occupy, is not reduced.
- The vulnerability of a beach user in the event of being struck by a landslide is not reduced.
- Rockfalls control the risk to beach users and, as mentioned earlier, they can occur with little or no warning and are very rapid to extremely rapid, meaning evacuation may not be possible.
- Earthquakes are likely a key trigger of landslides, especially for rock avalanches. Yet, it is not known when they will occur and the risk cannot be significantly reduced by risk management. Other key landslide triggers are easier to 'manage' via closure, such as large seas causing erosion or heavy rainfall.
- The CKL showed no obvious trigger. So, the risk associated with non-obvious triggered landslides cannot be significantly reduced.

DOC reports a higher level of risk reduction than one order of magnitude at TNP with the applied control measures. The reasons for this risk reduction being higher than that anticipated at Clifton Beach is that the key hazards which control the risk at TNP are volcanic eruption and weather. These hazards could be argued to have much better warning indicators before occurrence than landsliding at Clifton Beach.

10. Risk Criteria and Context

As context for helping HDC and DOC in establishing tolerable risk criteria and decision-making:

- A balance is required to be achieved between protecting people from the hazard (and the decisions of others) and enabling them to live as they wish
- Beach users are undertaking a recreational activity in accessing the beach. They can choose whether to access the beach or not
- Employees having to access the beach as part of their employment duties also have some degree of choice
- Beach users decide if the risk of accessing the beach is worth the benefit gained (i.e. risk vs reward)
- 'Imposed risk', where people have no or little choice but to accept the risk and have limited control over it, is not a key consideration in this instance[11]
- By accessing the outdoors for recreational purposes, people inherently 'expect' and 'accept' some risk and probably more risk than 'normal'.

The key limitations of risk management until this point have been:

- Landslide hazard was not recognised, or if it was, was not reliably assessed
- If the risk was recognised, it was not being actively managed in an AS/NZ ISO 31000:2009 risk management framework
- Beach users could not make their own reliable, risk-informed decision about accessing the beach. They knew the reward but not the risk
- In some instances, individuals may have assumed that the risk was 'acceptable'. For example:
  - Tourists completing the Cape Kidnappers Walking Track may have assumed that if the walk is being promoted by the DOC, then the risk is 'acceptable'
  - Passengers of GBA may have as assumed that if the trips were being run, then the risk was 'acceptable'.

[11] There are some instances where this may be applicable, however. Such as the head of household deciding to access the beach, on behalf of their family.

11. Conclusions and Guidance

11.1 Conclusions

The key conclusions of this hazard assessment can be summarised as:

- A balance is required to be achieved between protecting people from the hazard (and the decisions of others) and enabling them to live as they wish.
- Beach users are undertaking a recreational activity in accessing the beach. They can choose whether to access the beach or not. They choose if the risk of accessing the beach is worth the reward. Until this point, the risk has not been reliably quantified.
- To this point, most beach users have probably not made a conscious risk-based decision about accessing the beach.
- By accessing the outdoors for recreational purposes, people inherently 'expect' and 'accept' some risk and probably more risk than 'normal'.
- Most tourists are expected to have a low awareness and tolerance of risk.
- Key conclusions for the parameters of the risk calculation are:
  - Probability of landsliding - is judged high, compared to most 'typical' sites. This is as the site comprises coastal cliffs, which are eroding. The potential source area for landslides is very large, due to the long length and height of the cliffs.
  - Spatial impact of landsliding – is judged high, compared to most 'typical' sites. This is as the cliffs are typically very high and steep, with the beach at the base of the cliffs.
  - Temporal spatial probability of beach users – as beach users are itinerant and spend a short time on the beach, their exposure is low. This is the key aspect that reduces the risk at the site.
  - Vulnerability of a beach user if struck – is judged high, compared to most 'typical' sites. This is as rockfalls travel fast and may hit beach users directly from above. Those in cars have the lowest vulnerability due to the protection provided, while those on trailers are between the two.
- An employee of GBA is likely the individual most at risk.
- The current risk management may reduce the risks, assuming they are implemented correctly.
- Evacuation in the event of landsliding is a key consideration. Many instances have occurred where beach users have evacuated away from a landslide so as not to be struck.

11.2 Possible Risk Management Approach

One possible approach to risk management could be in allowing beach users to access the beach should they wish. This could only be considered with risk management per AS/NZ ISO 31000:2009 risk management framework. Key aspects of which would be:

- The estimated risk is communicated to all beach users. It is contextualised against other everyday risks they can understand.
- Beach users make their own risk-informed decision whether accessing the beach for the benefit gained is worth the risk involved.
- Risks are managed with an ALARP approach, consistent with the Health and Safety at Work Act (2015) and other instances where societal risk is a key consideration.

The overall QRA has 'established the context' and is a 'risk assessment' as per the requirements of AS/NZ IS0 31000:2009 (Figure 11-1). A separate assessment is required if the above risk management philosophy is adopted, to confirm the requirements to address the other key areas of the AS/NZ IS0 31000:2009:

- 'Risk treatment'
- 'Monitoring and review'
- 'Communication and consultation'.

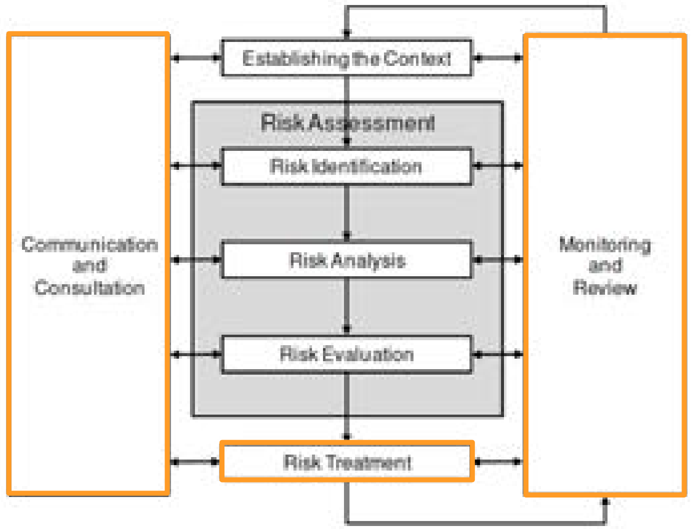


Figure 11-1: AS/NZ ISO 31000:2009 risk management framework

11.3 Hazard Assessment Review

This is the first landslide hazard assessment for Clifton Beach. It represents the starting point for landslide hazard risk analysis and management at Clifton Beach. A number of assumptions and simplifications have been made.

The findings of this hazard assessment should be reviewed on an annual basis, as more information is acquired to more reliably assign parameters for the risk calculation. Some key knowledge gaps which should be considered or future ideas for consideration are:

- More reliably defining the annual probability of landsliding by ongoing monitoring. The monitoring completed as part of this hazard assessment is a snapshot in time and may not be representative of medium to long term landsliding.
- Landslide triggers and causes.
- Areas of higher risk.
- Beach visitor numbers.
- The impacts of climate change and coastal processes.
- A better quantification of the risk reduction gained from any future applied risk management.

12. References

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13. Limitations

This report has been prepared for Hastings District Council and the Department of Conservation in accordance with the generally accepted practices and standards in use at the time it was prepared. Stantec accepts no liability to any third party who relies on this report.

The information contained in this report is accurate to the best of our knowledge at the time of issue. Stantec has made no independent verification of this information beyond the agreed scope set out in the report.

The interpretations as to the likely subsurface conditions contained in this report are based on the site observations and field investigations made at discrete locations as described in this report. The type, spacing and frequency of the investigations, sampling, and testing of materials were selected to meet the technical, financial and time requirements agreed by the client. Stantec accepts no liability for any unknown or adverse ground conditions that would have been identified had further investigations, sampling, and testing been undertaken.

Actual ground conditions encountered may vary from the predicted subsurface conditions. For example, subsurface groundwater conditions often change seasonally and over time. No warranty is expressed or implied that the actual conditions encountered will conform exactly to the conditions described herein.

Where conditions encountered at the site differ from those inferred in this report Stantec should be notified of such changes and should be given an opportunity to review the recommendations made in this report in light of any further information.

This report does not purport to describe all the site characteristics and properties. Subsurface conditions and testing relevant to construction works must be undertaken and assessed by any contractors as necessary for their own purposes.

Appendices

Appendix A Landslide Glossary (from AGS 2007)

Acceptable Risk – A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.

Annual Exceedance Probability (AEP) – The estimated probability that an event of specified magnitude will be exceeded in any year.

Consequence – The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.

Elements at Risk – The population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.

Frequency – A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.

Hazard – A condition with the potential for causing an undesirable consequence (the landslide). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.

Individual Risk to Life – The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.

Landslide Activity – The stage of development of a landslide; pre failure when the slope is strained throughout but is essentially intact; failure characterised by the formation of a continuous surface of rupture; post failure which includes movement from just after failure to when it essentially stops; and reactivation when the slope slides along one or several pre-existing surfaces of rupture. Reactivation may be occasional (e.g. seasonal) or continuous (in which case the slide is “active”).

Landslide Intensity – A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, kinetic energy per unit area.

Landslide Risk - The AGS Australian GeoGuide LR7 (AGS, 2007e) should be referred to for an explanation of Landslide Risk.

Landslide Susceptibility – The classification, and volume (or area) of landslides which exist or potentially may occur in an area or may travel or retrogress onto it. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding.

Likelihood – Used as a qualitative description of probability or frequency.

Probability – A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event.

There are two main interpretations:

(i) Statistical – frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It

includes also the idea of population variability. Such a number is called an “objective” or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

(ii) Subjective probability (degree of belief) – Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.

Qualitative Risk Analysis – An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.

Quantitative Risk Analysis – An analysis based on numerical values of the probability, vulnerability and consequences and resulting in a numerical value of the risk.

Risk – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.

Risk Analysis – The use of available information to estimate the risk to individual, population, property, or the environment, from hazards. Risk analyses generally contain the following steps: Scope definition, hazard identification and risk estimation.

Risk Assessment – The process of risk analysis and risk evaluation.

Risk Control or Risk Treatment – The process of decision making for managing risk and the implementation or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.

Risk Estimation – The process used to produce a measure of the level of health, property or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis and their integration.

Risk Evaluation – The stage at which values and judgments enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk Management – The complete process of risk assessment and risk control (or risk treatment).

Societal Risk – The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental and other losses.

Susceptibility – see Landslide Susceptibility

Temporal Spatial Probability – The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.

Tolerable Risk – A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.

Vulnerability – The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

Appendix B Landslide Classification (from AGS 2007)

APPENDIX B - LANDSLIDE TERMINOLOGY

The following provides a summary of landslide terminology which should (for uniformity of practice) be adopted when classifying and describing a landslide. It has been based on Cruden & Varnes (1996) and the reader is recommended to refer to the original documents for a more detailed discussion, other terminology and further examples of landslide types and processes.

Landslide

The term ***landslide*** denotes "the movement of a mass of rock, debris or earth down a slope". The phenomena described as landslides are not limited to either the "land" or to "sliding", and usage of the word has implied a much more extensive meaning than its component parts suggest. Ground subsidence and collapse are excluded.

Classification of Landslides

Landslide classification is based on Varnes (1978) system which has two terms: the first term describes the material type and the second term describes the type of movement.

The material types are ***Rock***, ***Earth*** and ***Debris***, being classified as follows:-

The material is either rock or soil.

Rock: is "a hard or firm mass that was intact and in its natural place before the initiation of movement."

Soil: is "an aggregate of solid particles, generally of minerals and rocks, that either was transported or was formed by the weathering of rock in place. Gases or liquids filling the pores of the soil form part of the soil."

Earth: "describes material in which 80% or more of the particles are smaller than 2 mm, the upper limit of sand sized particles."

Debris: "contains a significant proportion of coarse material; 20% to 80% of the particles are larger than 2 mm and the remainder are less than 2 mm."

The terms used should describe the displaced material in the landslide before it was displaced.

The types of movement describe how the landslide movement is distributed through the displaced mass. The five kinematically distinct types of movement are described in the sequence ***fall***, ***topple***, ***slide***, ***spread*** and ***flow***.

The following table shows how the two terms are combined to give the landslide type:

Table B1: Major types of landslides. Abbreviated version of Varnes' classification of slope movements (Varnes, 1978).

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly Coarse	Predominantly Fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (Deep creep)	Debris flow	Earth flow
			(Soil creep)	
COMPLEX	Combination of two or more principle types of movement			

Figure B1 gives schematics to illustrate the major types of landslide movement. Further information and photographs of landslides are available on the USGS website at http://landslides.usgs.gov.

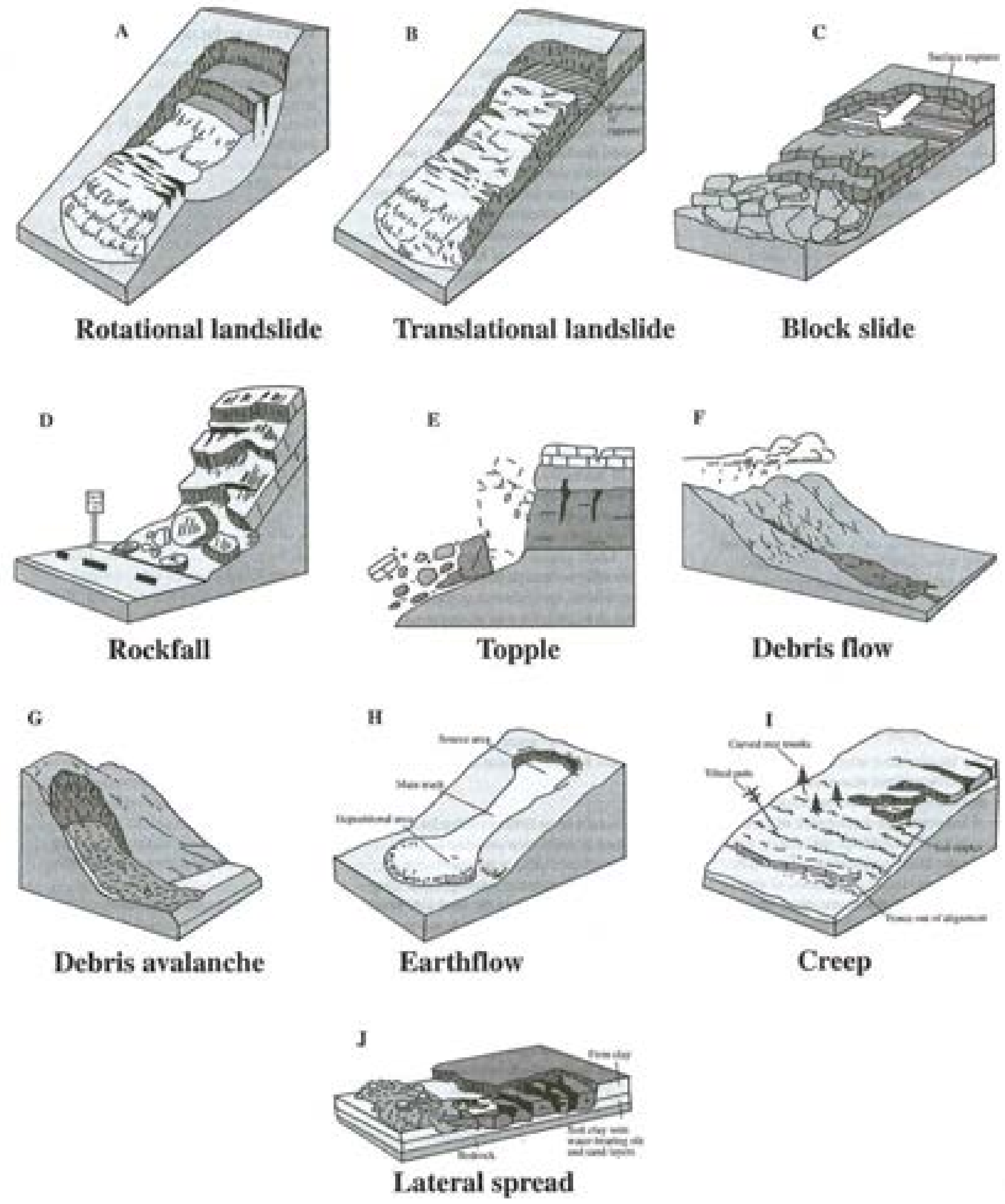

Figure B1: These schematics illustrate the major types of landslide movement.
(From US Geological Survey Fact Sheet 2004-3072, July 2004, with kind permission for reproduction.)

The nomenclature of a landslide can become more elaborate as more information about the movement becomes available. To build up the complete identification of the movement, descriptors are added in front of the two-term classification using a preferred sequence of terms. The suggested sequence provides a progressive narrowing of the focus of the descriptors, first by time and then by spatial location, beginning with a view of the whole landslide, continuing with parts of the movement and finally defining the materials involved. The recommended sequence, as shown in Table B2, describes activity (including state, distribution and style) followed by descriptions of all movements (including rate, water content, material and type). Definitions of the terms in Table B2 are given in Cruden & Varnes (1996).

Second or subsequent movements in complex or composite landslides can be described by repeating, as many times as necessary, the descriptors used in Table B2. Descriptors that are the same as those for the first movement may then be dropped from the name.

For example, the very large and rapid slope movement that occurred near the town of Frank, Alberta, Canada, in 1903 was a *complex, extremely rapid, dry rock fall – debris flow*. From the full name of this landslide at Frank, one would know that both the debris flow and the rock fall were extremely rapid and dry because no other descriptors are used for the debris flow.

The full name of the landslide need only be given once; subsequent references should then be to the initial material and type of movement; for the above example, "the rock fall" or "the Frank rock fall" for the landslide at Frank, Alberta.

Table B2: Glossary for forming names of landslides.

Activity

State	**Distribution**	**Style**
Active	Advancing	Complex
Reactivated	Retrogressive	Composite
Suspended	Widening	Multiple
Inactive	Enlarging	Successive
Dormant	Confined	Single
Abandoned	Diminishing	
Stabilised	Moving	
Relict		

Description of First Movement

Rate	**Water Content**	**Material**	**Type**
Extremely rapid	Dry	Rock	Fall
Very rapid	Moist	Earth	Topple
Rapid	Wet	Debris	Slide
Moderate	Very Wet		Spread
Slow			Flow
Very slow			
Extremely slow			

Note: Subsequent movements may be described by repeating the above descriptors as many times as necessary. These terms are described in more detail in Cruden & Varnes (1996) and examples are given.

Landslide Features

Varnes (1978, Figure 2.1t) provided an idealised diagram showing the features for a *complex earth slide – earth flow,* which has been reproduced here as Figure B2. Definitions of landslide dimensions are given in Cruden & Varnes (1996).

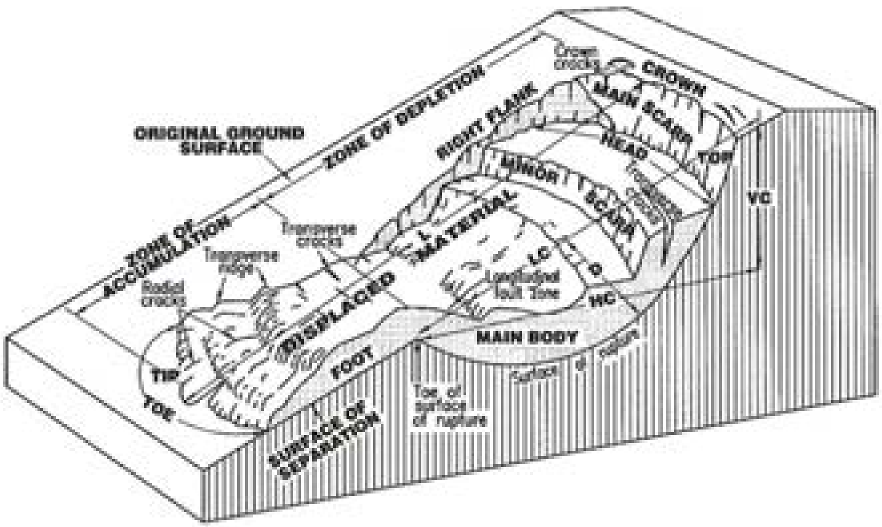

Figure B2: Block of Idealised Complex Earth Slide – Earth Flow

(*Varnes, D J (1978,)Slope Movement Types and Processes. In Special Report 176: Landslides: Analysis and Control(R L Schuster & R J Krizek, eds.), TRB, National Research Council, Washington, DC, pp.11-33).*

Rate of Movement
Figure B3 shows the velocity scale proposed by Cruden & Varnes (1996) which rationalises previous scales. The term "creep" has been omitted due to the many definitions and interpretations in the literature.

Velocity Class	Description	Velocity (mm/sec)	Typical Velocity	Probable Destructive Significance
7	Extremely Rapid			Catastrophe of major violence; buildings destroyed by impact of displaced material; many deaths; escape unlikely
		5×10^{3}	5 m/sec	
6	Very Rapid			Some lives lost; velocity too great to permit all persons to escape
		5×10^{1}	3 m/min	
5	Rapid			Escape evaluation possible; structures; possessions, and equipment destroyed
		5×10^{-1}	1.8 m/hr	
4	Moderate			Some temporary and insensitive structures can be temporarily maintained
		5×10^{-3}	13 m/month	
3	Slow			Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
		5×10^{-5}	1.6 m/year	
2	Very Slow			Some permanent structures undamaged by movement
		5×10^{-7}	15 mm/year	
	Extremely **SLOW**			Imperceptible without instruments; construction **POSSIBLE WITH PRECAUTIONS**

Figure B3: Proposed Landslide Velocity Scale and Probable Destructive Significance.

REFERENCES AND ACKNOWLEDGEMENT

Cruden, D.M., & Varnes, D.J. (1996), "Landslide Types and Processes", Ch.3 in "Landslides. Investigation and Mitigation", Eds Turner, A.K. and Schuster, R.L. Special Report 247, Transport Research Board, National Research Council, Washington D.C. Extracts reprinted above by kind permission of the authors and publishers. Copies of the publication can be obtained from "Transport Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington D.C. 20418, USA.

IAEG (International Association of Engineering Geology) Commission on Landslides, (1990). Suggested nomenclature for landslides, Bulletin IAEG, No. 41, pp.13-16.

Varnes, D.J. (1978). Slope Movement Types and Processes. In *Special Report 176: Landslides: Analysis and Control* (R.L. Schuster and R.J. Krizek, eds.), TRB, National Research Council, Washington, D.C., pp.11-33.

WP/WLI (International Geotechnical Societies' UNESCO Working Party on World Landslide Inventory) (1990). A suggested method for reporting a landslide. Bulletin IAEG, 41, pp.5-12

WP/WLI (International Geotechnical Societies' UNESCO Working Party on World Landslide Inventory) (1993). A suggested method for describing the activity of a landslide. Bulletin International Association of Engineering Geology, 47: 53-57.

WP/WLI (International Geotechnical Societies' UENSCO Working Party on World Landslide Inventory) (1994). Multilingual Glossary for Landslides, Bitech Press, Vancouver, in press.

Appendix C Drawings

Stantec

HASTINGS
DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

DRAWINGS INDEX

DWG No.	DRAWING TITLE
310203423-100-C000	COVER AND INDEX SHEET
310203423-100-C100	GENERAL ARRANGEMENT BEACH FRONT
310203423-100-C101	DETAILED PLAN 1 BEACH FRONT
310203423-100-C102	DETAILED PLAN 2 BEACH FRONT
310203423-100-C103	DETAILED PLAN 3 BEACH FRONT
310203423-100-C104	DETAILED PLAN 4 BEACH FRONT
310203423-100-C110	ELEVATION OF CLIFF FACES SHEET 1 OF 6
310203423-100-C111	ELEVATION OF CLIFF FACES SHEET 2 OF 6
310203423-100-C112	ELEVATION OF CLIFF FACES SHEET 3 OF 6
310203423-100-C113	ELEVATION OF CLIFF FACES SHEET 4 OF 6
310203423-100-C114	ELEVATION OF CLIFF FACES SHEET 5 OF 6
310203423-100-C115	ELEVATION OF CLIFF FACES SHEET 6 OF 6
310203423-100-C120	EXISTING CROSS SECTIONS - 0m TO 1000m
310203423-100-C121	EXISTING CROSS SECTIONS - 1250m TO 2250m
310203423-100-C122	EXISTING CROSS SECTIONS - 2500m TO 3250m
310203423-100-C123	EXISTING CROSS SECTIONS - 3500m TO 4250m
310203423-100-C124	EXISTING CROSS SECTIONS - 4500m TO 5250m
310203423-100-C125	EXISTING CROSS SECTIONS - 5500m TO 6250m
310203423-100-C126	EXISTING CROSS SECTIONS - 6500m TO 7750m
310203423-100-C127	EXISTING CROSS SECTIONS - 8000m TO 9250m
310203423-100-C128	EXISTING CROSS SECTIONS - 9500m TO 9750m
310203423-100-C130	LANDSLIDE PLAN SHEET 1 OF 4
310203423-100-C131	LANDSLIDE PLAN SHEET 2 OF 4
310203423-100-C132	LANDSLIDE PLAN SHEET 3 OF 4
310203423-100-C133	LANDSLIDE PLAN SHEET 4 OF 4

LOCALITY PLAN

WORKING PLOT

NOTES:

1. All levels are in terms of IT XX SO7407 BCRN (RL 2.2994m, NZVD) ; and all co-ordinates are in terms of. Hawkes Bay Circuit, IT XX SO 7407 BCRN - 801731.459mN, 426390.813mE.

2. The Contractor is responsible for the location and protection of all survey marks and their offset positions.

3. Pipes, cables and other utilities, foundations, levels, reference marks and other obstructions indicated on this drawing are based only on readily available record plans and other information. This information may not be complete, accurate nor up to date. Prior to carrying out any excavation or other physical work, Contractors shall obtain the latest information from utility providers and carry out detailed exploratory work, tracing, locating, protection and alterations as are required under NZS 3910 Clause 5.13.

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ORIGINAL SIZE A1

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REV	REVISIONS	DRN	CHK	APP	DATE
A	ISSUED FOR DISCUSSION	BN			21.08.19

SURVEYED	THE SURVEYING COMPANY LTD	MAR 19
DESIGNED		
DRAWN	B NIKOLAISON	AUG 19
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

GENERAL ARRANGEMENT
BEACH FRONT

Status Stamp: WORKING PLOT
Date Stamp: 21.08.19
Scales: 1 : 10000
Drawing No. 310203423-100-C100
Rev. A

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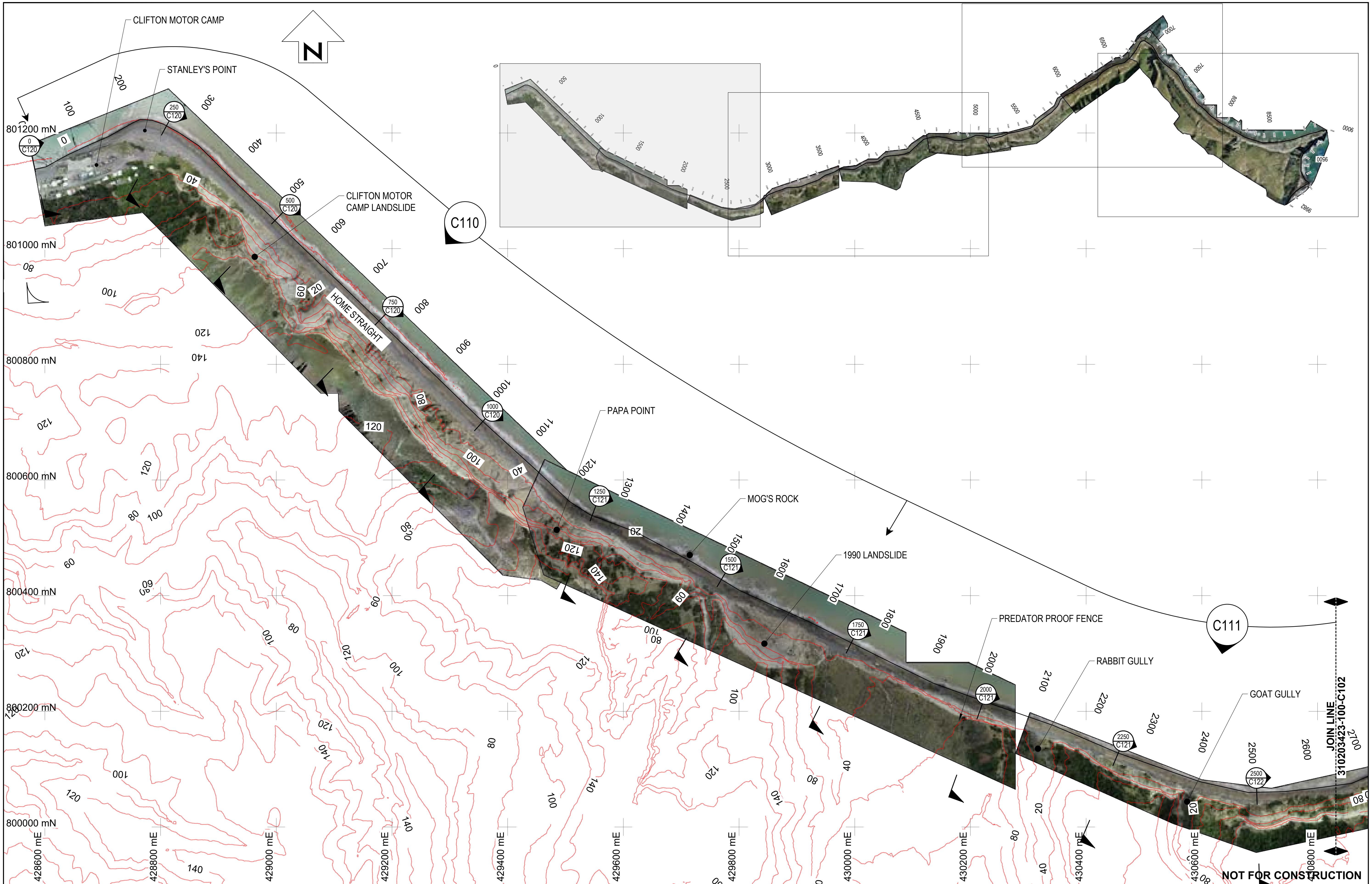

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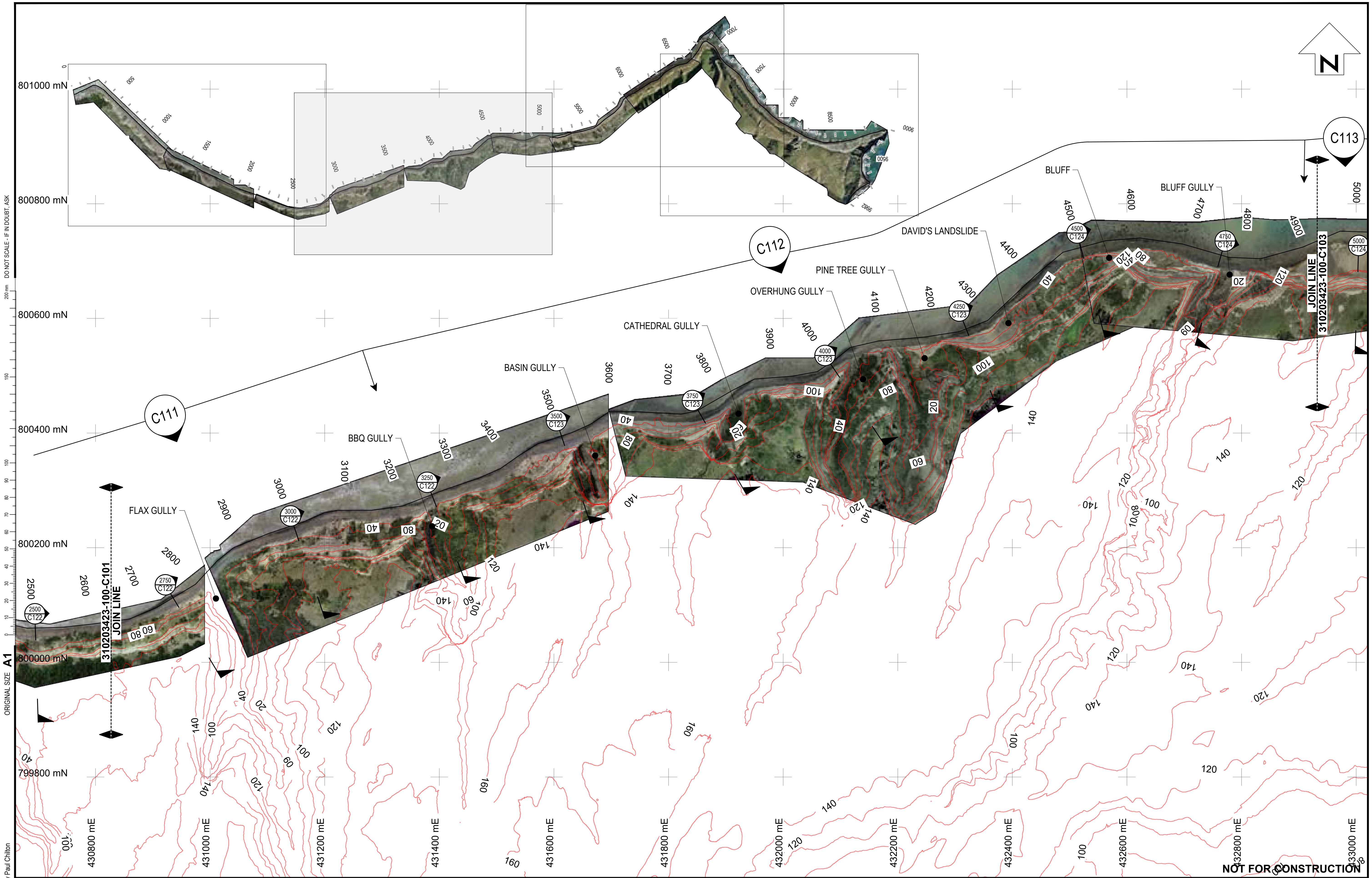
CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

DETAILED PLAN 1
BEACH FRONT

Status Stamp	WORKING PLOT
Date Stamp	21.08.19
Scales	1 : 3000
Drawing No.	310203423-100-C101
Rev.	A



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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

DETAILED PLAN 2
BEACH FRONT

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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

DETAILED PLAN 3
BEACH FRONT

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Drawing No.: 310203423-100-C103
Rev.: A

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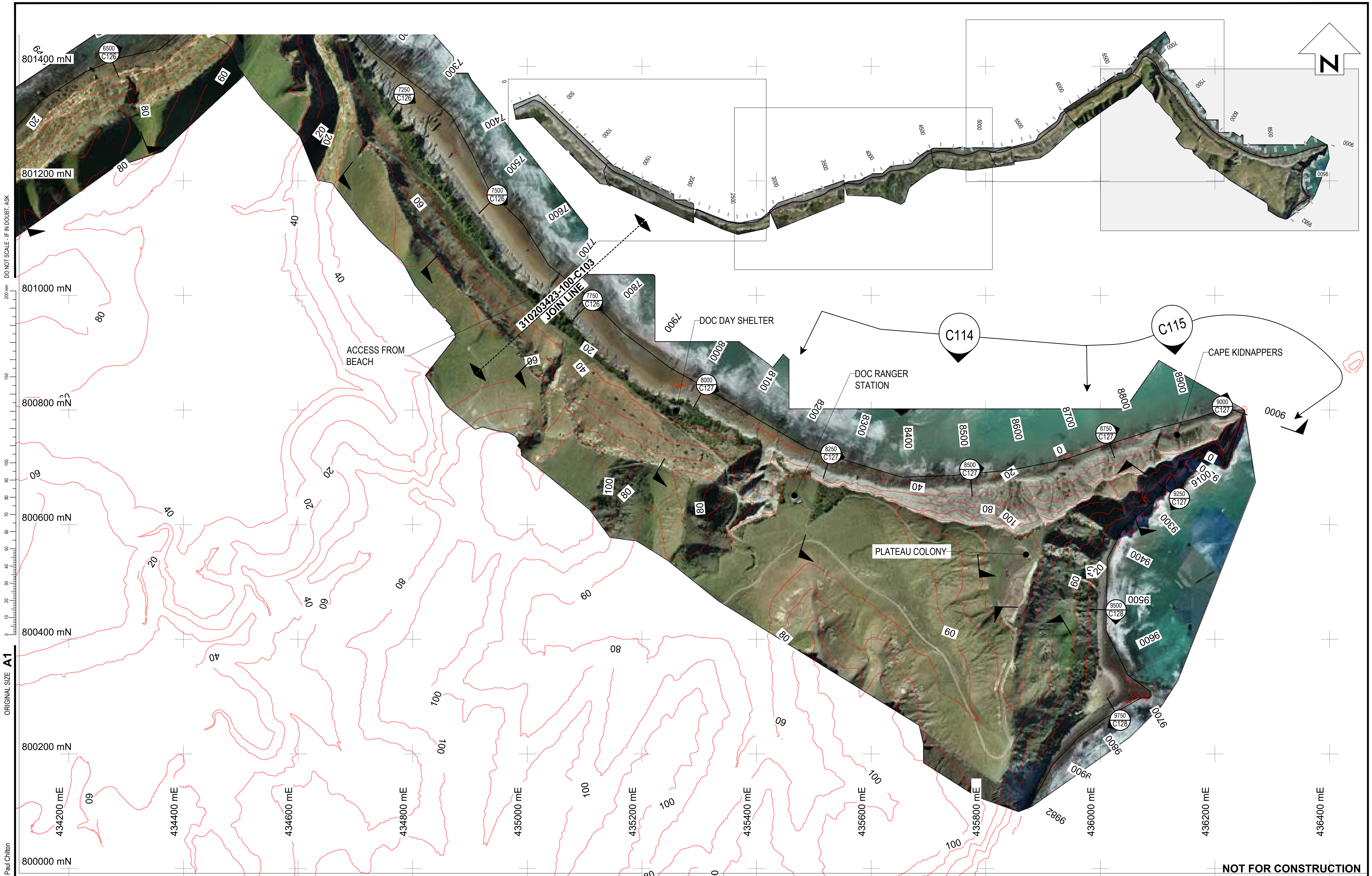

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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

DETAILED PLAN 4
BEACH FRONT

Status Stamp: WORKING PLOT

Date Stamp: 21.08.19

Scales: 1 : 3000

Drawing No.: 310203423-100-C104

Rev.: A

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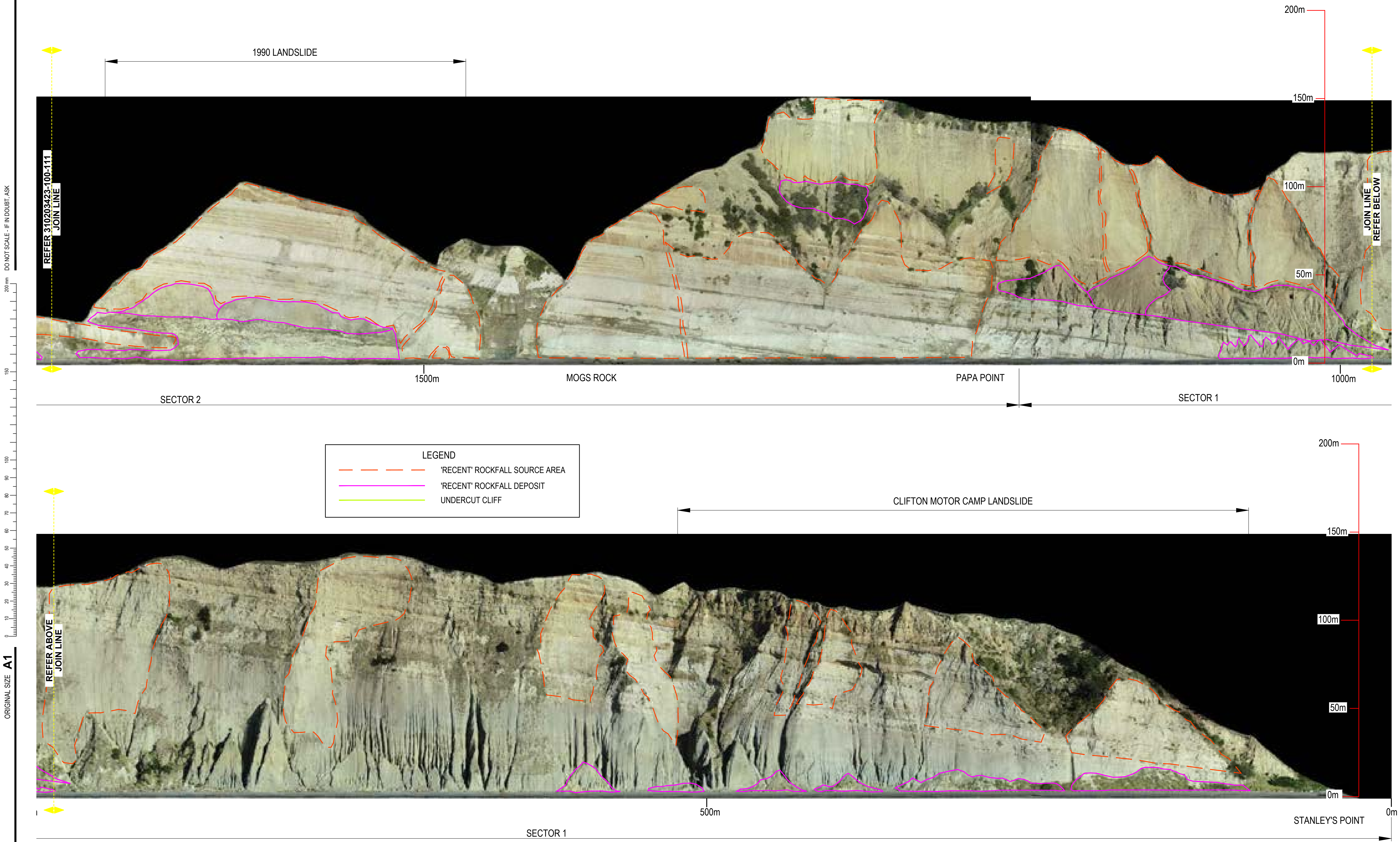

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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

ELEVATION OF CLIFF FACES
SHEET 1 OF 6

Status Stamp: **WORKING PLOT**

Date Stamp:

Scales: AS SHOWN @ A1

Drawing No. 310203423-100-C110

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LEGEND

- 'RECENT' ROCKFALL SOURCE AREA
- 'RECENT' ROCKFALL DEPOSIT
- UNDERCUT CLIFF

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ORIGINAL SIZE A1

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DESIGN CHECK		
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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

ELEVATION OF CLIFF FACES
SHEET 2 OF 6

Status Stamp: WORKING PLOT

Date Stamp:

Scales: AS SHOWN @ A1

Drawing No.: 310203423-100-C111

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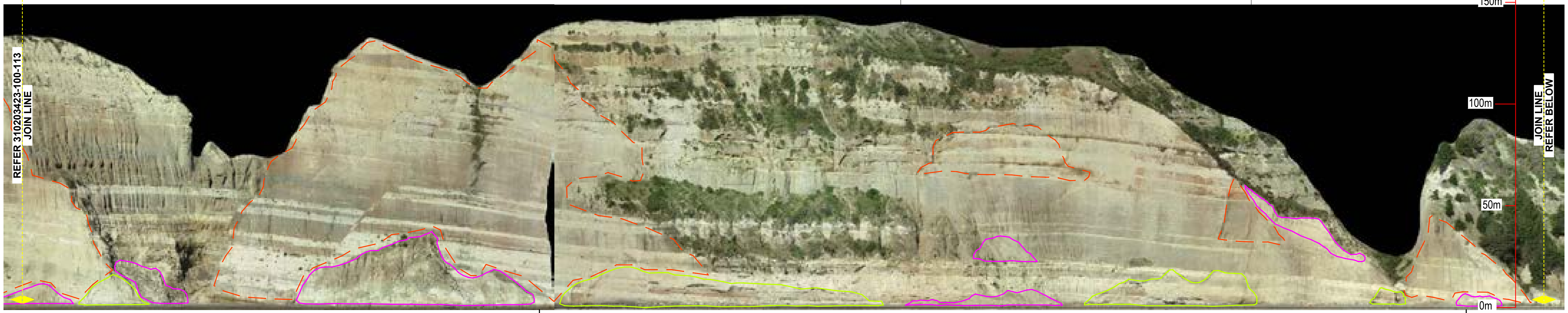
DAVID'S LANDSLIDE



BLUFF GULLY

SECTOR 6

4500m

BLUFF POINT

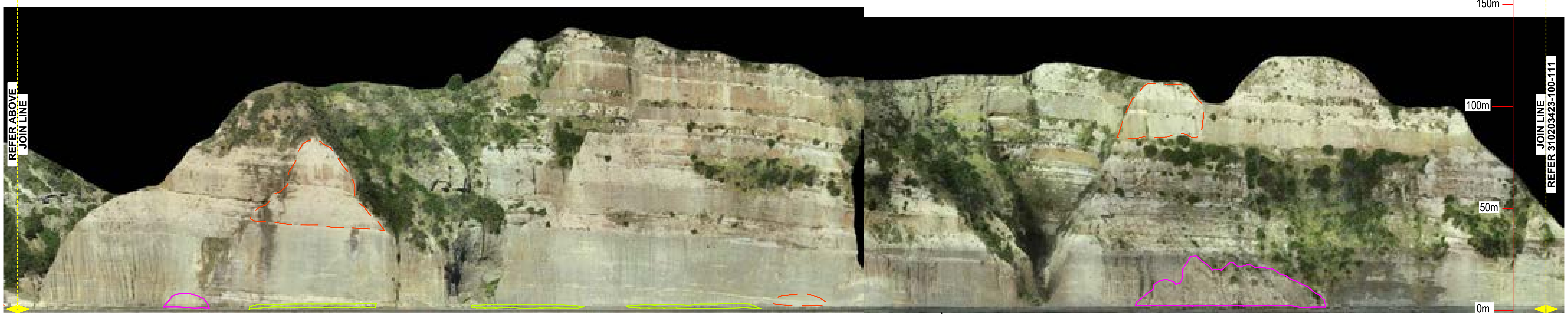
OVERHUNG GULLY

4000m

SECTOR 5

LEGEND

- 'RECENT' ROCKFALL SOURCE AREA
- 'RECENT' ROCKFALL DEPOSIT
- UNDERCUT CLIFF



PINE TREE GULLY

SECTOR 5

CATHEDRAL GULLY

3500m

BASIN GULLY

SECTOR 4

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ORIGINAL SIZE A1

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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

ELEVATION OF CLIFF FACES
SHEET 3 OF 6

Status Stamp: WORKING PLOT

Date Stamp

Scales: AS SHOWN @ A1

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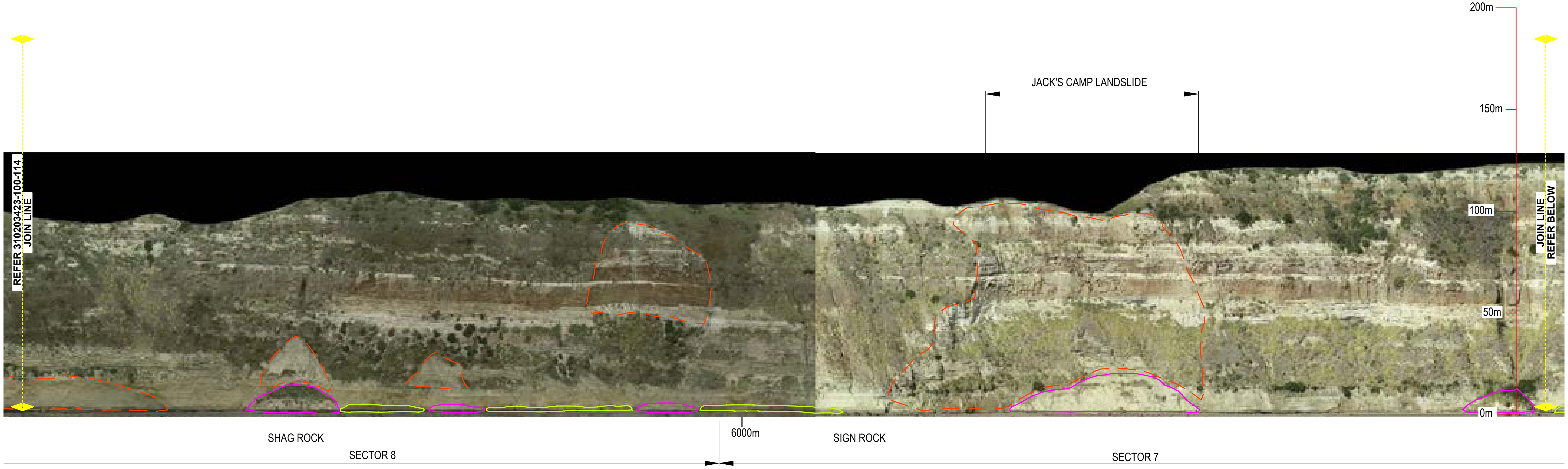
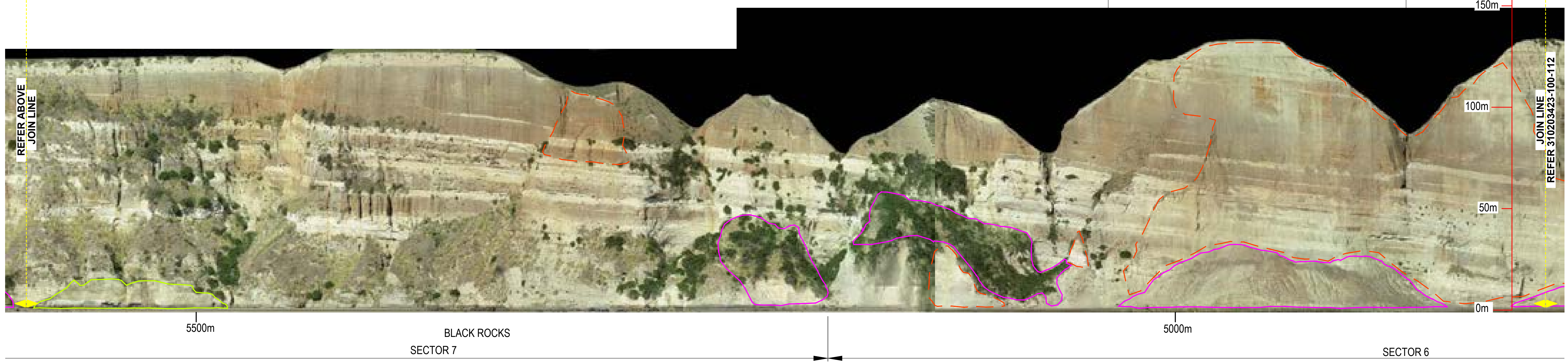


LEGEND

(orange dashed line)	'RECENT' ROCKFALL SOURCE AREA
(magenta line)	'RECENT' ROCKFALL DEPOSIT
(yellow-green line)	UNDERCUT CLIFF

200m

CAPE KIDNAPPERS LANDSLIDE



ORIGINAL SIZE A1

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APPROVED		
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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

ELEVATION OF CLIFF FACES
SHEET 4 0F 6

Status Stamp: WORKING PLOT

Date Stamp:

Scales: AS SHOWN @ A1

Drawing No. 310203423-100-C113

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LEGEND

- 'RECENT' ROCKFALL SOURCE AREA
- 'RECENT' ROCKFALL DEPOSIT
- UNDERCUT CLIFF

ORIGINAL SIZE A1

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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

ELEVATION OF CLIFF FACES
SHEET 5 0F 6

Status Stamp: WORKING PLOT

Date Stamp

Scales: AS SHOWN @ A1

Drawing No. 310203423-100-C114

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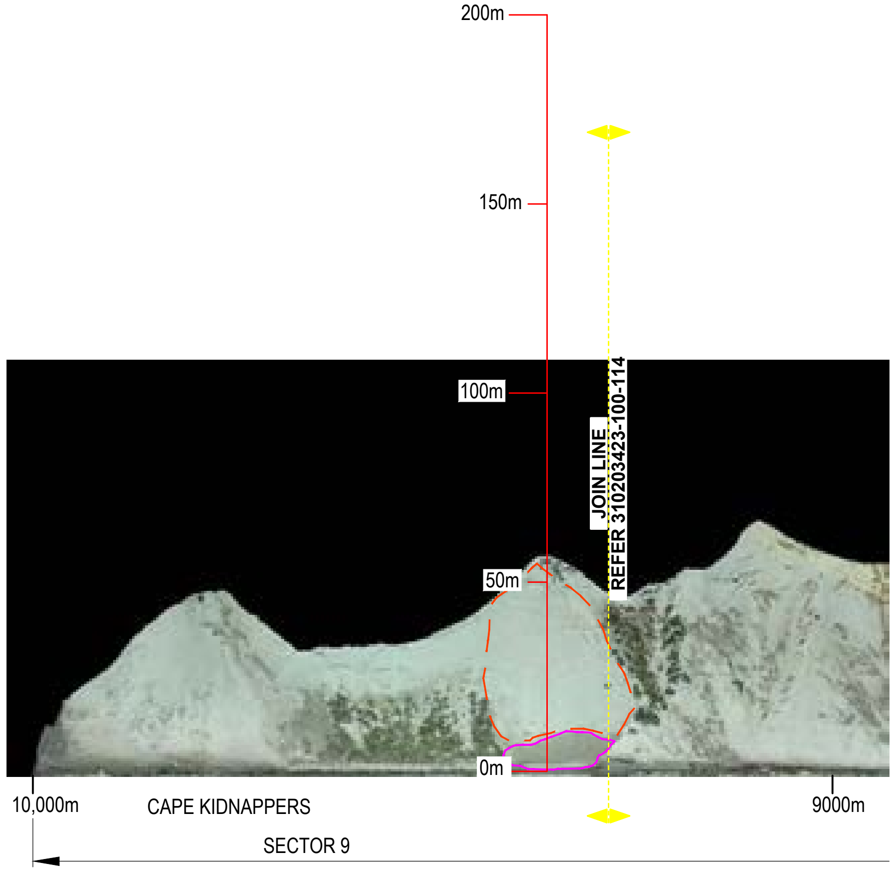
ORIGINAL SIZE A1

LEGEND

- 'RECENT' ROCKFALL SOURCE AREA
- 'RECENT' ROCKFALL DEPOSIT
- UNDERCUT CLIFF



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DESIGN REVIEW		
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CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

ELEVATION OF CLIFF FACES
SHEET 6 0F 6

Status Stamp: WORKING PLOT

Date Stamp:

Scales: AS SHOWN @ A1

Drawing No.: 310203423-100-C115

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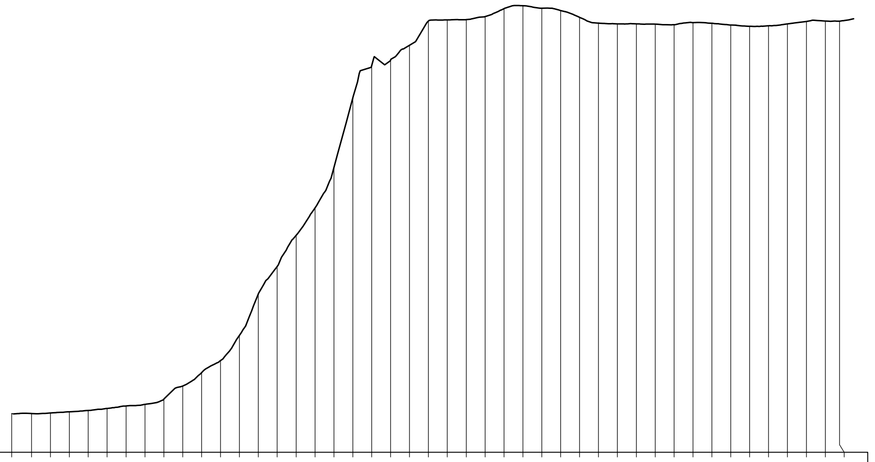
ORIGINAL SIZE A1



DATUM RL -10.500

OFFSET	EXISTING LEVEL
-20.262	-0.226
-15.000	-0.221
-10.000	-0.075
-5.000	0.242
0.000	0.597
5.000	1.133
10.000	1.774
15.000	2.198
20.000	3.582
25.000	7.077
30.000	10.618
35.000	13.799
40.000	20.496
45.000	31.452
50.000	38.767
55.000	46.957
60.000	54.245
65.000	64.979
70.000	83.435
75.000	91.942
80.000	93.396
85.000	97.294
90.000	103.734
95.000	104.024
100.000	104.105
105.000	104.918
110.000	107.000
115.000	107.789
120.000	107.138
125.000	106.484
130.000	104.693
135.000	103.175
140.000	102.977
145.000	102.990
150.000	102.913
155.000	102.768
160.000	103.329
165.000	103.132
170.000	102.662
175.000	102.331
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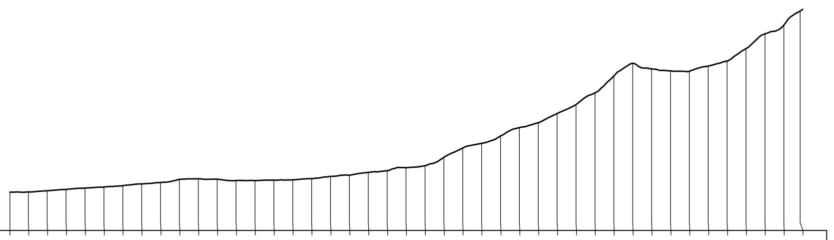
CHAINAGE 500.000



DATUM RL -10.500

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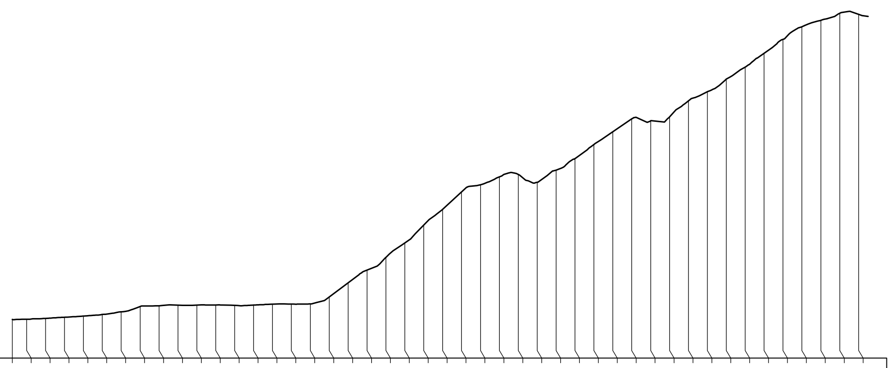
-5.000	-0.356
0.000	-0.024
5.000	0.326
10.000	0.683
15.000	0.933
20.000	1.315
25.000	1.784
30.000	2.148
35.000	2.977
40.000	3.105
45.000	3.009
50.000	2.658
55.000	2.647
60.000	2.762
65.000	2.857
70.000	3.149
75.000	3.768
80.000	4.044
85.000	4.810
90.000	5.255
95.000	6.033
100.000	6.585
105.000	8.785
110.000	11.234
115.000	12.472
120.000	14.424
125.000	16.632
130.000	17.926
135.000	20.348
140.000	22.707
145.000	25.790
150.000	30.245
155.000	33.618
160.000	32.137
165.000	31.599
170.000	31.542
175.000	32.878
180.000	34.233
185.000	37.505
190.000	41.375
195.000	43.717
199.336	47.385

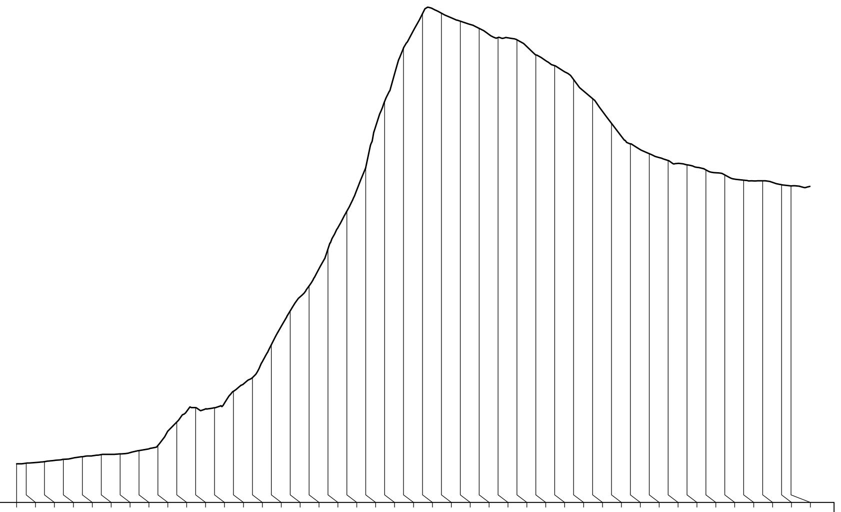
CHAINAGE 250.000



DATUM RL -10.500

OFFSET	EXISTING LEVEL
-23.818	-0.249
-20.000	-0.193
-15.000	0.032
-10.000	0.327
-5.000	0.647
0.000	1.064
5.000	1.773
10.000	3.162
15.000	3.367
20.000	3.546
25.000	3.558
30.000	3.569
35.000	3.472
40.000	3.551
45.000	3.800
50.000	3.810
55.000	3.866
60.000	5.699
65.000	9.457
70.000	12.823
75.000	16.212
80.000	20.002
85.000	24.747
90.000	28.906
95.000	33.526
100.000	35.408
105.000	37.504
110.000	38.154
115.000	36.092
120.000	39.306
125.000	42.351
130.000	46.094
135.000	49.492
140.000	52.897
145.000	52.363
150.000	53.407
155.000	57.669
160.000	60.068
165.000	63.437
170.000	66.576
175.000	70.250
180.000	73.945
185.000	77.302
190.000	79.006
195.000	80.856
200.000	80.566

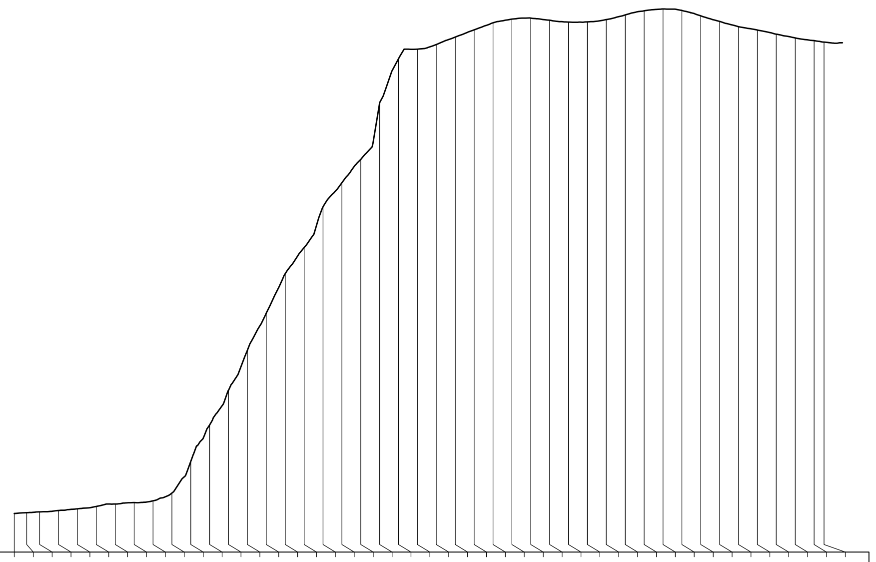
CHAINAGE 0.000



DATUM RL -10.000

OFFSET	EXISTING LEVEL
-7.372	0.209
-4.846	0.382
0.000	0.777
5.000	1.407
10.000	2.097
15.000	2.629
20.000	2.845
25.000	3.708
30.000	5.052
35.000	11.253
40.000	15.044
45.000	15.025
50.000	19.399
55.000	22.958
60.000	31.673
65.000	40.645
70.000	47.227
75.000	56.958
80.000	67.013
85.000	78.619
90.000	95.988
95.000	110.171
100.000	119.177
105.000	119.328
110.000	117.205
115.000	115.312
120.000	112.871
125.000	112.274
130.000	108.295
135.000	105.431
140.000	101.779
145.000	96.727
150.000	90.229
155.000	84.783
160.000	82.181
165.000	80.379
170.000	79.255
175.000	77.889
180.000	76.549
185.000	75.175
190.000	75.017
195.000	73.969
197.509	73.653

CHAINAGE 1000.000



DATUM RL -10.500

OFFSET	EXISTING LEVEL
-16.719	-0.296
-13.452	-0.089
-10.000	0.141
-5.000	0.499
0.000	0.958
5.000	1.566
10.000	2.203
15.000	2.582
20.000	3.050
25.000	5.126
30.000	13.455
35.000	23.148
40.000	32.316
45.000	42.917
50.000	52.683
55.000	63.097
60.000	69.990
65.000	80.724
70.000	87.159
75.000	93.325
80.000	108.297
85.000	119.900
90.000	122.445
95.000	123.692
100.000	125.643
105.000	127.547
110.000	129.421
115.000	130.393
120.000	130.641
125.000	130.085
130.000	129.596
135.000	129.665
140.000	130.259
145.000	131.492
150.000	132.579
155.000	133.065
160.000	132.674
165.000	131.268
170.000	129.787
175.000	128.388
180.000	127.516
185.000	126.425
190.000	125.434
195.000	124.700
197.634	124.319

CHAINAGE 750.000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE
A	WORKING PLOT	PAC			11/2019

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW		
APPROVED	NOT APPROVED	
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 0m TO 1000m

Status Stamp: **WORKING PLOT**

Date Stamp:

Scales: 1 : 1000 @ A1

Drawing No.: 310203423-100-C120

Rev.: A

Last modified: Nov 15 2019 By Paul Chilton

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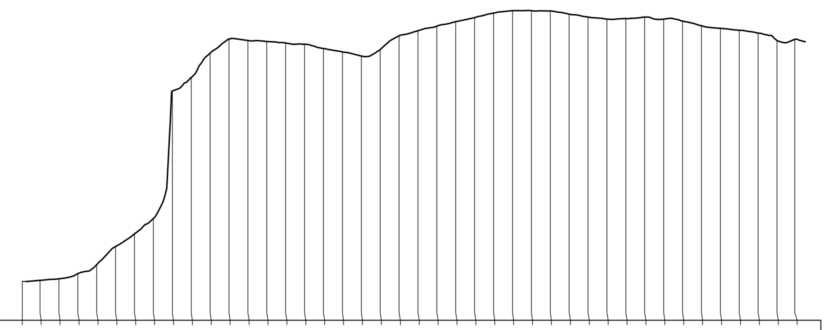
DATUM RL -9.500

OFFSET	EXISTING LEVEL
-13.283	0.715
-10.000	0.764
-5.000	0.775
0.000	0.888
5.000	1.170
10.000	1.619
15.000	2.378
20.000	3.693
25.000	3.567
30.000	11.089
35.000	27.308
40.000	32.480
45.000	33.936
50.000	37.596
55.000	43.559
60.000	49.774
65.000	62.532
70.000	67.813
75.000	70.906
80.000	72.459
85.000	75.182
90.000	78.375
95.000	81.319
100.000	85.100
105.000	88.059
110.000	91.034
115.000	94.674
120.000	97.095
125.000	99.231
130.000	101.206
135.000	100.719
140.000	97.241
145.000	99.685
150.000	101.388
155.000	101.361
160.000	101.817
165.000	104.696
170.000	107.298
175.000	110.536
180.000	115.206
185.000	118.792
190.000	118.175
195.000	118.106
199.682	119.013

CHAINAGE 1500.000

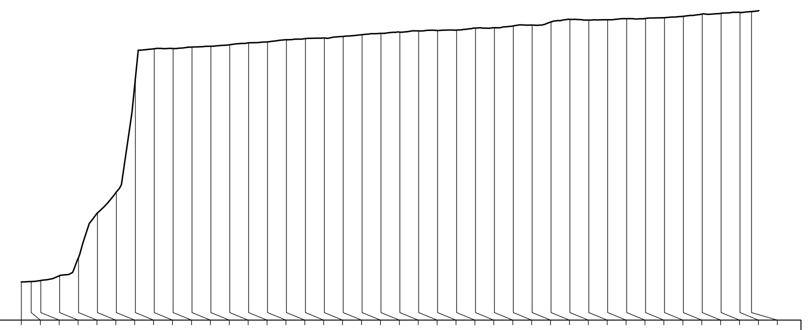
DATUM RL -9.750



OFFSET	EXISTING LEVEL
-4.679	0.524
0.000	0.807
5.000	1.209
10.000	2.564
15.000	4.911
20.000	9.771
25.000	13.091
30.000	17.161
35.000	50.862
40.000	54.419
45.000	60.919
50.000	64.690
55.000	64.268
60.000	63.978
65.000	63.599
70.000	63.255
75.000	62.137
80.000	61.226
85.000	60.158
90.000	61.864
95.000	65.510
100.000	66.851
105.000	68.051
110.000	69.259
115.000	70.328
120.000	71.503
125.000	72.133
130.000	72.161
135.000	72.058
140.000	71.236
145.000	70.463
150.000	69.915
155.000	70.084
160.000	70.475
165.000	69.933
170.000	69.387
175.000	68.157
180.000	67.489
185.000	66.986
190.000	66.213
195.000	64.250
199.697	64.605

CHAINAGE 2250.000

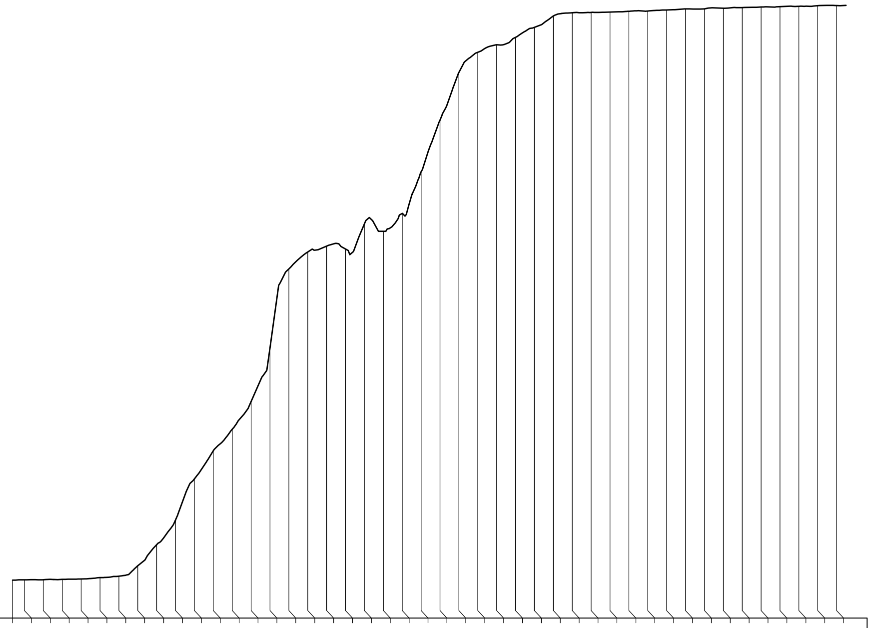
DATUM RL -9.500



OFFSET	EXISTING LEVEL
4.858	0.572
7.442	0.693
10.000	0.983
15.000	2.265
20.000	7.090
25.000	18.846
30.000	24.371
35.000	54.109
40.000	62.309
45.000	62.346
50.000	62.746
55.000	62.971
60.000	63.362
65.000	63.852
70.000	64.126
75.000	64.679
80.000	64.963
85.000	65.137
90.000	65.542
95.000	66.012
100.000	66.371
105.000	66.715
110.000	66.996
115.000	67.141
120.000	67.233
125.000	67.783
130.000	67.845
135.000	68.336
140.000	68.547
145.000	69.408
150.000	70.059
155.000	69.868
160.000	69.962
165.000	70.258
170.000	70.299
175.000	70.528
180.000	70.893
185.000	71.476
190.000	71.685
195.000	71.897
198.042	72.137

CHAINAGE 2000.000

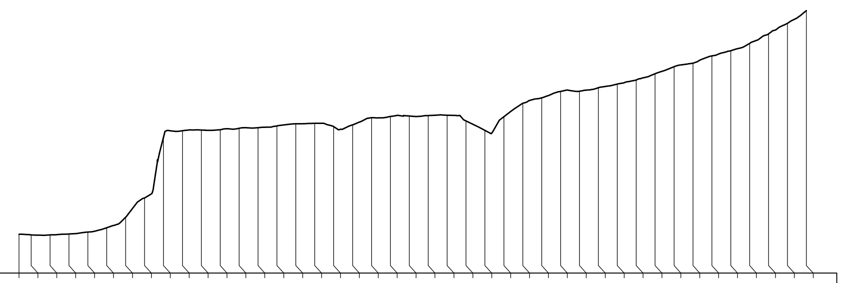
DATUM RL -9.500



OFFSET	EXISTING LEVEL
-18.159	0.562
-15.000	0.625
-10.000	0.655
-5.000	0.746
0.000	0.857
5.000	1.219
10.000	1.598
15.000	4.337
20.000	9.922
25.000	16.502
30.000	27.341
35.000	34.766
40.000	40.454
45.000	47.780
50.000	61.976
55.000	82.897
60.000	87.369
65.000	88.914
70.000	88.151
75.000	94.796
80.000	92.841
85.000	97.540
90.000	108.544
95.000	122.282
100.000	134.898
105.000	140.204
110.000	142.179
115.000	144.148
120.000	146.817
125.000	149.796
130.000	150.664
135.000	150.747
140.000	150.837
145.000	151.047
150.000	151.111
155.000	151.402
160.000	151.687
165.000	151.693
170.000	151.866
175.000	152.043
180.000	152.182
185.000	152.266
190.000	152.374
195.000	152.547
200.000	152.556

CHAINAGE 1250.000

DATUM RL -9.750



OFFSET	EXISTING LEVEL
-8.204	0.526
-5.000	0.367
0.000	0.365
5.000	0.595
10.000	1.108
15.000	2.247
20.000	5.029
25.000	10.111
30.000	26.247
35.000	27.911
40.000	28.106
45.000	28.174
50.000	28.551
55.000	28.738
60.000	29.214
65.000	29.757
70.000	29.881
75.000	29.006
80.000	29.485
85.000	31.372
90.000	31.688
95.000	31.816
100.000	31.937
105.000	32.016
110.000	30.513
115.000	28.016
120.000	31.606
125.000	35.179
130.000	36.610
135.000	38.333
140.000	38.384
145.000	39.297
150.000	40.259
155.000	41.356
160.000	42.994
165.000	44.844
170.000	45.769
175.000	47.718
180.000	49.093
185.000	51.053
190.000	53.570
195.000	56.338
200.000	59.707

CHAINAGE 1750.000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 1250m TO 2250m

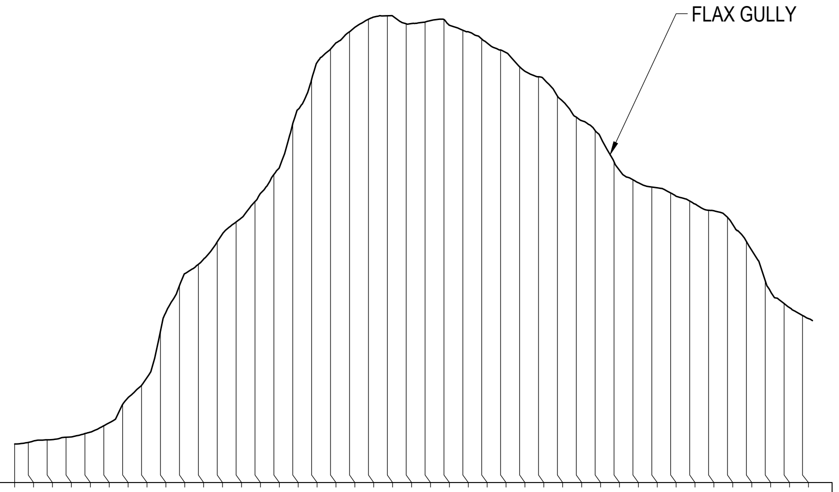
Status Stamp: **WORKING PLOT**

Date Stamp

Scales: 1 : 1000 @ A1

Drawing No.: 310203423-100-C121

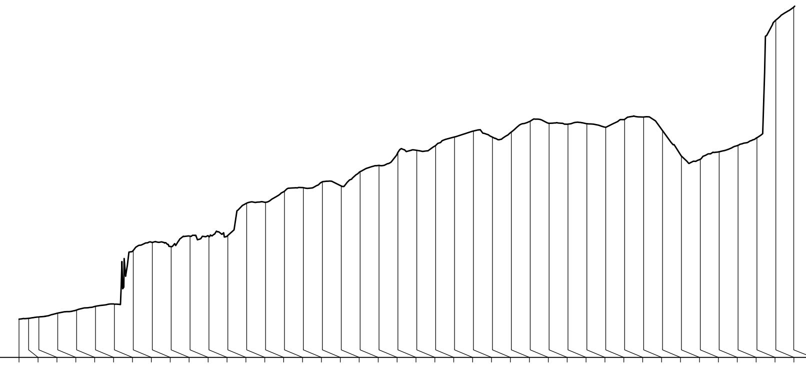
Rev.: A



DATUM RL -9.250

OFFSET	EXISTING LEVEL
-8.576	0.931
-5.000	1.337
0.000	2.037
5.000	2.734
10.000	3.704
15.000	5.757
20.000	11.465
25.000	16.462
30.000	30.885
35.000	42.825
40.000	48.481
45.000	54.404
50.000	59.675
55.000	65.104
60.000	72.245
65.000	85.810
70.000	97.468
75.000	105.414
80.000	110.002
85.000	113.304
90.000	114.214
95.000	112.112
100.000	112.590
105.000	113.241
110.000	110.416
115.000	108.088
120.000	105.186
125.000	100.724
130.000	98.079
135.000	93.003
140.000	87.438
145.000	83.838
150.000	75.615
155.000	70.846
160.000	68.933
165.000	67.351
170.000	65.237
175.000	62.775
180.000	60.933
185.000	54.535
190.000	44.187
195.000	38.103
199.868	34.932

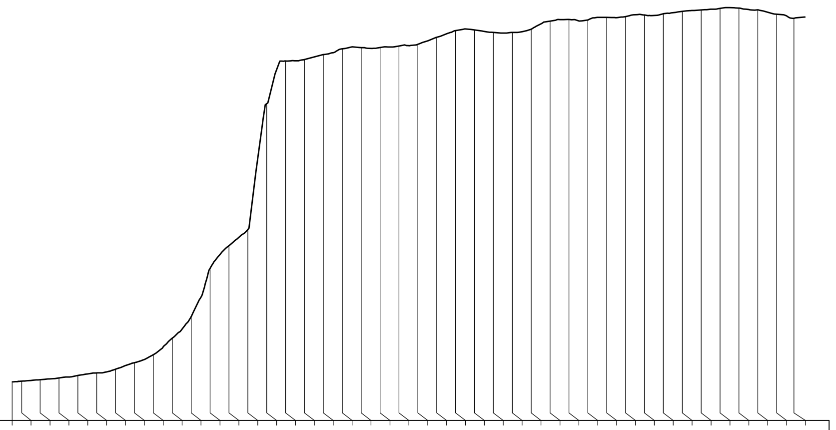
CHAINAGE 2750.000



DATUM RL -9.500

OFFSET	EXISTING LEVEL
-5.226	0.634
-2.717	0.847
0.000	1.202
5.000	2.221
10.000	3.039
15.000	4.035
20.000	4.591
25.000	18.838
30.000	20.886
35.000	19.809
40.000	22.580
45.000	22.426
50.000	22.781
55.000	31.301
60.000	31.532
65.000	34.507
70.000	35.398
75.000	36.938
80.000	35.872
85.000	39.627
90.000	41.291
95.000	44.747
100.000	45.278
105.000	46.578
110.000	48.828
115.000	50.407
120.000	48.785
125.000	50.118
130.000	53.012
135.000	52.446
140.000	52.216
145.000	52.336
150.000	51.386
155.000	53.462
160.000	54.087
165.000	50.499
170.000	43.783
175.000	42.923
180.000	44.910
185.000	46.613
190.000	48.642
195.000	79.751
199.731	83.167

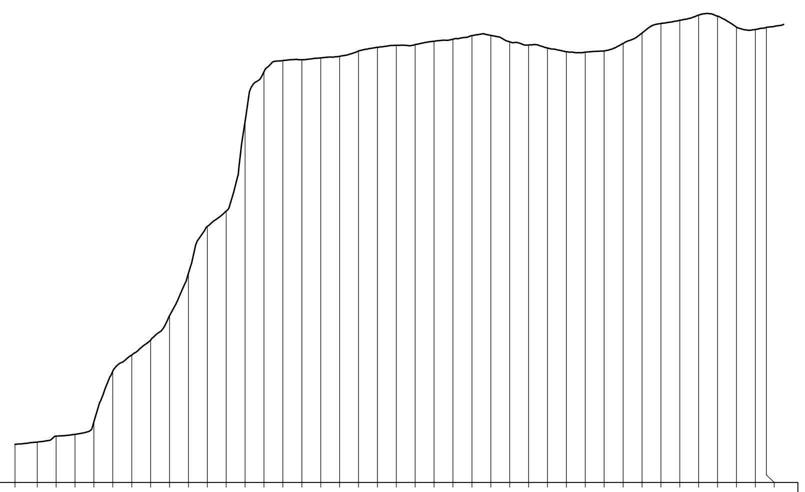
CHAINAGE 3250.000



DATUM RL -9.500

OFFSET	EXISTING LEVEL
-7.383	0.700
-4.855	0.891
0.000	1.282
5.000	1.732
10.000	2.375
15.000	3.053
20.000	4.054
25.000	5.772
30.000	7.876
35.000	12.259
40.000	17.917
45.000	30.708
50.000	36.688
55.000	40.956
60.000	74.215
65.000	85.465
70.000	85.895
75.000	87.171
80.000	88.710
85.000	89.020
90.000	89.049
95.000	89.439
100.000	89.883
105.000	91.741
110.000	93.534
115.000	93.681
120.000	93.034
125.000	93.030
130.000	93.862
135.000	96.000
140.000	96.466
145.000	96.333
150.000	97.028
155.000	97.222
160.000	97.662
165.000	97.965
170.000	98.580
175.000	98.953
180.000	99.379
185.000	99.463
190.000	98.983
195.000	97.833
199.547	96.746

CHAINAGE 2500.000



DATUM RL -9.500

OFFSET	EXISTING LEVEL
-0.876	0.567
5.000	1.156
10.000	2.739
15.000	3.220
20.000	6.545
25.000	19.948
30.000	24.196
35.000	28.111
40.000	34.564
45.000	45.767
50.000	58.158
55.000	62.220
60.000	86.010
65.000	99.036
70.000	101.995
75.000	102.223
80.000	102.698
85.000	103.123
90.000	104.530
95.000	105.523
100.000	106.016
105.000	106.212
110.000	107.114
115.000	107.636
120.000	108.588
125.000	108.655
130.000	106.946
135.000	106.107
140.000	105.316
145.000	104.331
150.000	104.211
155.000	104.547
160.000	106.507
165.000	109.276
170.000	111.779
175.000	112.636
180.000	114.011
185.000	113.737
190.000	110.823
195.000	110.198
197.907	110.760

CHAINAGE 3000.000

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

Last modified: Nov 15 2019 By Paul Chilton

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 2500m TO 3250m

Status Stamp: **WORKING PLOT**

Date Stamp

Scales: 1 : 1000 @ A1

Drawing No. 310203423-100-C122

Rev. A

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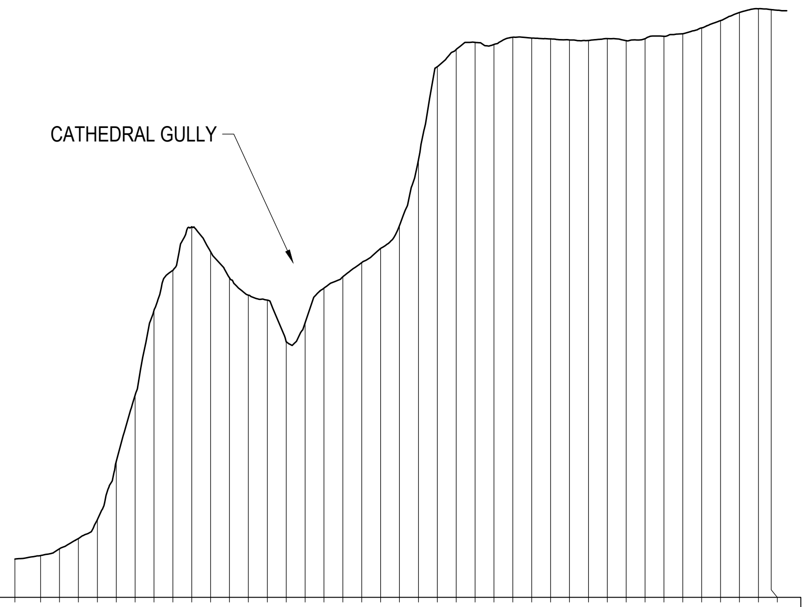
DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1



DATUM RL -8.750

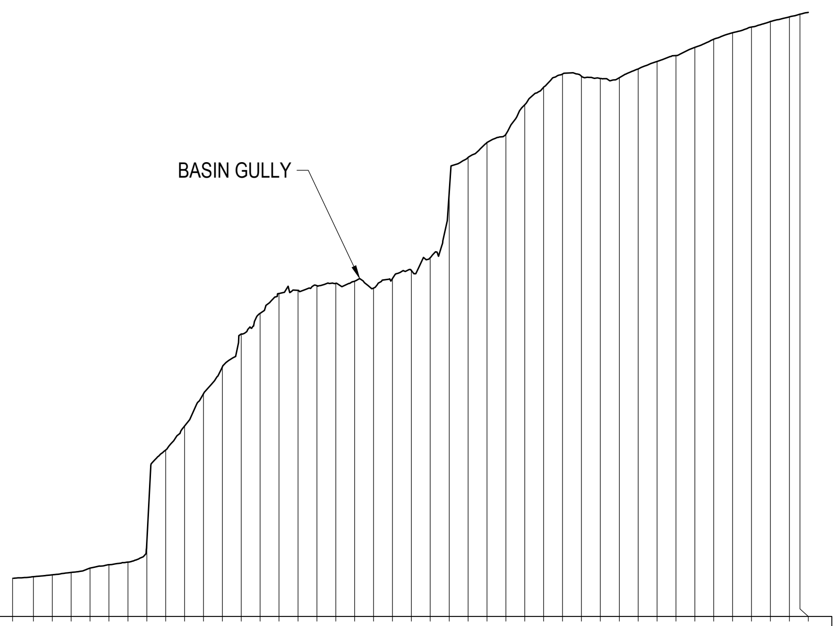
EXISTING LEVEL	OFFSET
1.364	-1.828
2.318	5.000
4.105	10.000
6.825	15.000
11.808	20.000
27.237	25.000
44.738	30.000
67.096	35.000
77.798	40.000
89.275	45.000
82.650	50.000
75.779	55.000
71.203	60.000
69.894	65.000
58.928	70.000
63.875	75.000
73.073	80.000
76.044	85.000
79.814	90.000
83.564	95.000
89.646	100.000
106.975	105.000
131.655	110.000
136.199	115.000
138.059	120.000
137.513	125.000
139.421	130.000
139.218	135.000
138.991	140.000
138.729	145.000
138.563	150.000
139.051	155.000
138.530	160.000
139.037	165.000
139.688	170.000
140.338	175.000
141.900	180.000
143.833	185.000
145.971	190.000
146.971	195.000
146.732	198.420

CHAINAGE 3750.000

DATUM RL -9.500

EXISTING LEVEL	OFFSET
0.701	-15.543
1.029	-12.845
1.508	-10.000
2.184	-5.000
2.101	0.000
2.361	5.000
2.794	10.000
19.091	15.000
24.218	20.000
33.323	25.000
46.643	30.000
85.474	35.000
97.352	40.000
97.945	45.000
98.159	50.000
99.738	55.000
100.374	60.000
101.490	65.000
102.076	70.000
105.693	75.000
110.210	80.000
113.481	85.000
115.483	90.000
116.917	95.000
121.640	100.000
128.564	105.000
134.185	110.000
137.247	115.000
138.810	120.000
139.353	125.000
141.517	130.000
144.460	135.000
144.773	140.000
145.246	145.000
145.395	150.000
145.688	155.000
145.822	160.000
145.760	165.000
145.428	170.000
144.518	175.000
143.575	180.000
143.085	185.000
140.813	190.000
139.610	195.000
138.783	198.478

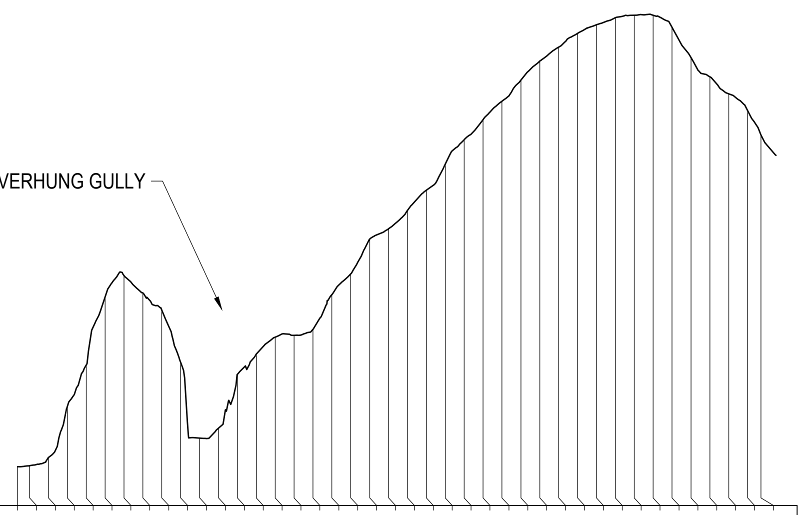
CHAINAGE 4250.000



DATUM RL -9.500

EXISTING LEVEL	OFFSET
0.611	-10.502
1.012	-5.000
1.494	0.000
2.151	5.000
3.277	10.000
4.183	15.000
4.859	20.000
9.603	25.000
34.489	30.000
40.833	35.000
49.351	40.000
56.478	45.000
65.167	50.000
70.645	55.000
75.860	60.000
76.709	65.000
77.934	70.000
78.552	75.000
79.107	80.000
77.314	85.000
79.819	90.000
81.949	95.000
85.357	100.000
102.388	105.000
111.816	110.000
115.768	115.000
117.967	120.000
125.759	125.000
130.368	130.000
133.899	135.000
133.301	140.000
132.702	145.000
132.886	150.000
135.219	155.000
137.199	160.000
138.763	165.000
140.922	170.000
143.076	175.000
144.802	180.000
146.302	185.000
147.759	190.000
148.991	195.000
149.694	197.828

CHAINAGE 3500.000



DATUM RL -9.500

EXISTING LEVEL	OFFSET
0.740	1.829
1.014	5.000
3.179	10.000
16.726	15.000
27.665	20.000
45.685	25.000
51.321	30.000
46.733	35.000
42.170	40.000
28.367	45.000
8.310	50.000
10.969	55.000
25.193	60.000
30.570	65.000
35.023	70.000
35.486	75.000
37.124	80.000
46.295	85.000
51.775	90.000
60.962	95.000
63.709	100.000
68.552	105.000
73.878	110.000
80.815	115.000
87.247	120.000
92.580	125.000
97.457	130.000
102.990	135.000
108.036	140.000
111.749	145.000
115.385	150.000
117.658	155.000
119.519	160.000
120.191	165.000
120.199	170.000
116.991	175.000
108.992	180.000
103.891	185.000
99.404	190.000
94.924	195.000
88.491	198.507

CHAINAGE 4000.000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 3500m TO 4250m

Status Stamp: WORKING PLOT

Date Stamp:

Scales: 1 : 1000 @ A1

Drawing No. 310203423-100-C123

Rev. A

Last modified: Nov 15 2019 By Paul Chilton

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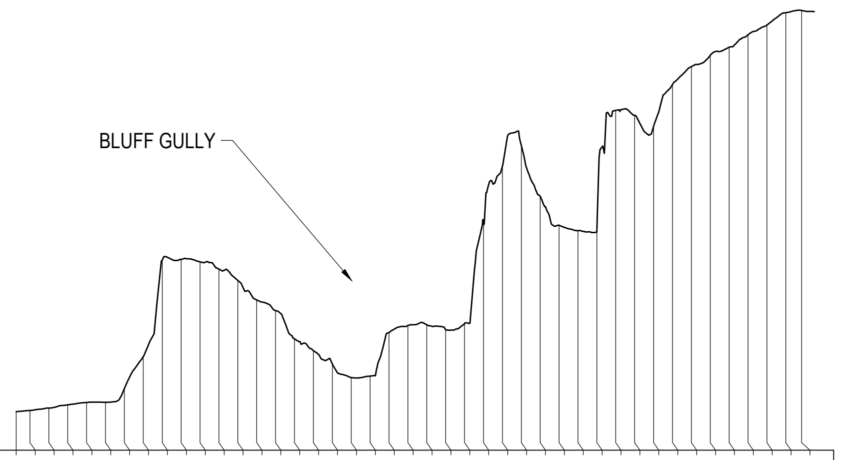
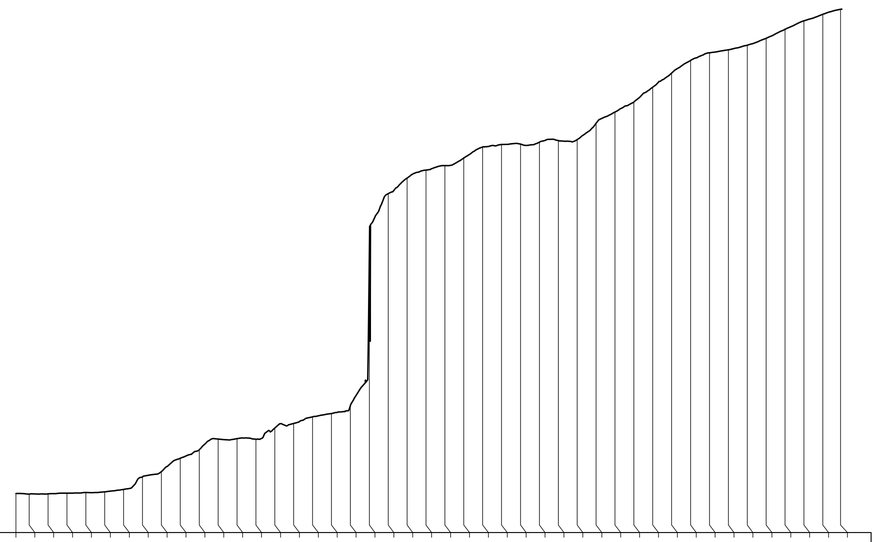


DATUM RL -9.500

EXISTING LEVEL	0.708	1.002	1.639	2.480	3.107	3.156	6.828	15.220	40.710	40.909	40.280	38.361	35.378	30.207	27.377	19.945	16.801	13.335	9.717	10.079	21.589	23.456	23.640	22.311	23.983	50.892	65.496	71.041	57.569	49.952	48.521	48.139	80.302	78.961	76.080	87.161	91.887	94.840	96.998	100.285	102.846	106.118	106.716
OFFSET	-8.609	-5.000	0.000	5.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	155.000	160.000	165.000	170.000	175.000	180.000	185.000	190.000	195.000	199.187

CHAINAGE 4750.000



DATUM RL -10.000

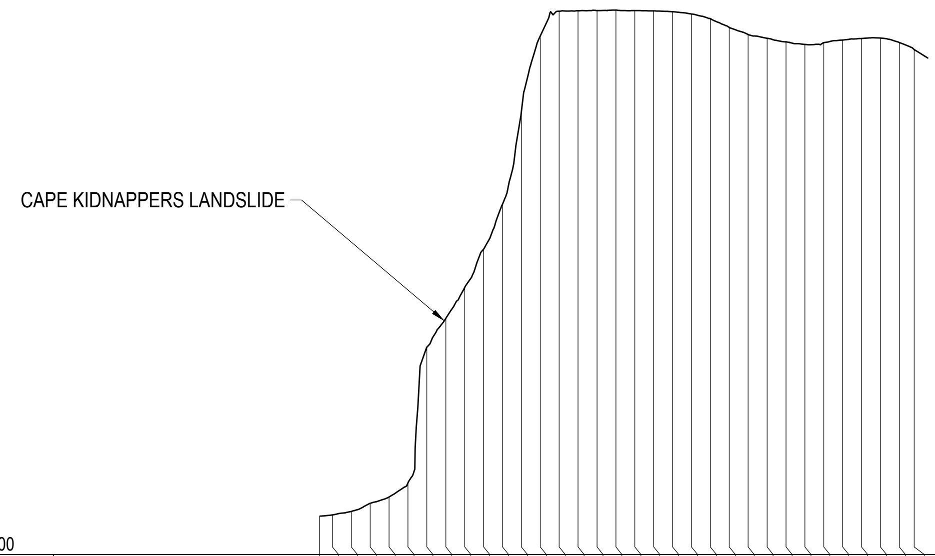
EXISTING LEVEL	0.316	0.180	0.246	0.419	0.578	0.768	1.415	4.760	6.102	9.649	11.866	14.721	14.817	14.638	17.637	18.857	20.602	21.465	23.540	62.817	79.573	83.686	85.789	86.996	88.982	91.924	92.554	92.671	93.190	93.630	93.866	98.153	101.134	103.806	107.715	111.449	114.797	116.811	117.597	118.813	120.649	123.036	125.265	126.981	128.306
OFFSET	-18.496	-15.000	-10.000	-5.000	0.000	5.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	155.000	160.000	165.000	170.000	175.000	180.000	185.000	190.000	195.000	199.675

CHAINAGE 5250.000

DATUM RL -9.750

EXISTING LEVEL	0.529	0.500	0.844	2.277	6.329	10.854	32.726	43.221	48.953	51.263	53.431	57.199	61.343	68.135	75.809	94.934	104.272	109.452	115.703	126.745	139.021	141.806	140.394	138.835	137.286	136.010	134.079	132.323	129.881	127.866	126.921	126.148	124.775	122.566	121.045	119.470	118.951	119.443	121.914	124.446	127.173	128.969	130.130
OFFSET	-8.245	-5.000	0.000	5.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	155.000	160.000	165.000	170.000	175.000	180.000	185.000	190.000	195.000	198.573

CHAINAGE 4500.000



DATUM RL -9.500

EXISTING LEVEL	0.669	0.974	1.873	4.044	5.735	9.451	45.386	53.004	61.202	71.359	83.237	107.802	127.760	134.336	134.471	134.506	134.638	134.503	134.418	134.215	133.609	132.349	130.063	128.159	127.173	126.236	125.555	126.012	126.714	127.116	127.236	126.047	124.194
OFFSET	41.602	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	155.000	160.000	165.000	170.000	175.000	180.000	185.000	190.000	195.000	198.931

CHAINAGE 5000.000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 4500m TO 5250m

Status Stamp: WORKING PLOT

Date Stamp:

Scales: 1 : 1000 @ A1

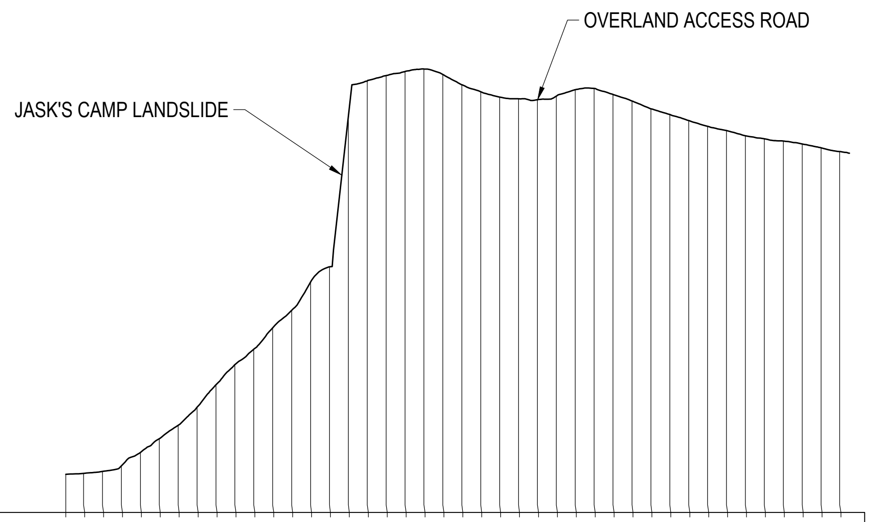
Drawing No. 310203423-100-C124

Rev. A

Last modified: Nov 15 2019 By Paul Chilton

DO NOT SCALE - IF IN DOUBT, ASK

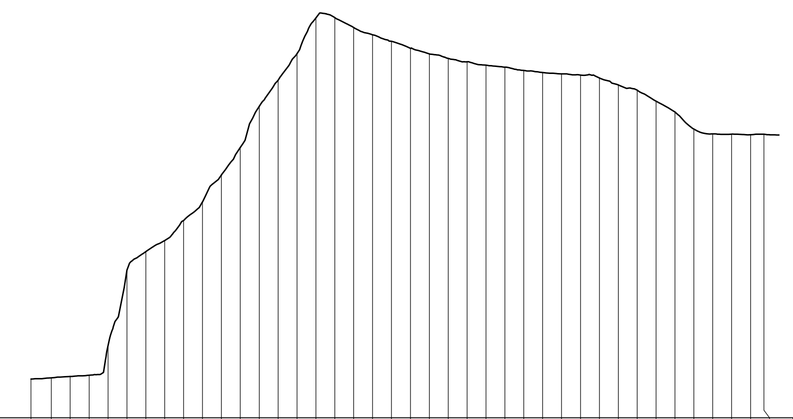
ORIGINAL SIZE A1



DATUM RL -9.500

OFFSET	EXISTING LEVEL
-4.721	0.572
0.000	0.826
5.000	1.346
10.000	2.833
15.000	6.331
20.000	9.964
25.000	13.499
30.000	18.284
35.000	24.247
40.000	29.556
45.000	33.635
50.000	39.281
55.000	43.912
60.000	51.344
65.000	55.394
70.000	94.984
75.000	104.552
80.000	105.970
85.000	107.037
90.000	107.669
95.000	106.242
100.000	103.538
105.000	101.675
110.000	100.268
115.000	99.811
120.000	99.583
125.000	100.538
130.000	102.212
135.000	102.565
140.000	100.950
145.000	99.254
150.000	97.182
155.000	95.666
160.000	94.063
165.000	92.548
170.000	91.417
175.000	90.034
180.000	89.256
185.000	88.646
190.000	87.871
195.000	86.853
199.934	85.849

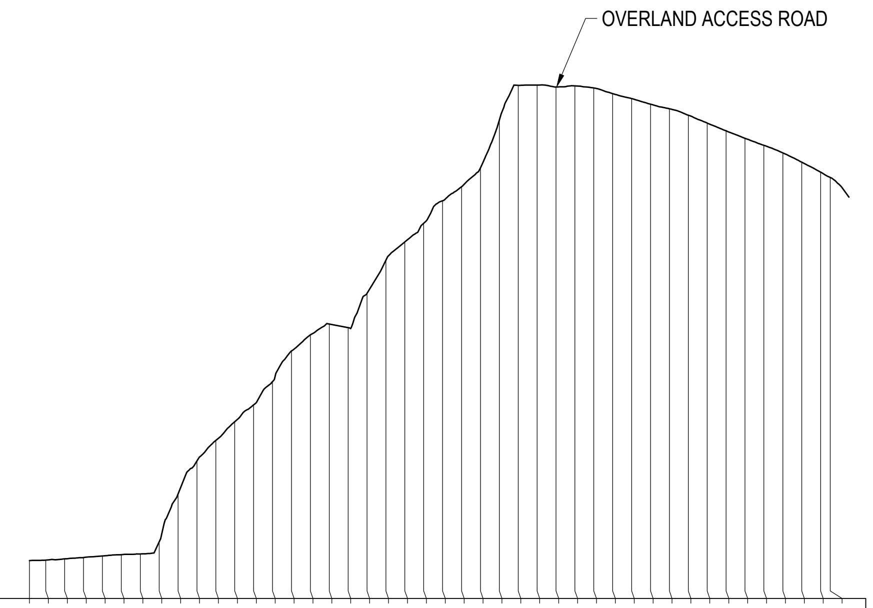
CHAINAGE 5750.000



DATUM RL -9.750

OFFSET	EXISTING LEVEL
4.613	0.511
10.000	0.795
15.000	1.169
20.000	1.512
25.000	9.334
30.000	29.302
35.000	34.200
40.000	37.150
45.000	42.462
50.000	47.384
55.000	54.515
60.000	61.756
65.000	72.626
70.000	79.535
75.000	86.581
80.000	96.036
85.000	96.098
90.000	93.485
95.000	91.561
100.000	89.855
105.000	87.998
110.000	86.519
115.000	85.309
120.000	84.414
125.000	83.537
130.000	82.993
135.000	82.138
140.000	81.562
145.000	81.229
150.000	80.897
155.000	80.136
160.000	78.287
165.000	76.911
170.000	73.991
175.000	71.145
180.000	66.618
185.000	65.350
190.000	65.283
195.000	65.113
198.537	65.265

CHAINAGE 6250.000



DATUM RL -9.750

OFFSET	EXISTING LEVEL
-14.306	0.303
-10.000	0.407
-5.000	0.735
0.000	1.081
5.000	1.503
10.000	1.838
15.000	2.031
20.000	5.177
25.000	17.942
30.000	26.652
35.000	32.113
40.000	37.069
45.000	41.519
50.000	47.682
55.000	55.780
60.000	60.052
65.000	62.928
70.000	61.952
75.000	71.063
80.000	79.773
85.000	84.666
90.000	89.593
95.000	95.539
100.000	99.228
105.000	104.217
110.000	116.886
115.000	126.108
120.000	126.186
125.000	125.675
130.000	125.971
135.000	125.411
140.000	123.909
145.000	122.602
150.000	121.122
155.000	119.911
160.000	118.203
165.000	116.107
170.000	114.061
175.000	112.077
180.000	110.238
185.000	108.223
190.000	105.771
195.000	103.133
197.547	101.731

CHAINAGE 5500.000

DATUM RL -9.750

OFFSET	EXISTING LEVEL
-2.918	0.454
0.000	0.592
5.000	0.991
10.000	1.434
15.000	1.763
20.000	4.730
25.000	18.042
30.000	22.627
35.000	32.035
40.000	38.048
45.000	55.161
50.000	62.179
55.000	68.844
60.000	74.911
65.000	79.147
70.000	82.475
75.000	85.689
80.000	88.965
85.000	92.373
90.000	96.869
95.000	101.086
100.000	103.746
105.000	103.356
110.000	102.064
115.000	100.065
120.000	98.015
125.000	96.128
130.000	94.586
135.000	92.662
140.000	90.415
145.000	87.683
150.000	84.471
155.000	83.009
160.000	80.791
165.000	80.754
170.000	82.627
175.000	86.006
180.000	89.594
185.000	93.084
190.000	94.944
195.000	96.332
199.319	96.154

CHAINAGE 6000.000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 5500m TO 6250m

Status Stamp: **WORKING PLOT**

Date Stamp

Scales: 1 : 1000 @ A1

Drawing No. 310203423-100-C125

Rev. A

Last modified: Nov 15 2019 By Paul Chilton

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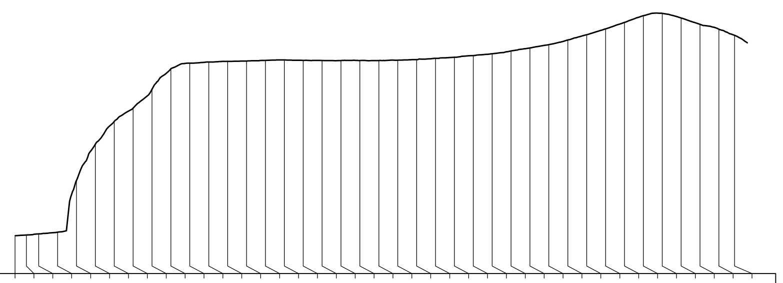
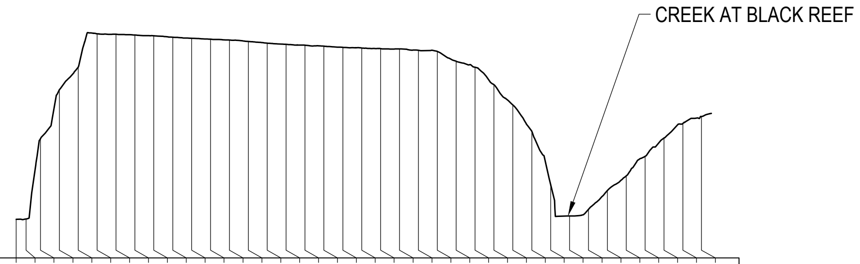
DO NOT SCALE - IF IN DOUBT, ASK



DATUM RL -9.500

OFFSET	EXISTING LEVEL
8.755	0.515
11.769	0.679
15.000	0.989
20.000	1.446
25.000	15.158
30.000	24.702
35.000	30.723
40.000	34.273
45.000	39.238
50.000	44.666
55.000	46.166
60.000	46.444
65.000	46.615
70.000	46.730
75.000	46.905
80.000	47.010
85.000	46.907
90.000	46.861
95.000	46.838
100.000	46.855
105.000	46.844
110.000	46.955
115.000	47.099
120.000	47.430
125.000	47.739
130.000	48.164
135.000	48.635
140.000	49.380
145.000	50.178
150.000	51.056
155.000	52.271
160.000	53.689
165.000	55.235
170.000	56.938
175.000	58.714
180.000	59.343
185.000	58.118
190.000	56.404
195.000	55.114
199.145	53.511

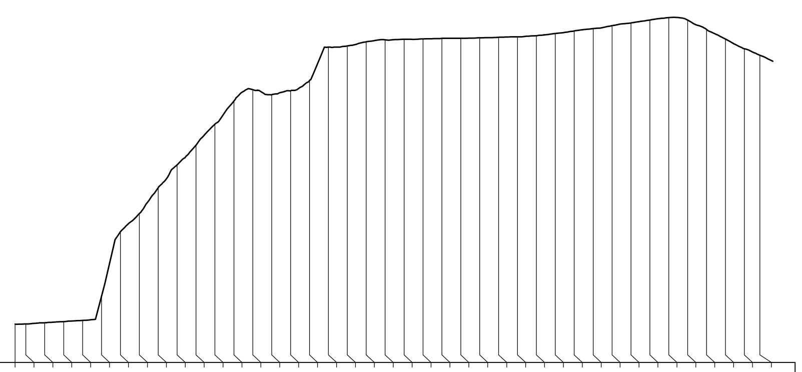
CHAINAGE 7000.000



DATUM RL -9.250

OFFSET	EXISTING LEVEL
18.584	0.940
21.181	1.009
25.000	22.262
30.000	35.183
35.000	41.240
40.000	50.008
45.000	49.887
50.000	49.689
55.000	49.508
60.000	49.110
65.000	48.826
70.000	48.604
75.000	48.347
80.000	47.979
85.000	47.552
90.000	47.221
95.000	46.990
100.000	46.743
105.000	46.431
110.000	46.254
115.000	46.083
120.000	46.006
125.000	45.653
130.000	45.366
135.000	42.753
140.000	41.144
145.000	36.535
150.000	31.185
155.000	24.226
160.000	10.155
165.000	1.836
170.000	3.542
175.000	8.550
180.000	12.421
185.000	17.591
190.000	22.478
195.000	26.312
199.884	28.099

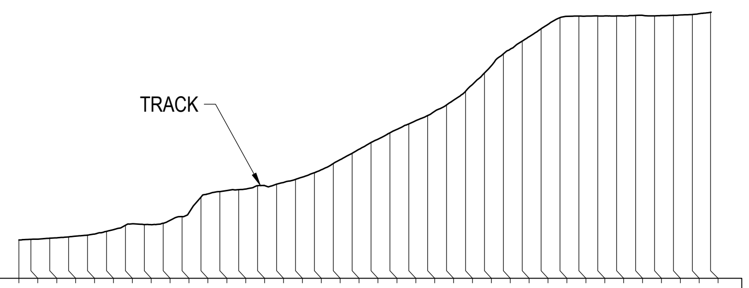
CHAINAGE 6750.000



DATUM RL -9.500

OFFSET	EXISTING LEVEL
2.137	0.605
5.000	0.654
10.000	0.994
15.000	1.303
20.000	1.610
25.000	8.027
30.000	25.041
35.000	29.838
40.000	36.678
45.000	42.723
50.000	47.906
55.000	53.484
60.000	59.580
65.000	62.554
70.000	61.243
75.000	62.279
80.000	64.940
85.000	73.801
90.000	74.125
95.000	75.192
100.000	75.733
105.000	75.892
110.000	75.989
115.000	76.115
120.000	76.154
125.000	76.261
130.000	76.410
135.000	76.509
140.000	76.811
145.000	77.397
150.000	78.088
155.000	78.724
160.000	79.489
165.000	80.190
170.000	80.955
175.000	81.603
180.000	80.936
185.000	78.458
190.000	75.908
195.000	73.380
199.075	71.642

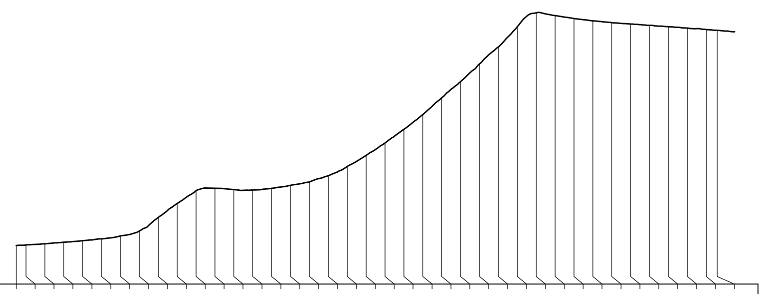
CHAINAGE 6500.000



DATUM RL -10.000

OFFSET	EXISTING LEVEL
16.835	0.115
20.000	0.279
25.000	0.570
30.000	0.934
35.000	1.415
40.000	2.392
45.000	4.006
50.000	4.188
55.000	4.512
60.000	6.282
65.000	11.393
70.000	12.906
75.000	13.404
80.000	14.442
85.000	14.842
90.000	16.089
95.000	17.887
100.000	20.284
105.000	22.996
110.000	25.852
115.000	28.439
120.000	30.759
125.000	32.977
130.000	35.791
135.000	39.364
140.000	44.182
145.000	49.228
150.000	52.645
155.000	55.878
160.000	58.823
165.000	59.248
170.000	59.276
175.000	59.276
180.000	59.413
185.000	59.284
190.000	59.451
195.000	59.653
199.813	60.221

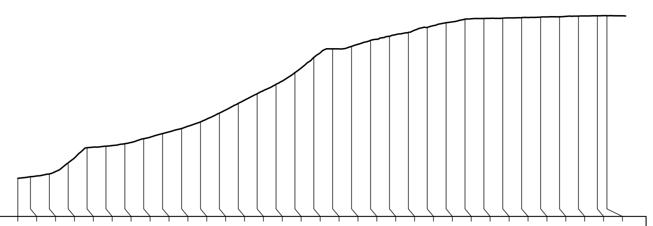
CHAINAGE 7750.000



DATUM RL -10.250

OFFSET	EXISTING LEVEL
12.424	-0.075
15.000	0.078
20.000	0.394
25.000	0.814
30.000	1.216
35.000	1.699
40.000	2.457
45.000	3.769
50.000	7.353
55.000	11.042
60.000	14.377
65.000	15.061
70.000	14.693
75.000	14.616
80.000	15.028
85.000	15.834
90.000	16.749
95.000	18.374
100.000	20.782
105.000	23.744
110.000	27.027
115.000	30.629
120.000	34.537
125.000	38.958
130.000	43.234
135.000	47.898
140.000	52.383
145.000	57.714
150.000	61.395
155.000	60.652
160.000	59.891
165.000	59.269
170.000	58.795
175.000	58.428
180.000	58.086
185.000	57.725
190.000	57.359
195.000	56.965
197.865	56.750

CHAINAGE 7500.000



DATUM RL -9.000

OFFSET	EXISTING LEVEL
41.662	1.041
45.000	1.477
50.000	2.229
55.000	5.166
60.000	9.134
65.000	9.523
70.000	10.207
75.000	11.530
80.000	12.874
85.000	14.214
90.000	15.959
95.000	18.263
100.000	20.832
105.000	23.386
110.000	25.862
115.000	28.963
120.000	32.977
125.000	35.222
130.000	35.903
135.000	37.474
140.000	38.579
145.000	39.567
150.000	40.905
155.000	42.113
160.000	43.074
165.000	43.251
170.000	43.342
175.000	43.475
180.000	43.619
185.000	43.700
190.000	43.893
195.000	43.977
197.558	43.995

CHAINAGE 7250.000

ORIGINAL SIZE A1

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 6500m TO 7750m

Status Stamp: WORKING PLOT

Date Stamp

Scales: 1 : 1000 @ A1

Drawing No.: 310203423-100-C126

Rev.: A

Last modified: Nov 15 2019 By Paul Chilton

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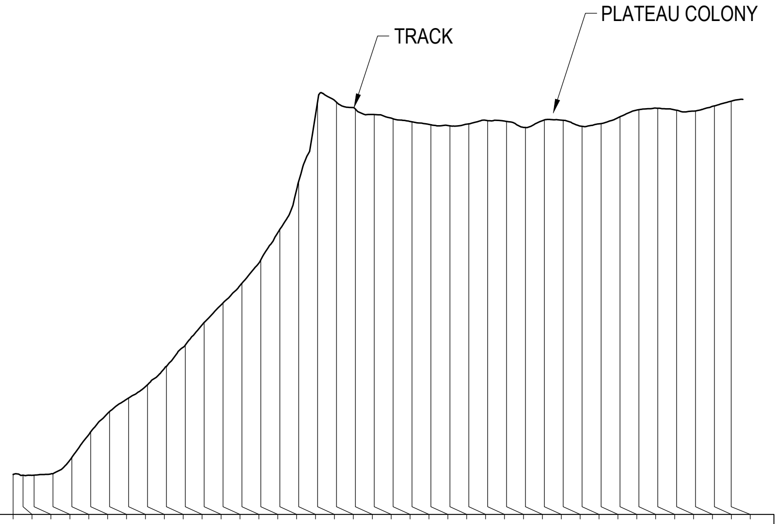
DO NOT SCALE - IF IN DOUBT, ASK

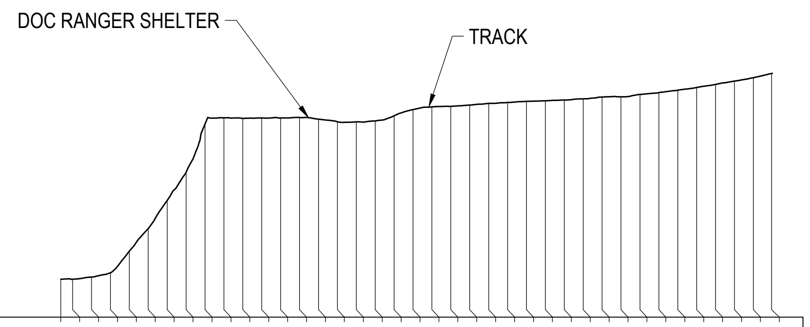
ORIGINAL SIZE A1



DATUM RL -9.250

EXISTING LEVEL	1.294	1.088	1.107	1.470	5.786	12.575	17.946	21.489	24.995	29.823	35.479	41.448	46.636	51.859	58.058	66.005	78.708	99.794	99.683	97.884	96.419	95.280	94.490	93.697	93.443	93.951	94.794	94.576	92.992	94.978	94.900	93.294	94.005	95.843	97.703	98.073	97.548	97.359	98.683	99.962
OFFSET	9.468	12.082	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	155.000	160.000	165.000	170.000	175.000	180.000	185.000	190.000	195.000	199.447

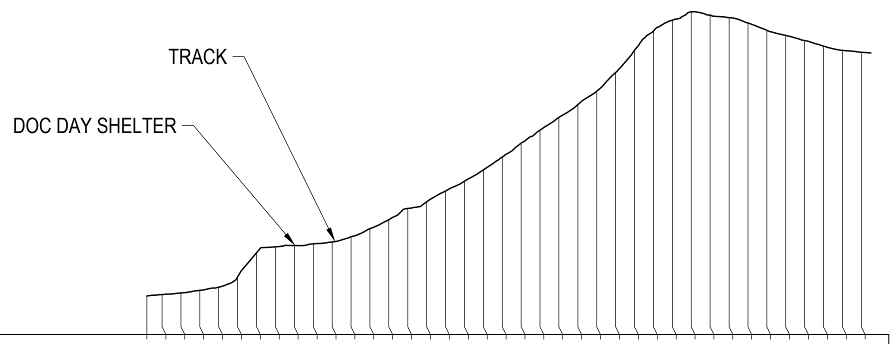
CHAINAGE 8500.000



DATUM RL -9.750

EXISTING LEVEL	0.308	0.285	0.869	2.008	7.724	13.702	21.120	28.556	41.324	42.989	42.835	42.961	42.959	43.100	42.622	41.959	41.927	42.152	43.536	45.169	45.881	46.031	46.373	46.793	47.046	47.318	47.489	47.686	48.021	48.496	48.535	49.177	49.658	50.297	51.007	51.835	52.719	53.615	54.731
OFFSET	11.853	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	155.000	160.000	165.000	170.000	175.000	180.000	185.000	190.000	195.000	199.796

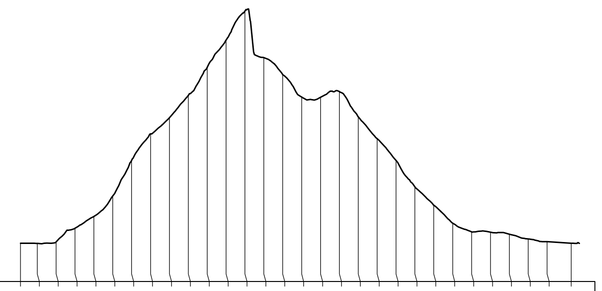
CHAINAGE 8250.000



DATUM RL -10.250

EXISTING LEVEL	-0.071	0.308	0.720	1.434	2.245	5.004	11.350	12.924	13.276	13.726	14.226	15.596	17.749	20.087	23.087	24.869	27.682	30.285	33.299	36.687	40.363	43.816	47.183	50.537	54.099	59.020	64.989	70.057	72.902	75.106	74.227	73.566	72.120	70.213	68.876	67.508	66.032	64.895	64.399
OFFSET	11.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	155.000	160.000	165.000	170.000	175.000	180.000	185.000	190.000	195.000	200.000

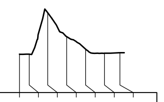
CHAINAGE 8000.000



DATUM RL -10.250

EXISTING LEVEL	-0.137	-0.160	0.230	3.839	6.980	12.408	21.799	28.822	33.082	39.001	46.403	53.596	61.328	48.978	44.468	38.547	38.486	39.979	33.326	27.542	21.769	14.806	9.933	5.183	2.903	2.792	2.264	1.011	0.310	-0.117
OFFSET	-14.457	-10.000	-5.000	0.000	5.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	131.378

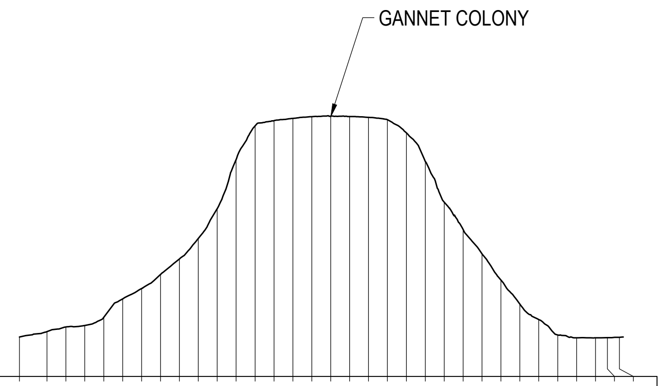
CHAINAGE 9250.000



DATUM RL -10.500

EXISTING LEVEL	-0.362	-0.358	10.588	4.297	0.991	-0.113	0.017
OFFSET	-7.459	-4.872	0.000	5.000	10.000	15.000	19.034

CHAINAGE 9000.000



DATUM RL -10.500

EXISTING LEVEL	-0.073	1.373	2.570	2.957	5.137	10.004	12.714	16.447	20.545	25.964	33.842	46.824	55.685	57.098	57.679	58.143	58.280	58.173	57.949	57.332	53.852	46.363	35.549	28.317	21.862	14.963	8.616	4.545	0.469	-0.295	-0.309	-0.260	-0.159
OFFSET	-2.270	5.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000	145.000	150.000	153.160	156.298

CHAINAGE 8750.000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW		
APPROVED	NOT APPROVED	
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 8000m TO 9250m

Status Stamp: WORKING PLOT

Date Stamp

Scales: 1 : 1000 @ A1

Drawing No. 310203423-100-C127

Rev. A

Last modified: Nov 15 2019 By Paul Chilton

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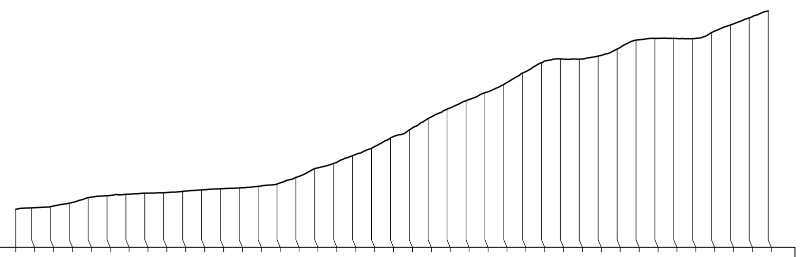
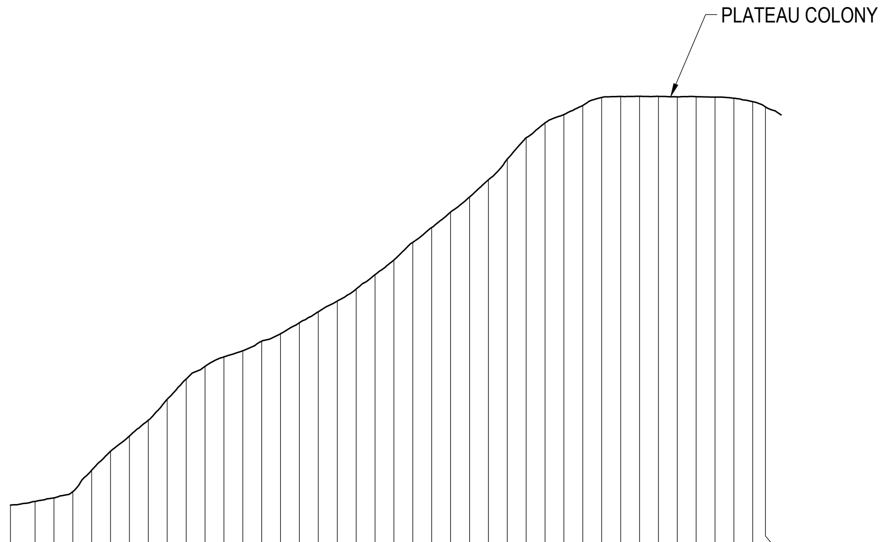


DATUM RL -10.000

OFFSET	EXISTING LEVEL
0.841	0.054
5.000	0.448
10.000	0.766
15.000	1.709
20.000	3.184
25.000	3.650
30.000	4.026
35.000	4.333
40.000	4.451
45.000	4.795
50.000	5.181
55.000	5.509
60.000	5.715
65.000	6.124
70.000	6.761
75.000	8.484
80.000	10.829
85.000	12.214
90.000	14.259
95.000	16.225
100.000	18.926
105.000	21.040
110.000	24.087
115.000	26.557
120.000	28.785
125.000	30.900
130.000	33.089
135.000	36.101
140.000	38.830
145.000	39.848
150.000	39.785
155.000	40.597
160.000	42.436
165.000	44.811
170.000	45.271
175.000	45.292
180.000	45.220
185.000	46.783
190.000	48.812
195.000	50.712
200.000	52.576

CHAINAGE 9750.000



DATUM RL -9.750

OFFSET	EXISTING LEVEL
-1.488	0.426
5.000	1.373
10.000	2.312
15.000	3.957
20.000	9.659
25.000	14.705
30.000	18.710
35.000	22.869
40.000	28.436
45.000	33.766
50.000	37.141
55.000	39.645
60.000	41.298
65.000	43.817
70.000	45.794
75.000	48.709
80.000	51.615
85.000	54.434
90.000	57.628
95.000	61.428
100.000	65.324
105.000	70.012
110.000	73.895
115.000	77.974
120.000	81.986
125.000	86.537
130.000	92.010
135.000	97.676
140.000	101.630
145.000	103.836
150.000	106.237
155.000	108.336
160.000	108.609
165.000	108.664
170.000	108.611
175.000	108.527
180.000	108.553
185.000	108.430
190.000	108.148
195.000	107.222
198.308	105.850

CHAINAGE 9500.000

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

Last modified: Nov 15 2019 By Paul Chilton

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REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED		
DRAWN	PAUL CHILTON	11/2019
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW	NOT APPROVED	
APPROVED		
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ANALYSIS

EXISTING CROSS SECTIONS - 9500m TO 9750m

Status Stamp: WORKING PLOT

Date Stamp

Scales

Drawing No. 310203423-100-C128

Rev. A

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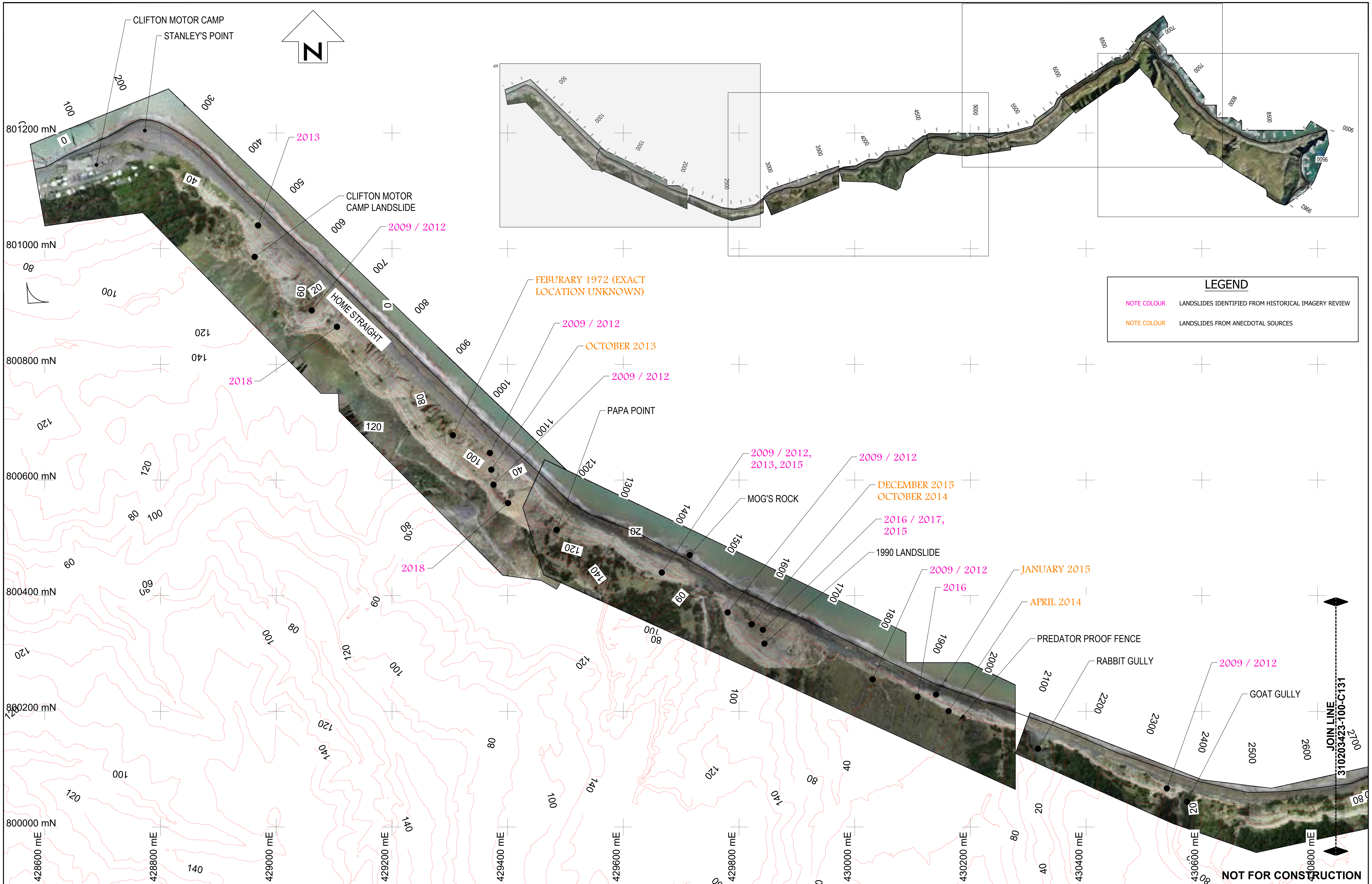


NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED	THE SURVEYING COMPANY LTD	MAR 19
DESIGNED		
DRAWN	B NIKOLAISON	AUG 19
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW		
APPROVED		
PROF REGISTRATION:		

NOT APPROVED

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

LANDSLIDE PLAN SHEET 1 OF 4

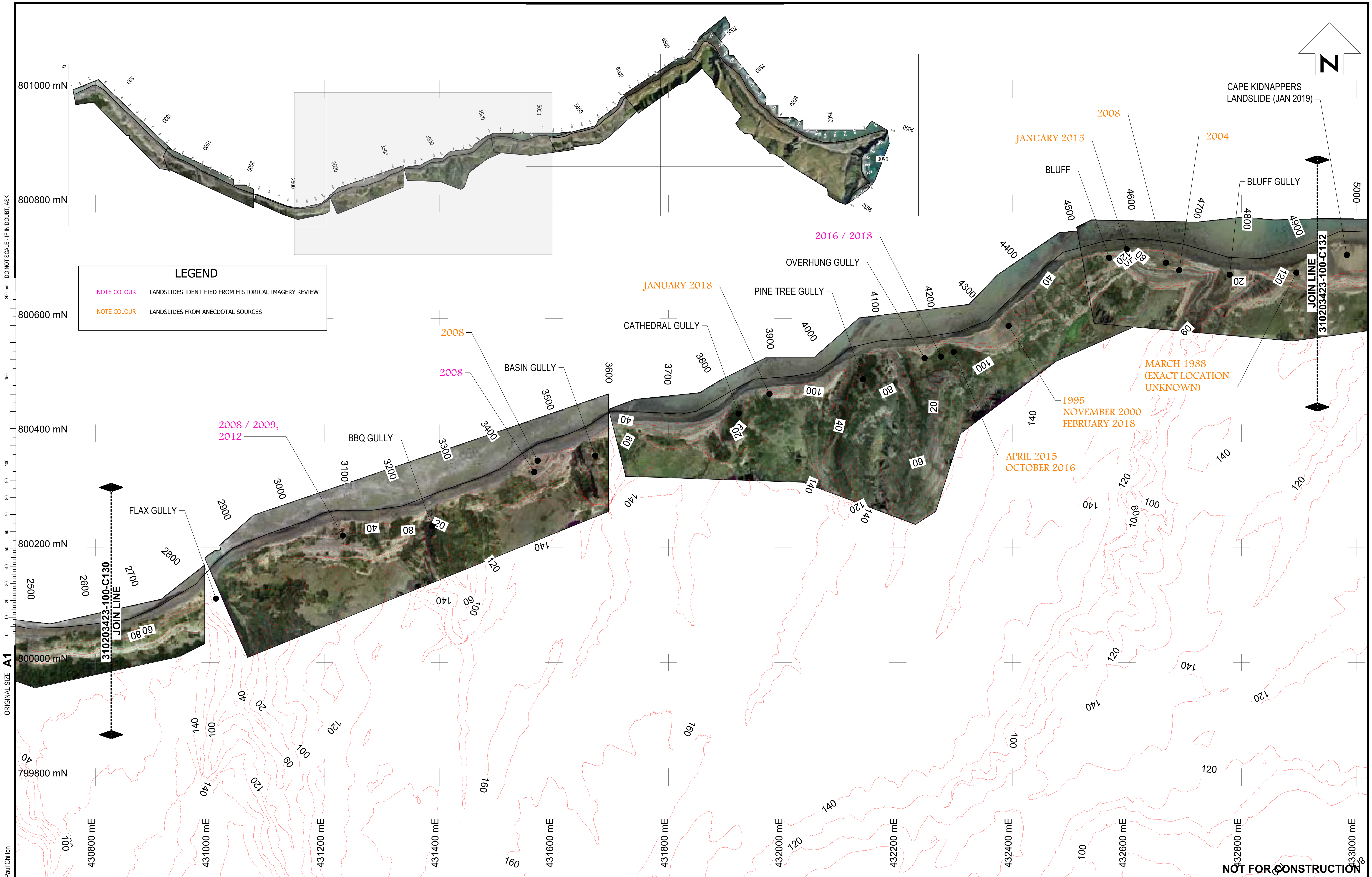
Status Stamp: WORKING PLOT

Date Stamp

Scales

Drawing No. 310203423-100-C130

Rev. A



DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED	THE SURVEYING COMPANY LTD	MAR 19
DESIGNED		
DRAWN	B NIKOLAISON	AUG 19
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW		
APPROVED		
PROF REGISTRATION:		

NOT APPROVED

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

LANDSLIDE PLAN SHEET 2 OF 4

Status Stamp: WORKING PLOT

Date Stamp

Scales

Drawing No. 310203423-100-C131

Rev. A

Last modified: Apr 8 2020 By Paul Chilton

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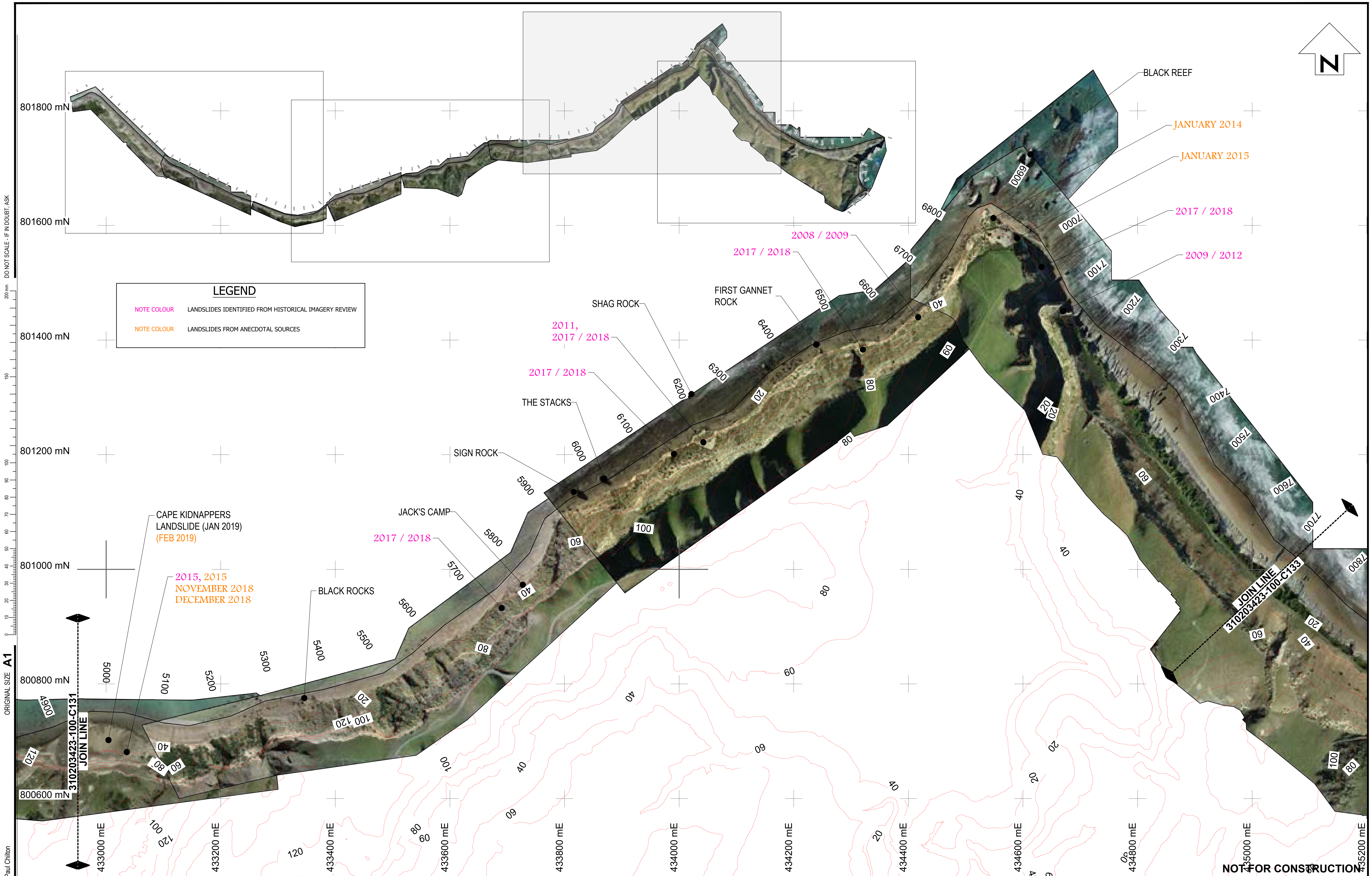

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

Last modified: Apr 8 2020 By Paul Chilton

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED	THE SURVEYING COMPANY LTD	MAR 19
DESIGNED		
DRAWN	B NIKOLAISON	AUG 19
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW		
APPROVED	NOT APPROVED	
PROF REGISTRATION:		

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

LANDSLIDE PLAN SHEET 3 OF 4

Status Stamp: WORKING PLOT

Date Stamp

Scales

Drawing No. 310203423-100-C132

Rev. A

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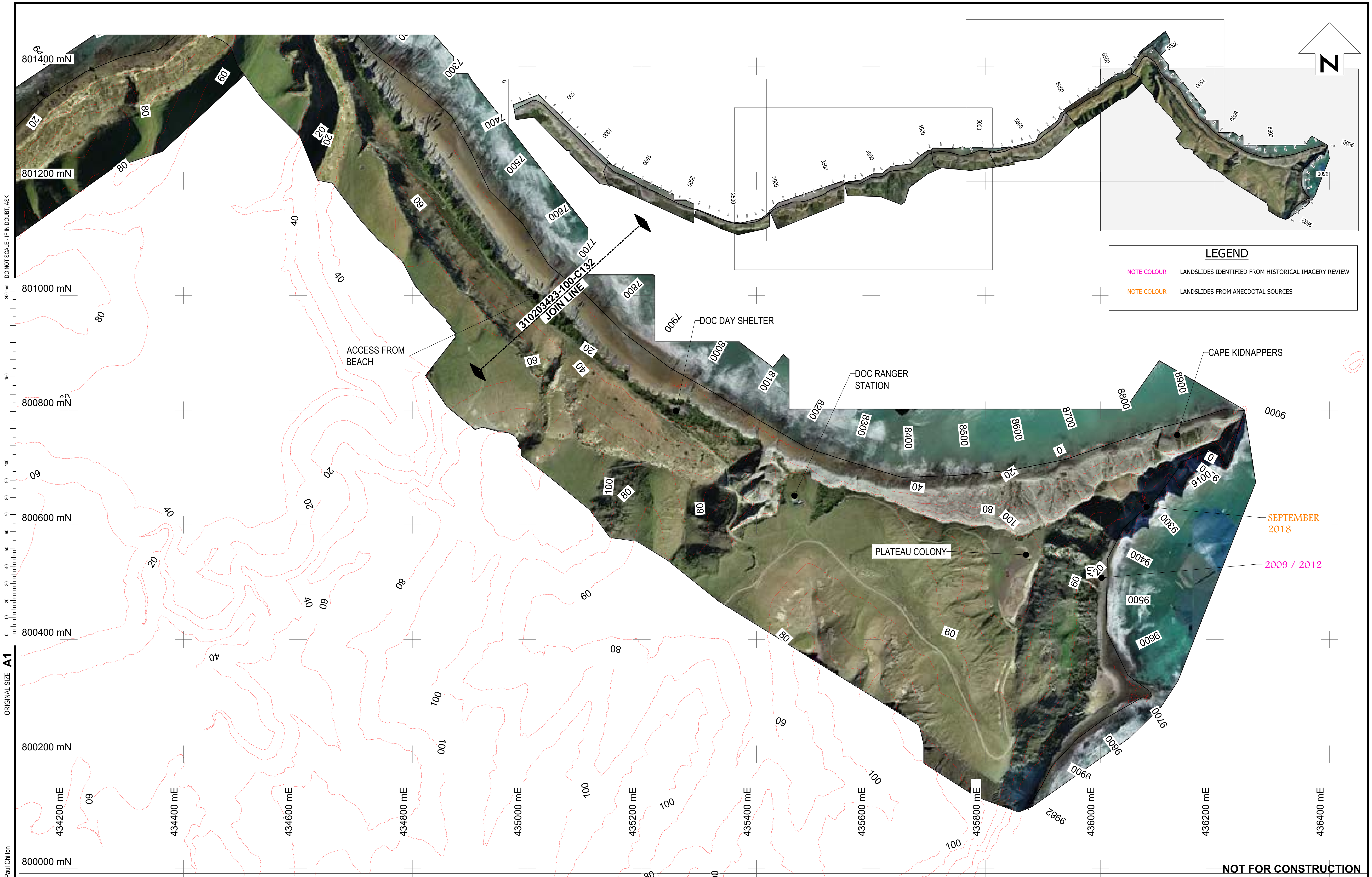

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

Last modified: Apr 8 2020 By Paul Chilton

REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED	THE SURVEYING COMPANY LTD	MAR 19
DESIGNED		
DRAWN	B NIKOLAISON	AUG 19
CAD REVIEW		
DESIGN CHECK		
DESIGN REVIEW		
APPROVED		
PROF REGISTRATION:		

NOT APPROVED

Stantec

Client: HASTINGS DISTRICT COUNCIL

CLIFTON BEACH
QUANTITATIVE RISK ASSESSMENT

LANDSLIDE PLAN SHEET 4 OF 4

Status Stamp: WORKING PLOT

Date Stamp

Scales

Drawing No. 310203423-100-C133

Rev. A

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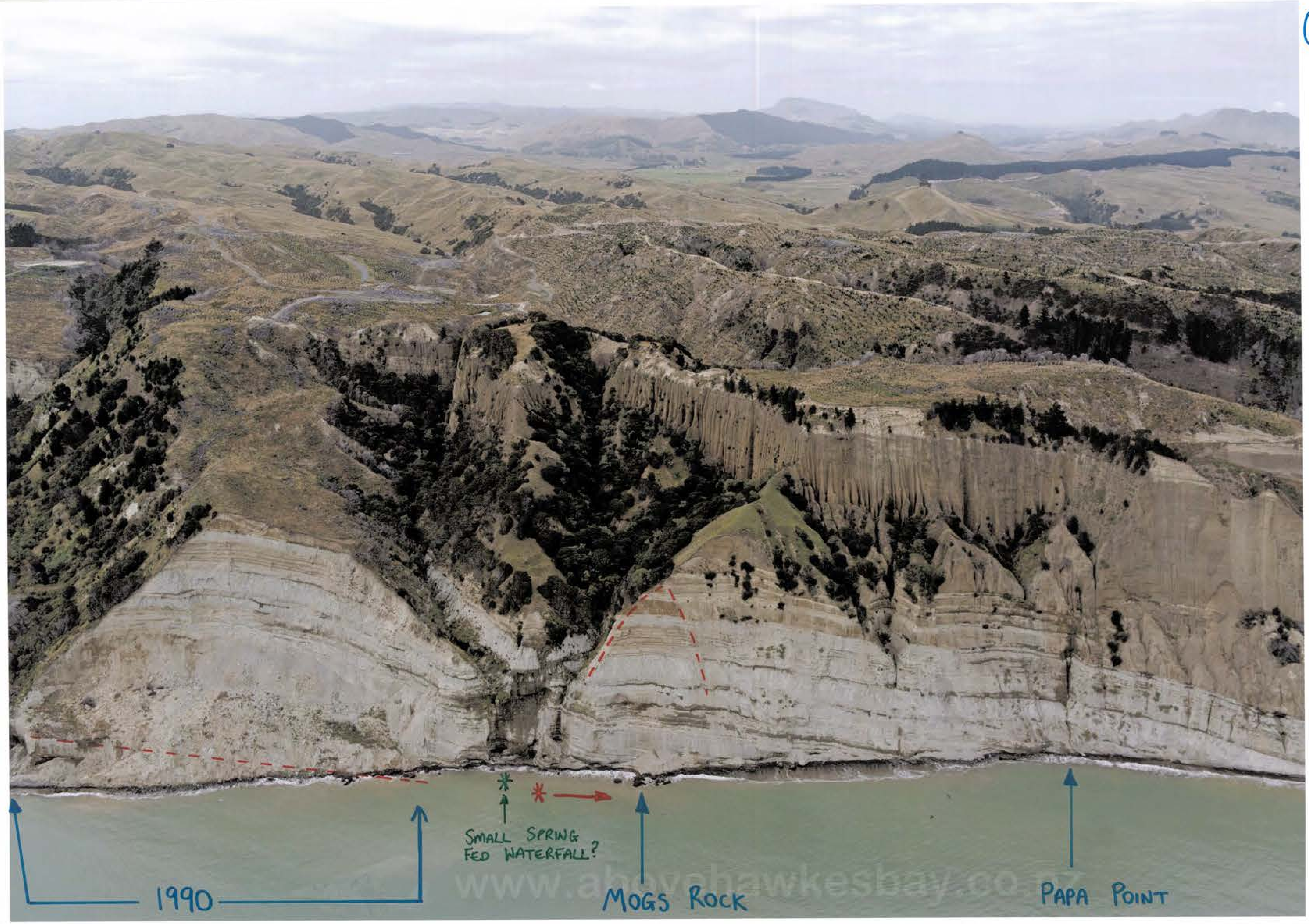
Appendix D GBA Hazard Maps

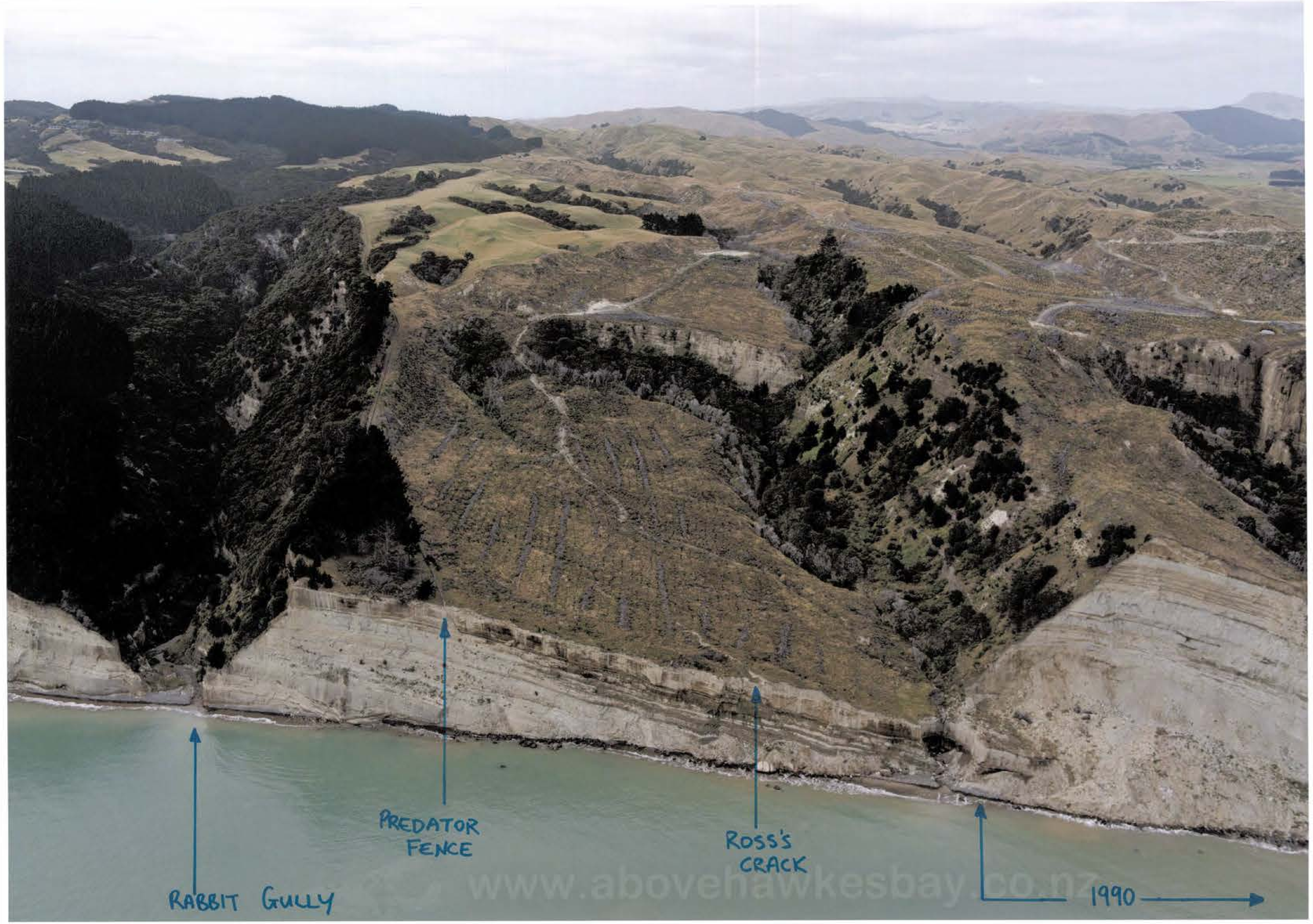
1


2
PAPA POINT
HOME STRAIGHT
www.abovehawkesbay.co.nz

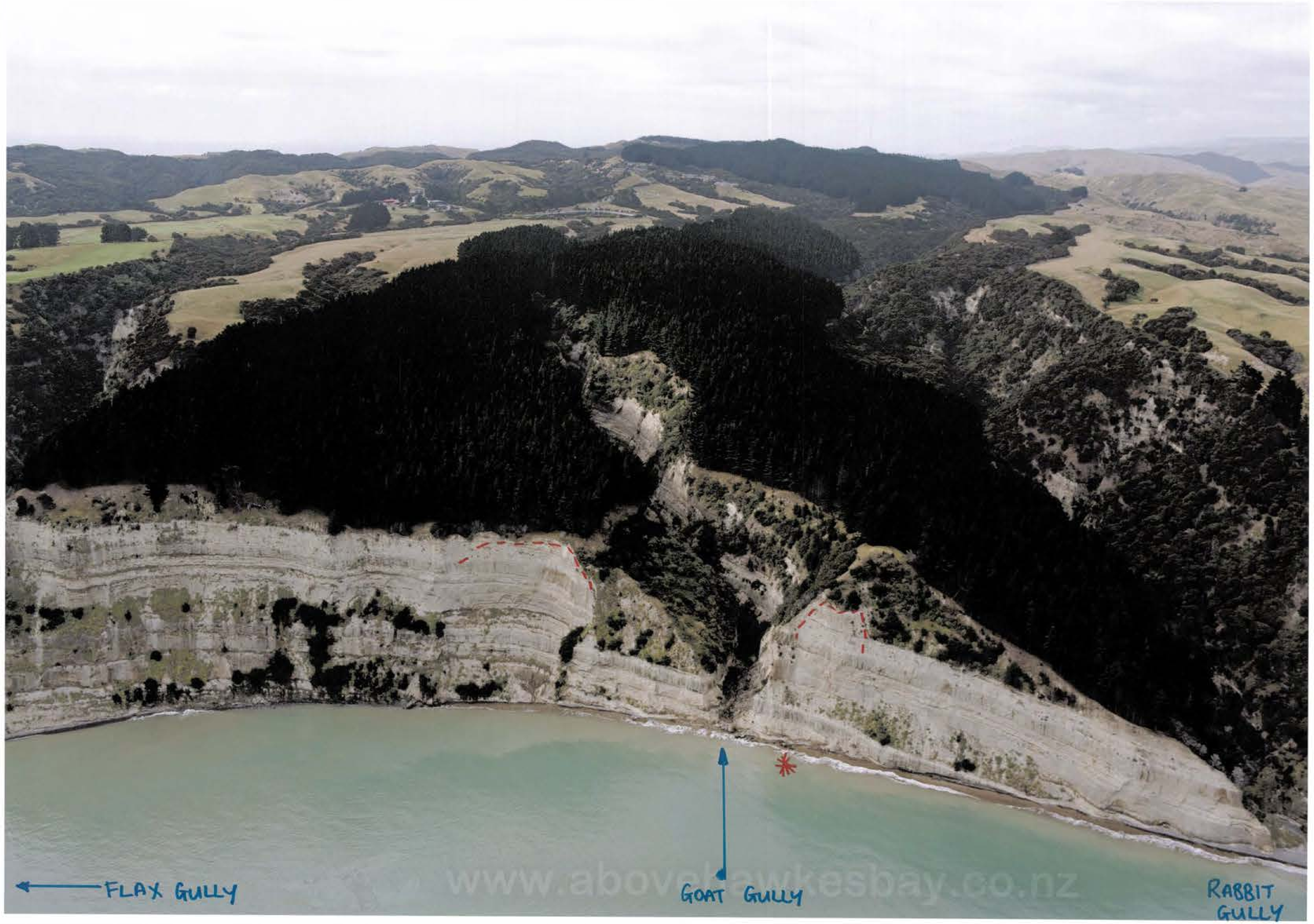
3



SMALL SPRING FED WATERFALL?
1990
MOGS ROCK
PAPA POINT
www.abovehawkesbay.co.nz


4
PREDATOR FENCE
ROSS'S CRACK
RABBIT GULLY
1990
www.abovehawkesbay.co.nz

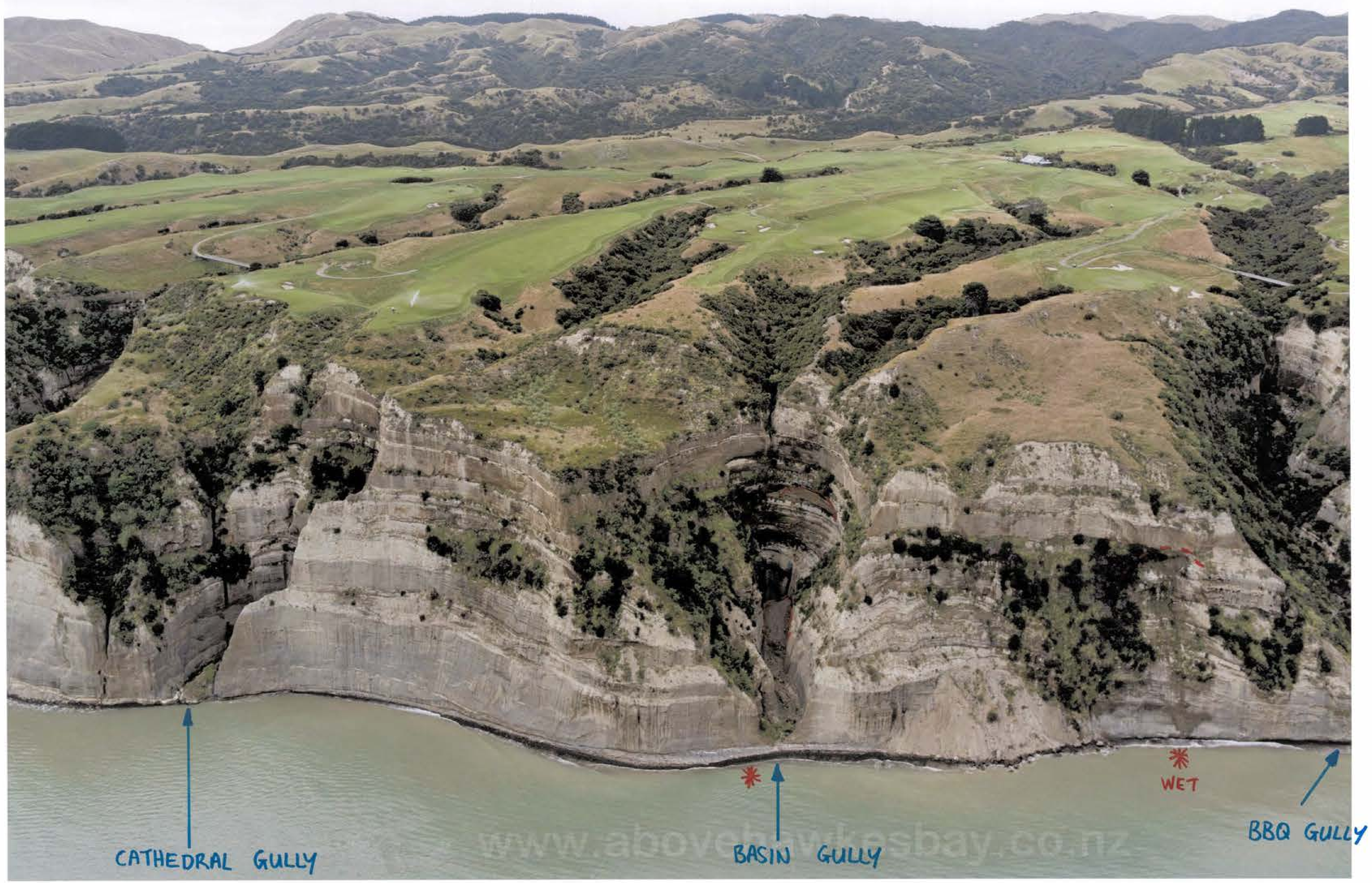
5

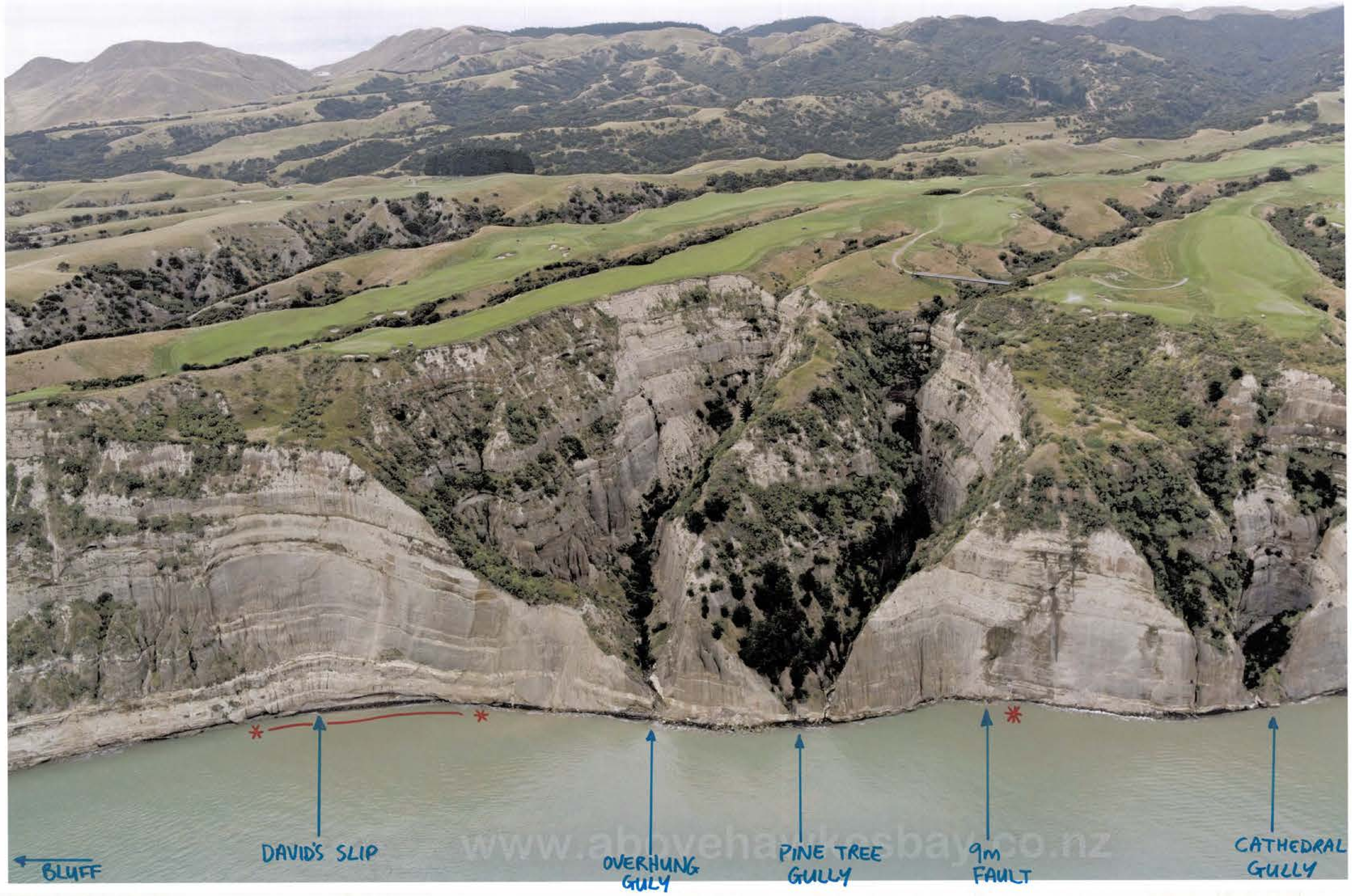


FLAX GULLY
GOAT GULLY
RABBIT GULLY
www.abovehawkesbay.co.nz

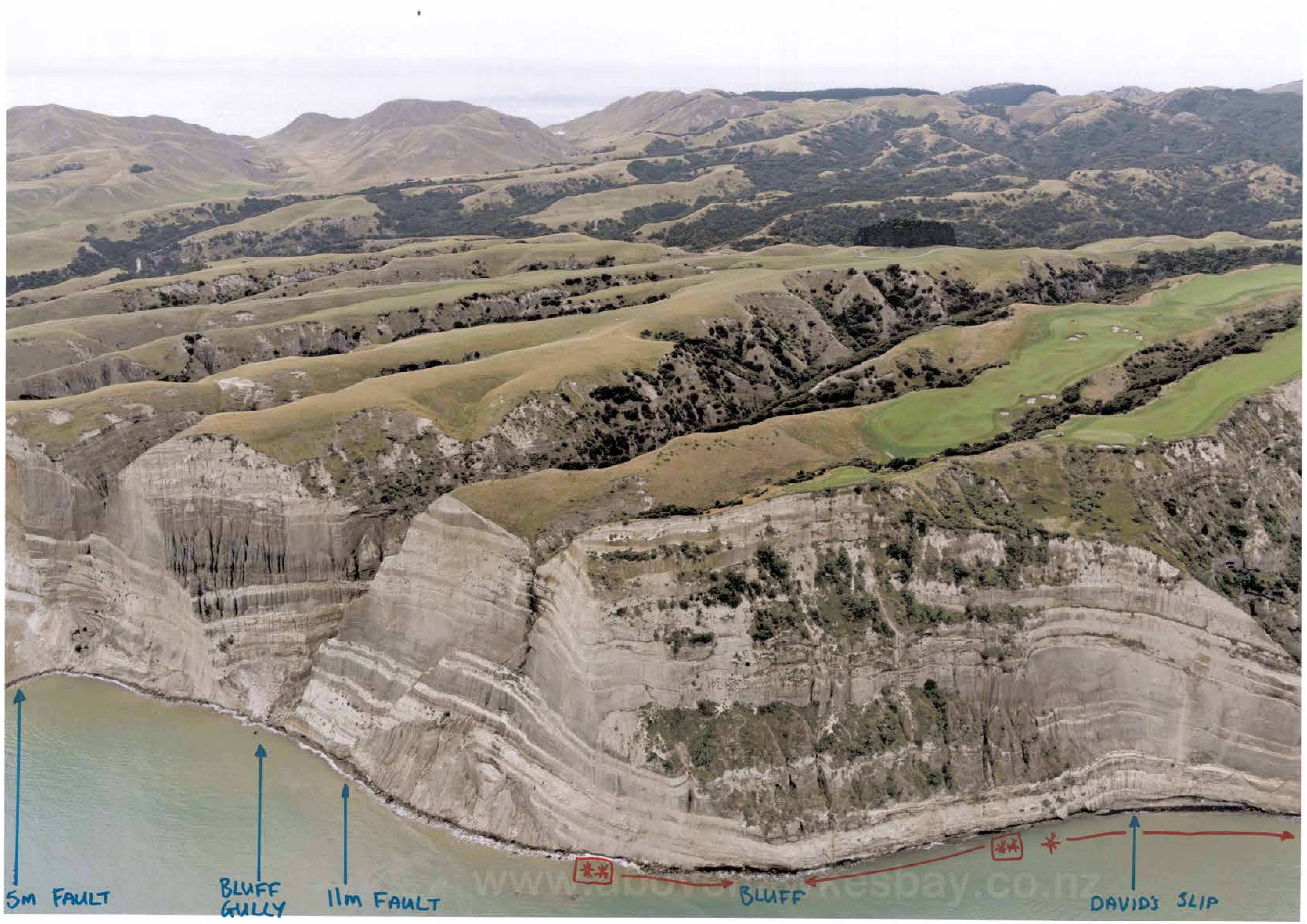
6

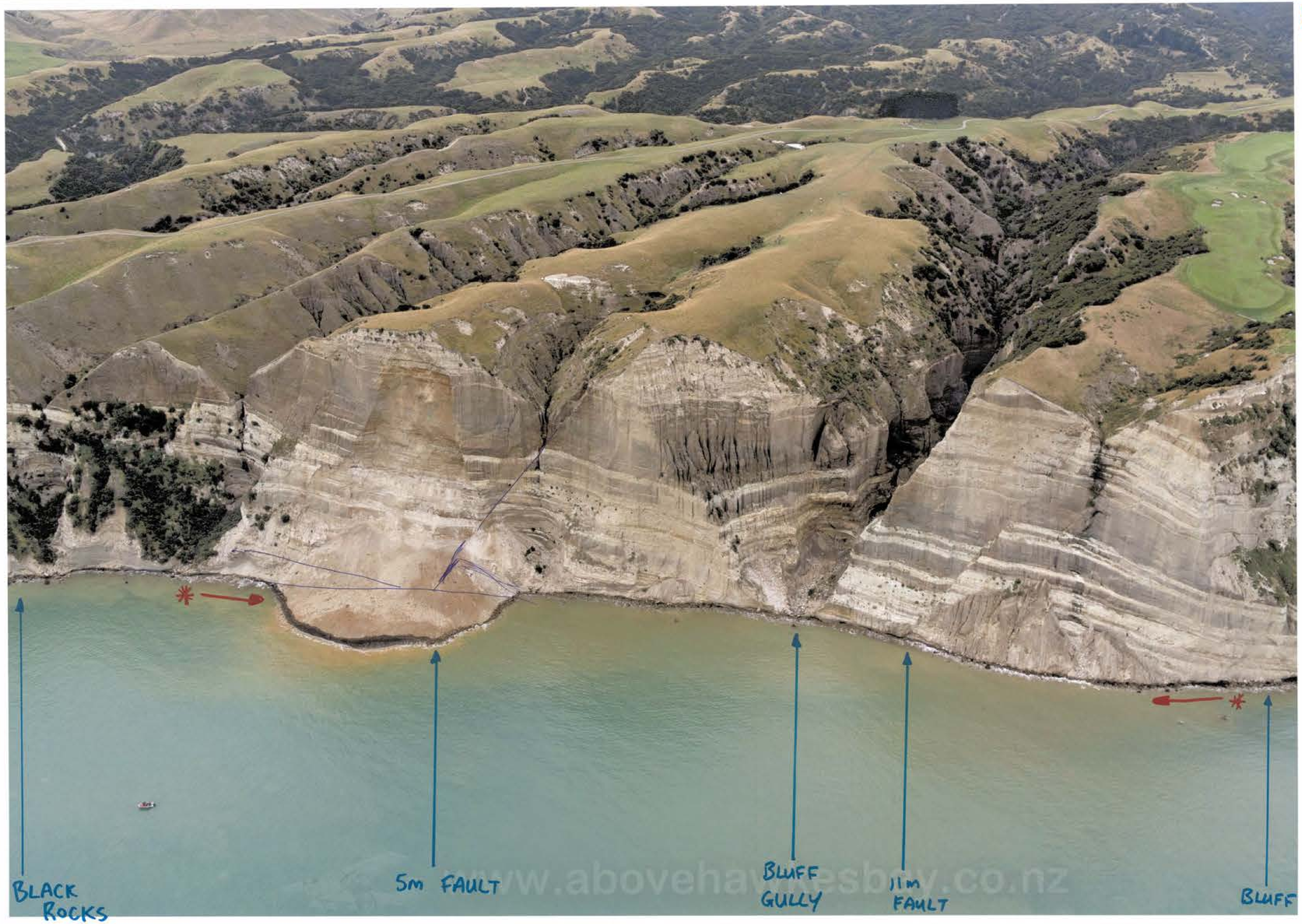
7

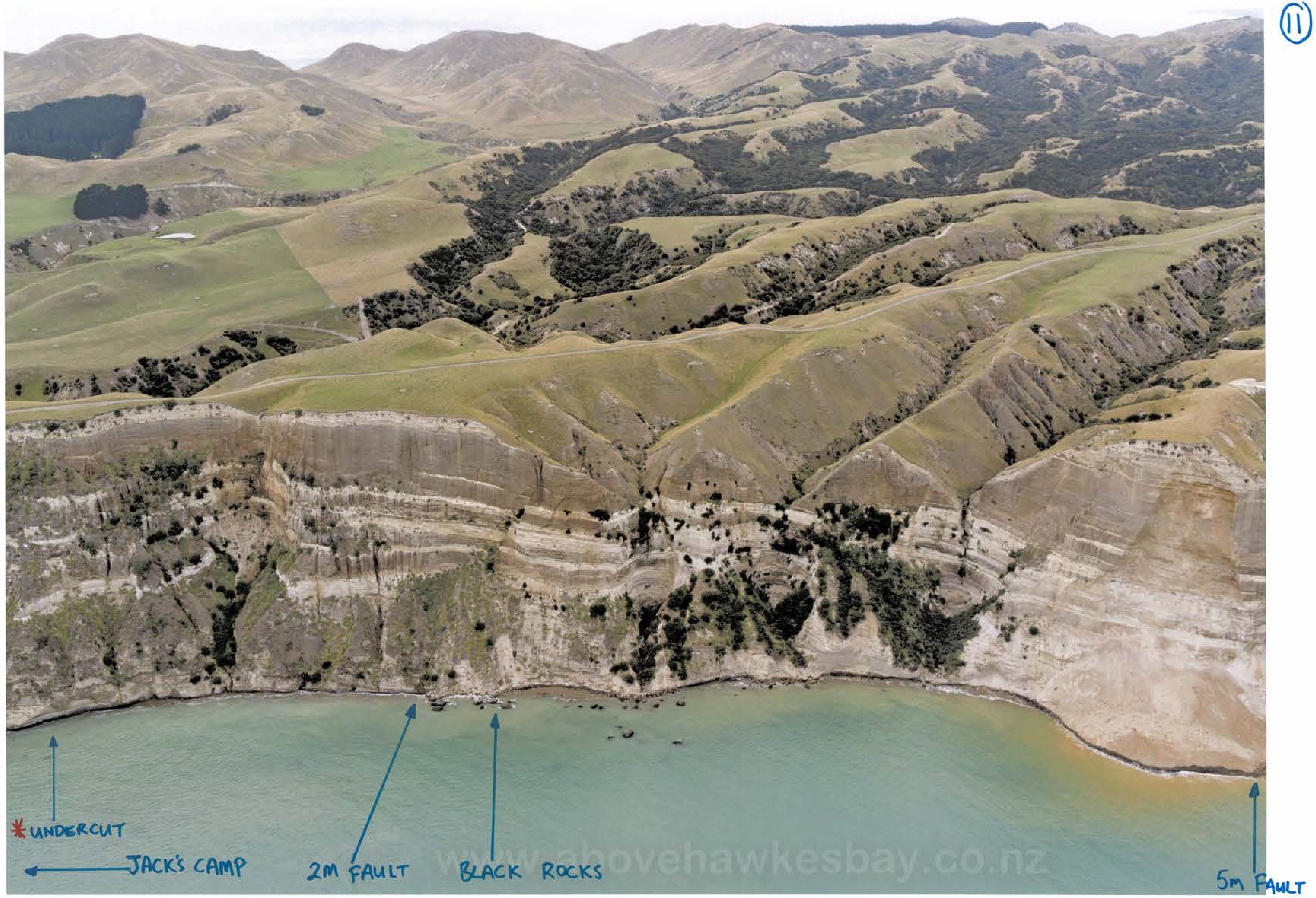

CATHEDRAL GULLY
BASIN GULLY
WET
BBQ GULLY
www.abovehawkesbay.co.nz


BLUFF
DAVID'S SLIP
OVERHUNG GULY
PINE TREE GULLY
9m FAULT
CATHEDRAL GULLY
www.abovehawkesbay.co.nz

9

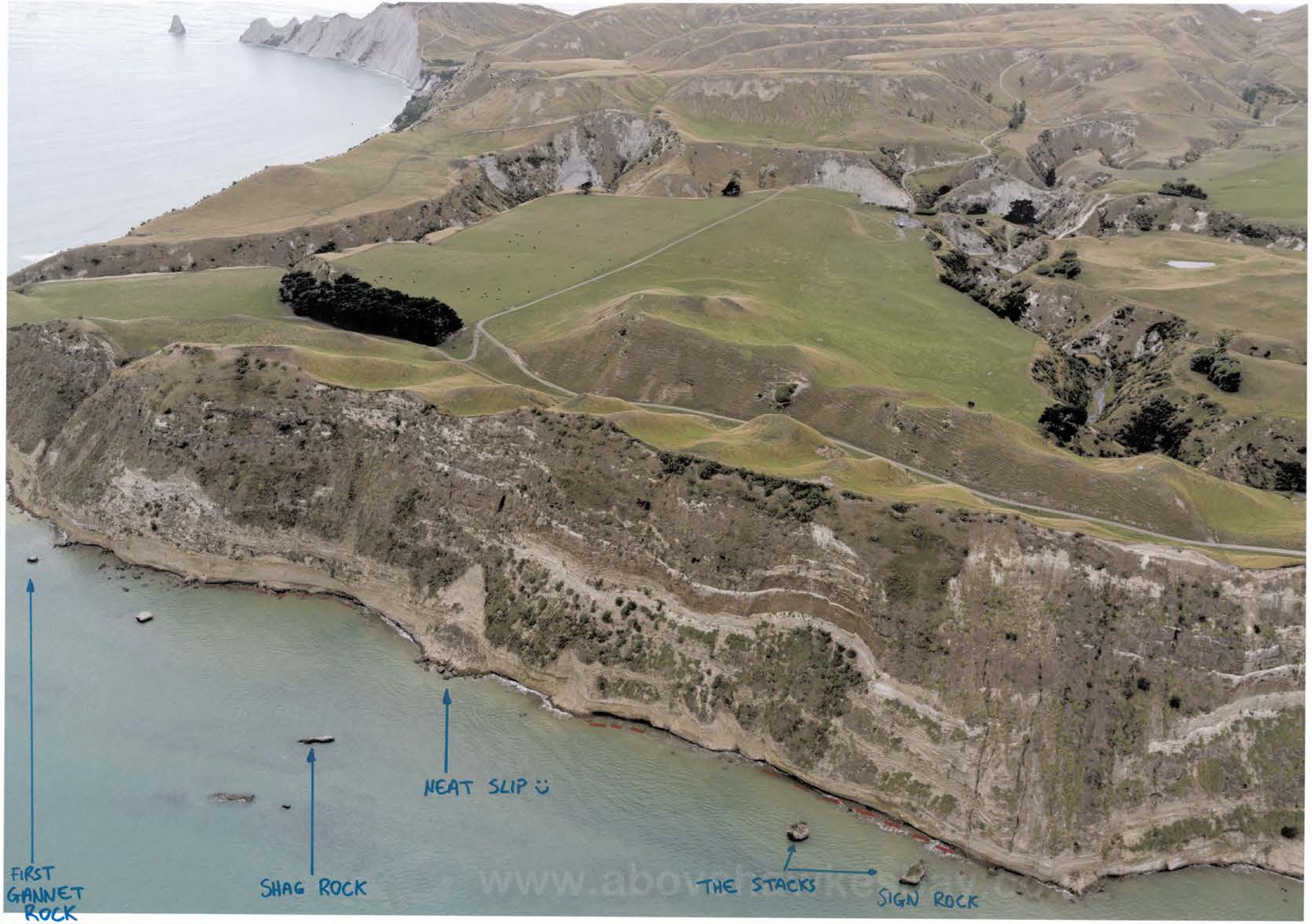



BLACK ROCKS
5m FAULT
BLUFF GULLY
11m FAULT
BLUFF
www.abovehawkesbay.co.nz


* UNDERCUT
JACK'S CAMP
2M FAULT
BLACK ROCKS
5m FAULT
www.abovehawkesbay.co.nz

12

13



Stanley's point to Papa Point ok.

(1) Home straight - Heavy swells @ times - all shingle no sand

---

(1) "Home Straight"

Stanleys Point to Papa Point

Ok most of time - Turns to all shingle with heavy swell - difficult to traverse and powerful wave action.

---

(2) Home Straight to Papa Point

Can loose all sand & shingle in Heavy Swell down to papa base layers.

Prone to small papa debri regularly from 50m north of papa point * to Mogs Rock. * on Map 3

---

(3) Mogs Rock - Regularly drops from bluff above - no stopping. Back fills behind rocks as in photo.

* Small spring fed waterfall - always wet, always small papa dropping off

1990 - Only section of cliff that is moving back rapidly - Sits on angled hard Papa bench and slip debris slides northwards and outwards.

Regularly drops onto existing slip debris.

(4) 1990 to Rabbit Gully
Caution - Regularly drops small debris
Very short tractor stops to point out Geo features

---

(5) Rabbit Gully to Flax Gully
* North Side of Goat Gully - no stopping.
* 100m South (Cape Side) of Goat Gully - no stopping.

---

(6) Flax Gully to BBQ Gully

---

(7) ~~Flax~~ BBQ Gully to Cathedral Gully
* Cape Side of BBQ Gully - Wet - spring?
No stopping - nothing there anyway!
* Basin Gully - not recommended to walk into/explore

---

(8) Cathedral Gully to Bluff
* 9m Fault Home Side (North) Wet, small debris
— Davids slip - Between Pigeon holes - No stopping -

(9) Davids Slip to 5m Fault

*→ Between Pigeon holes

[**]–[**] During reasonably heavy rain – drive near to low tide line – stones coming down runnels

5m Fault – Active!

BLUFF to Home Side of Black Rock – Park near Low tide line when stopping – small debris.

---

(10) Bluff to Black Rocks.

– Park near low tide mark when stopping

---

(11) 5m Fault to Jack's Camp.

Beginning of lower Sandstone layers.

* Undercut – Sandstone gives less warning of slipping/dropping

---

(12) Undercut to The Stacks

* Undercut – Sandstone gives less warning than earlier layers (shingles, ash, mudstone)

JACK'S CAMP – Many years ago Burden brothers built a tin building and camp site on old slip.

SIGN ROCK – start of Doc Reserve

13 SIGN Rock Corner to First Gannet Rock

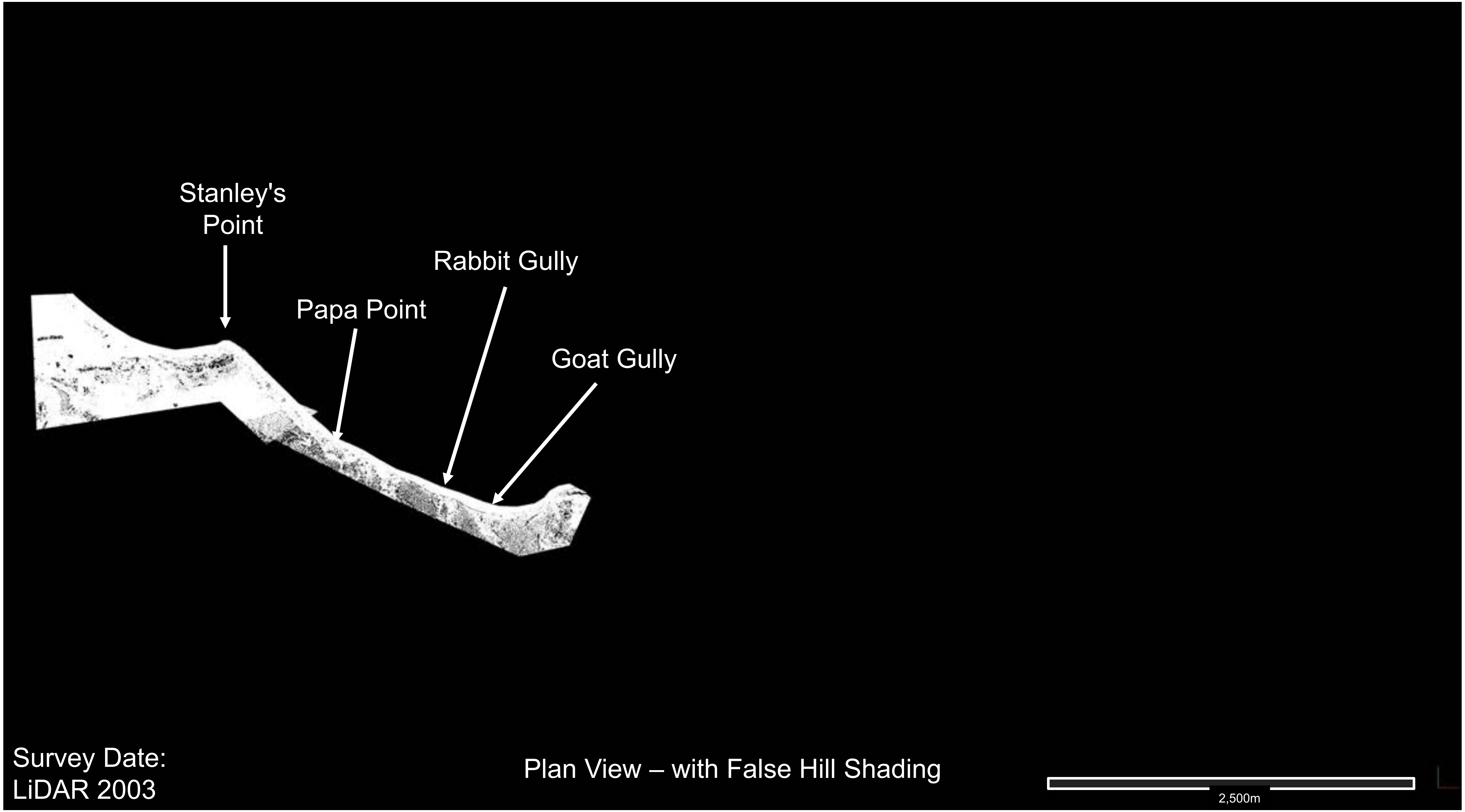
All lower sandstone layer - several undercuts

Some times sand is only deposited on upper high tide exposing terraces - we tend to drive along terraces (slightly slower) but further away from Cliff.

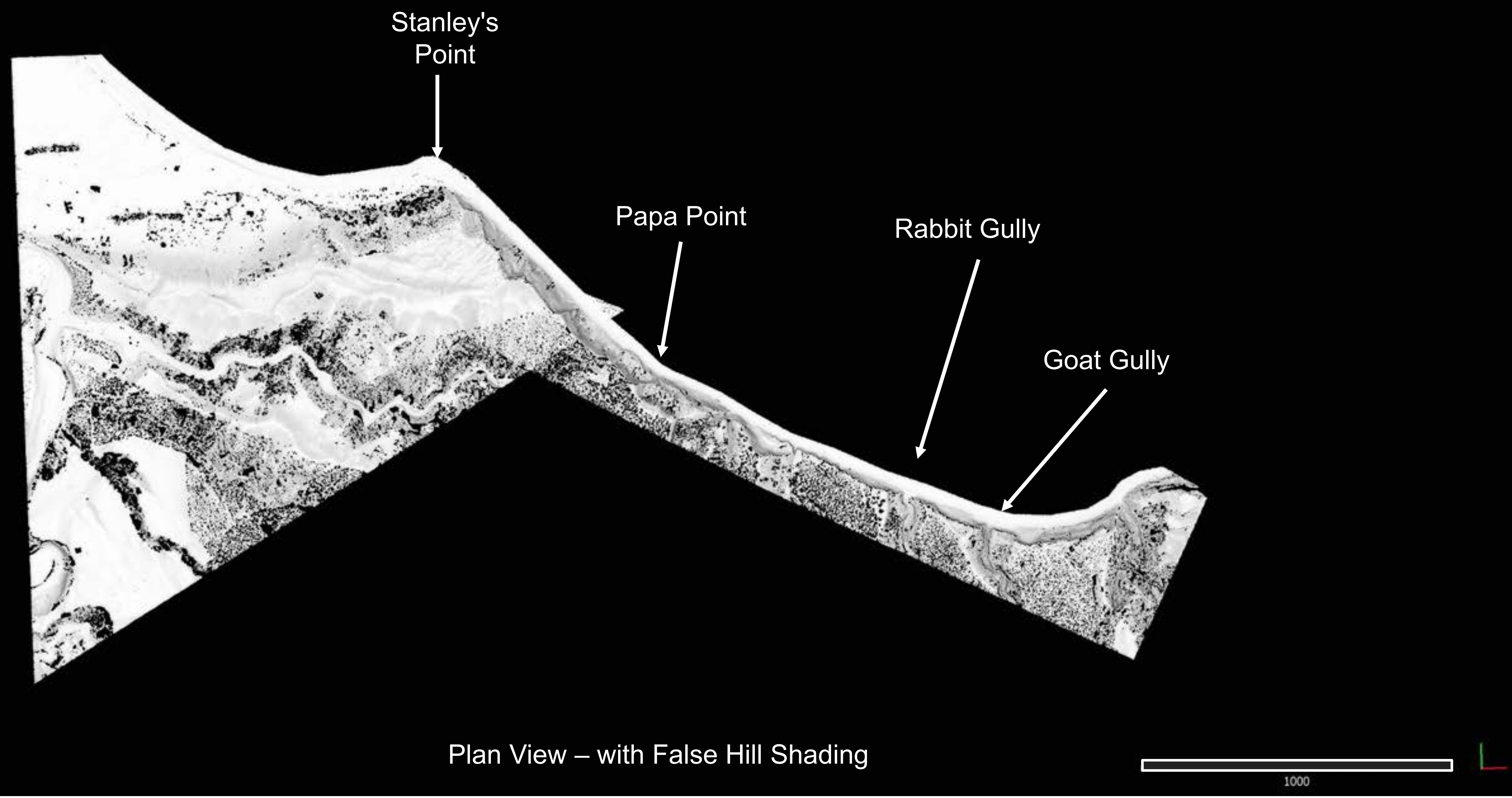
Can show you an impressive Tern nesting site from Oct - Dec if your evry brave enough to jump on our tour!

Appendix E Survey Comparison

2003 LiDAR vs 2012 LiDAR



Clifton Beach – Landslide QRA

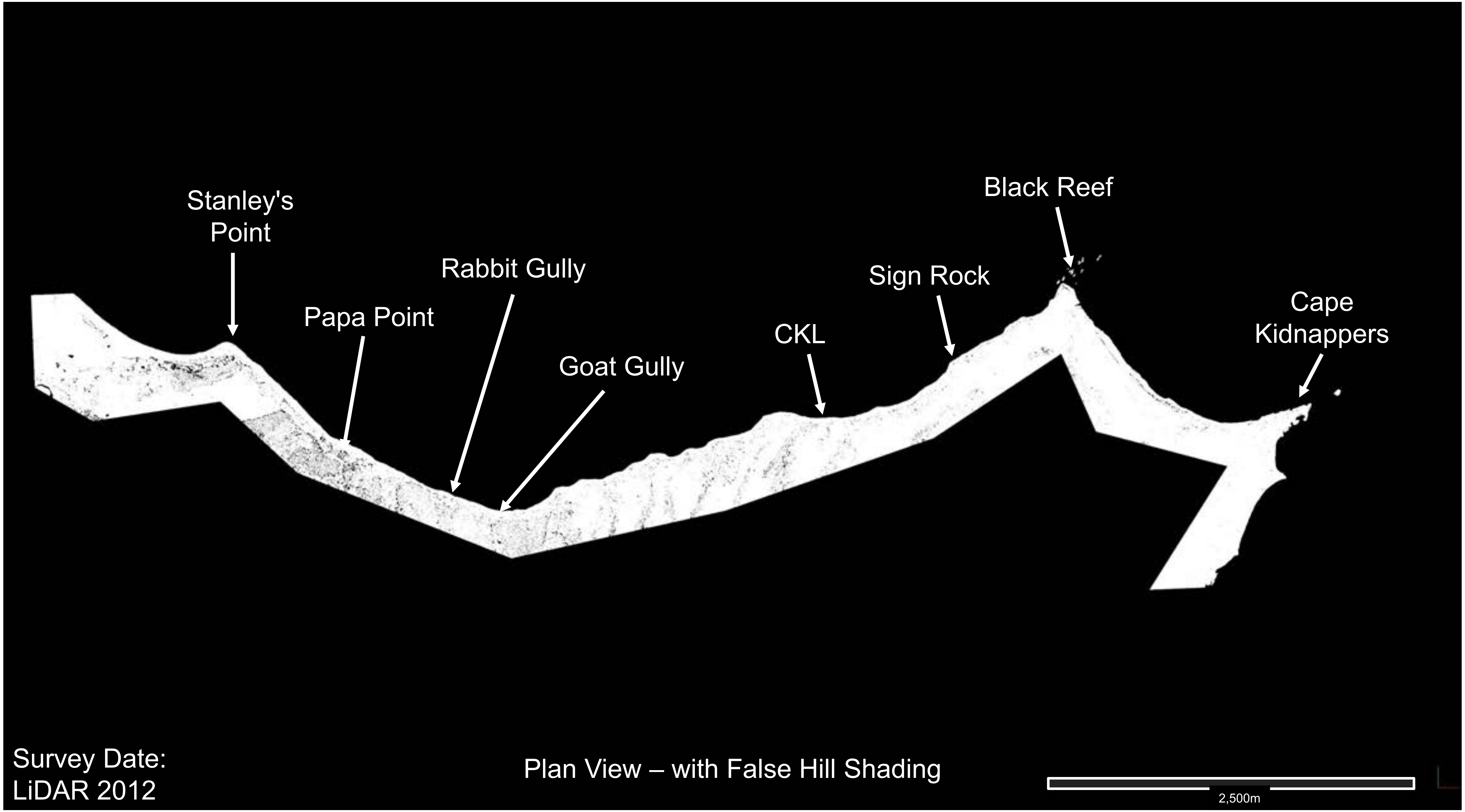


Survey Date:
LiDAR 2003

Plan View – with False Hill Shading

Clifton Beach – Landslide QRA

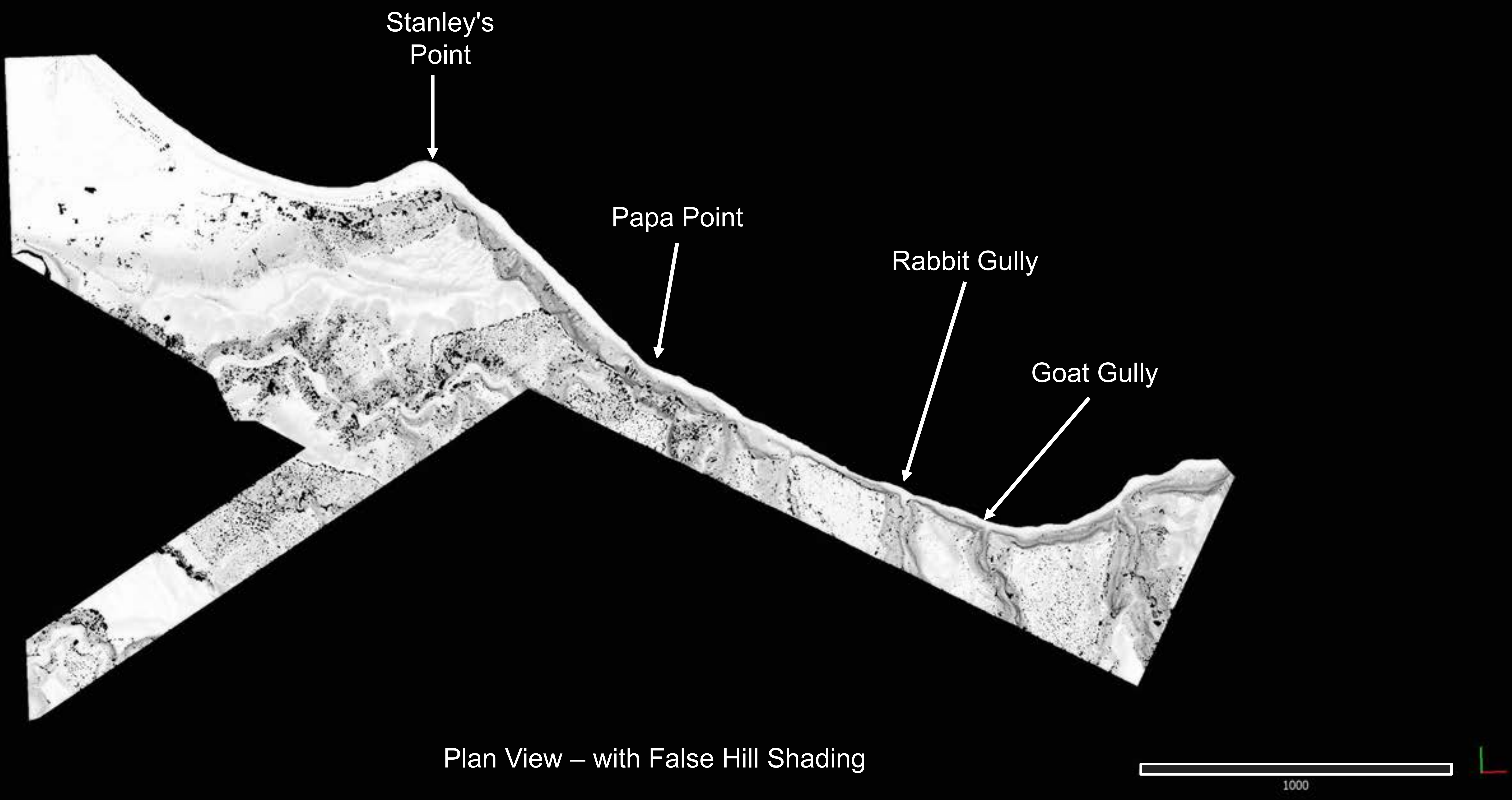
THE SURVEYING COMPANY
YOUR SUBDIVISION PROFESSIONALS



HASTINGS DISTRICT COUNCIL

Clifton Beach – Landslide QRA

Stantec

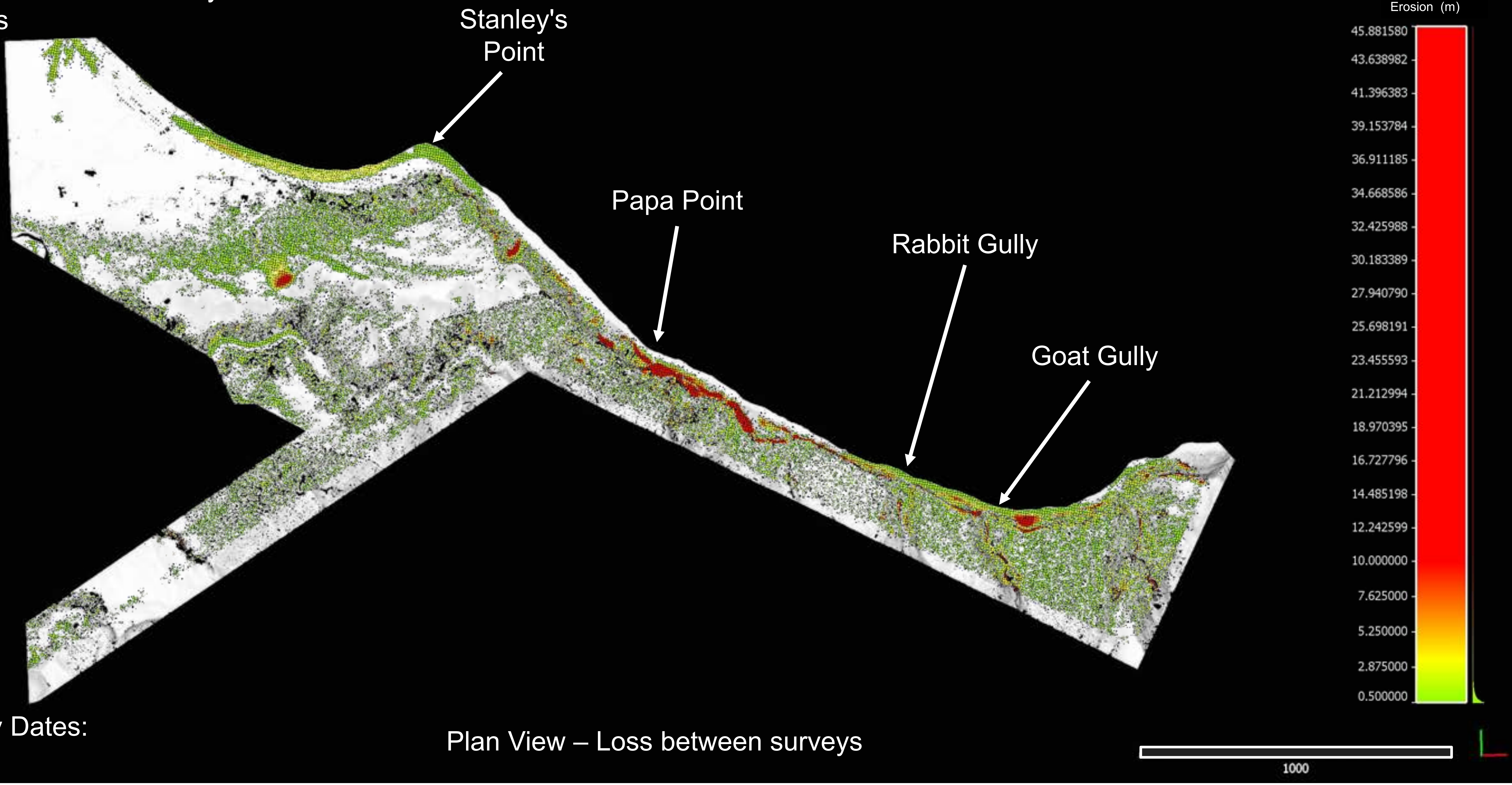


Survey Date:
LiDAR 2012

Plan View – with False Hill Shading

Clifton Beach – Landslide QRA

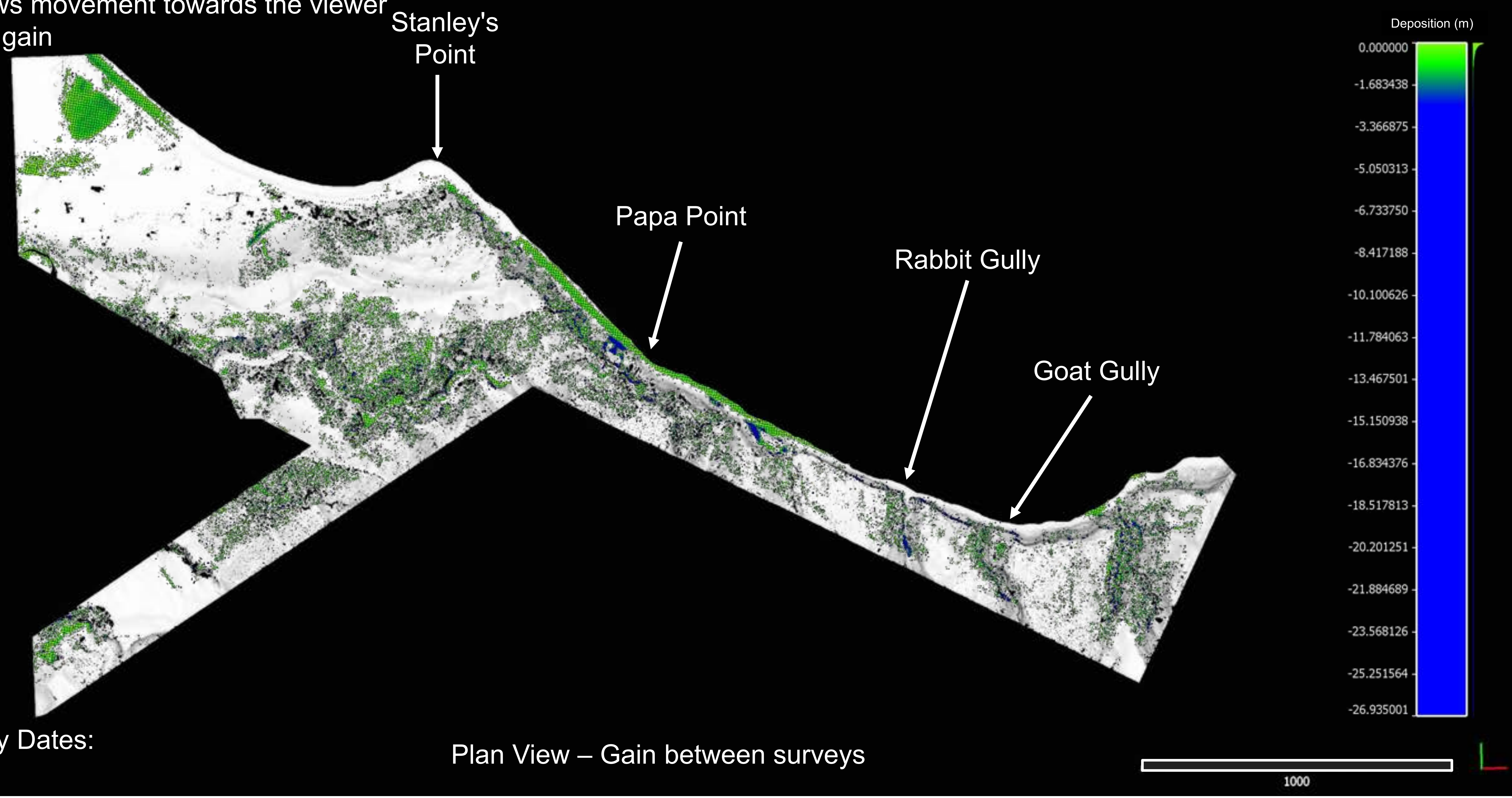
This figure shows movement away from the viewer
i.e. erosion / loss



Between Survey Dates:
2003 - 2012

Plan View – Loss between surveys

This figure shows movement towards the viewer
i.e. deposition / gain

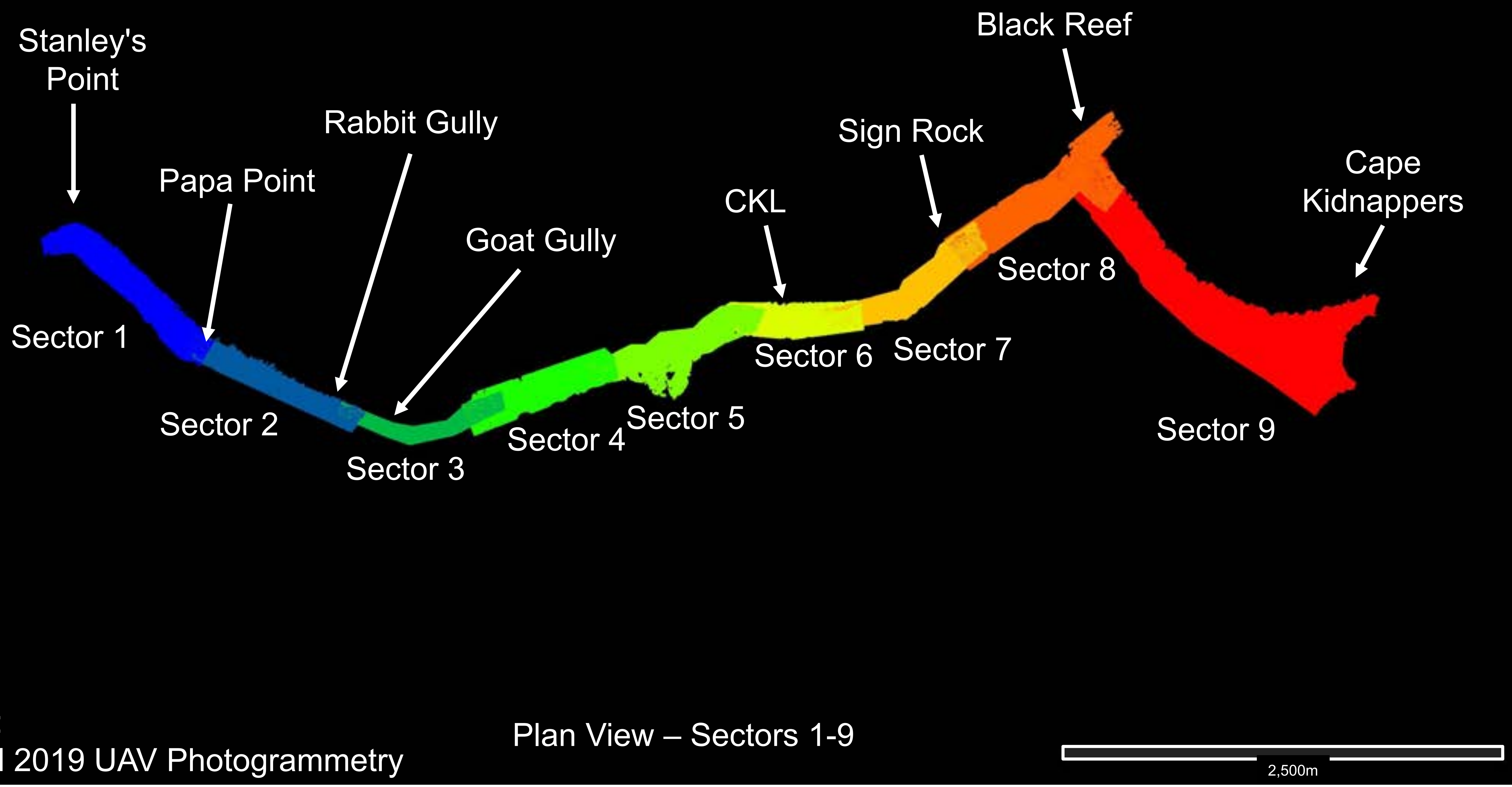


Between Survey Dates:
2003 - 2012

Plan View – Gain between surveys

2012 LiDAR vs 2019 UAV Photogrammetry

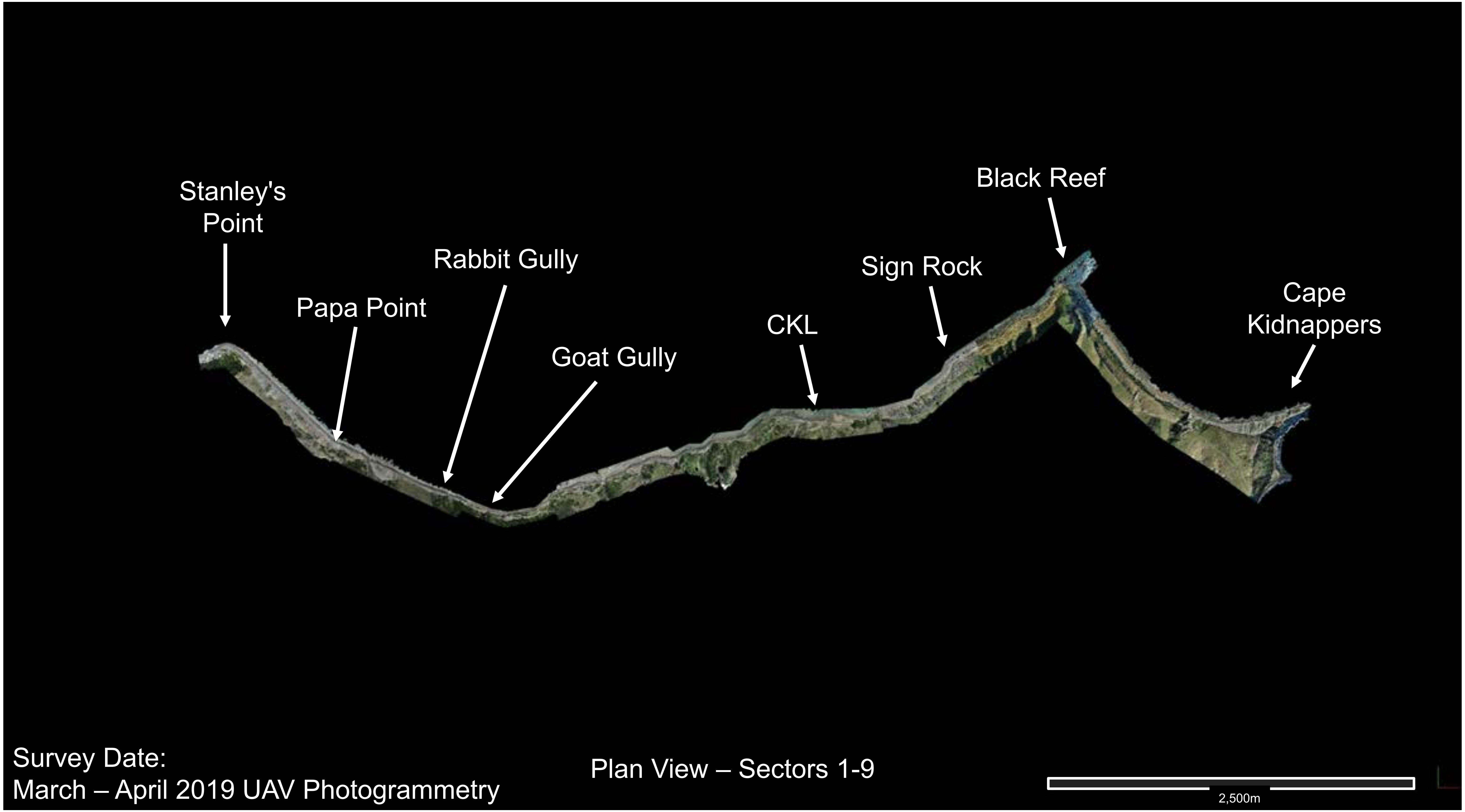
This figure shows the drone-surveyed sectors model extents and overlaps



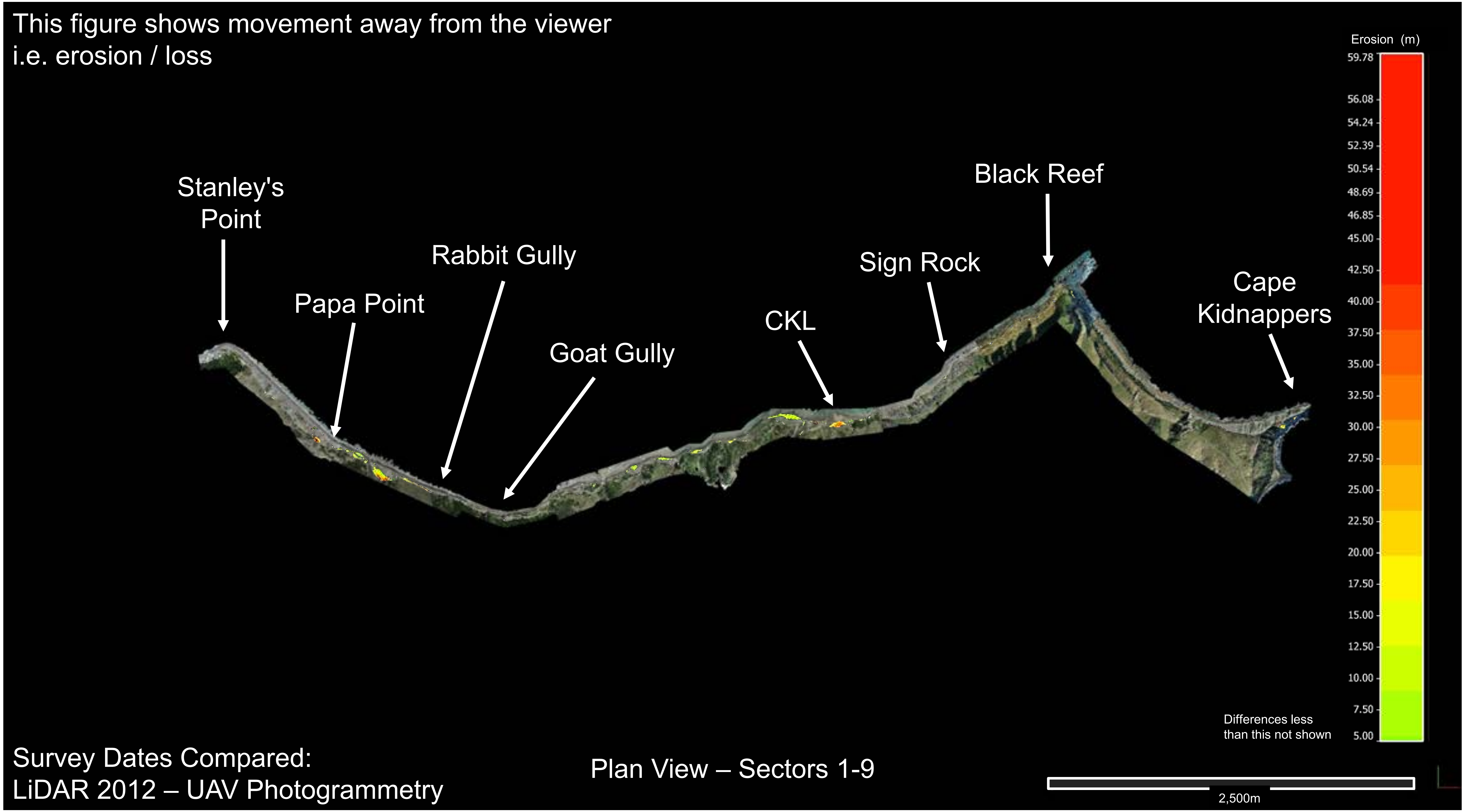
Survey Date:
March – April 2019 UAV Photogrammetry

Plan View – Sectors 1-9

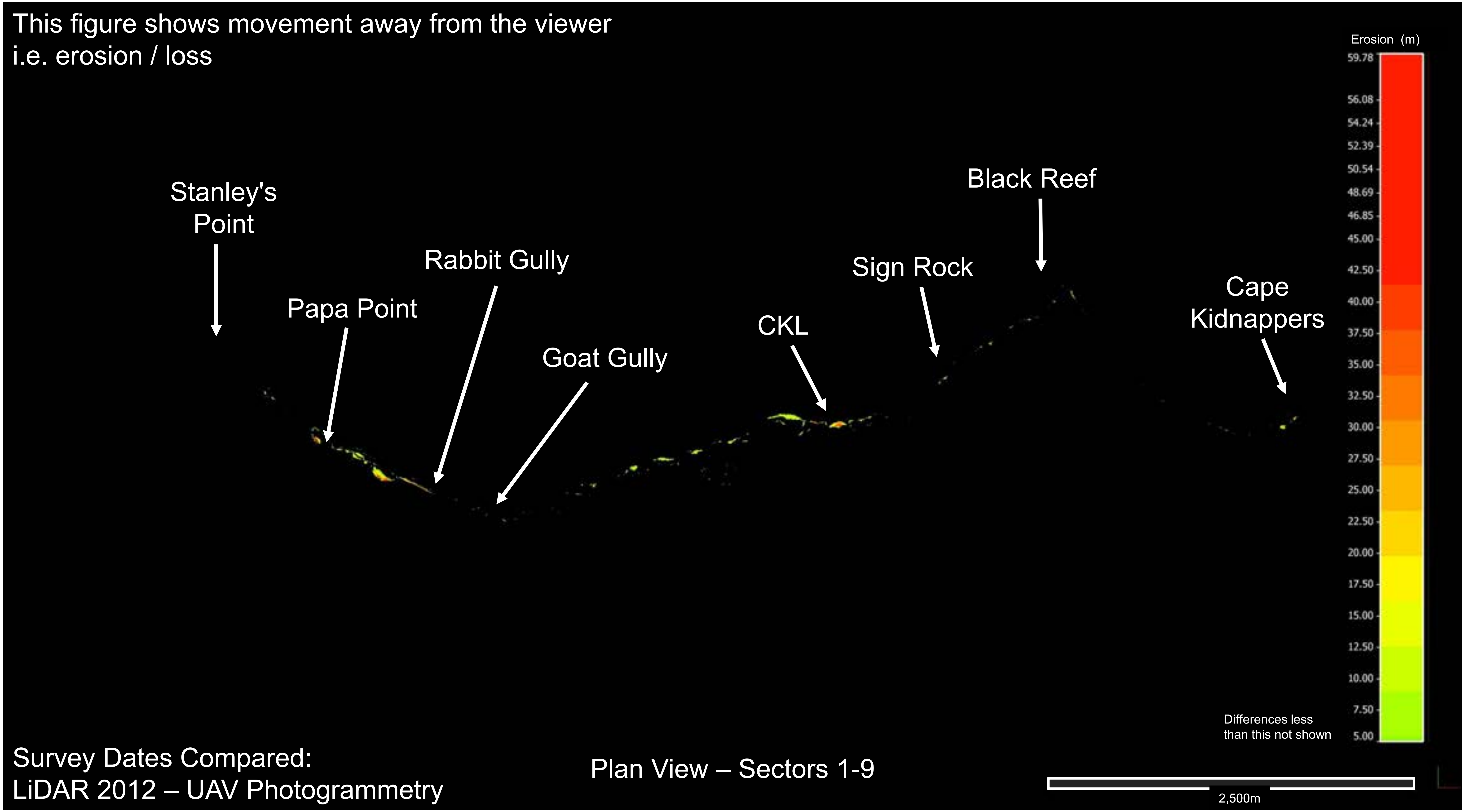
Clifton Beach – Landslide QRA



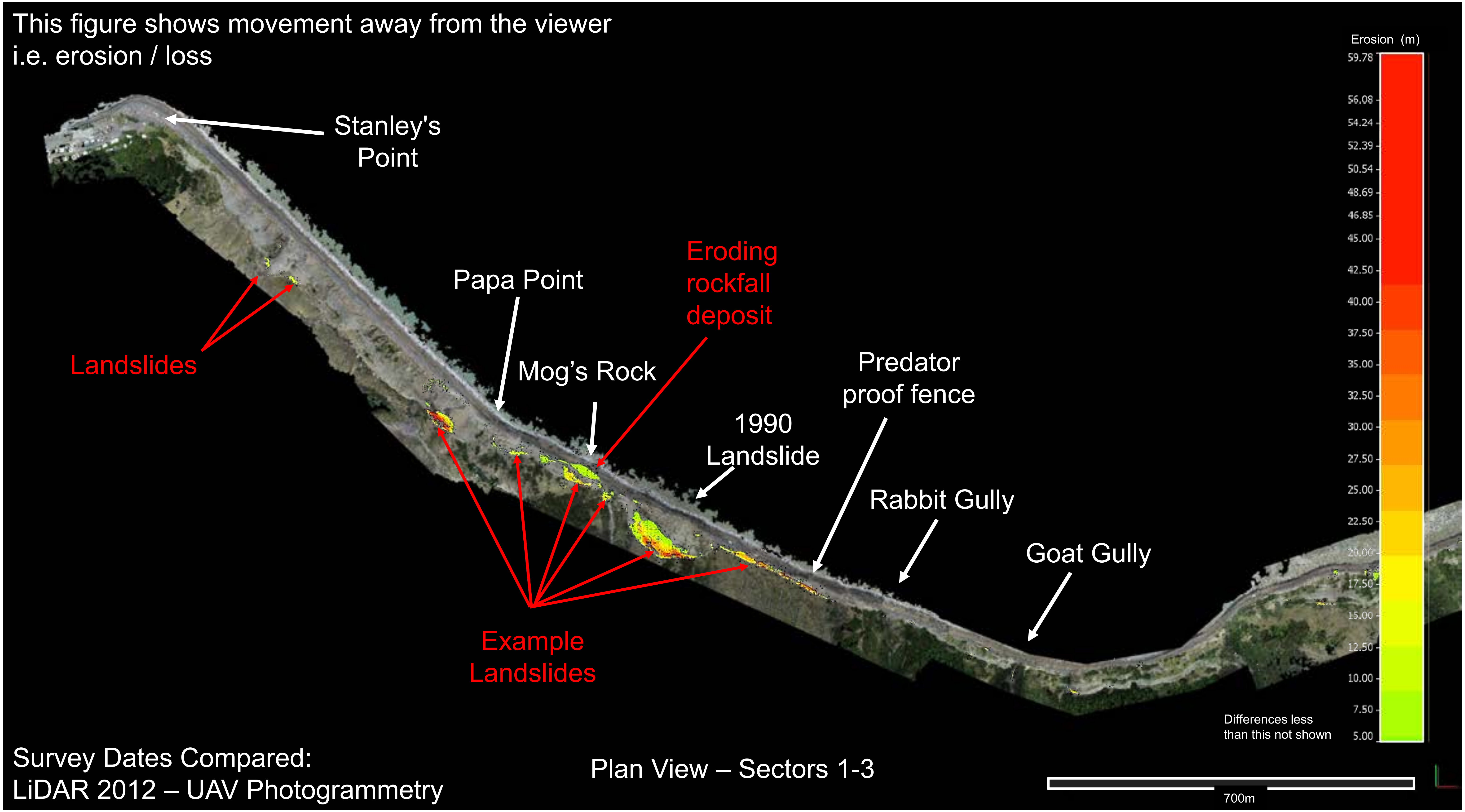
Clifton Beach – Landslide QRA



Clifton Beach – Landslide QRA

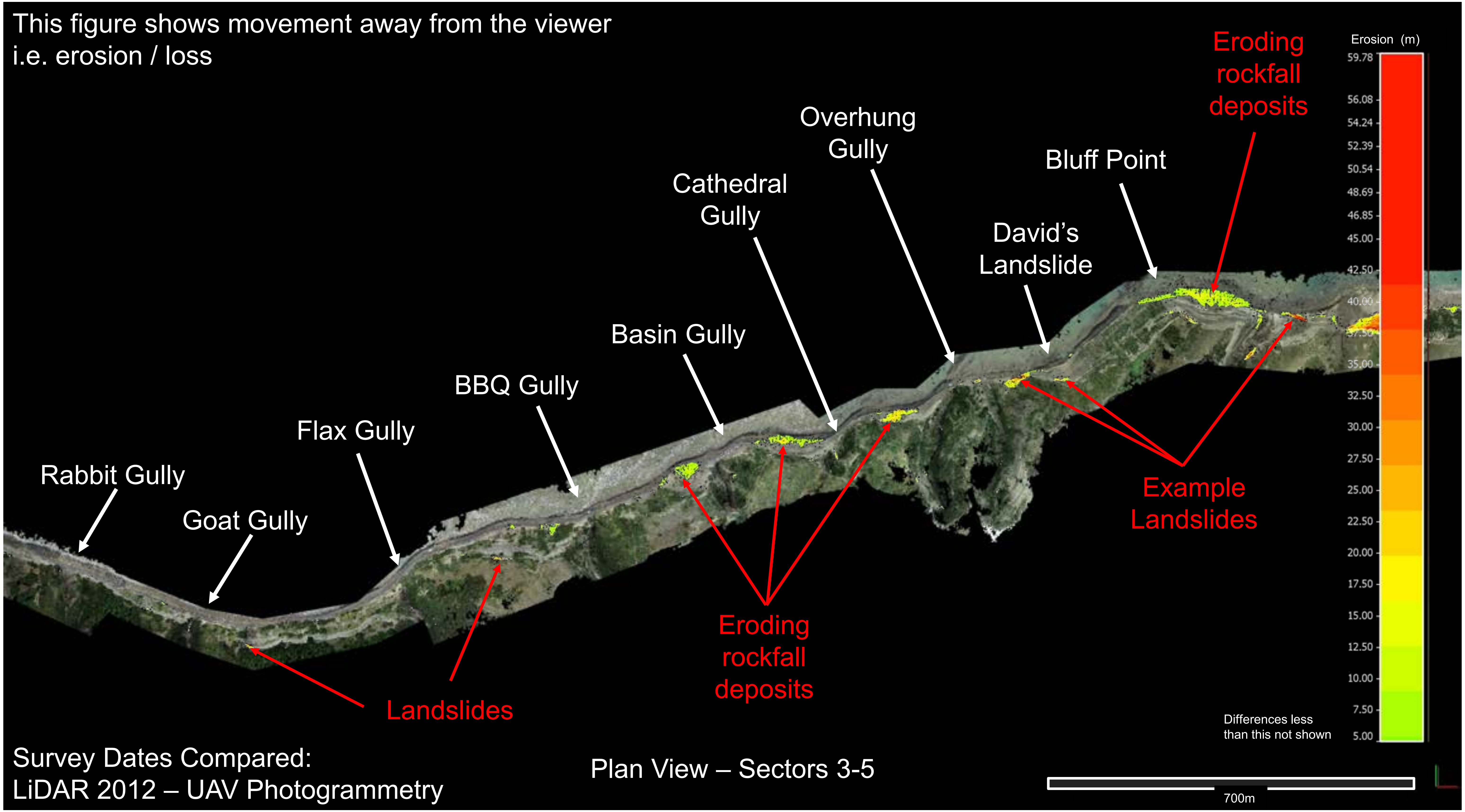


Clifton Beach – Landslide QRA



Clifton Beach – Landslide QRA

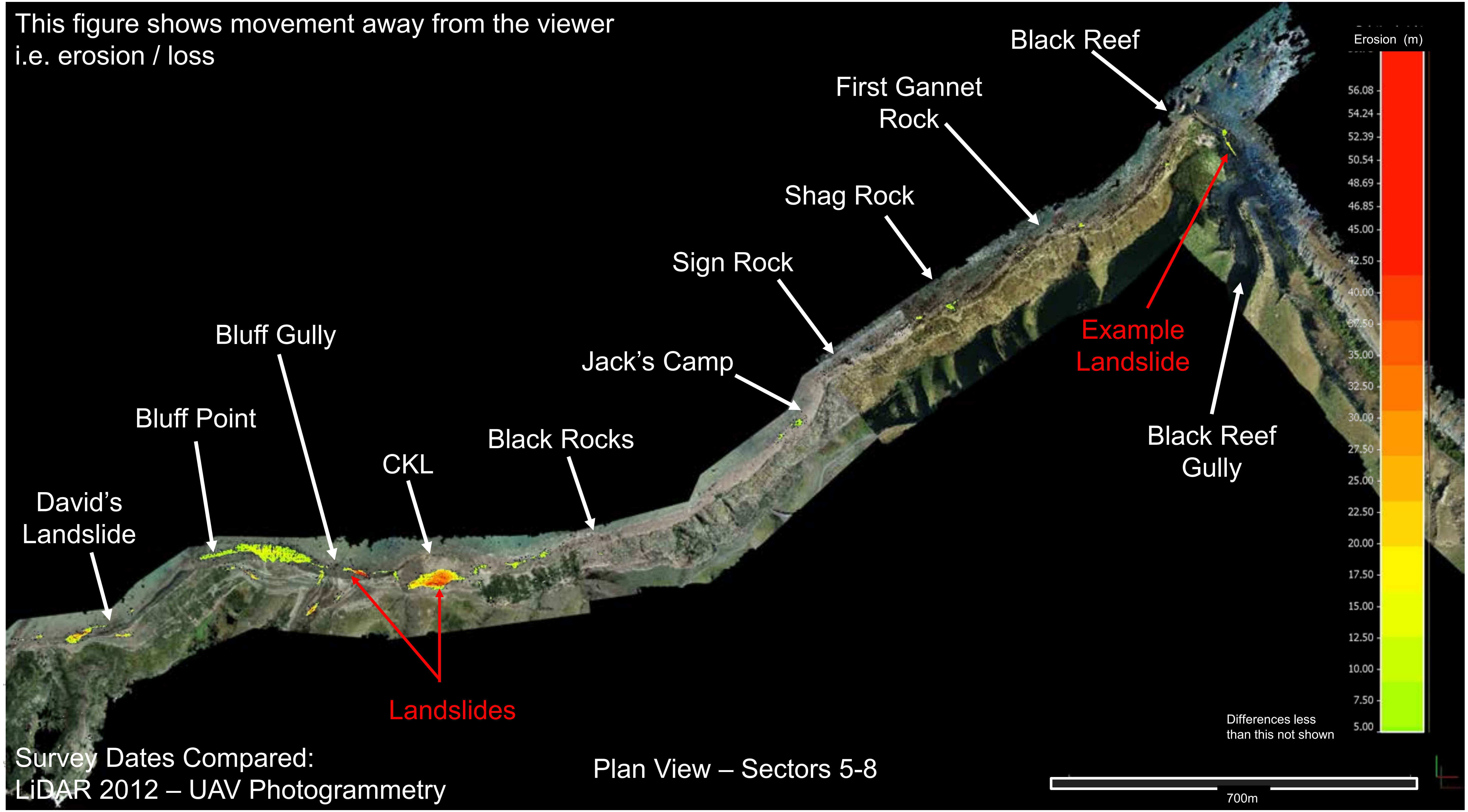
The Surveying Company
YOUR SUBDIVISION PROFESSIONALS



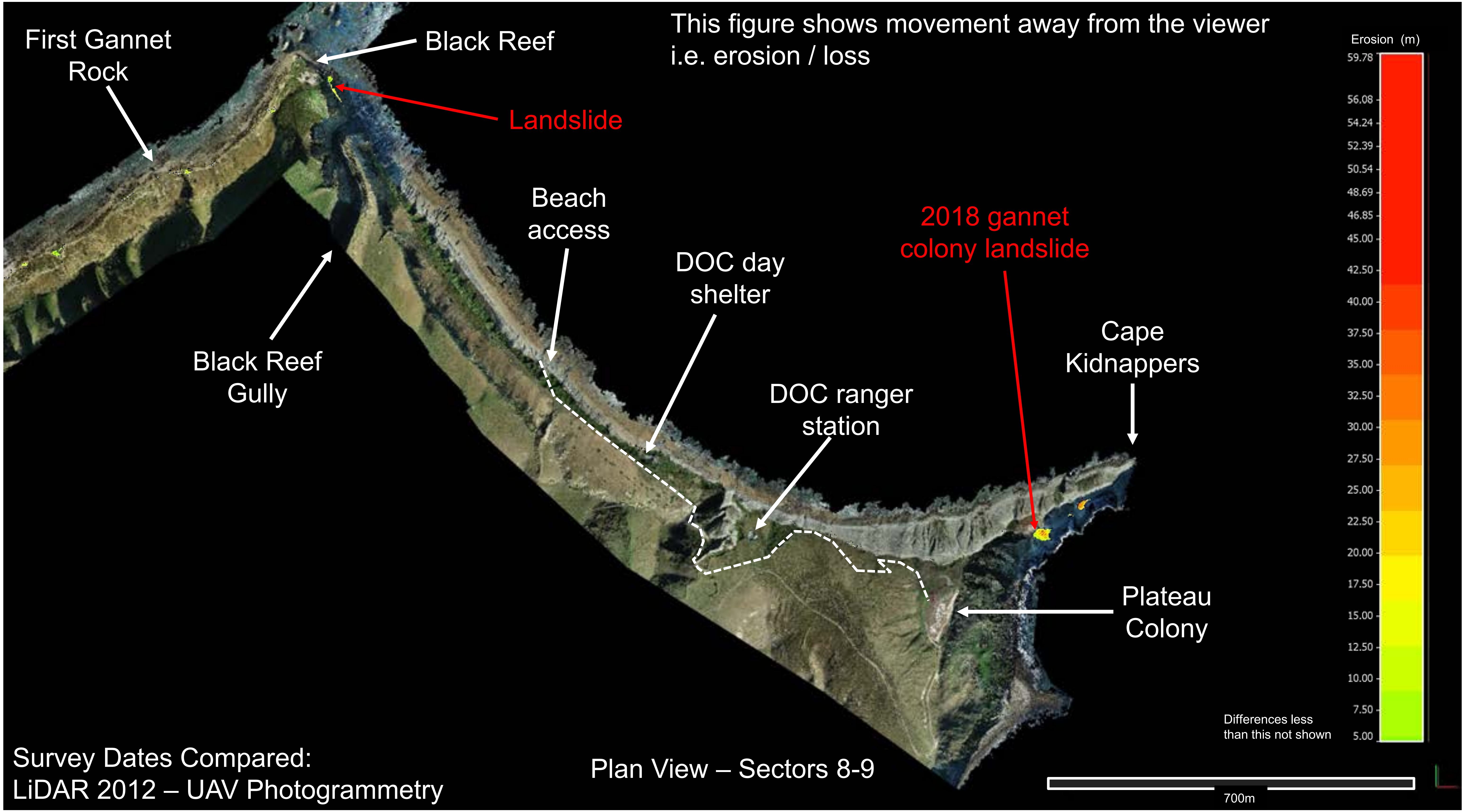
HASTINGS DISTRICT COUNCIL

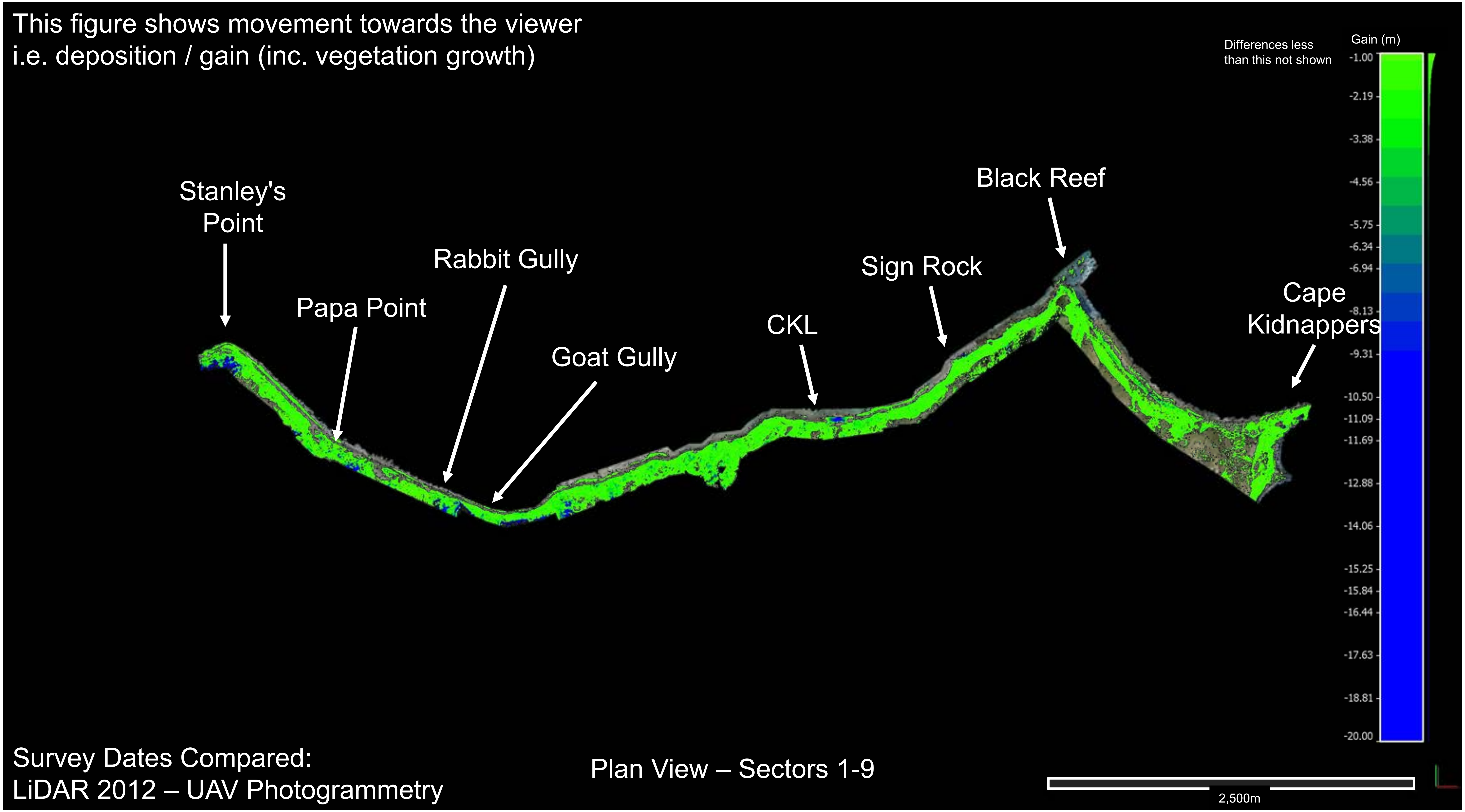
Clifton Beach – Landslide QRA

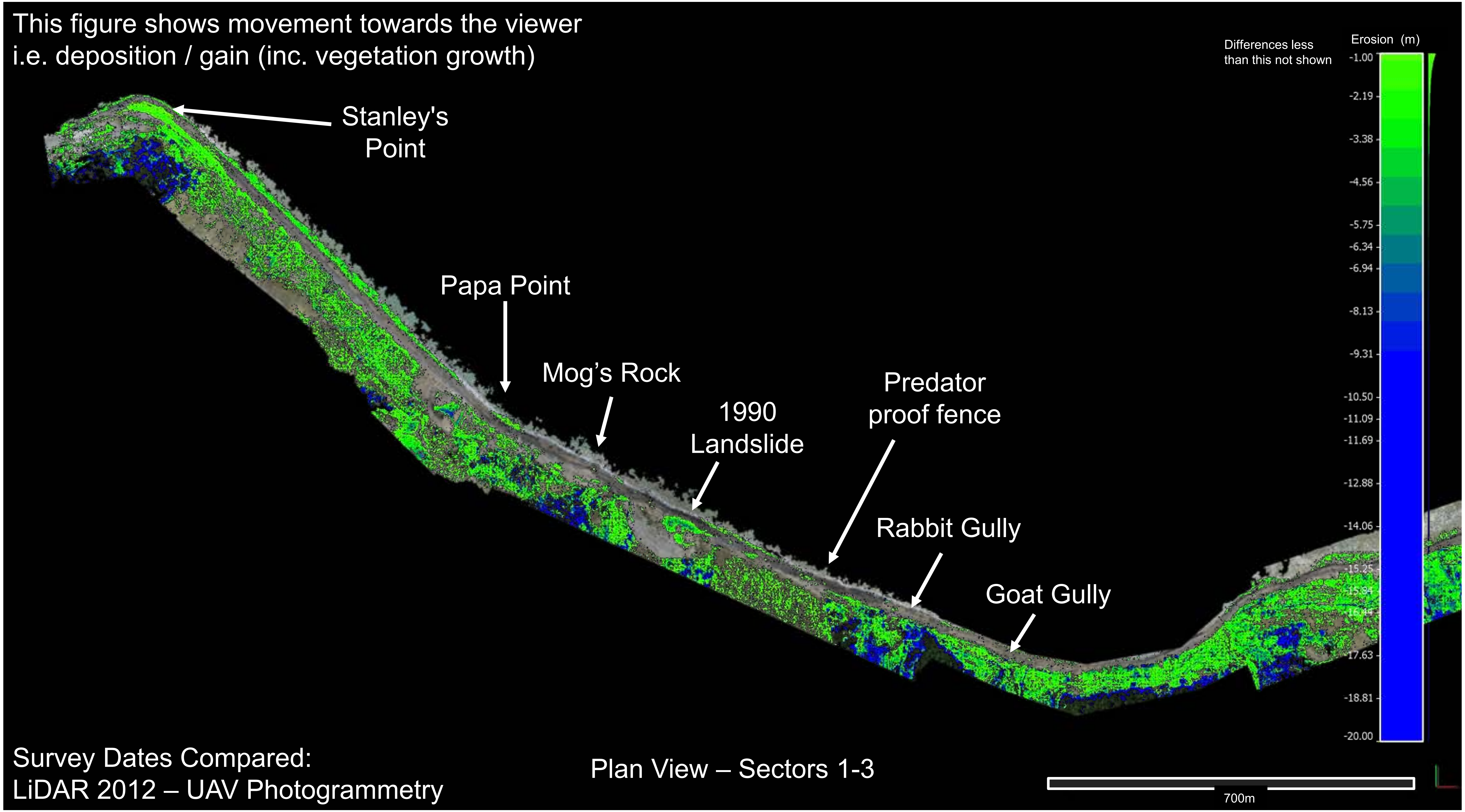
Stantec



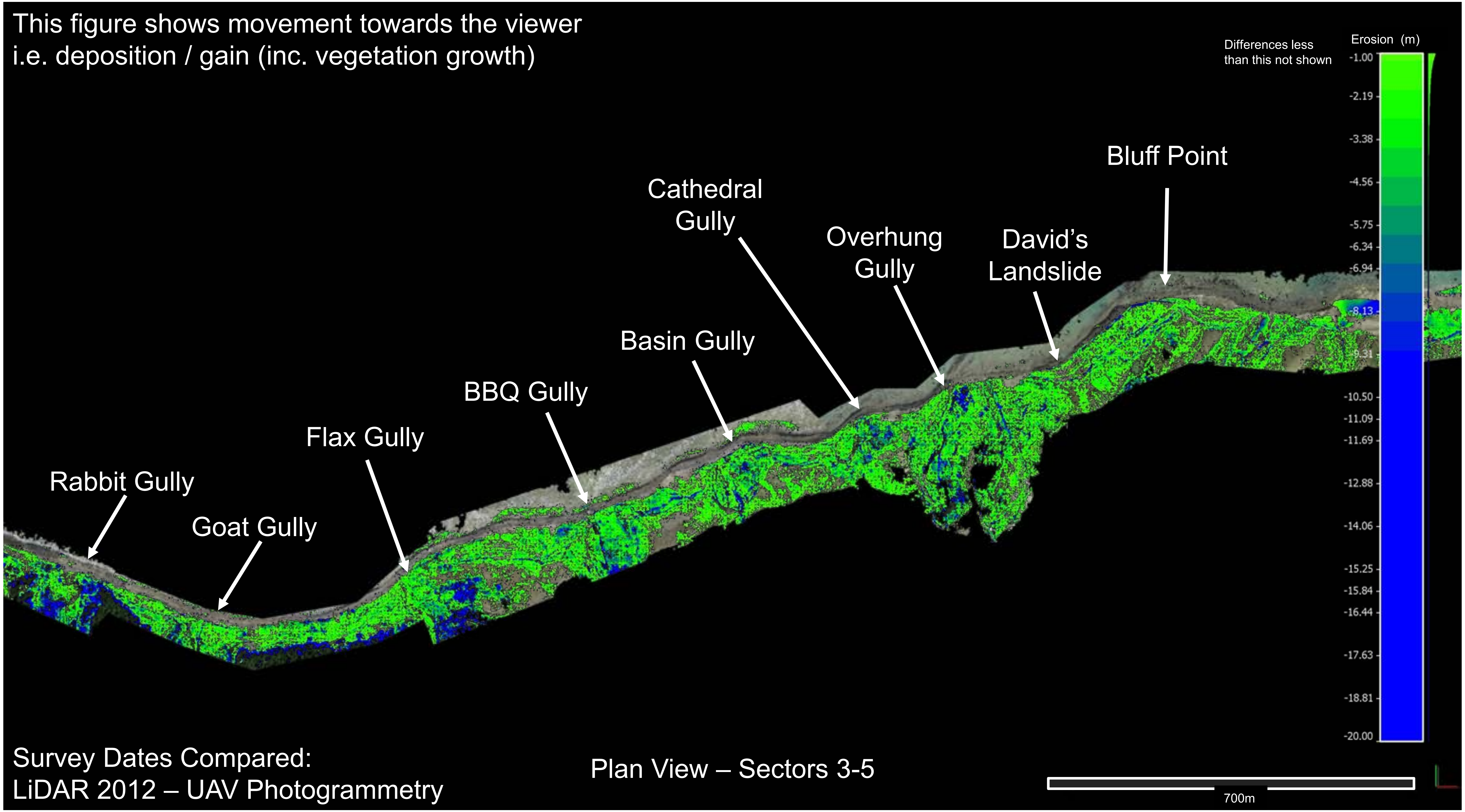
Clifton Beach – Landslide QRA


This figure shows movement away from the viewer
i.e. erosion / loss
First Gannet Rock
Black Reef
Landslide
Beach access
Black Reef Gully
DOC day shelter
DOC ranger station
2018 gannet colony landslide
Cape Kidnappers
Plateau Colony
Erosion (m)
59.78
56.08
54.24
52.39
50.54
48.69
46.85
45.00
42.50
40.00
37.50
35.00
32.50
30.00
27.50
25.00
22.50
20.00
17.50
15.00
12.50
10.00
7.50
5.00
Differences less than this not shown
700m
Survey Dates Compared:
LiDAR 2012 – UAV Photogrammetry
Plan View – Sectors 8-9

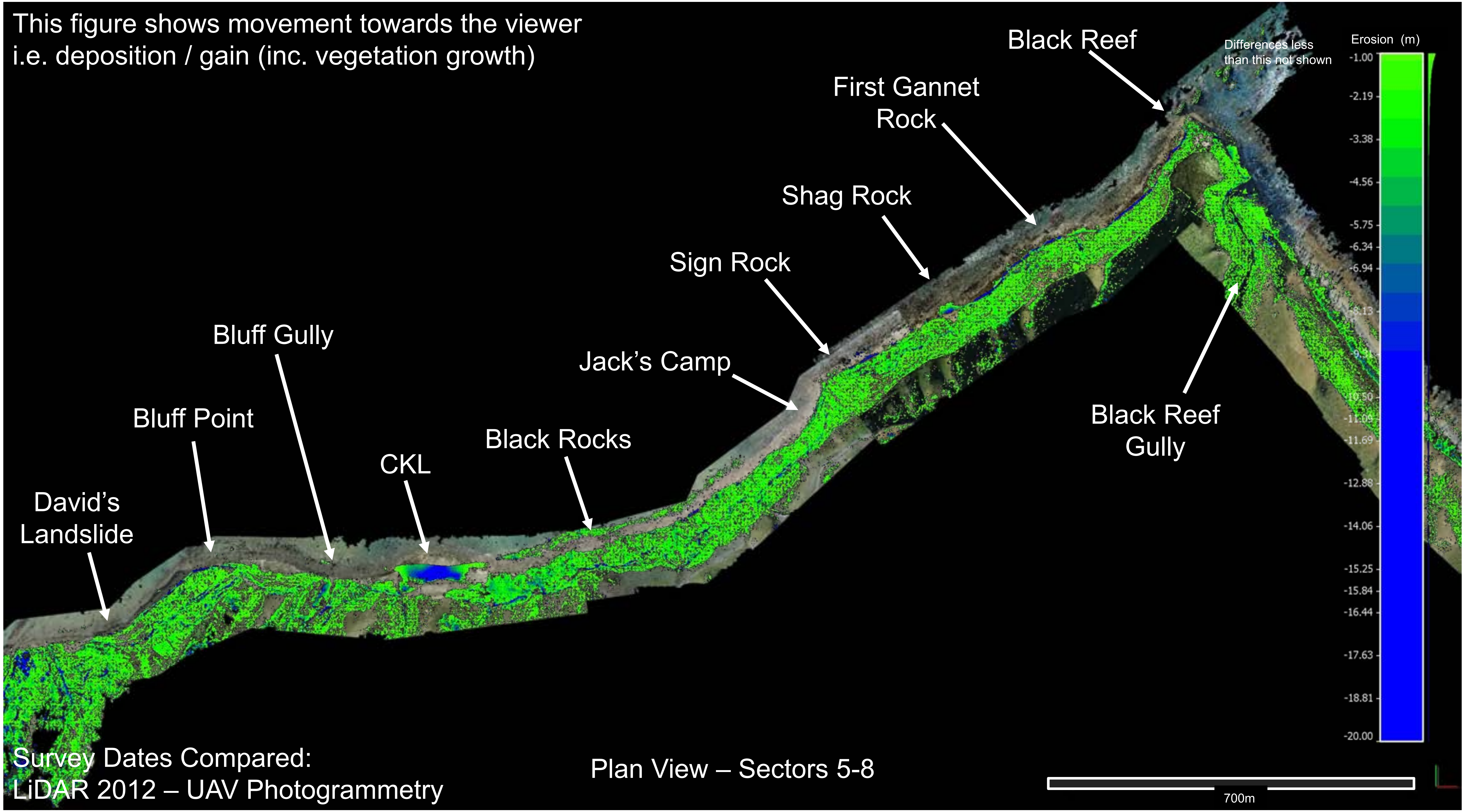

This figure shows movement towards the viewer
i.e. deposition / gain (inc. vegetation growth)
Differences less than this not shown
Gain (m)
-1.00
-2.19
-3.38
-4.56
-5.75
-6.34
-6.94
-8.13
-9.31
-10.50
-11.09
-11.69
-12.88
-14.06
-15.25
-15.84
-16.44
-17.63
-18.81
-20.00
Stanley's Point
Papa Point
Rabbit Gully
Goat Gully
CKL
Sign Rock
Black Reef
Cape Kidnappers
Survey Dates Compared:
LiDAR 2012 – UAV Photogrammetry
Plan View – Sectors 1-9
2,500m



Clifton Beach – Landslide QRA


This figure shows movement towards the viewer
i.e. deposition / gain (inc. vegetation growth)
Differences less than this not shown
Erosion (m)
-1.00
-2.19
-3.38
-4.56
-5.75
-6.34
-6.94
-8.13
-9.31
-10.50
-11.09
-11.69
-12.88
-14.06
-15.25
-15.84
-16.44
-17.63
-18.81
-20.00
Bluff Point
Cathedral Gully
Overhung Gully
David's Landslide
Basin Gully
BBQ Gully
Flax Gully
Rabbit Gully
Goat Gully
Survey Dates Compared:
LiDAR 2012 – UAV Photogrammetry
Plan View – Sectors 3-5
700m

The Surveying Company
YOUR SUBDIVISION PROFESSIONALS

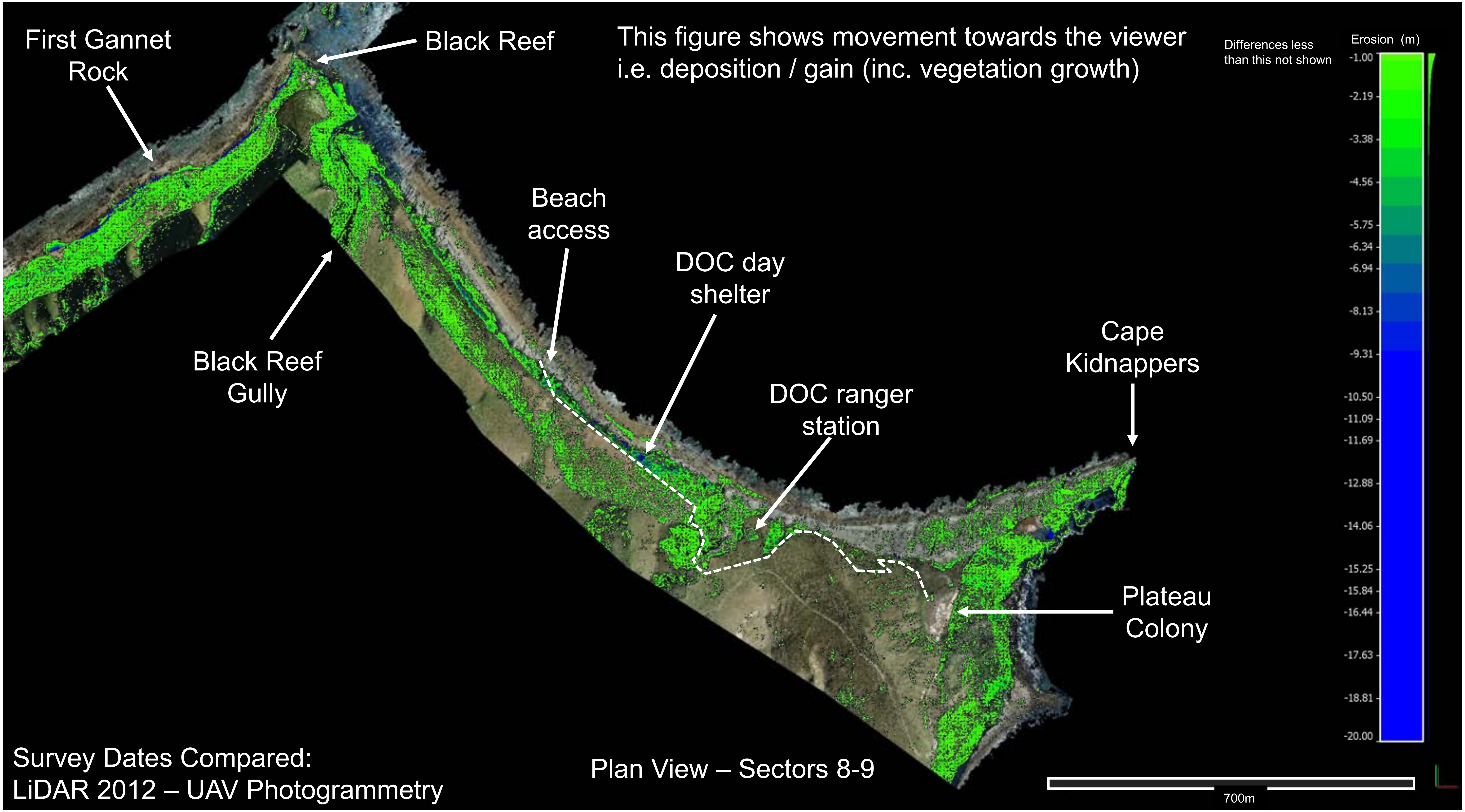


HASTINGS DISTRICT COUNCIL

Clifton Beach – Landslide QRA

Stantec

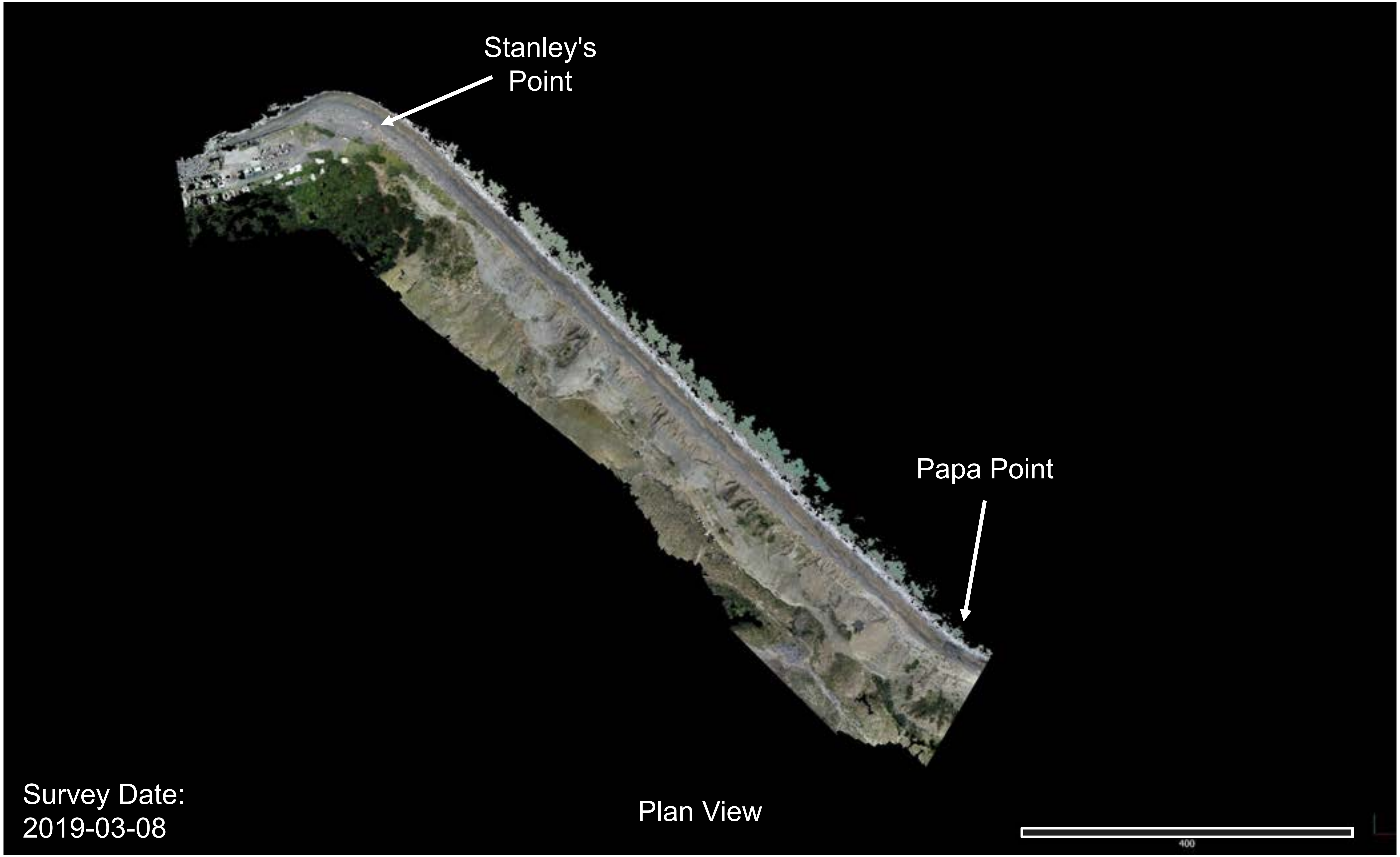
THE SURVEYING COMPANY
YOUR SUBDIVISION PROFESSIONALS



HASTINGS DISTRICT COUNCIL

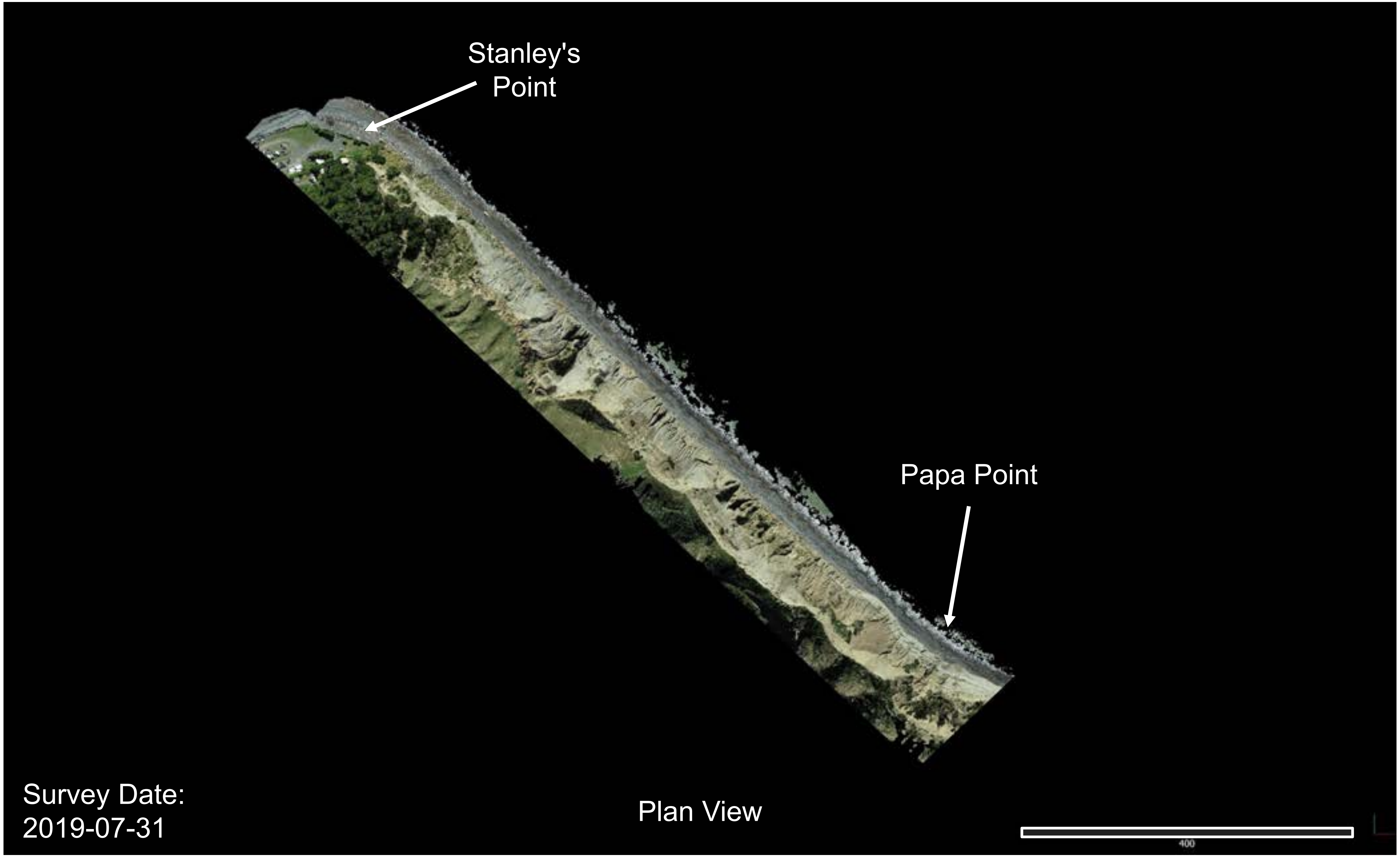
Clifton Beach – Landslide QRA

Stantec



Clifton Beach – Sector 1

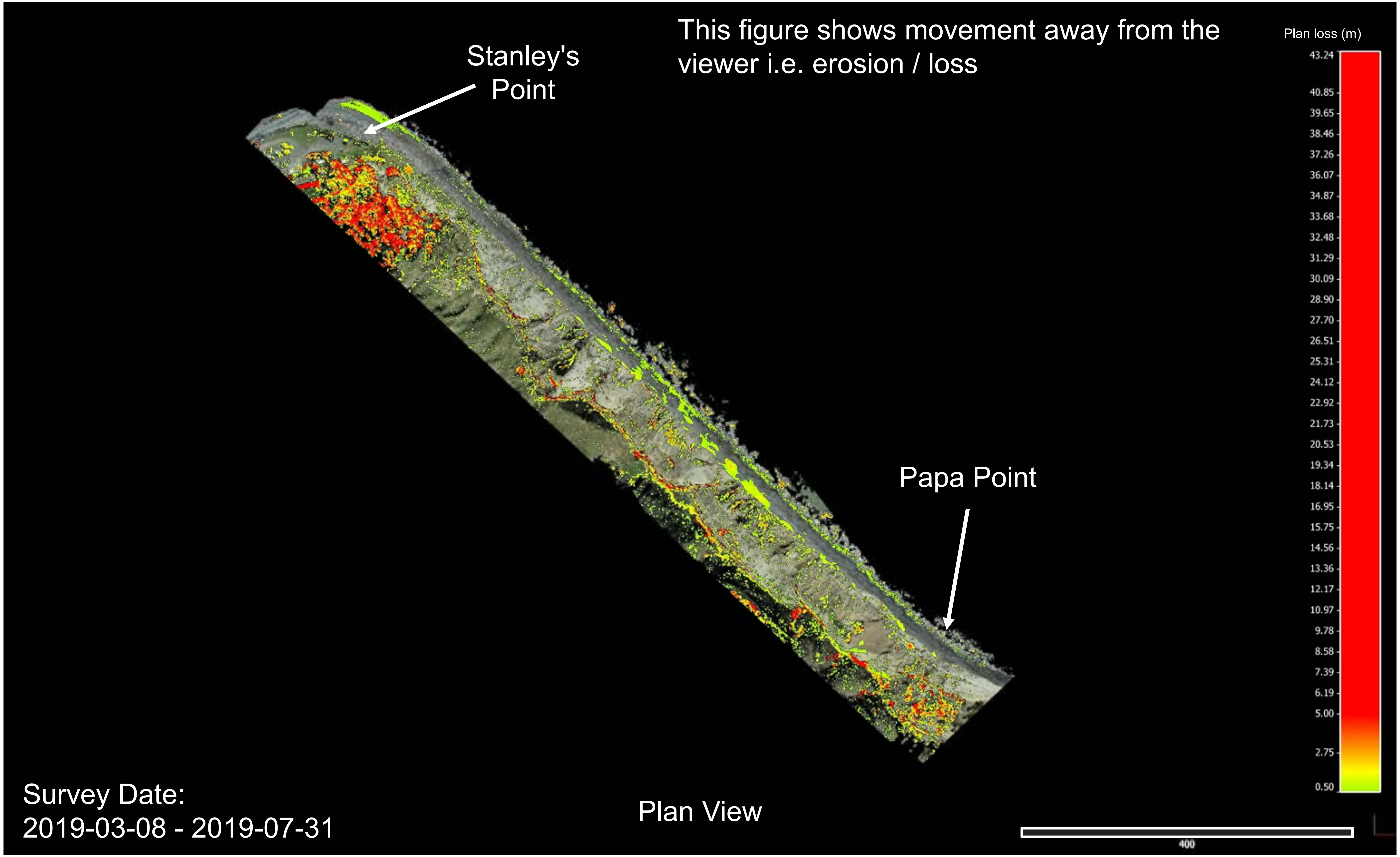
THE SURVEYING COMPANY
YOUR SUBDIVISION PROFESSIONALS



HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 1

Stantec



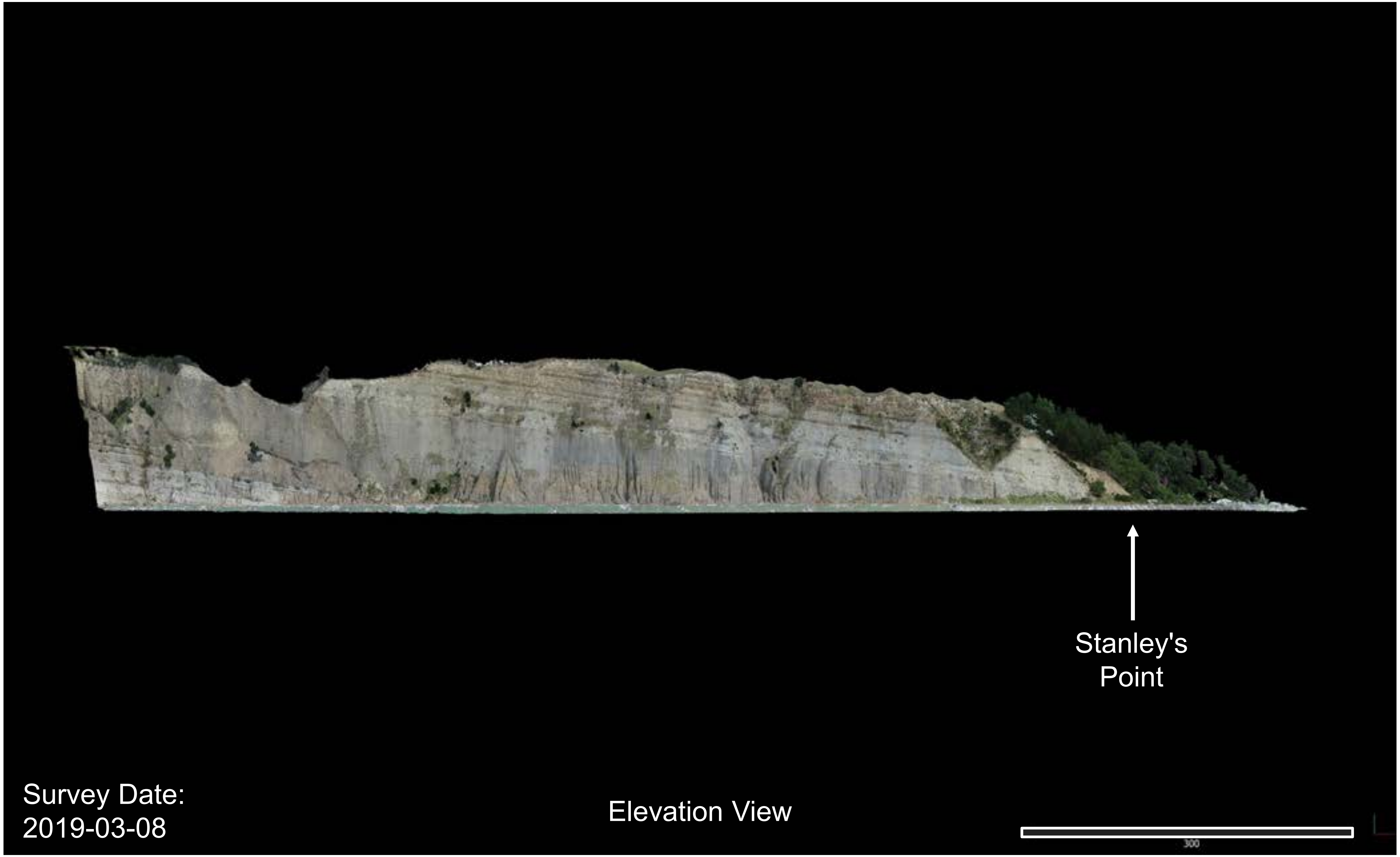
Clifton Beach – Sector 1

THE SURVEYING COMPANY
YOUR SUBDIVISION PROFESSIONALS

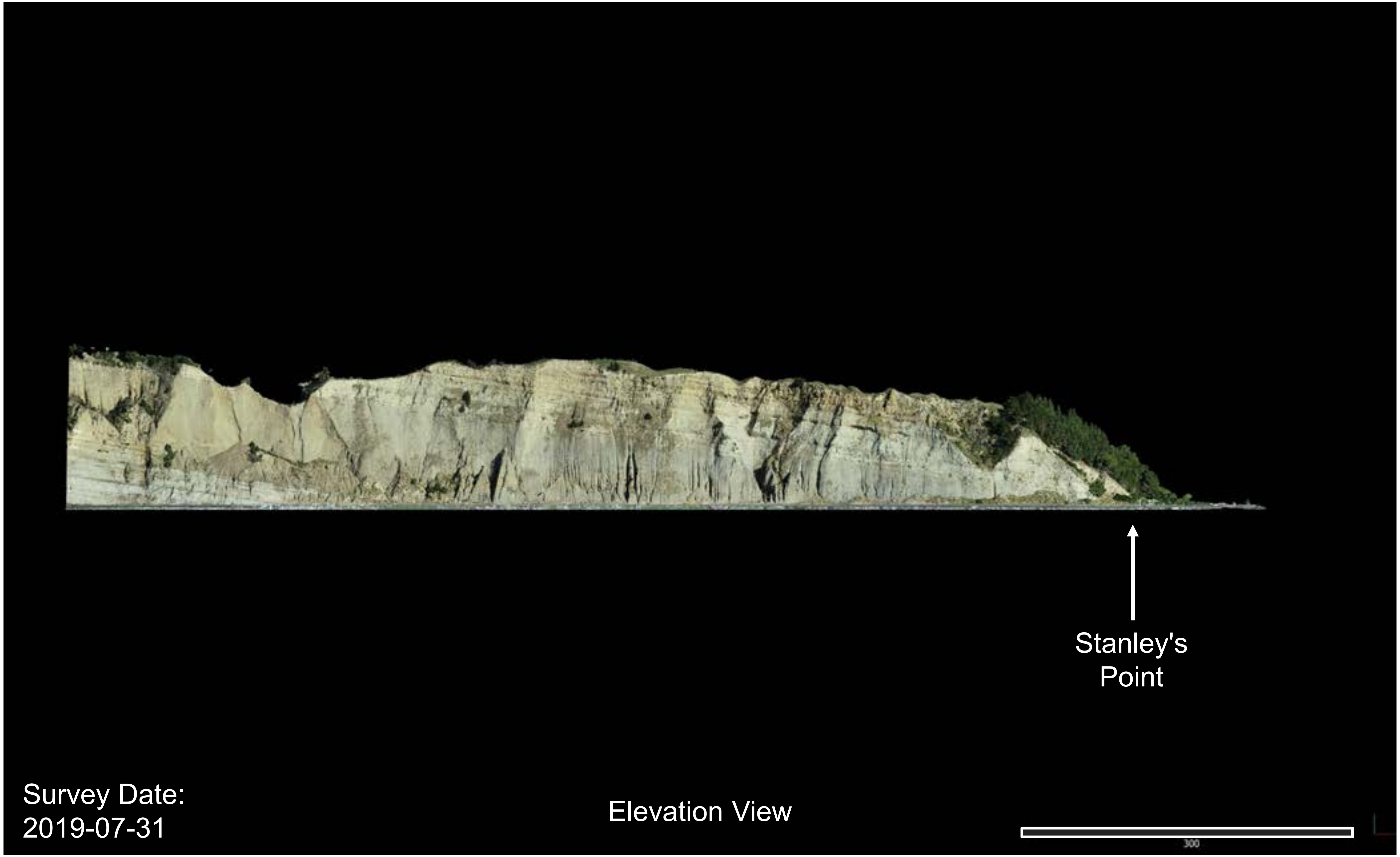
HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 1

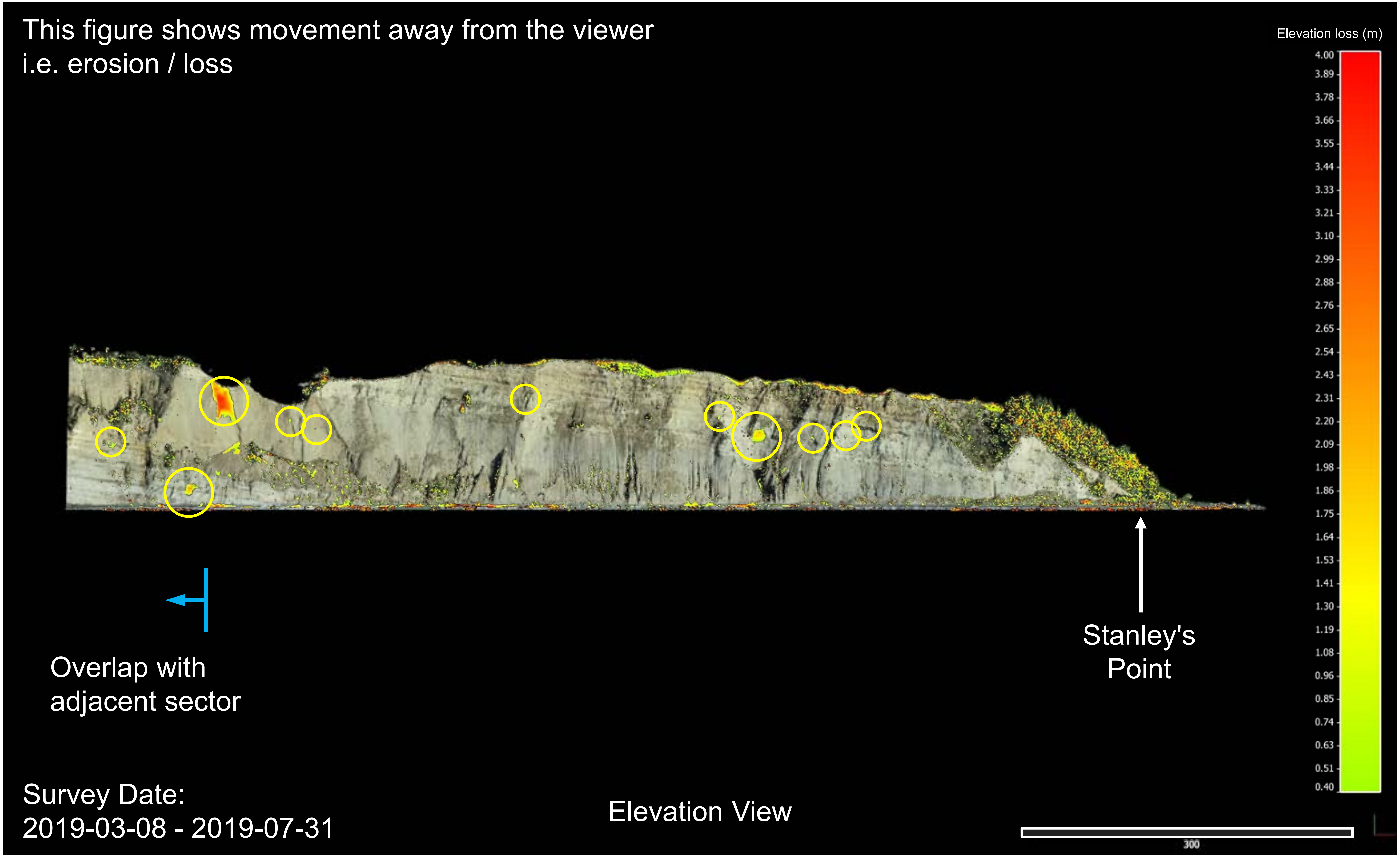
Stantec



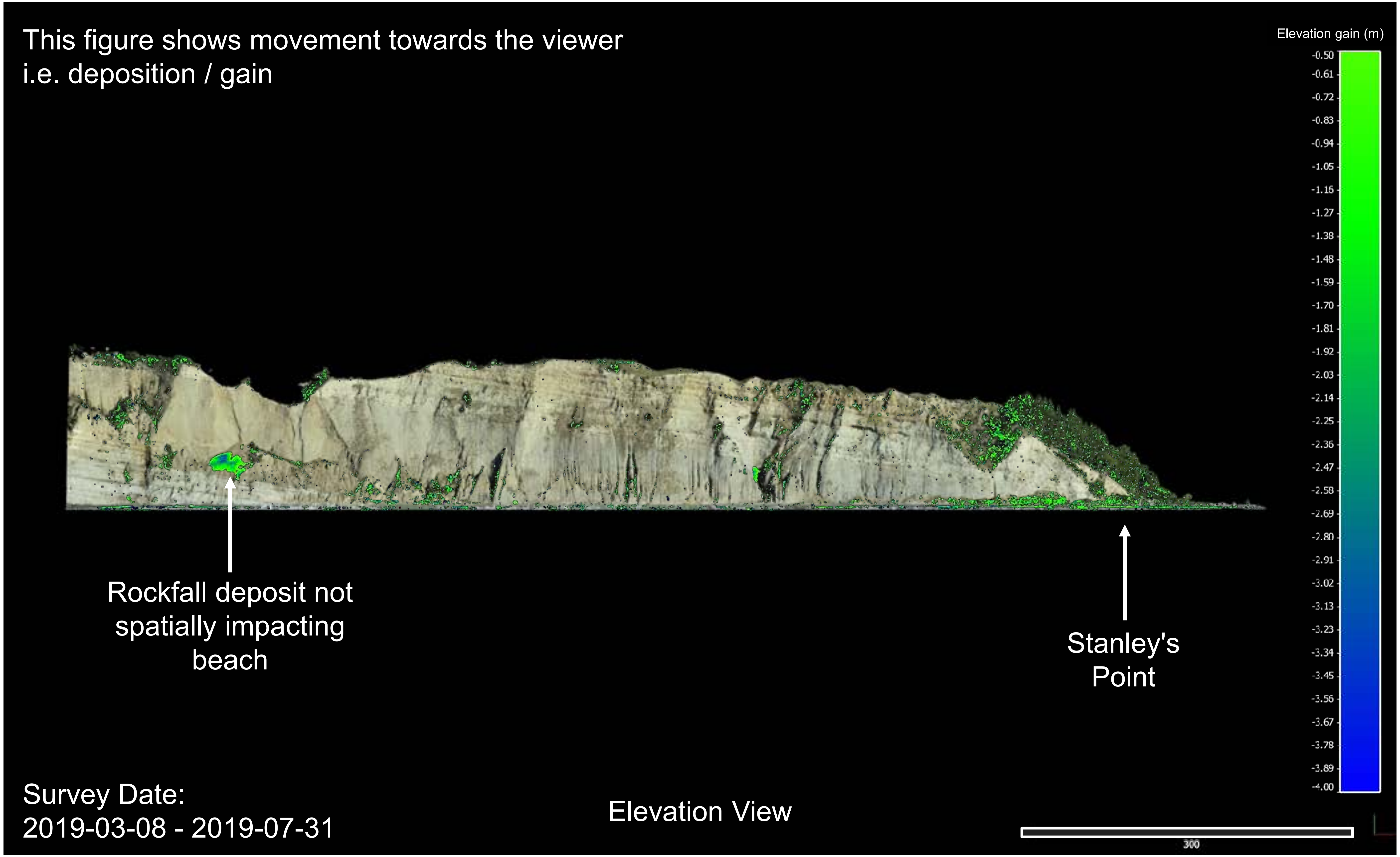
Clifton Beach – Sector 1



Clifton Beach – Sector 1

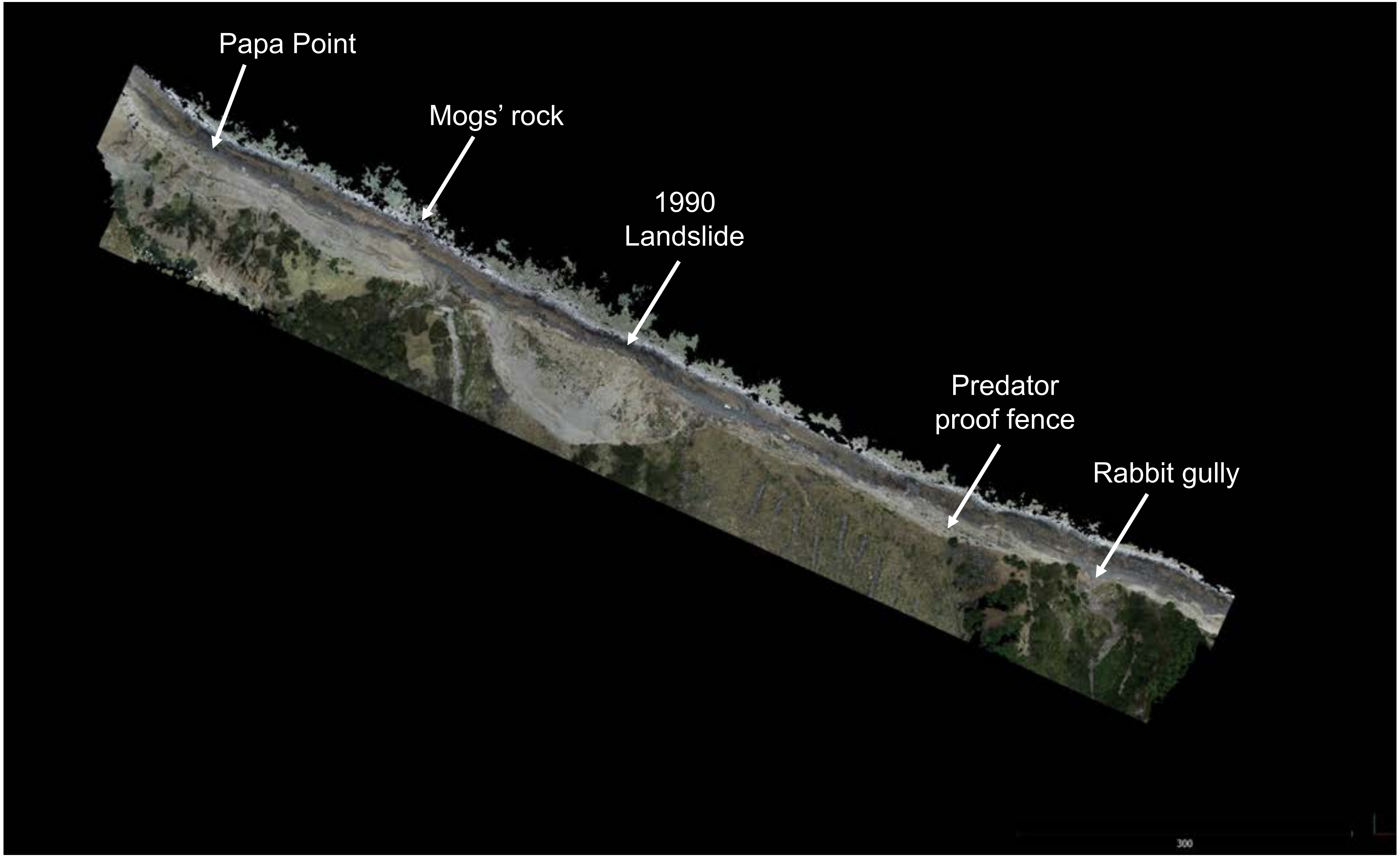


Clifton Beach – Sector 1



Clifton Beach – Sector 1

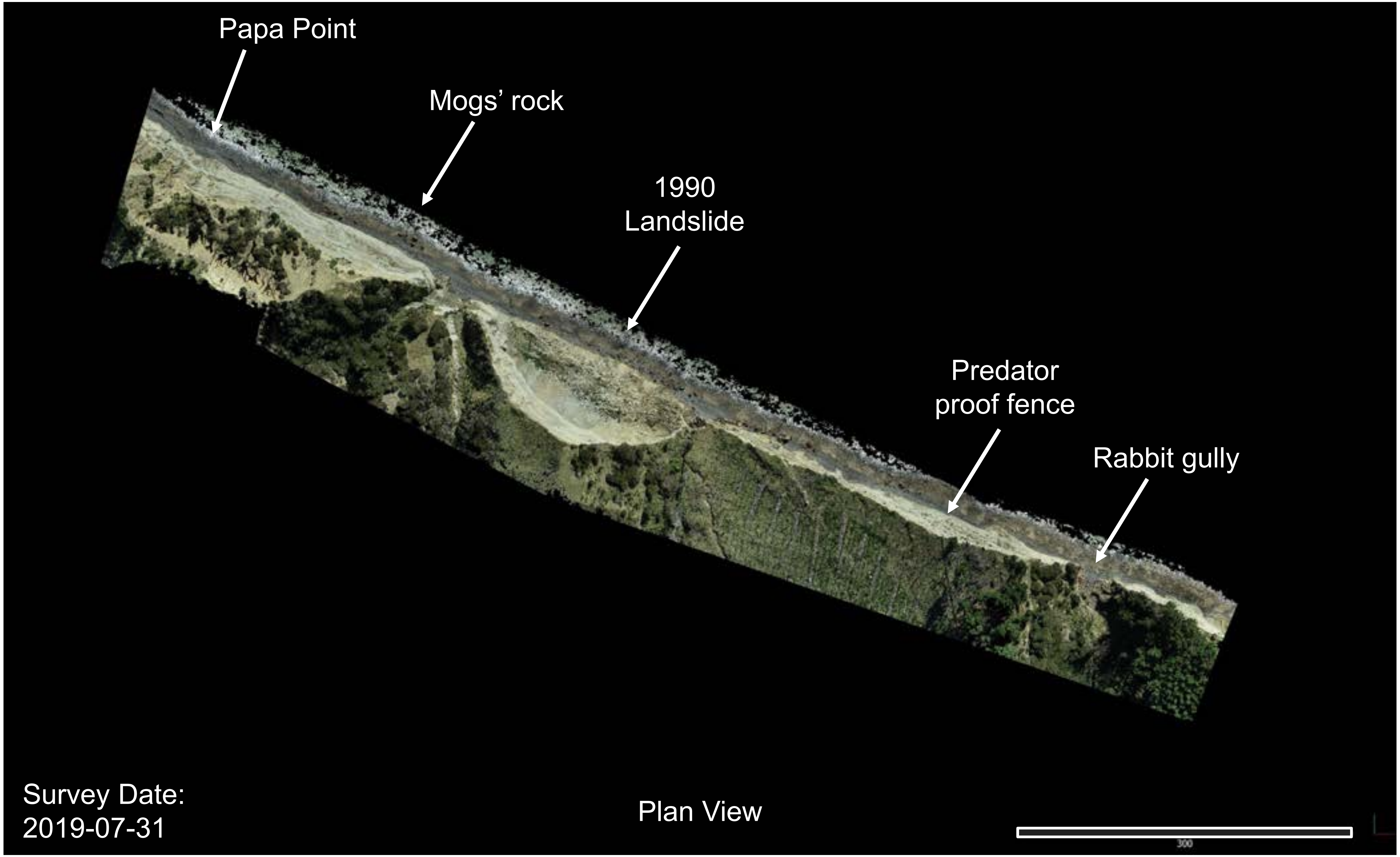
The Surveying Company
YOUR SUBDIVISION PROFESSIONALS



HASTINGS
DISTRICT COUNCIL

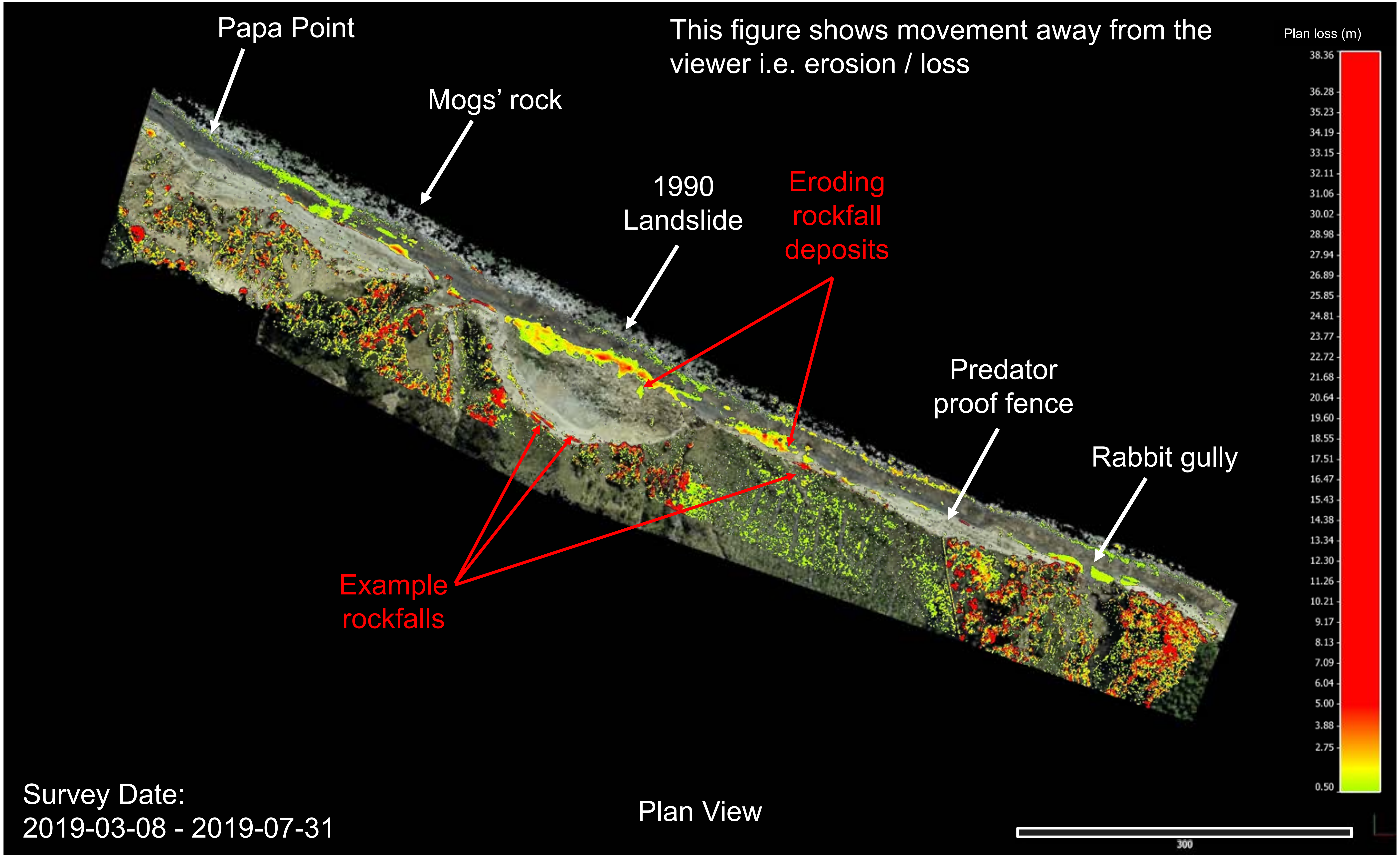
Clifton Beach – Sector 2

Stantec



Clifton Beach – Sector 2

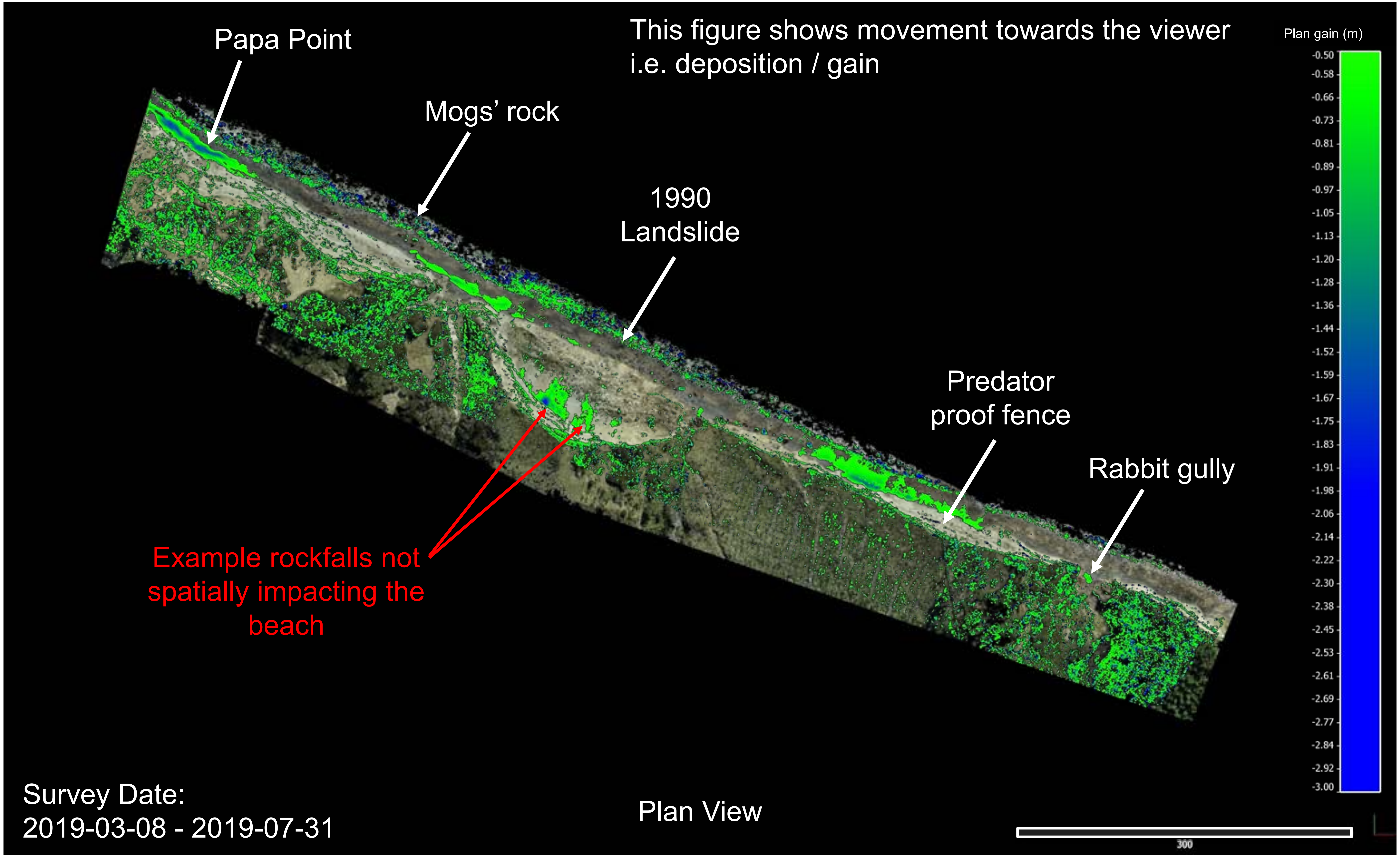
The Surveying Company
YOUR SUBDIVISION PROFESSIONALS



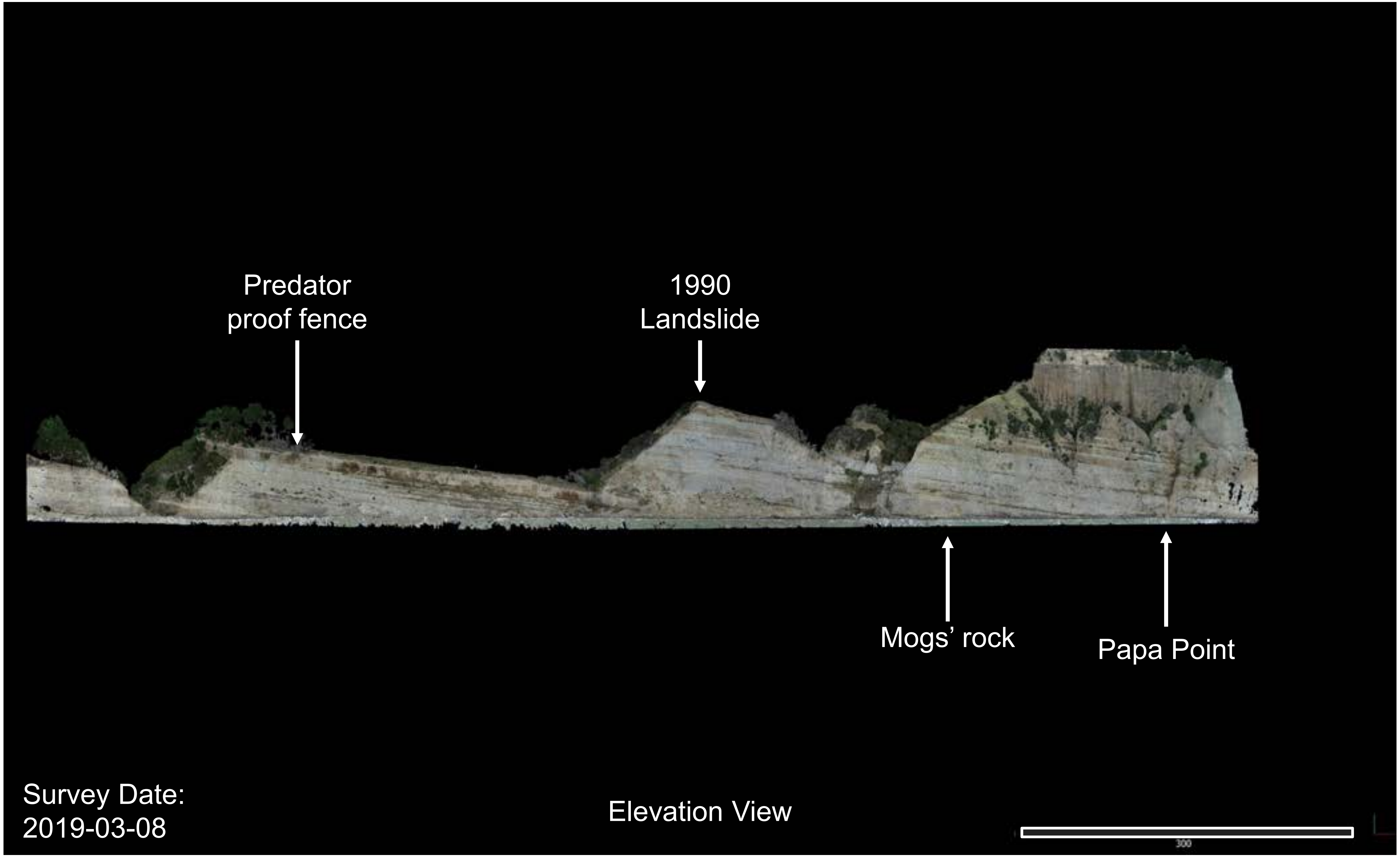
HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 2

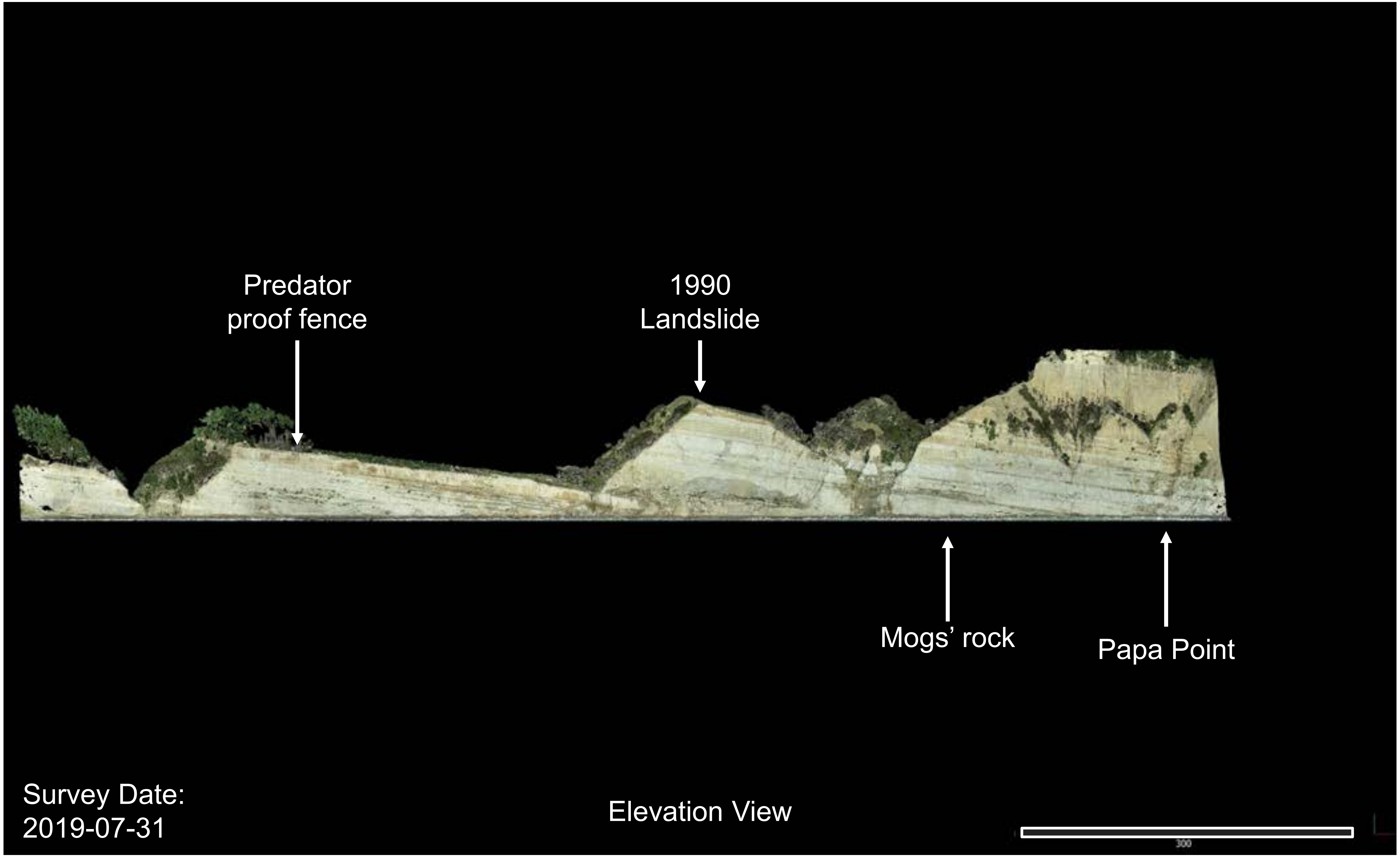
Stantec



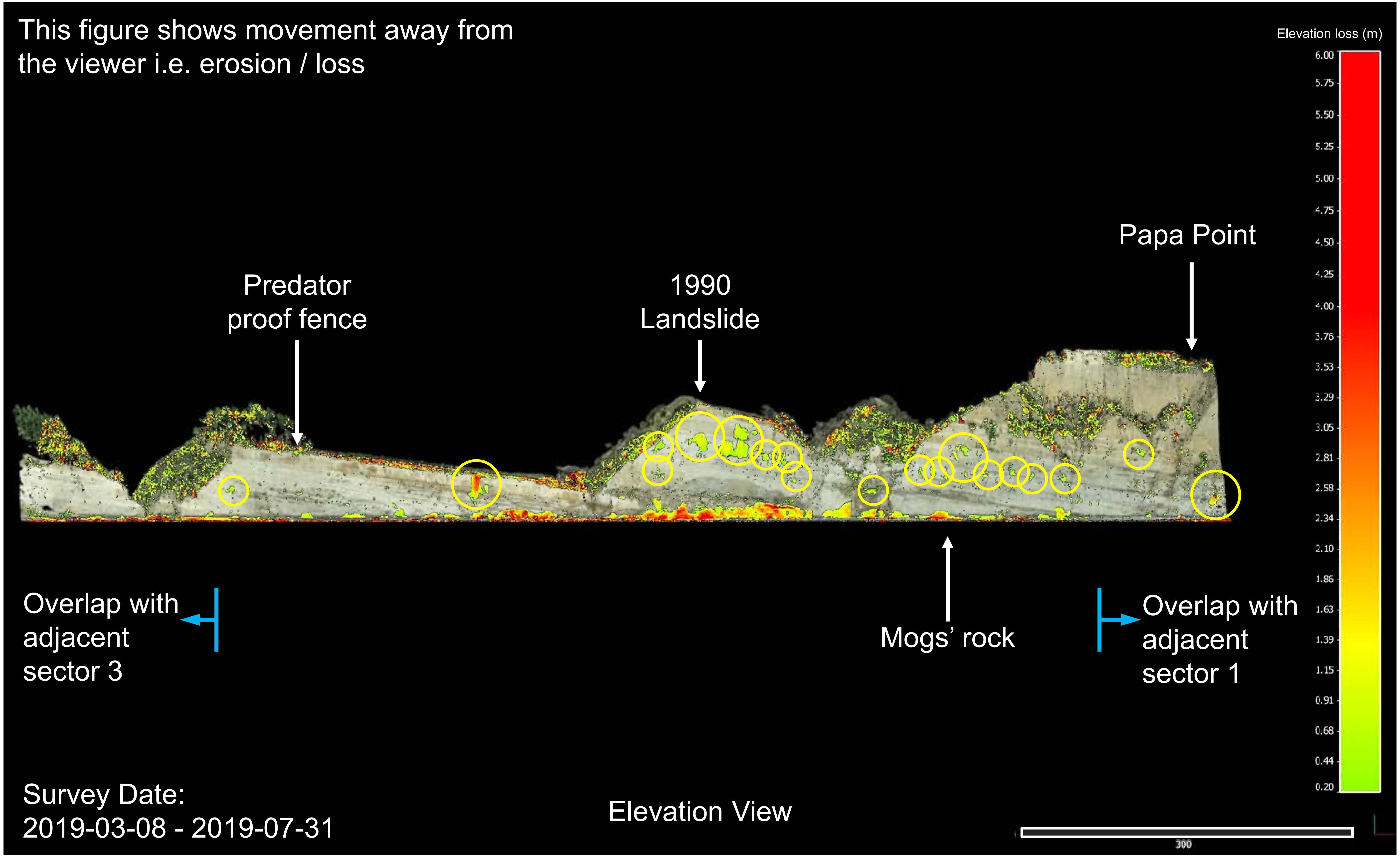
Clifton Beach – Sector 2



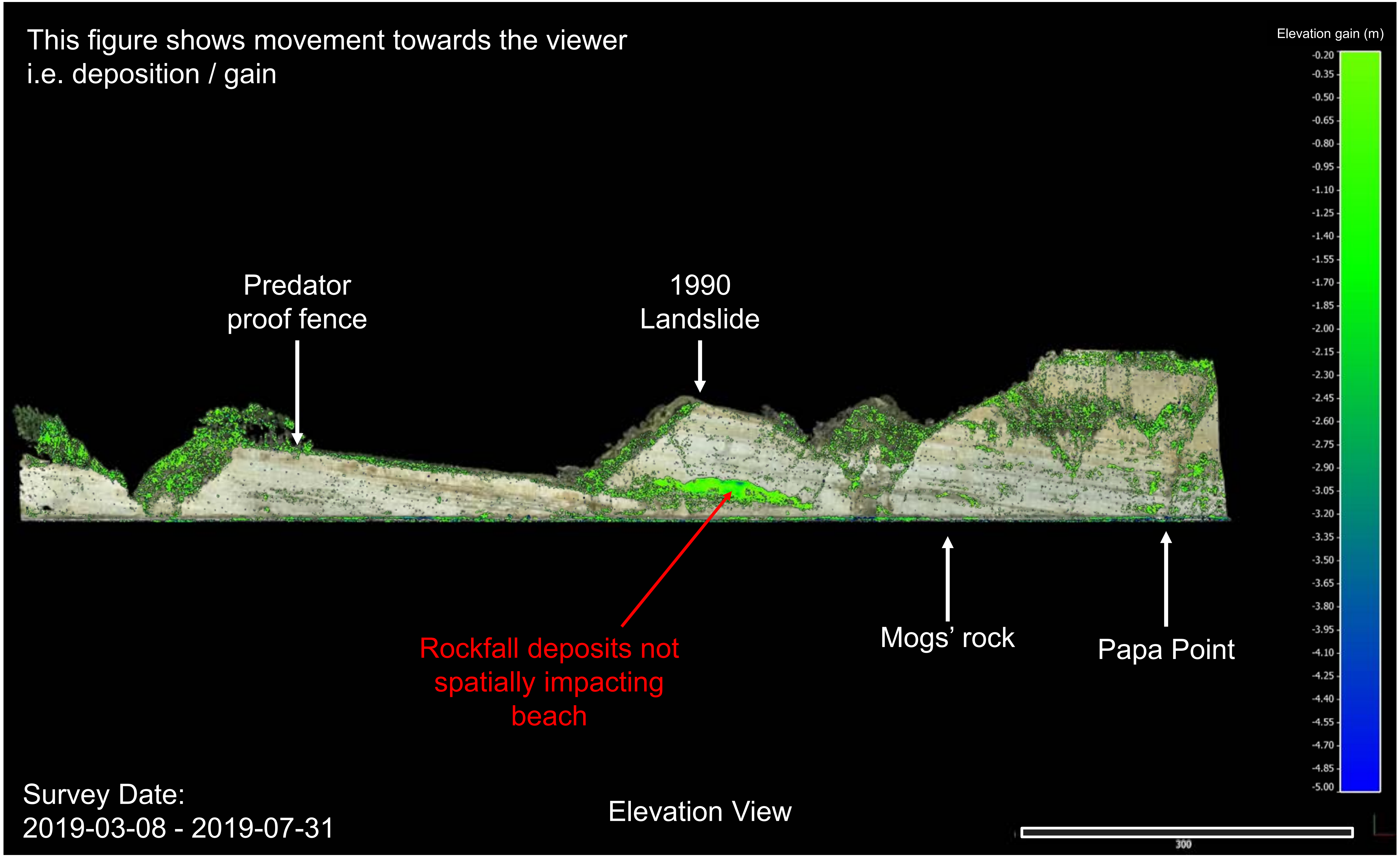
Clifton Beach – Sector 2



Clifton Beach – Sector 2

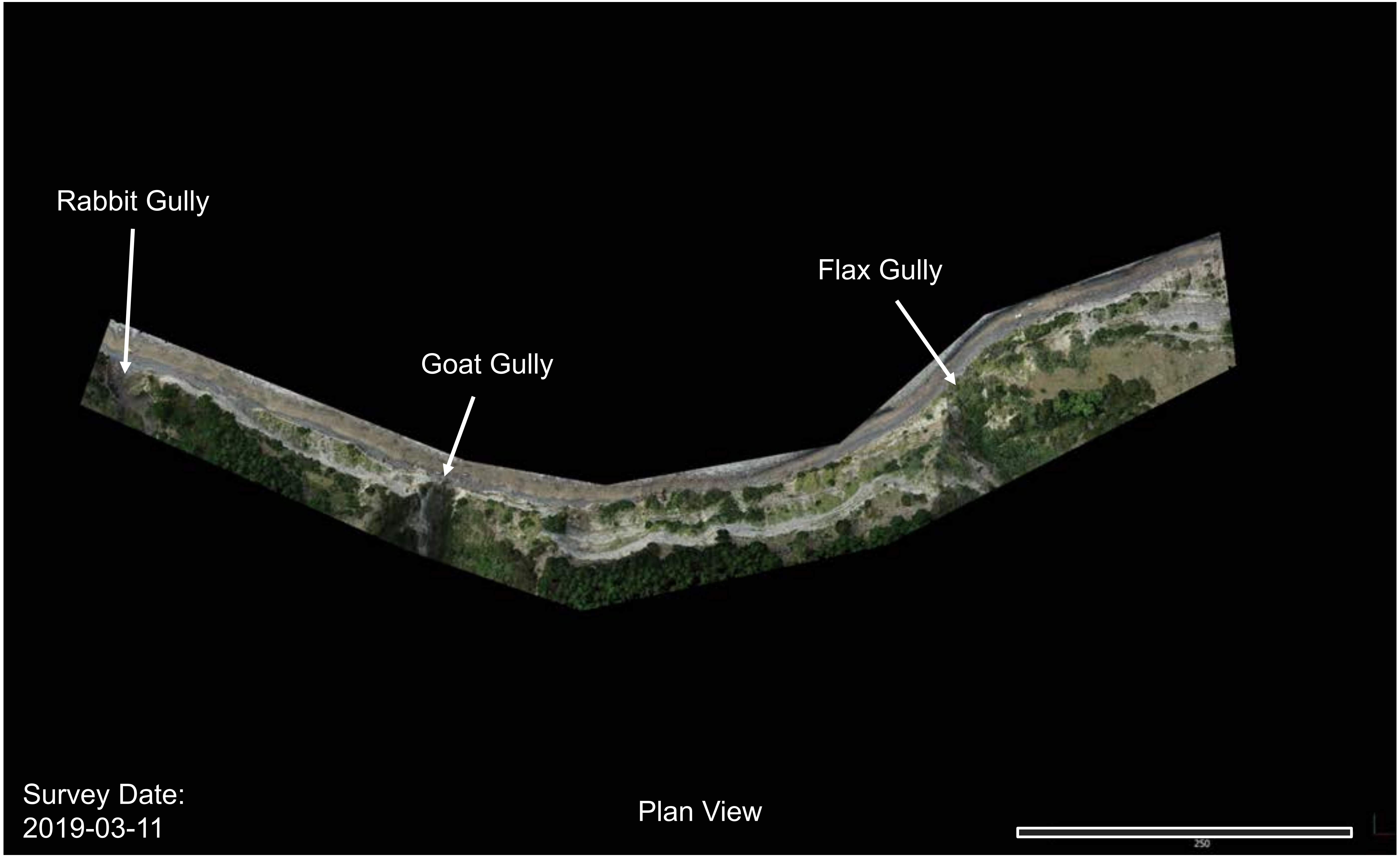


Clifton Beach – Sector 2



Clifton Beach – Sector 2

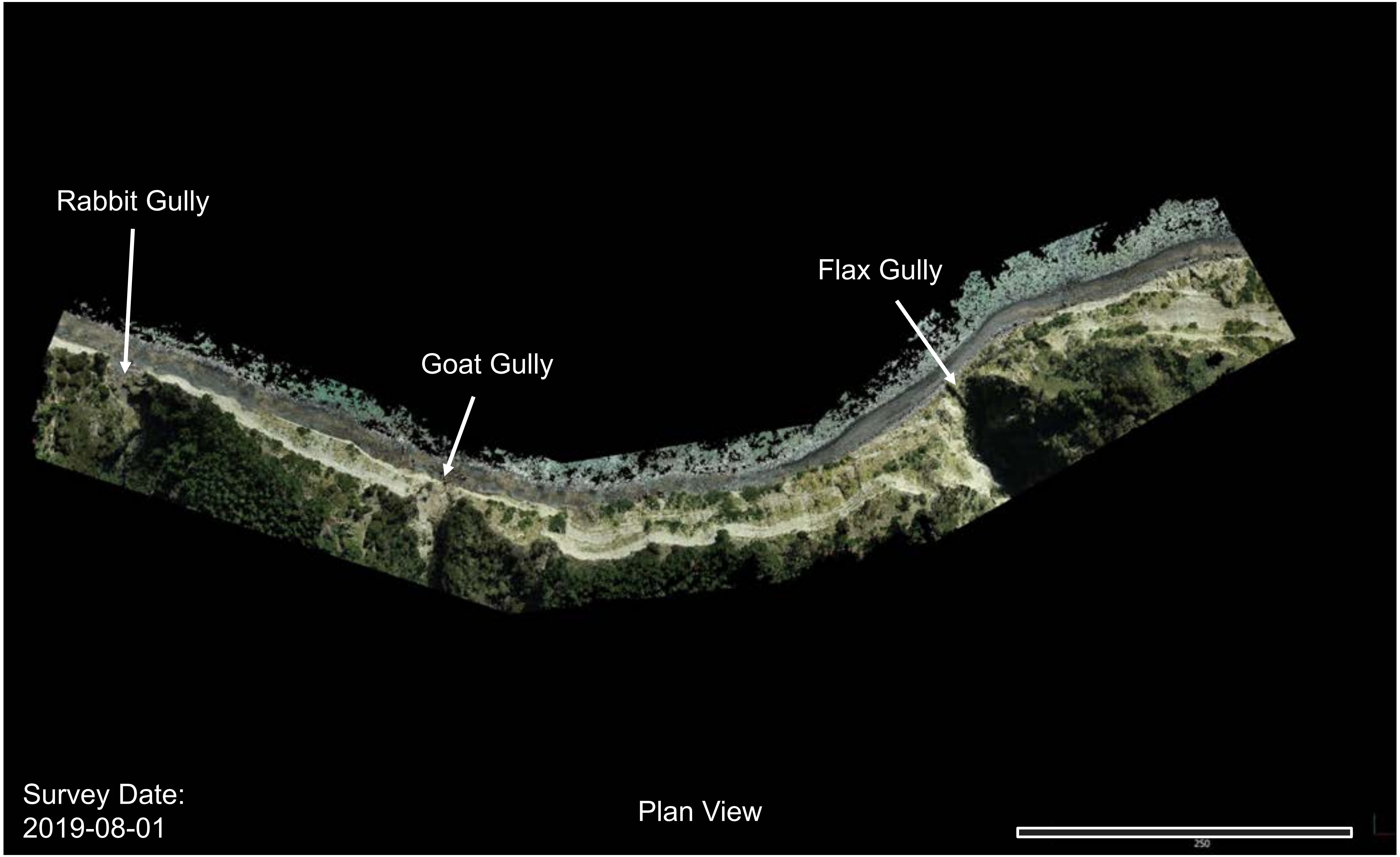
The Surveying Company
Your Subdivision Professionals



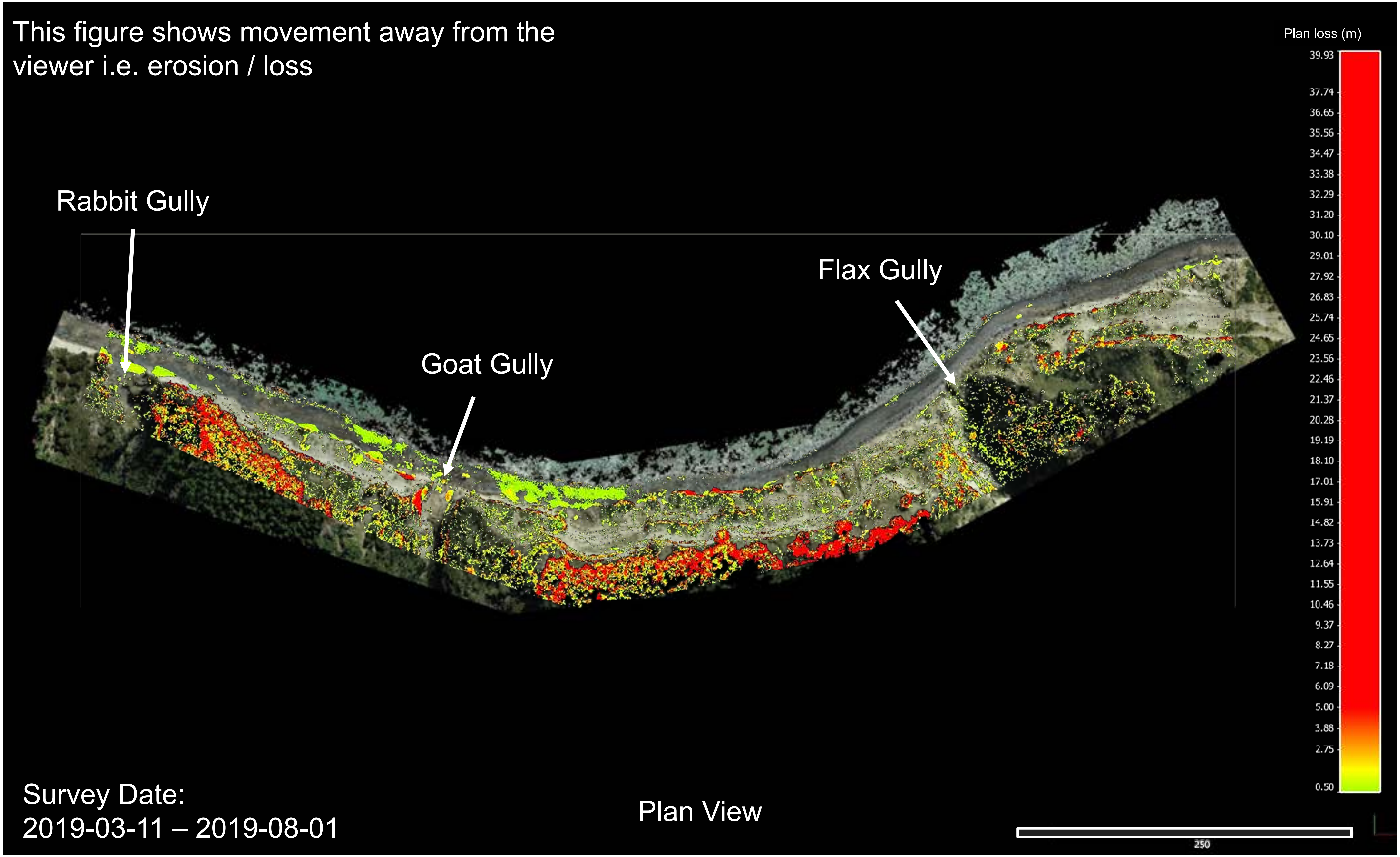
Hastings District Council

Clifton Beach – Sector 3

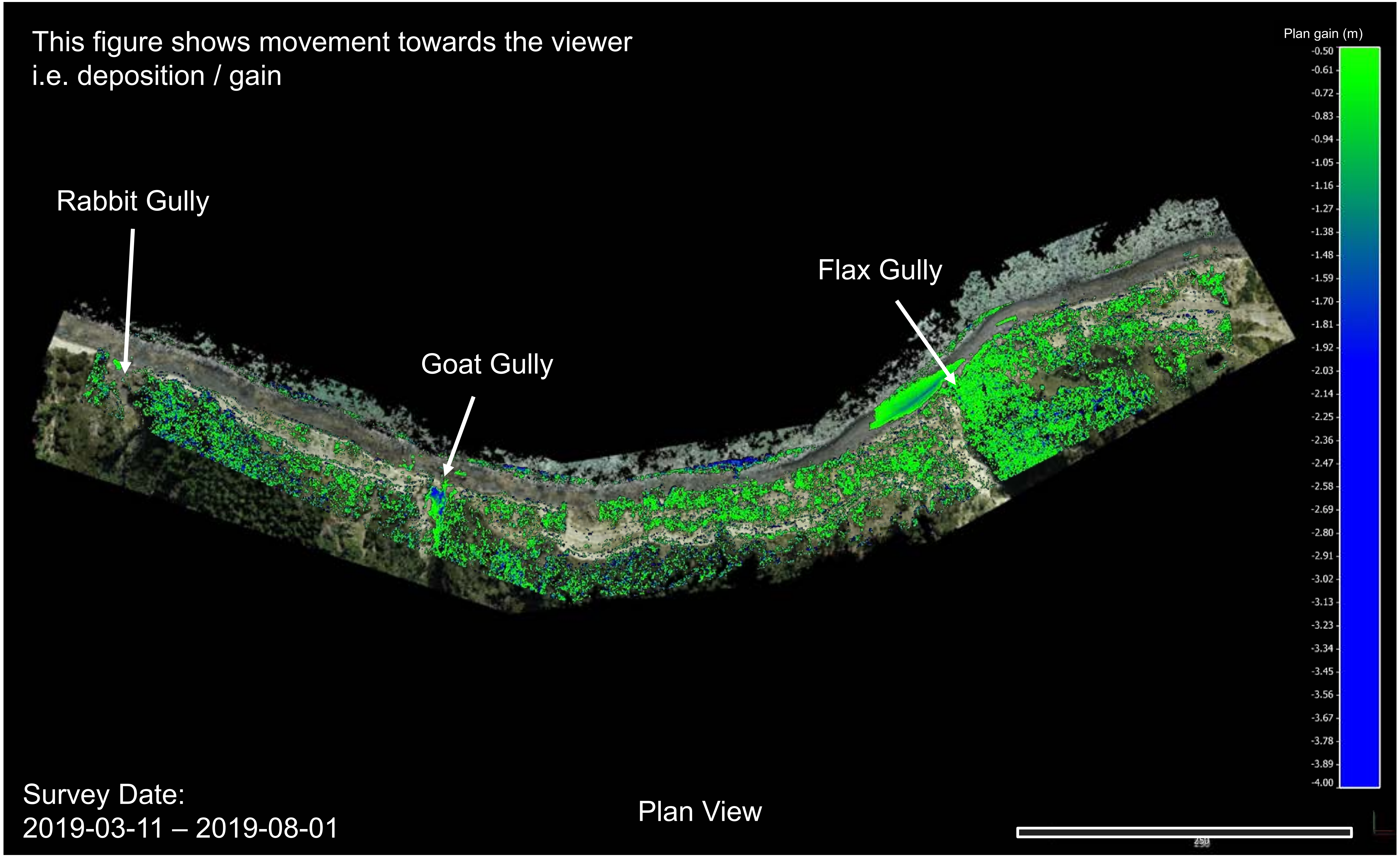
Stantec



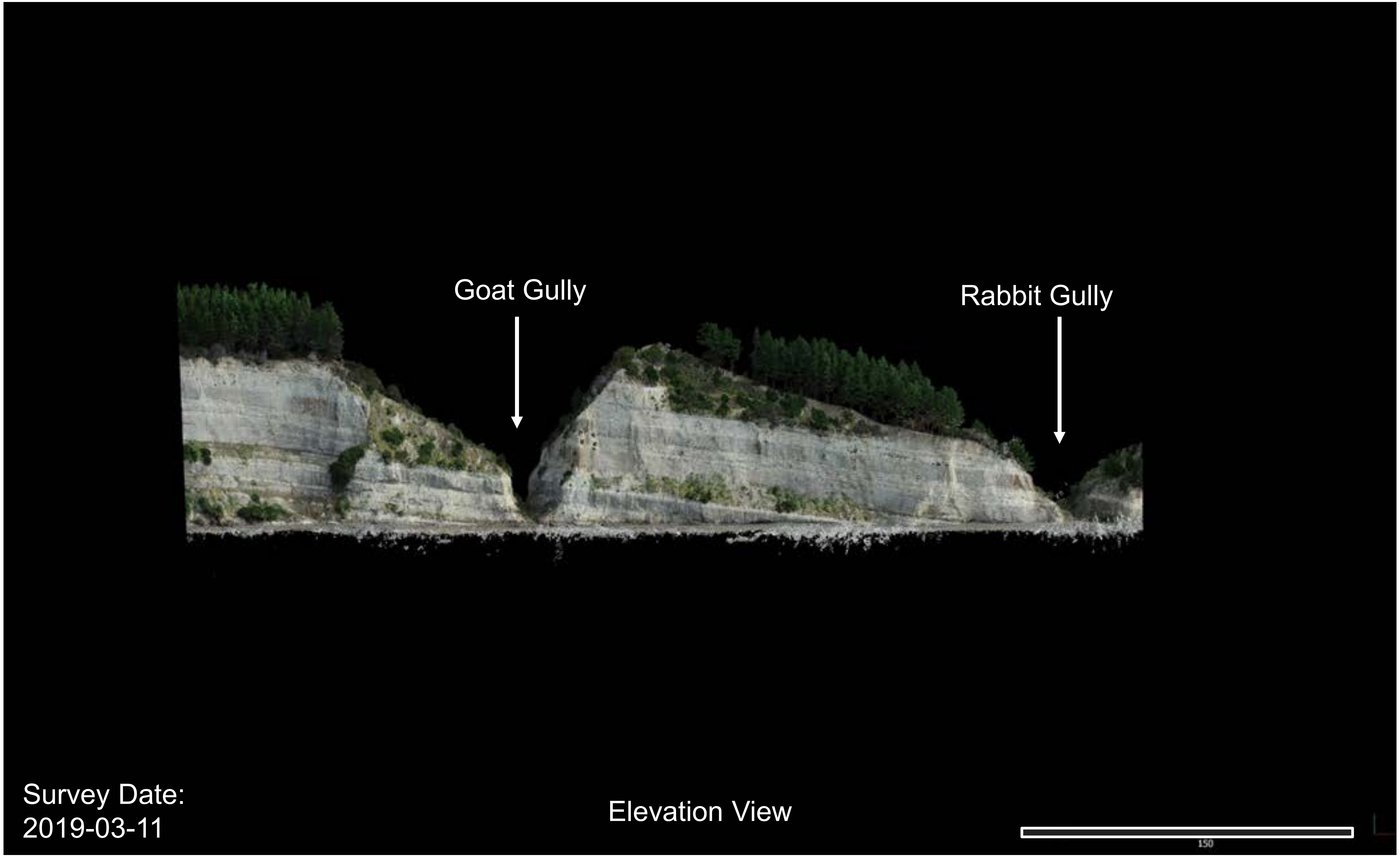
Clifton Beach – Sector 3



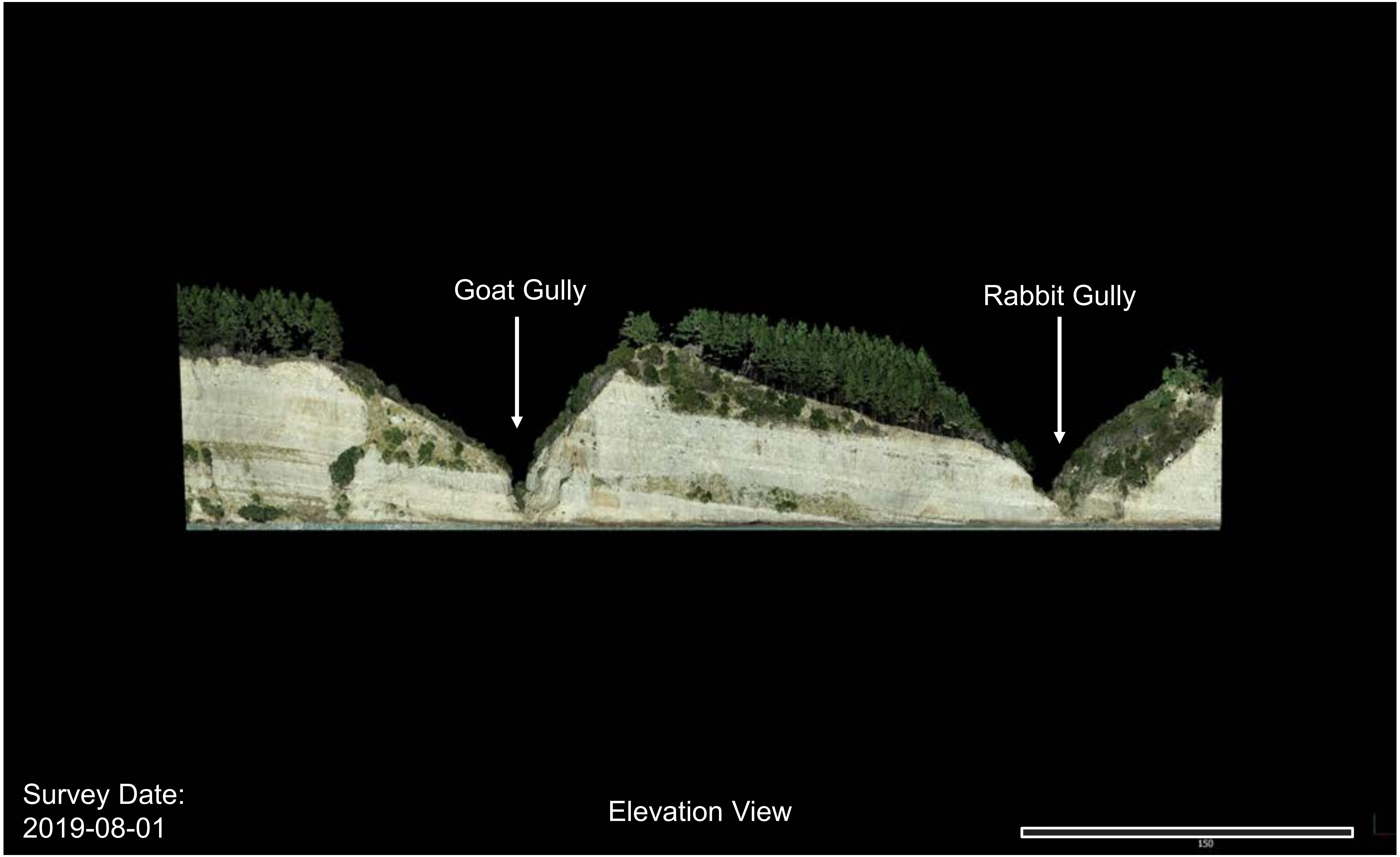
Clifton Beach – Sector 3



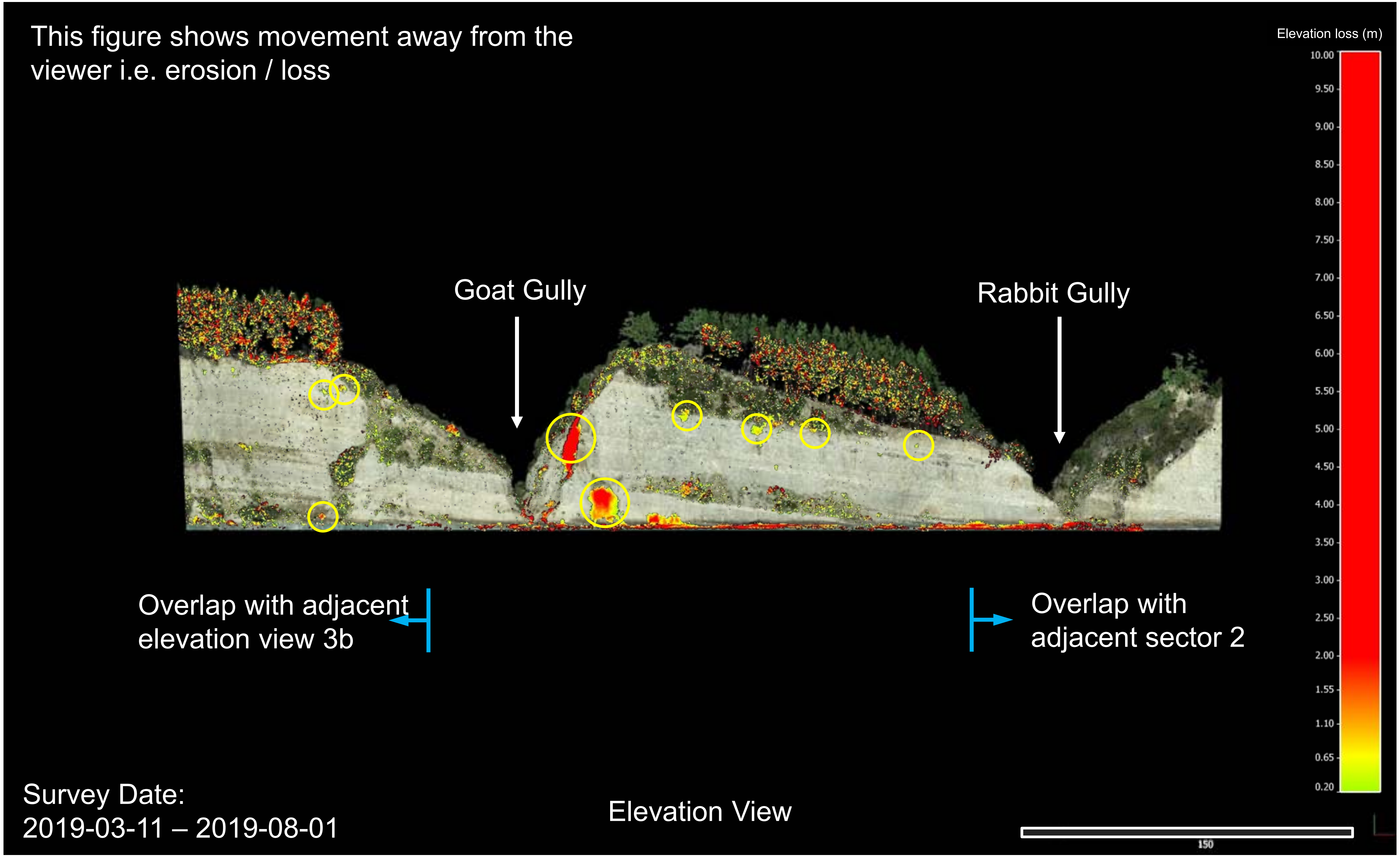
Clifton Beach – Sector 3



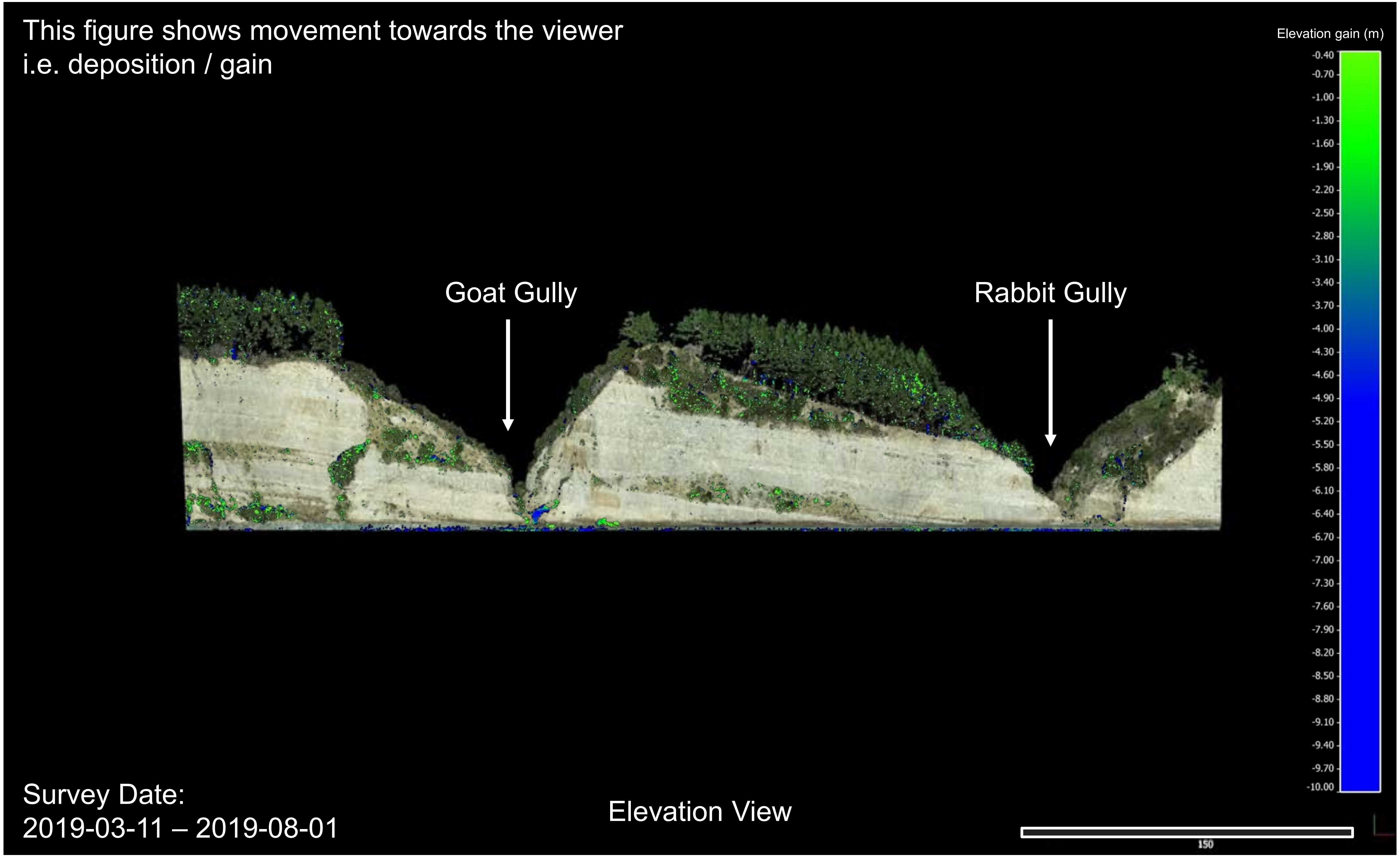
Clifton Beach – Sector 3a



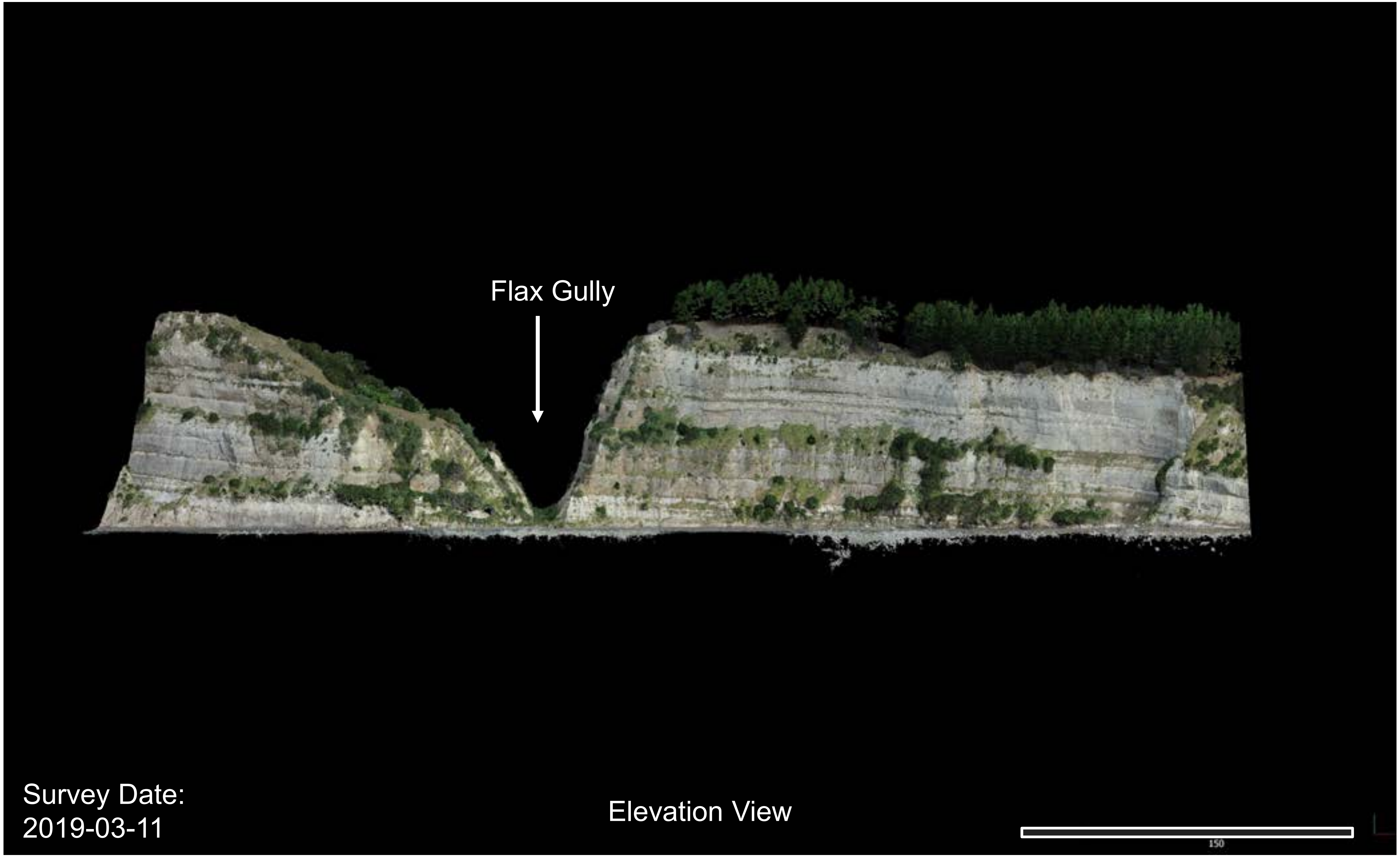
Clifton Beach – Sector 3a



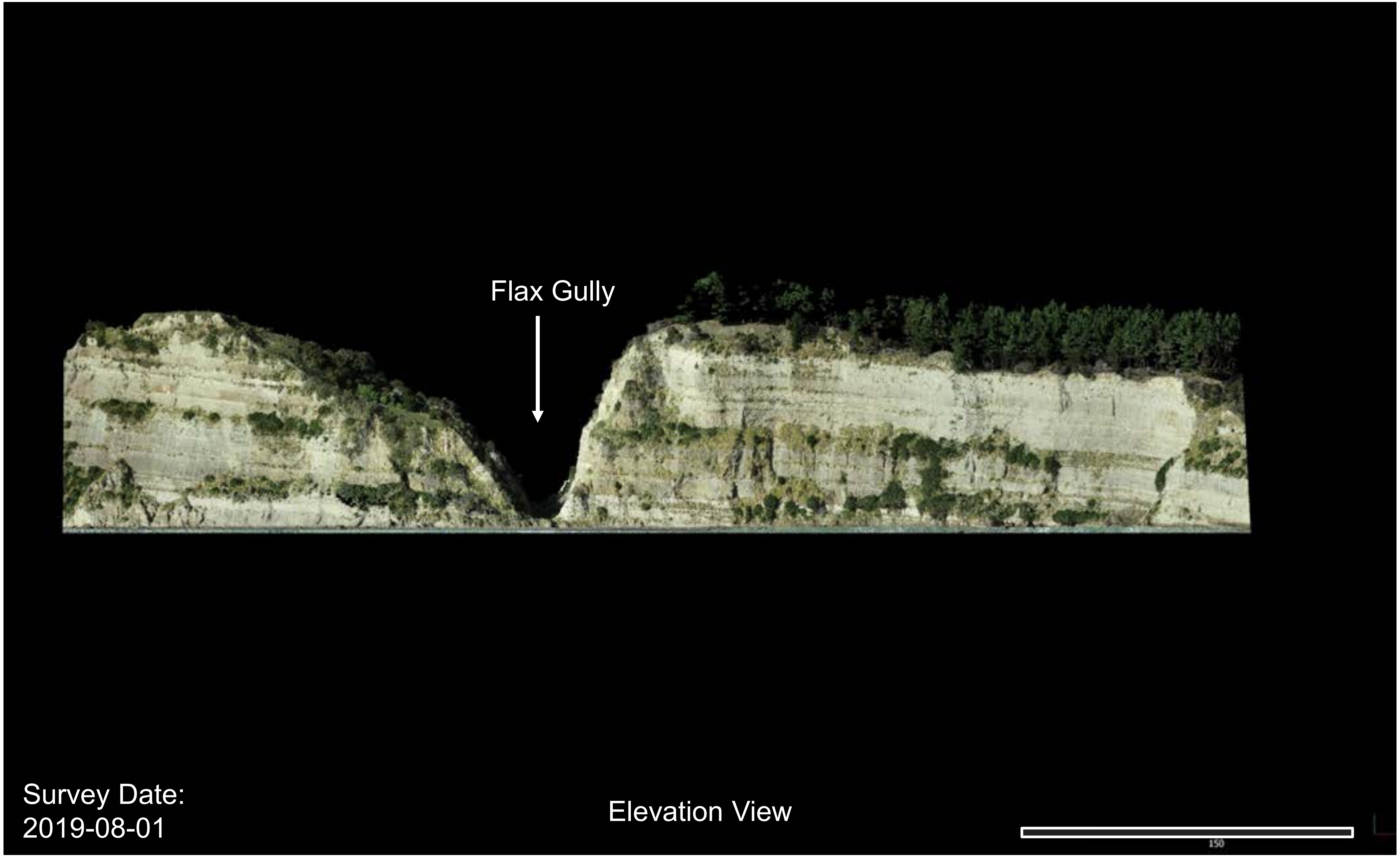
Clifton Beach – Sector 3a



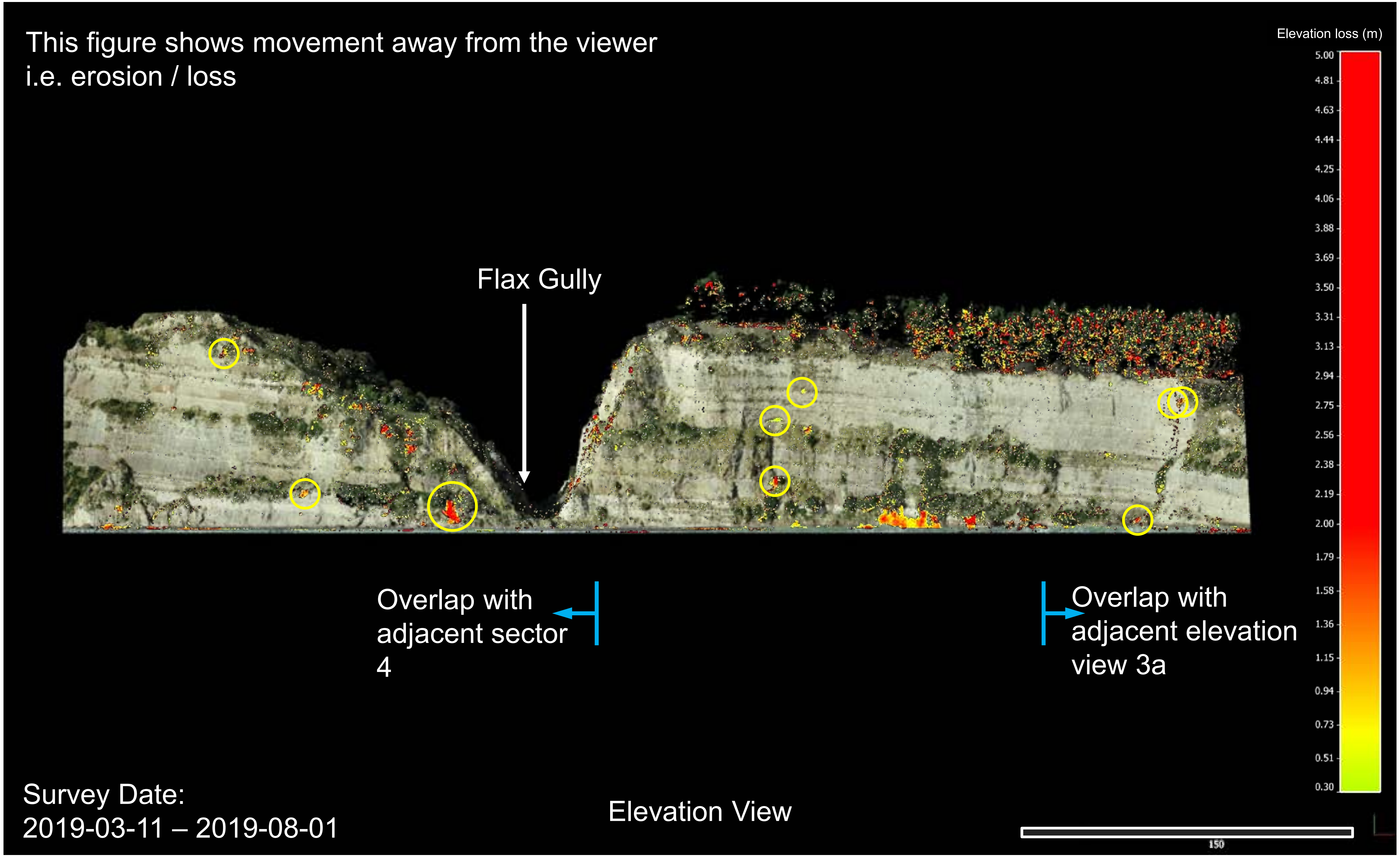
Clifton Beach – Sector 3a



Clifton Beach – Sector 3b



Clifton Beach – Sector 3b



Clifton Beach – Sector 3b

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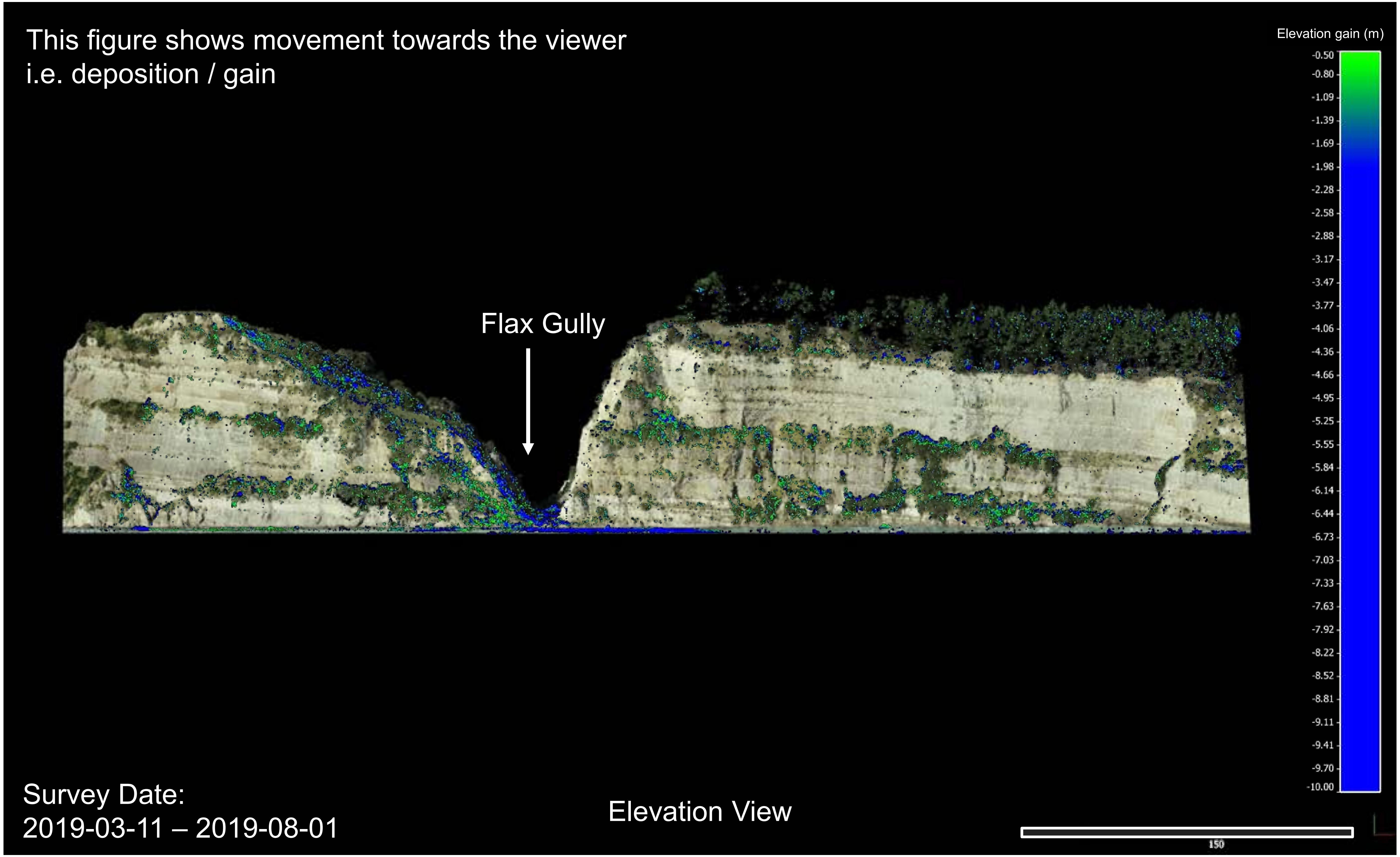
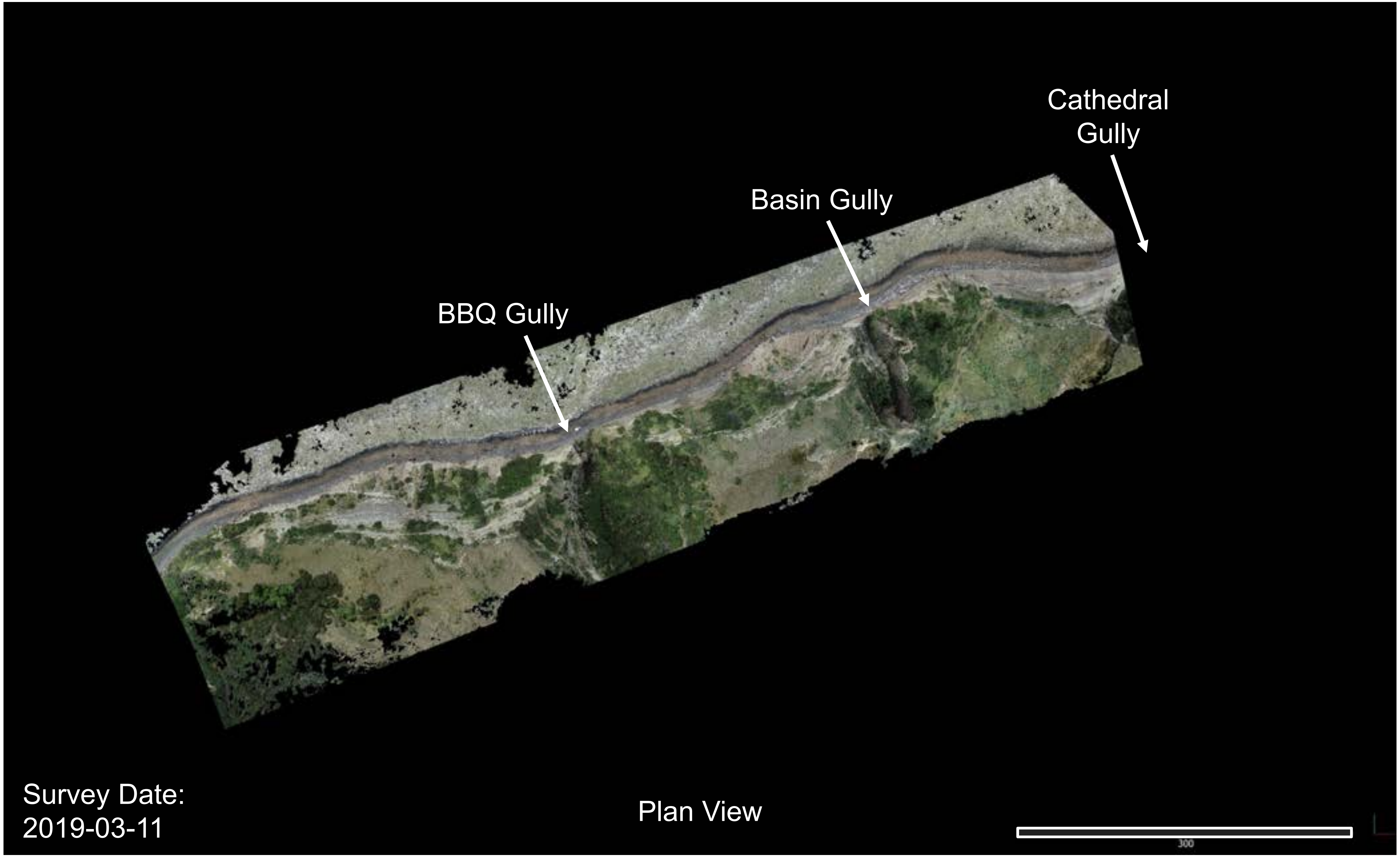
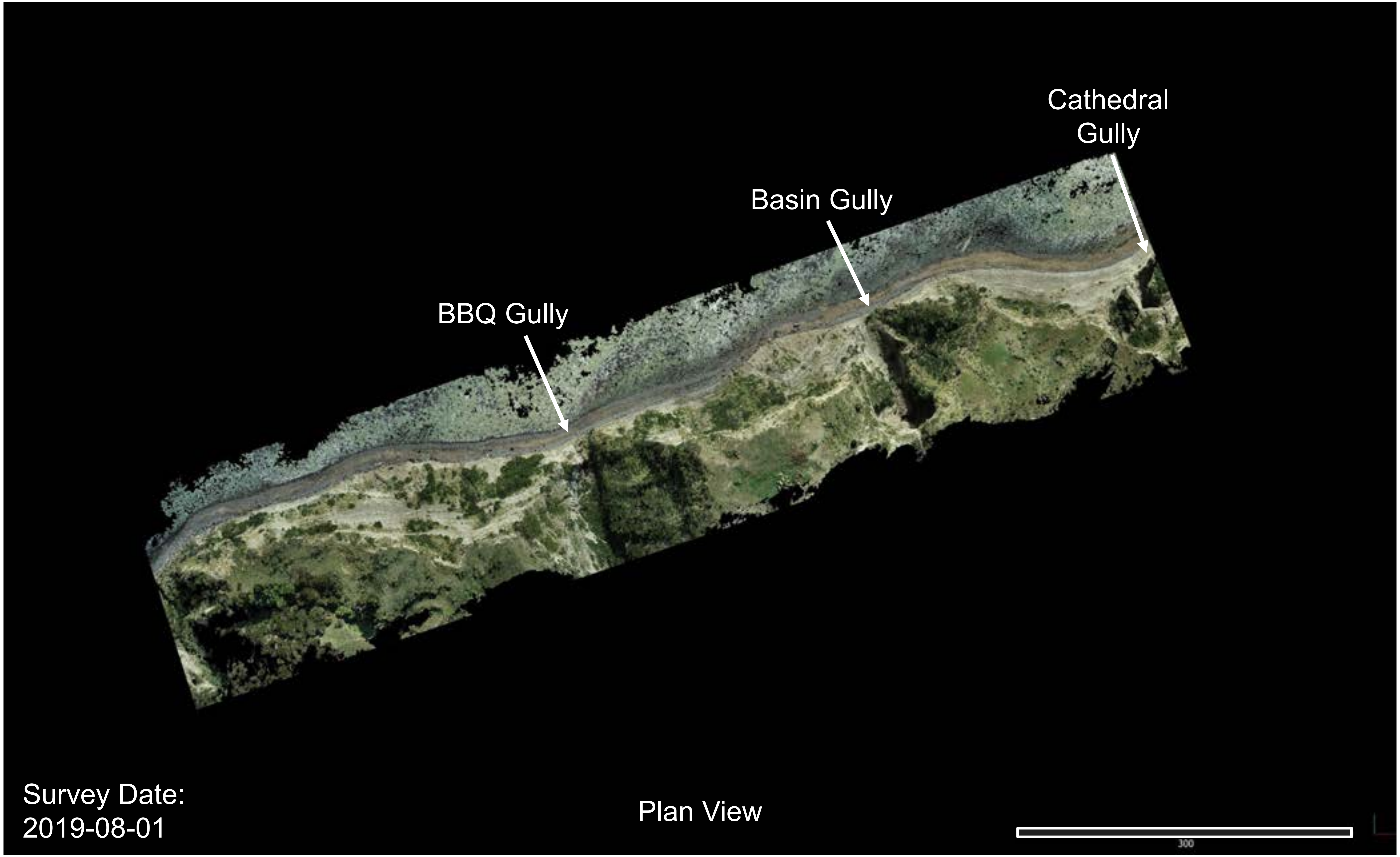


Clifton Beach – Sector 3b



Clifton Beach – Sector 4

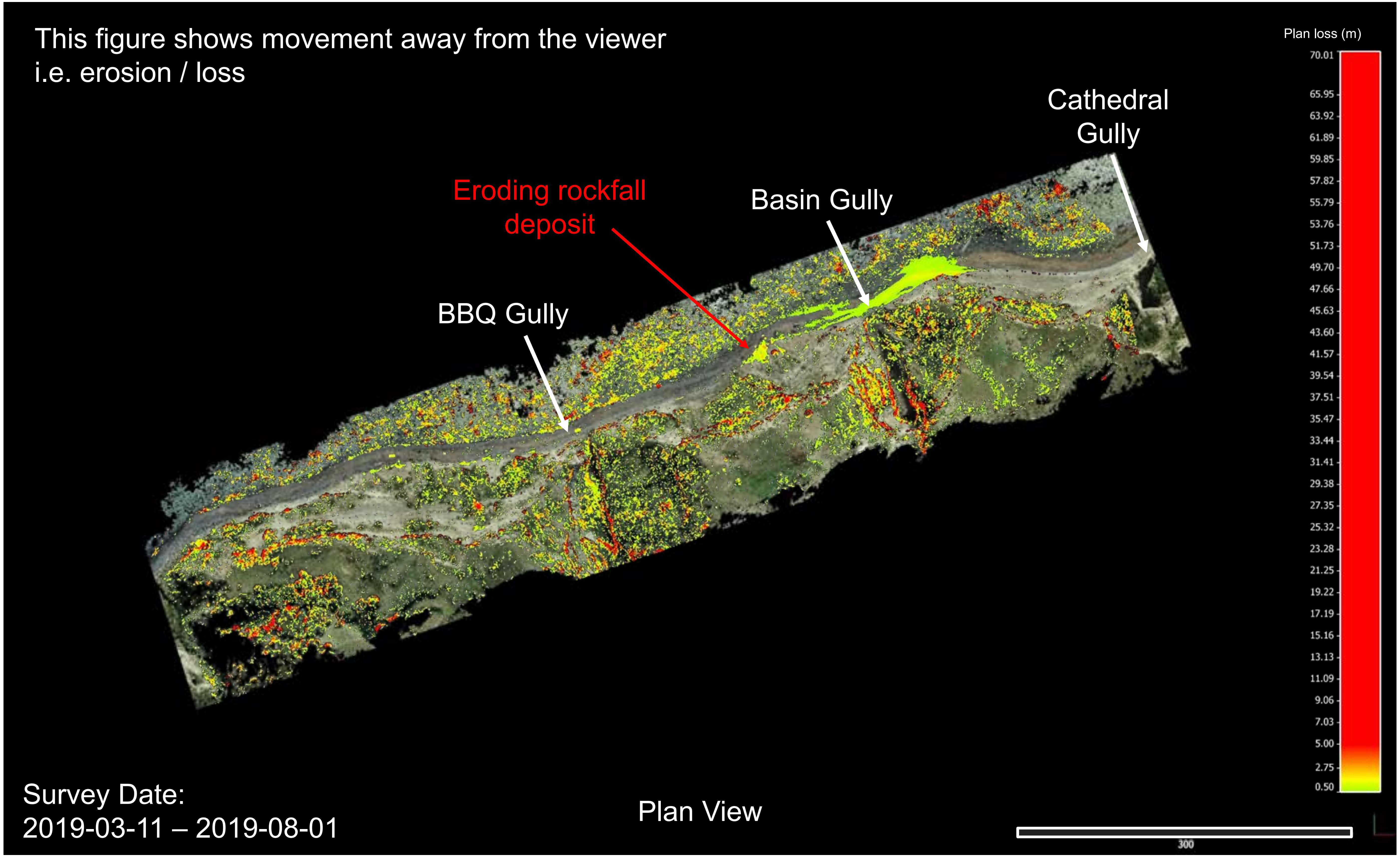
The Surveying Company
YOUR SUBDIVISION PROFESSIONALS



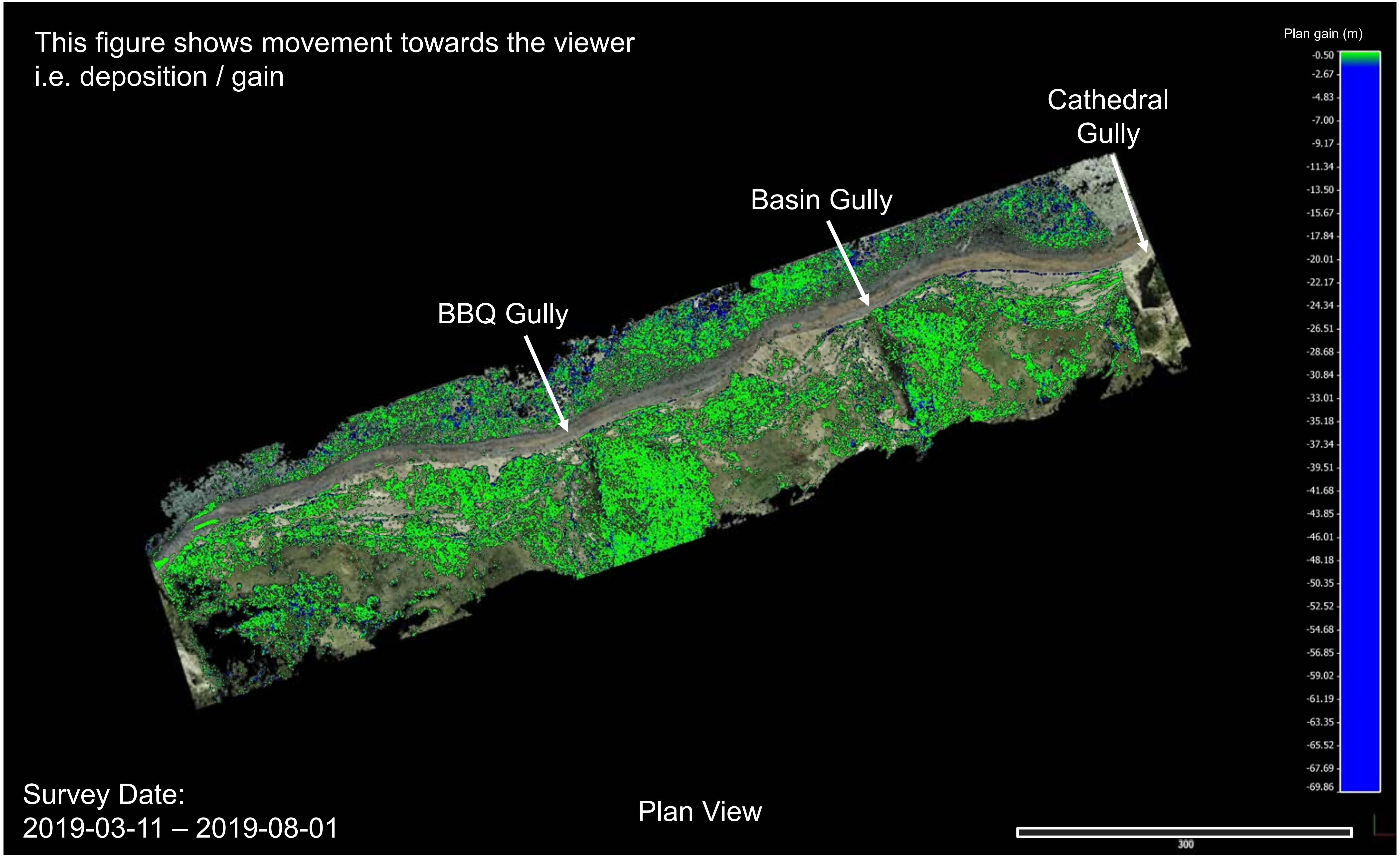
HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 4

Stantec

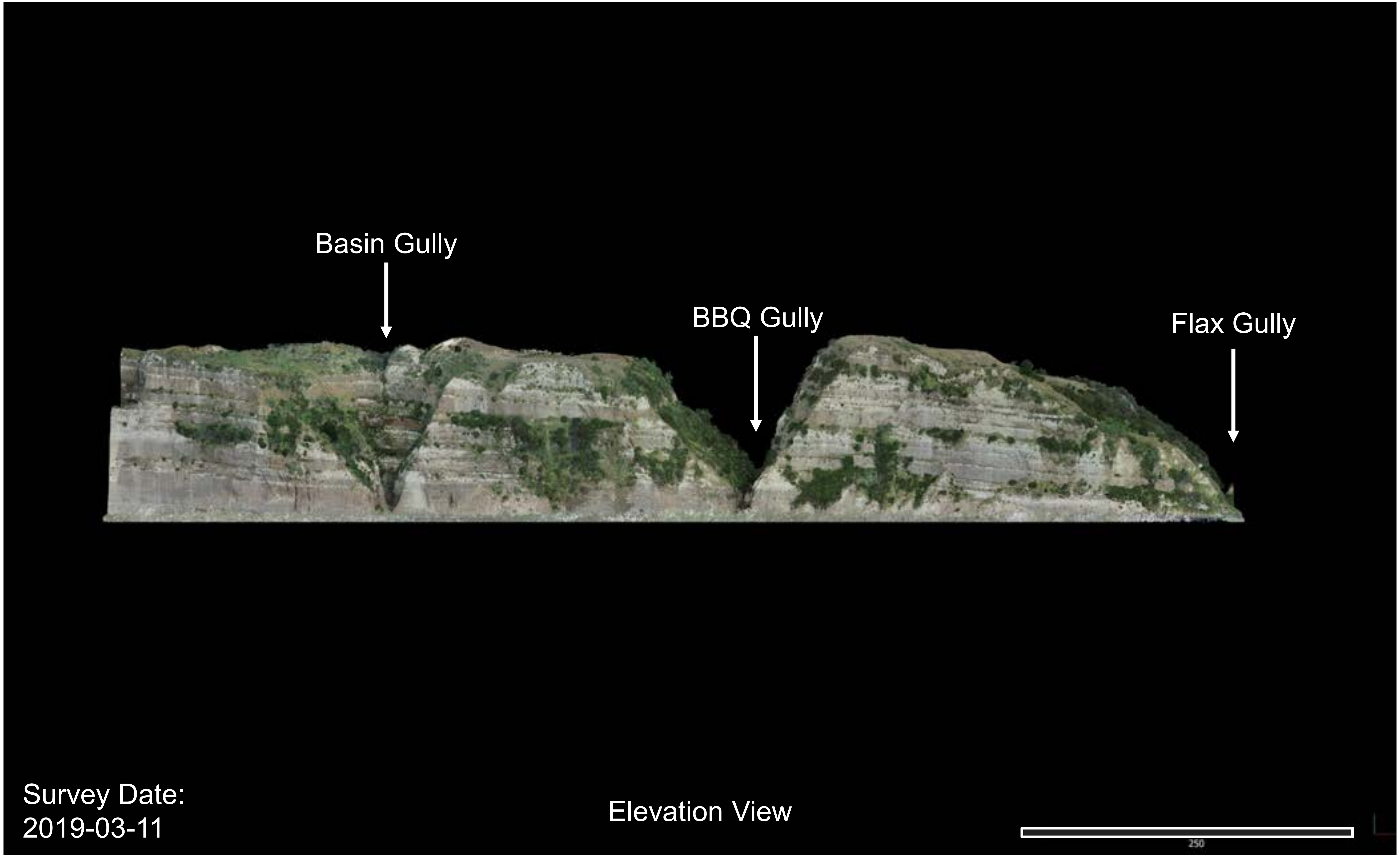


Clifton Beach – Sector 4



Clifton Beach – Sector 4

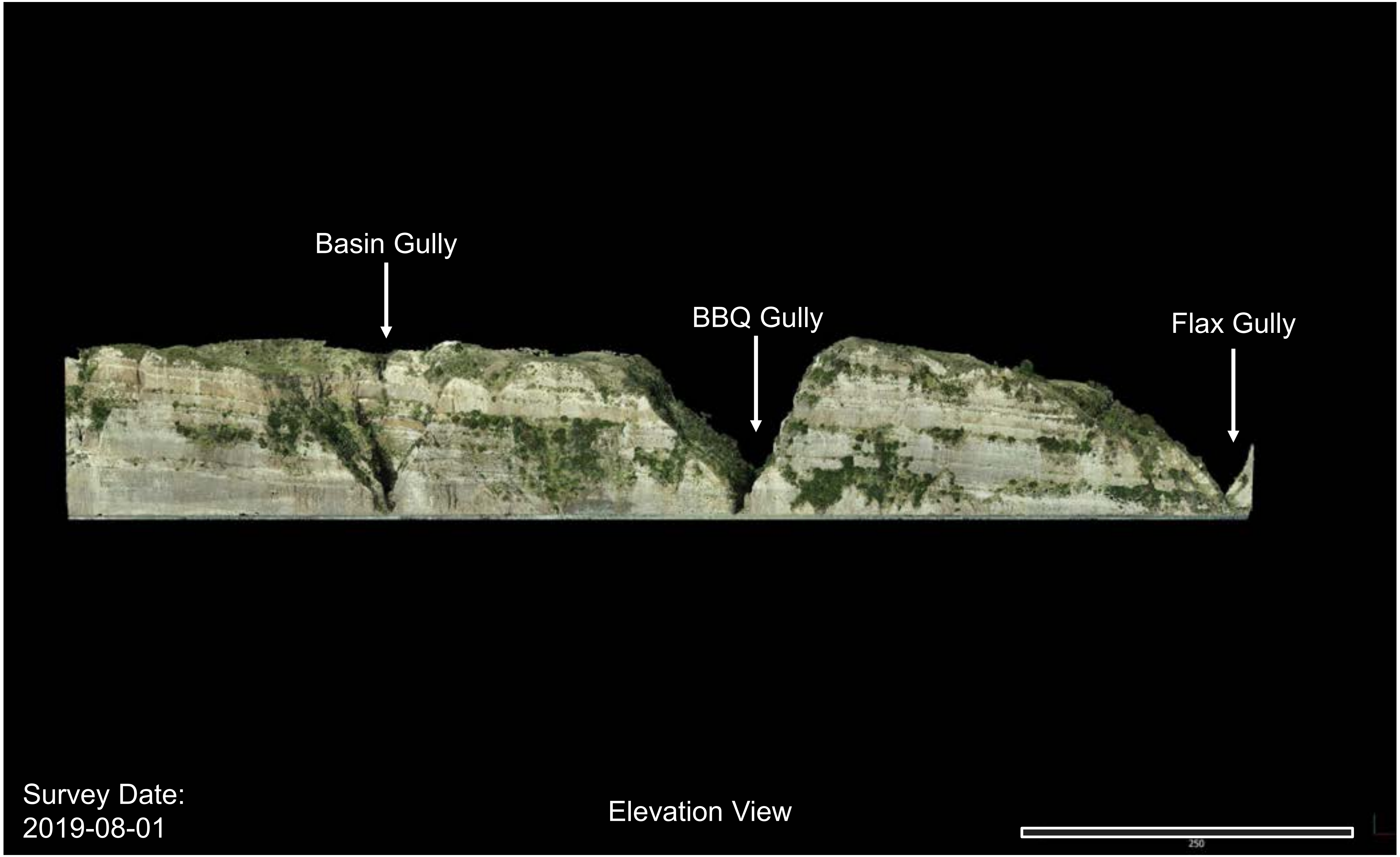
THE SURVEYING COMPANY
YOUR SUBDIVISION PROFESSIONALS



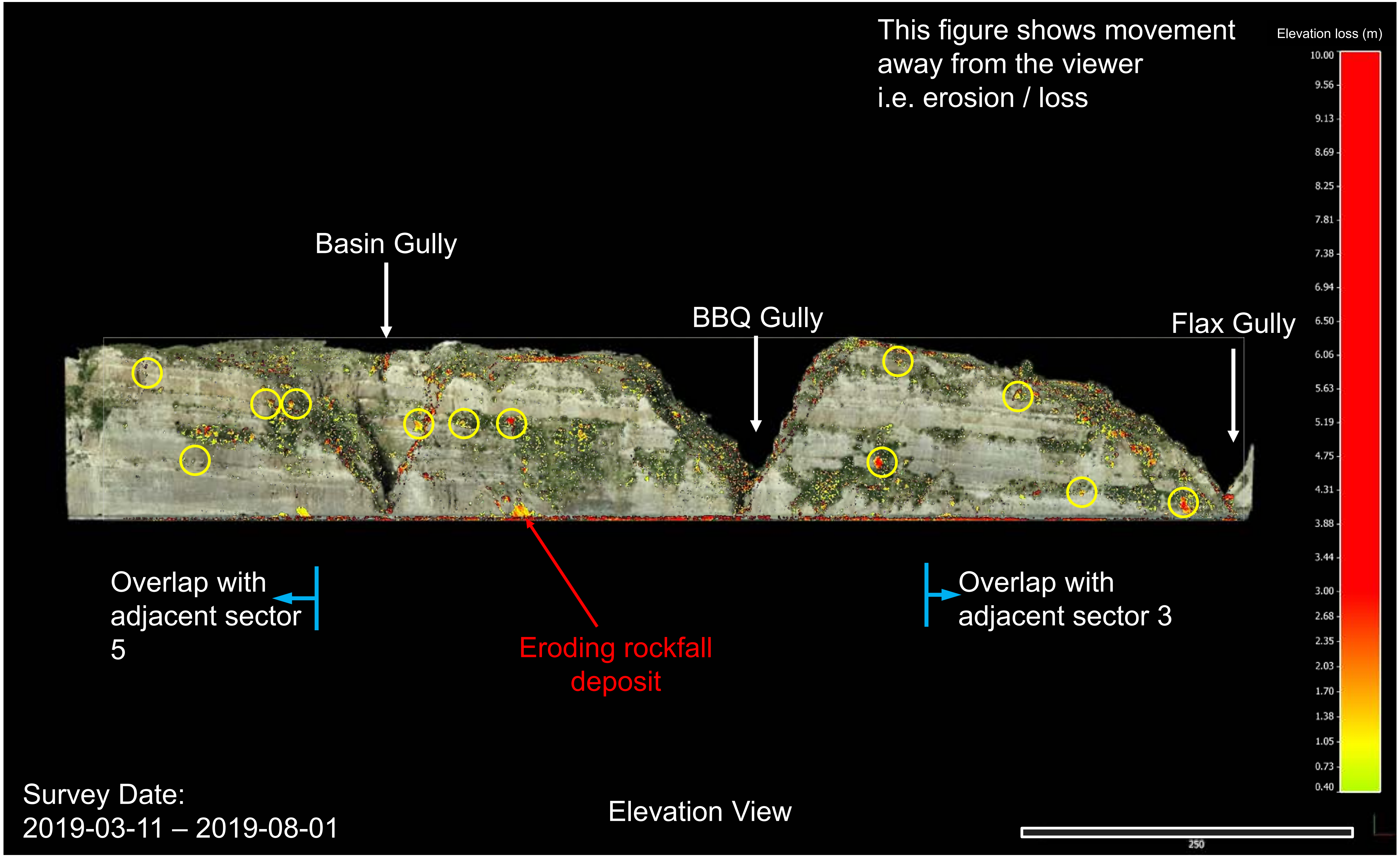
HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 4

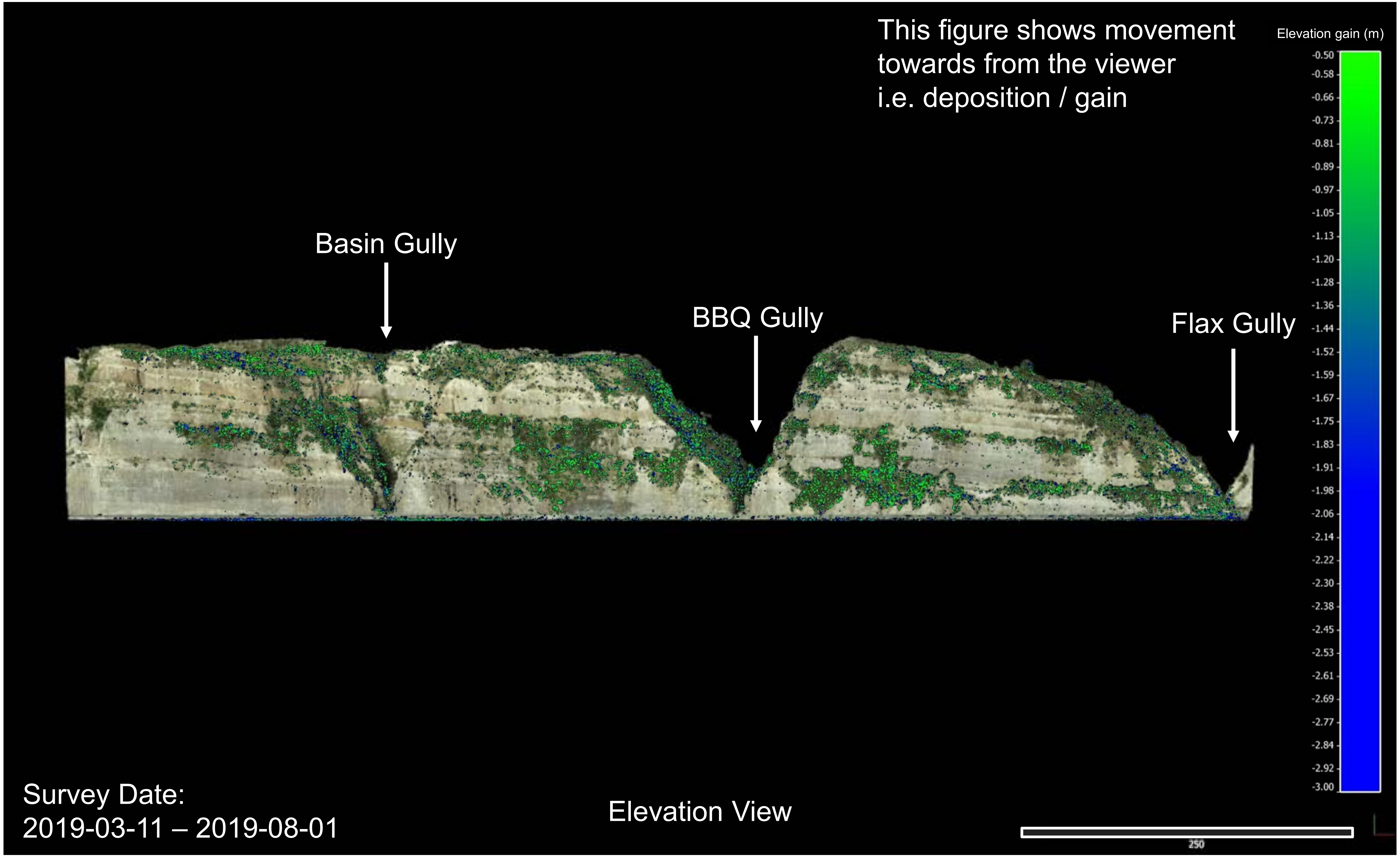
Stantec



Clifton Beach – Sector 4

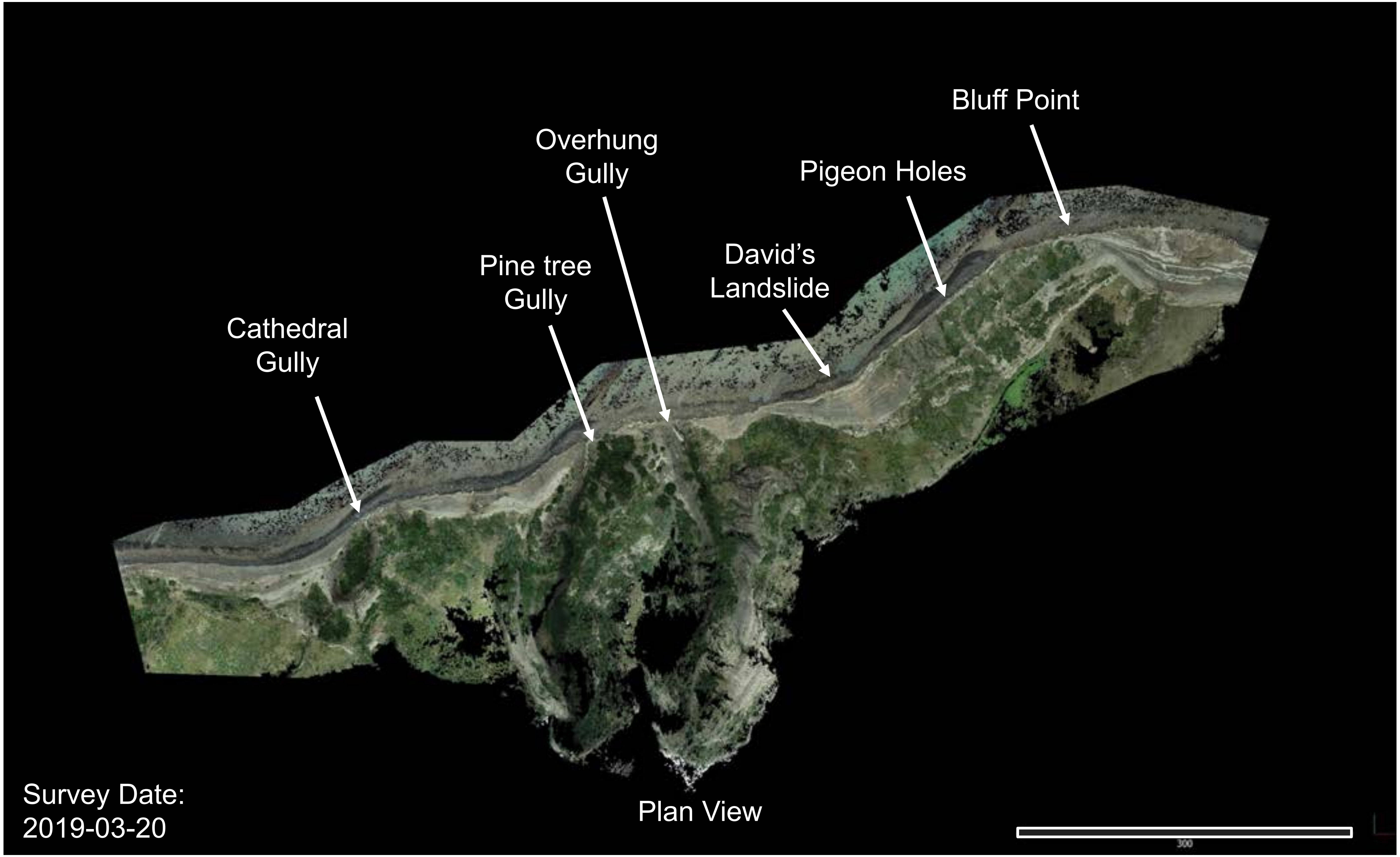


Clifton Beach – Sector 4



Clifton Beach – Sector 4

The Surveying Company
Your Subdivision Professionals

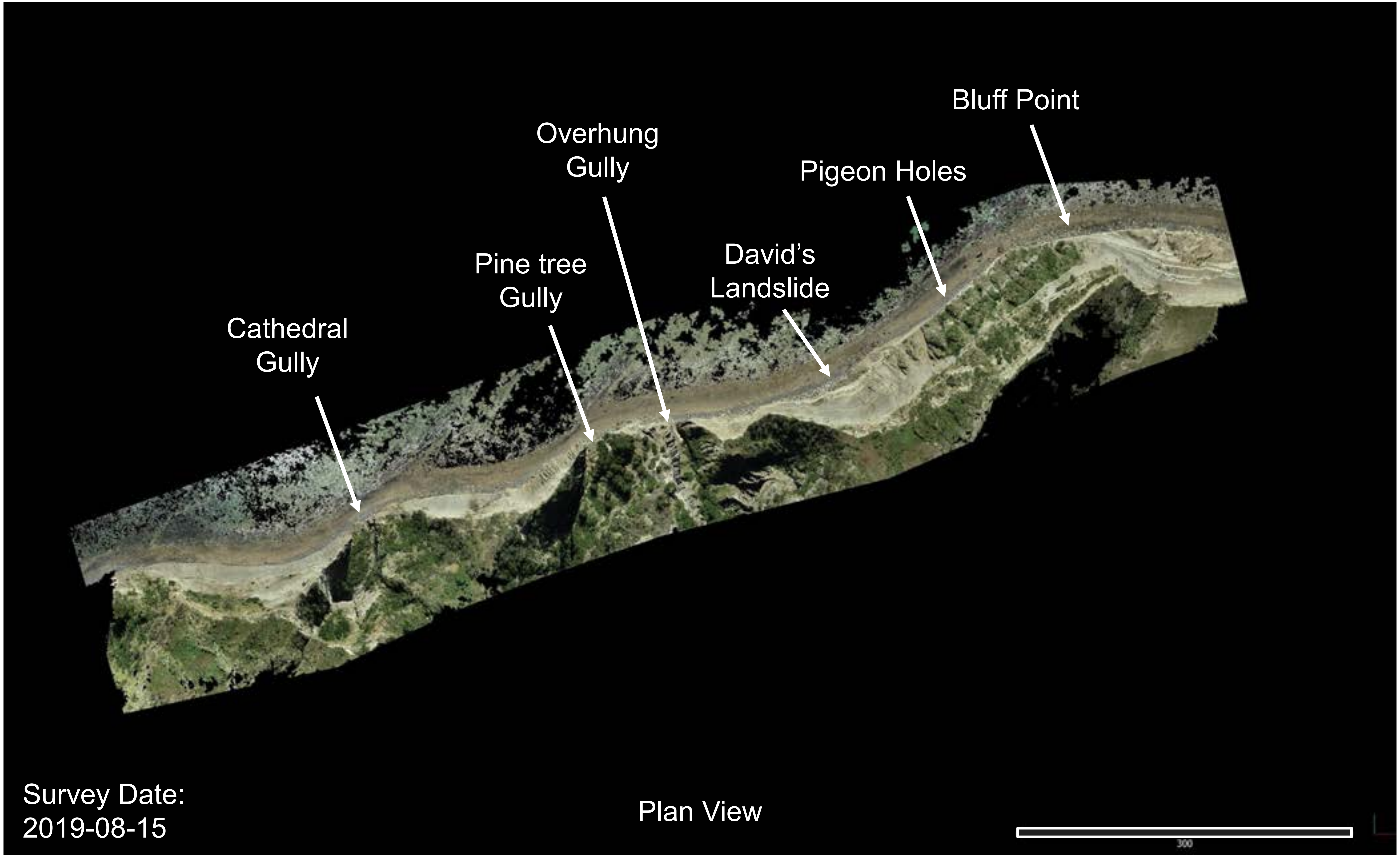


Hastings District Council

Clifton Beach – Sector 5

Stantec

THE SURVEYING COMPANY
YOUR SUBDIVISION PROFESSIONALS

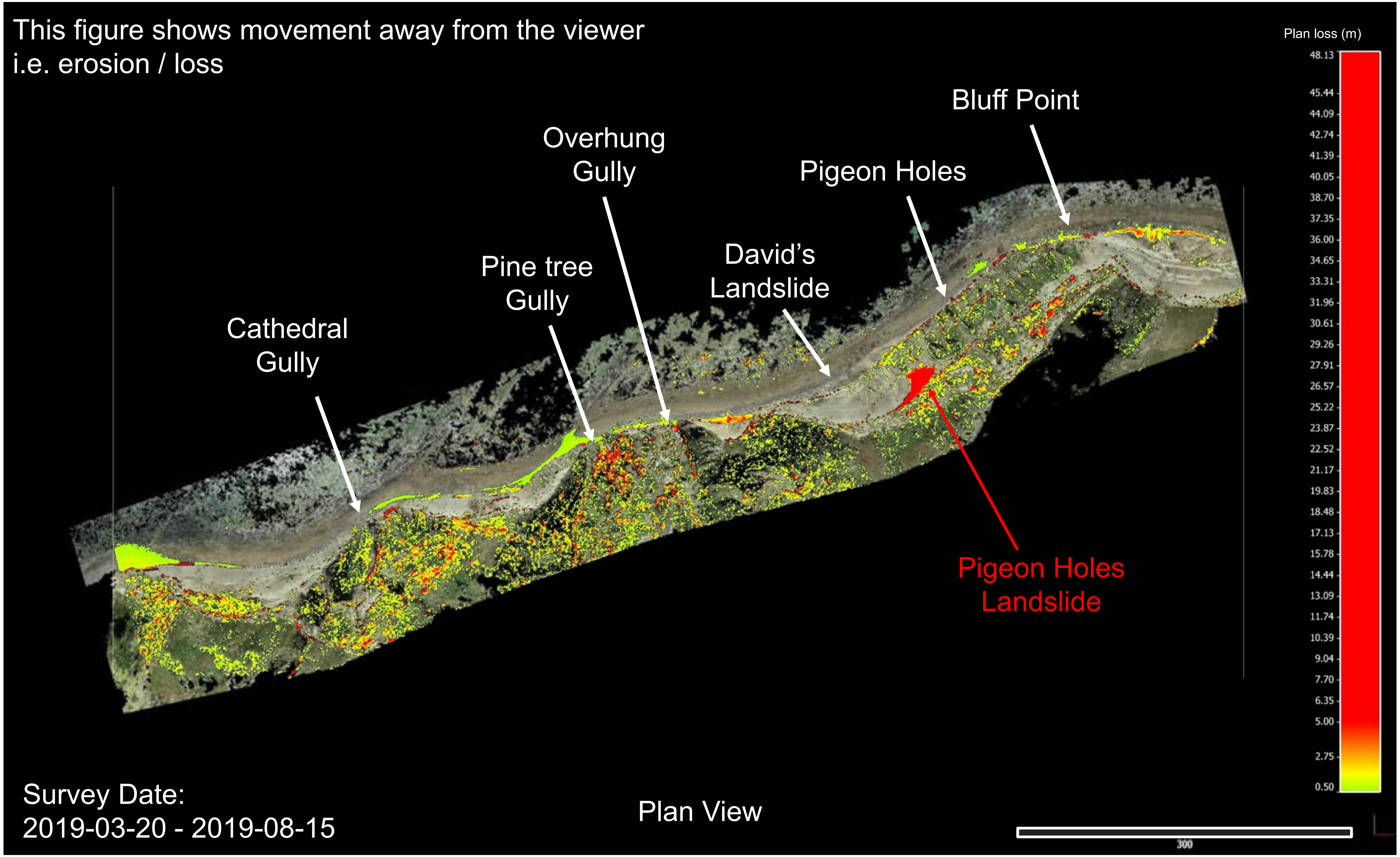


HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 5

Stantec

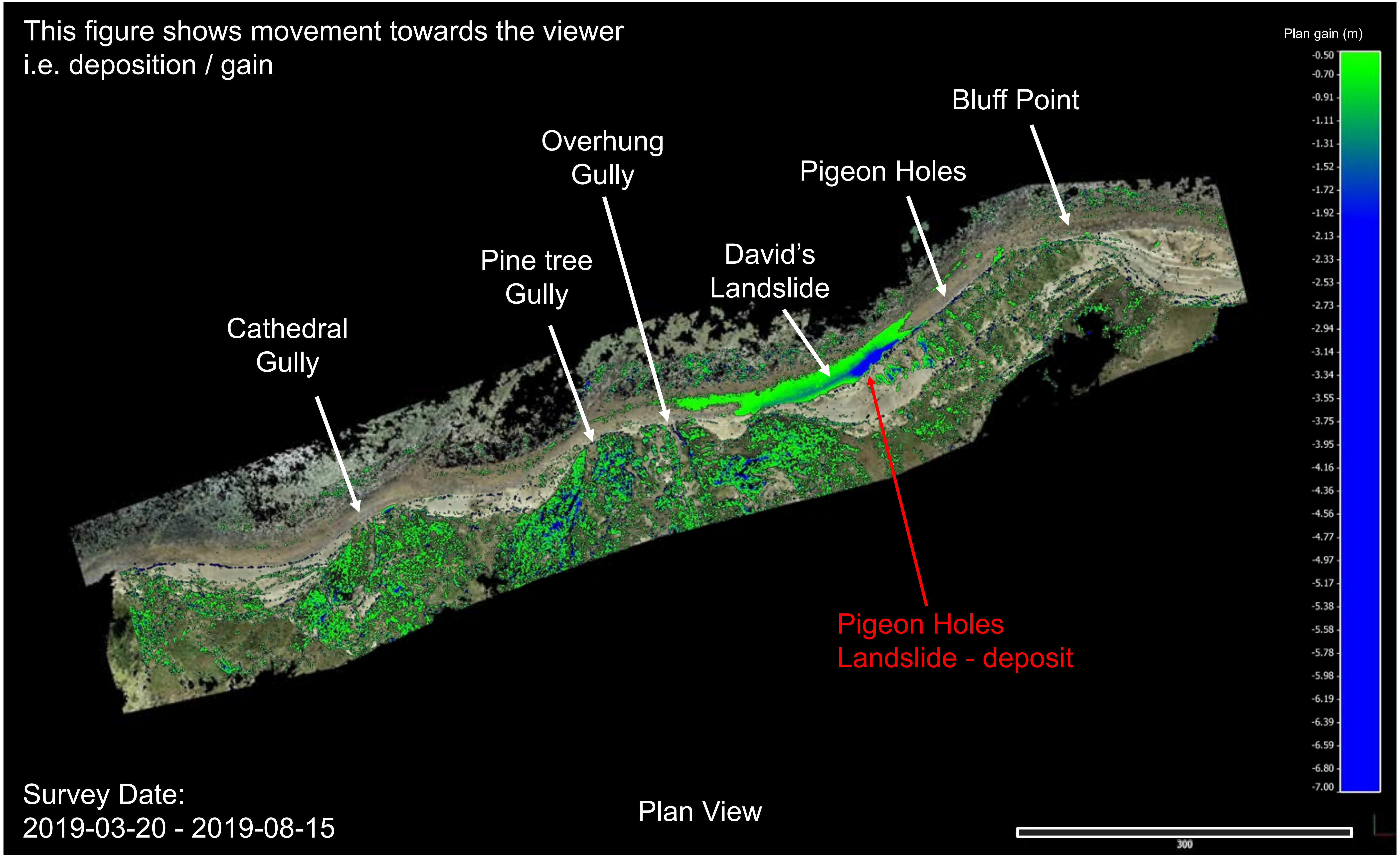
The Surveying Company
Your subdivision professionals



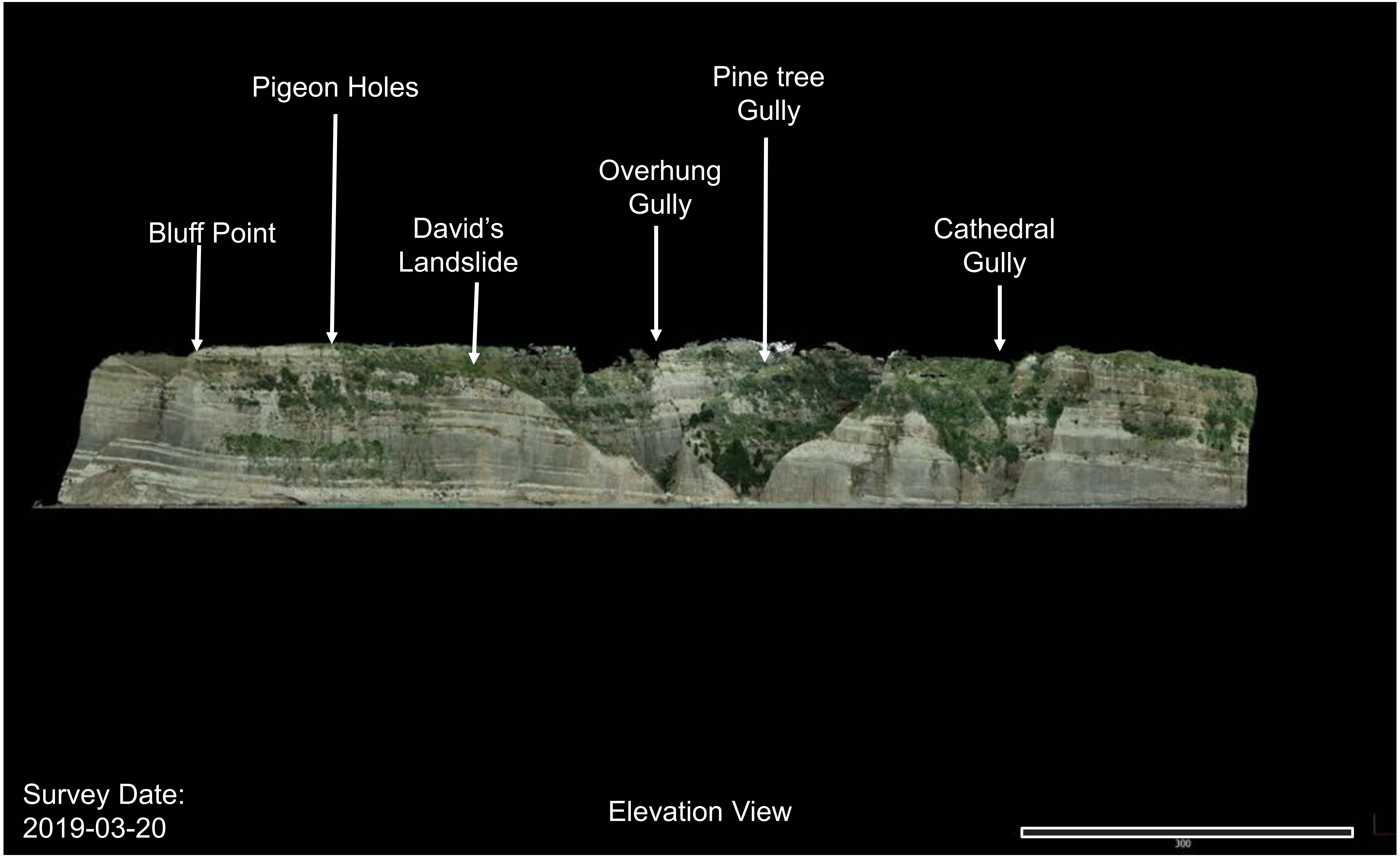
HASTINGS
DISTRICT COUNCIL

Clifton Beach – Sector 5

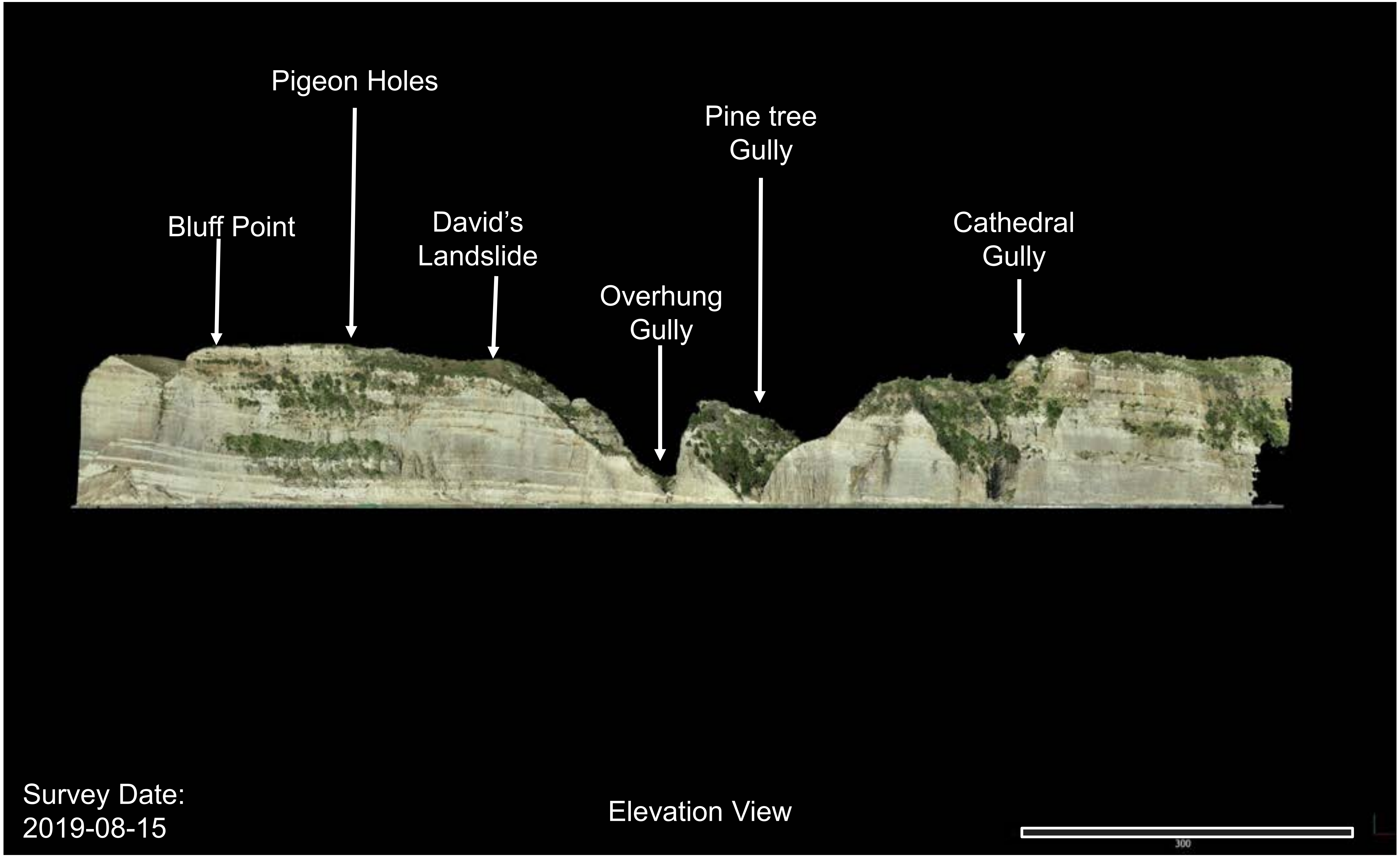
Stantec



Clifton Beach – Sector 5



Clifton Beach – Sector 5



Clifton Beach – Sector 5

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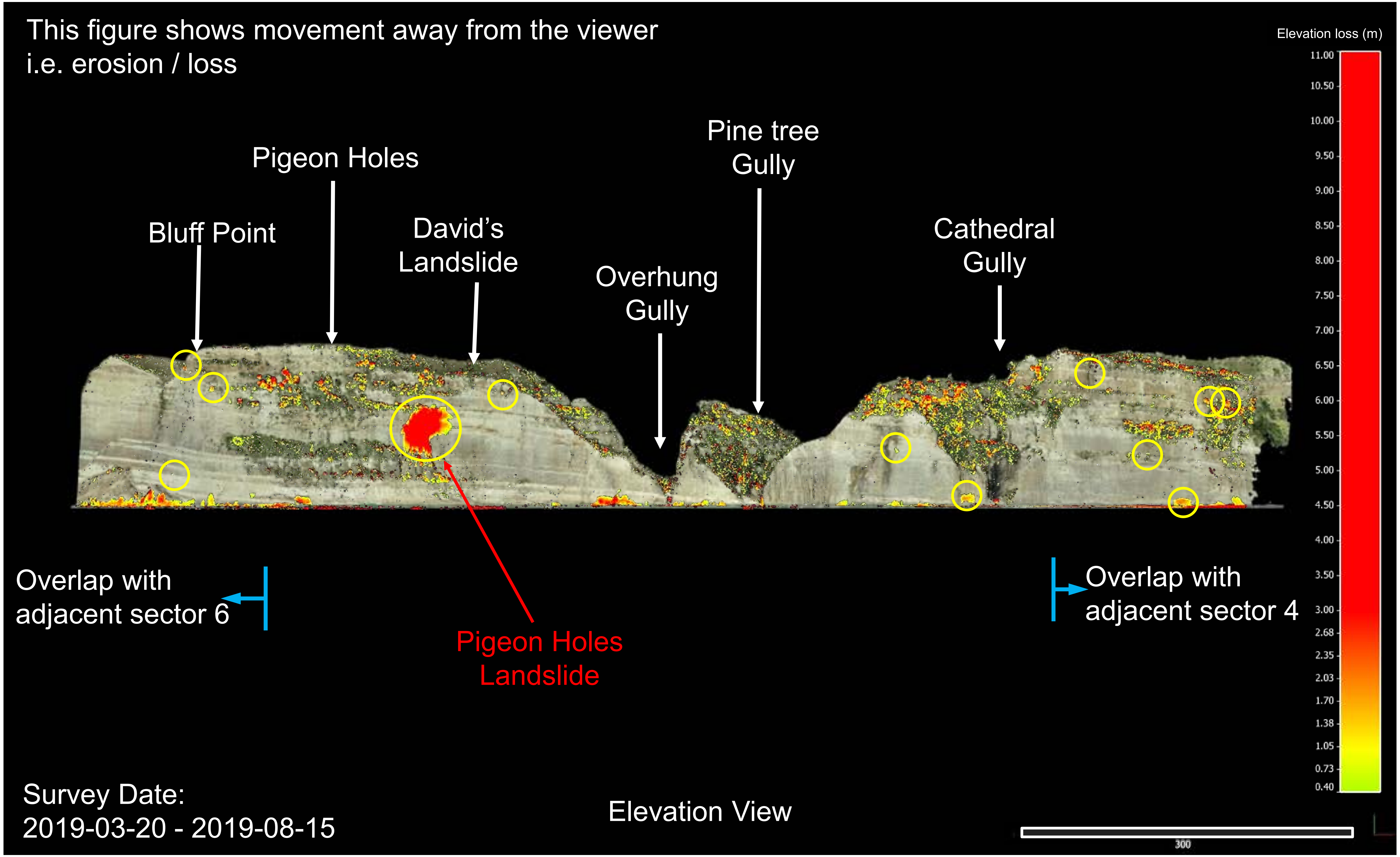
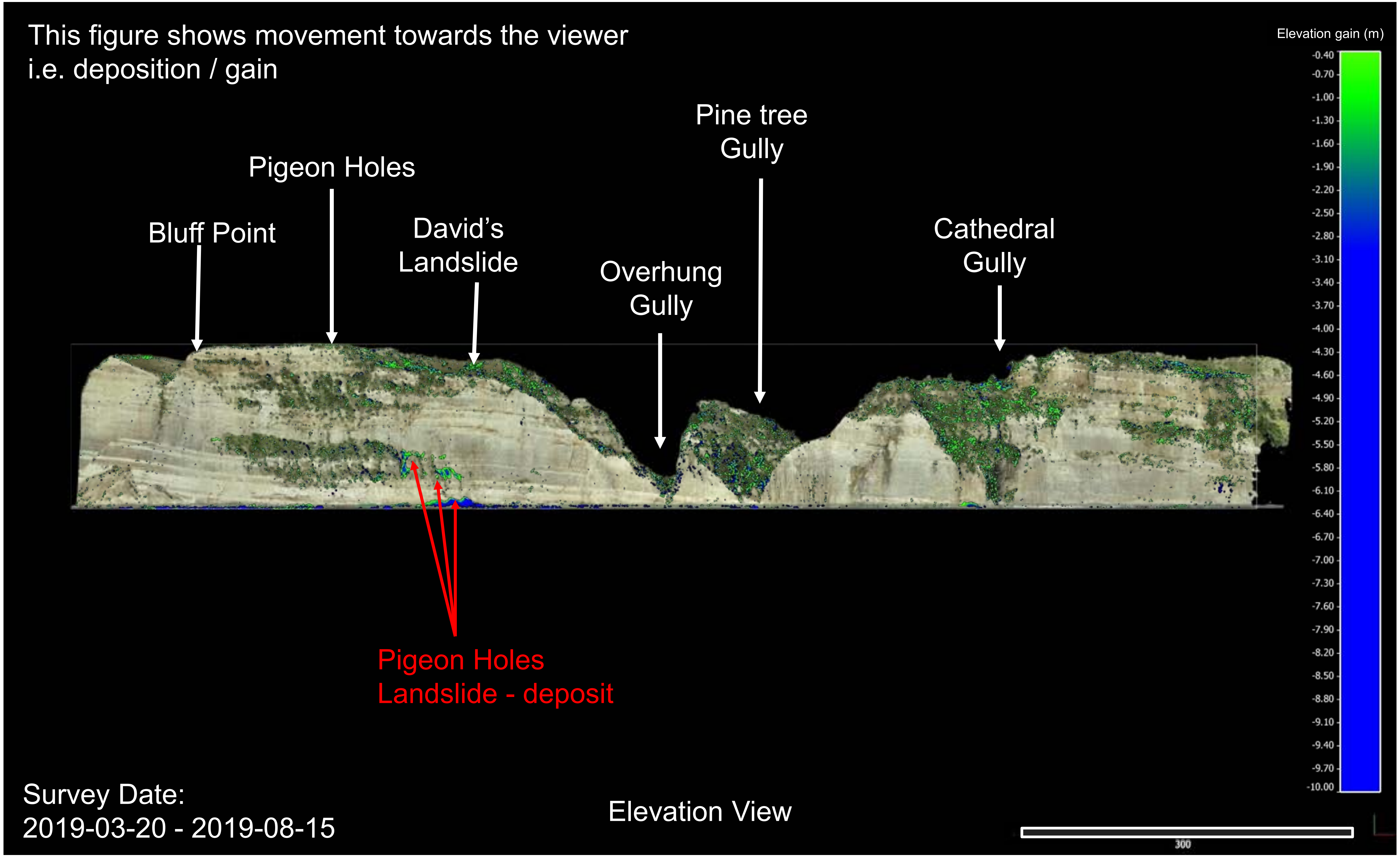
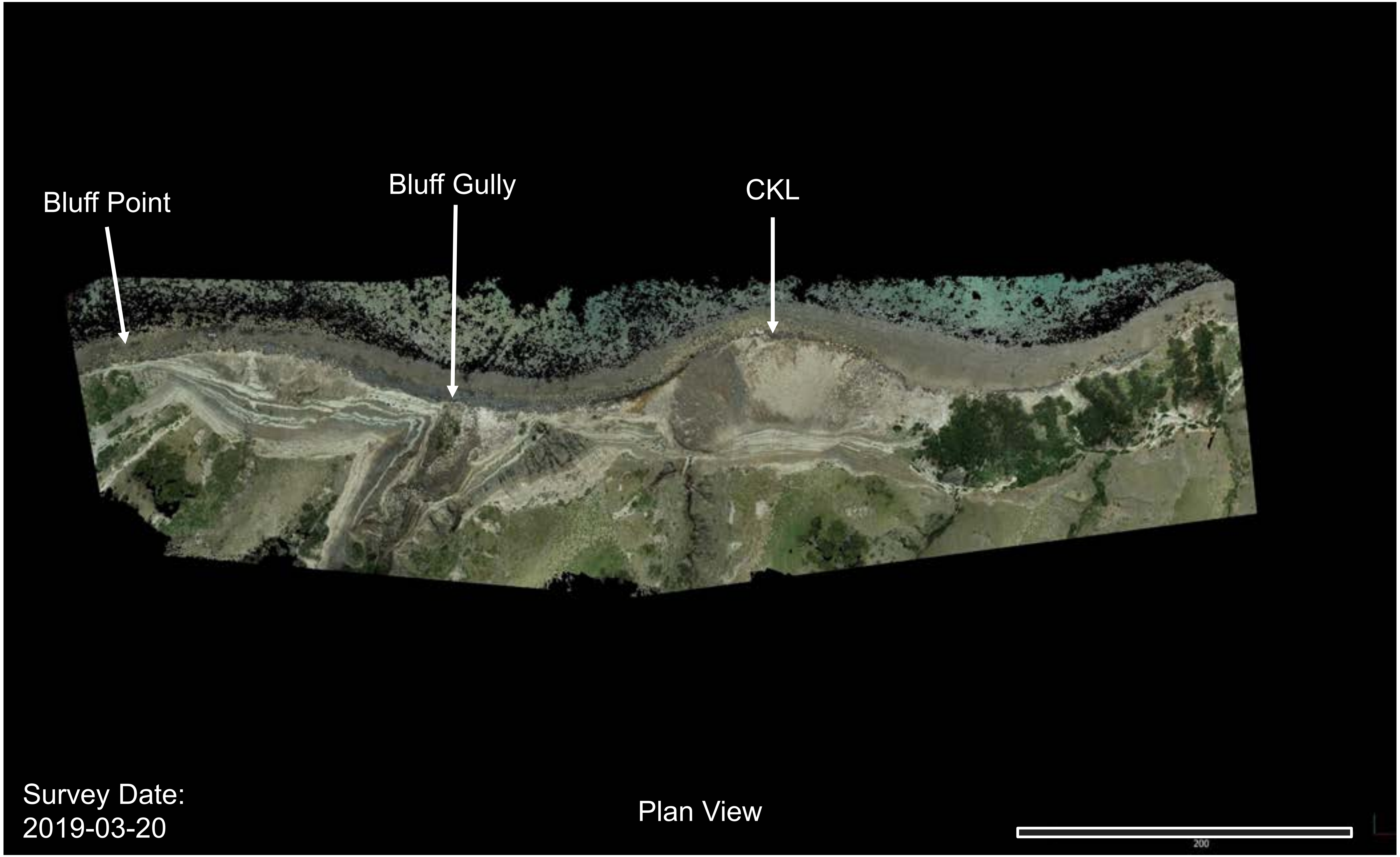


Clifton Beach – Sector 5



Clifton Beach – Sector 5



Clifton Beach – Sector 6

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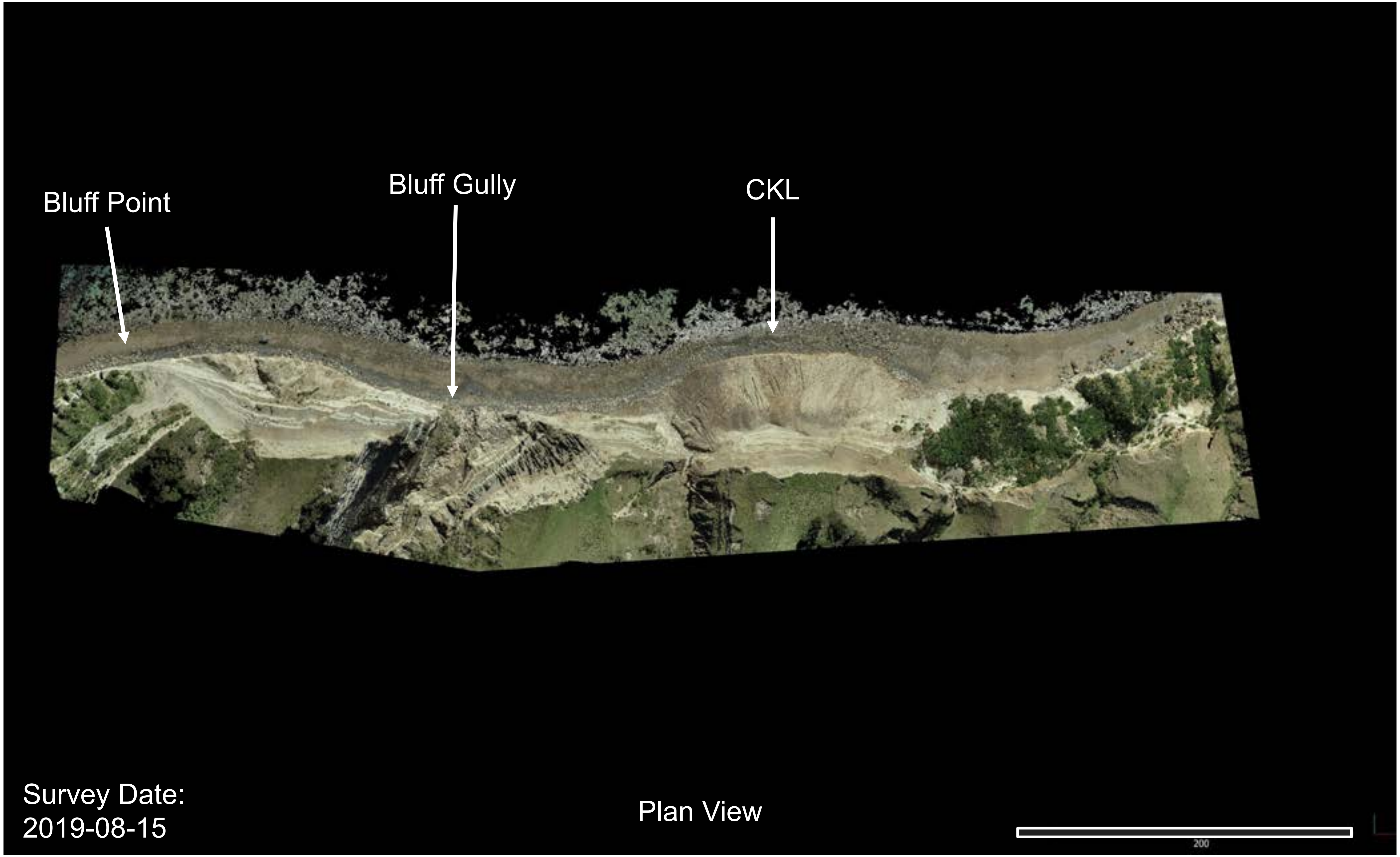

Clifton Beach – Sector 6

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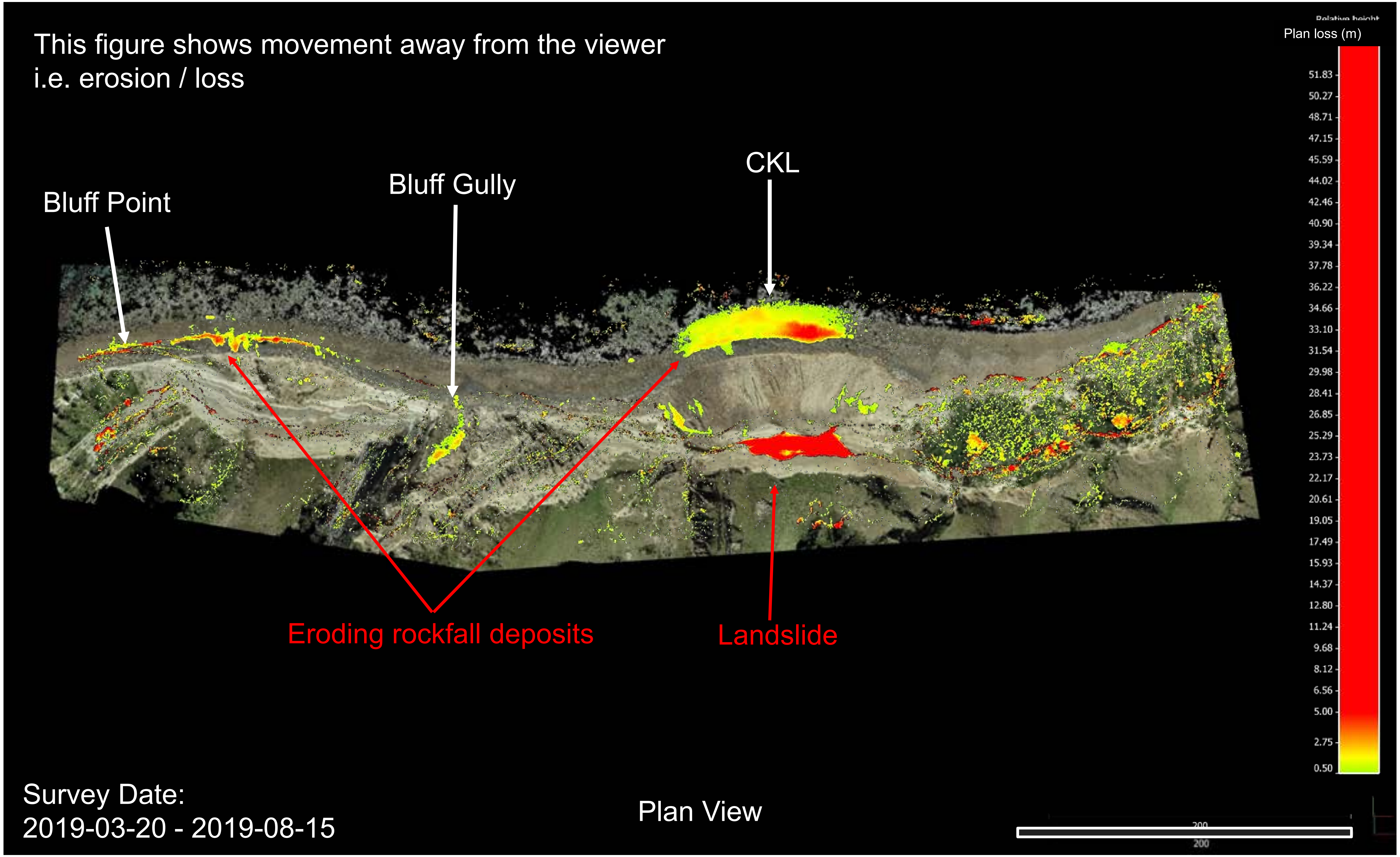
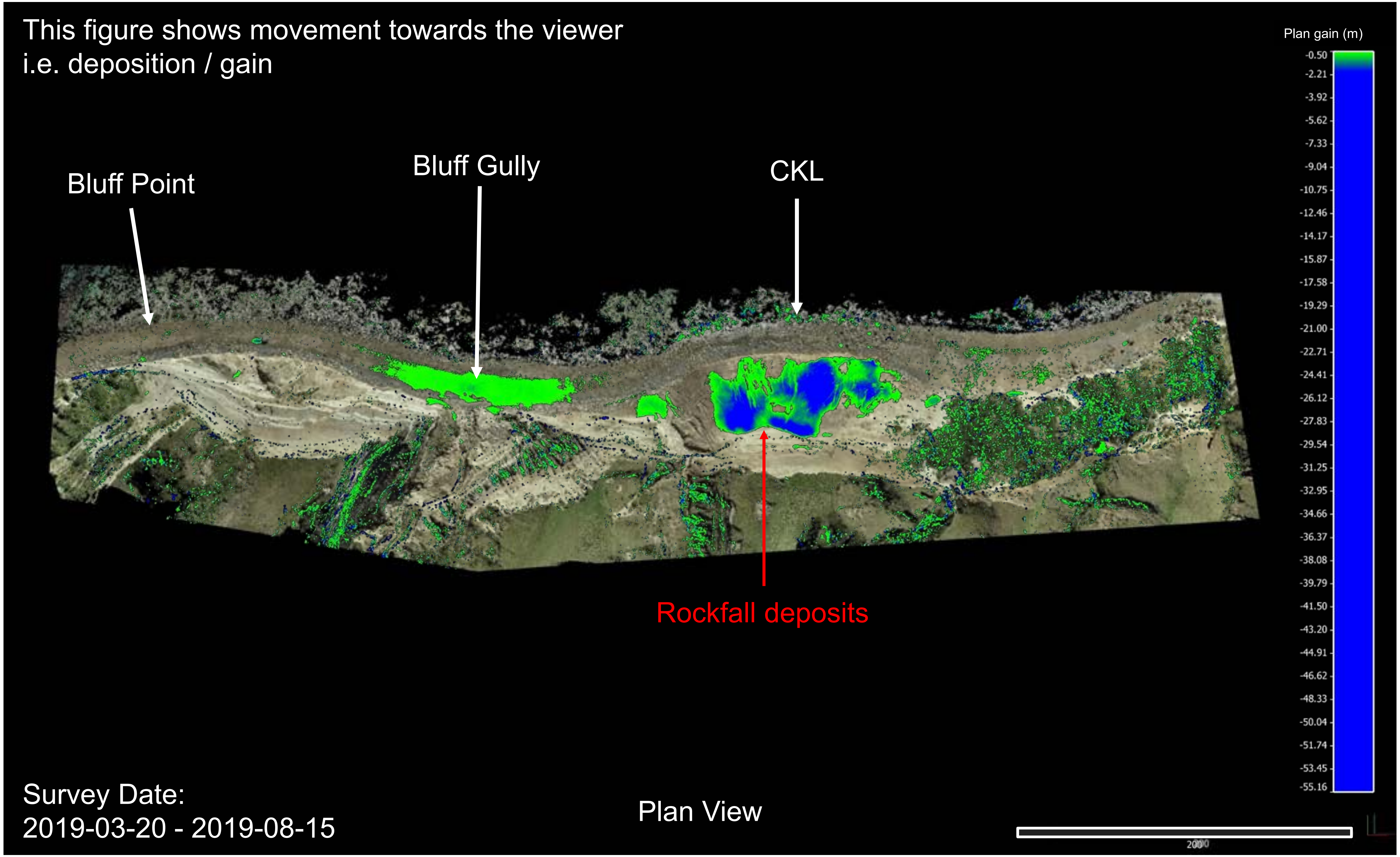
YOUR SUBDIVISION PROFESSIONALS



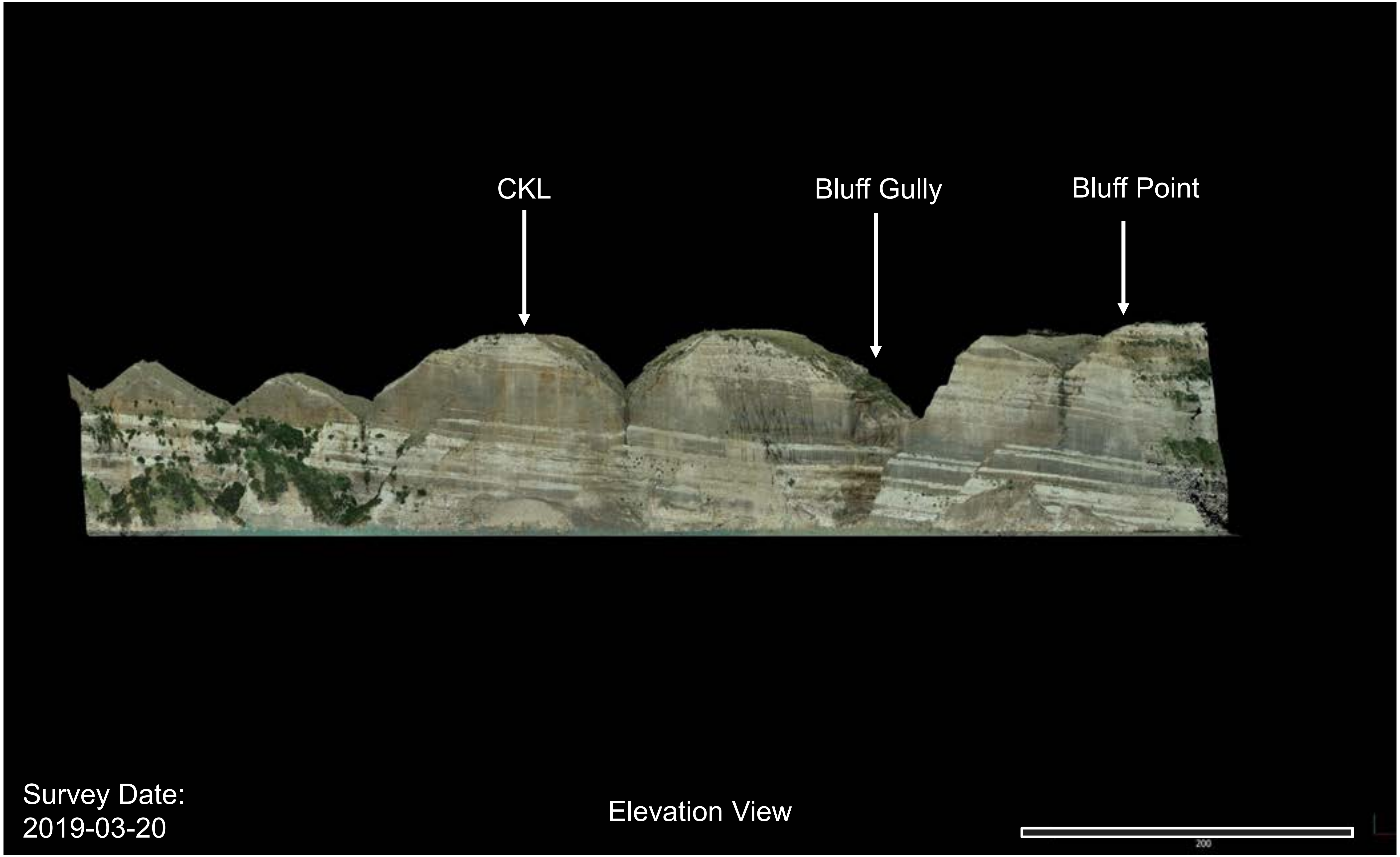
HASTINGS
DISTRICT COUNCIL

Clifton Beach – Sector 6

Stantec



Clifton Beach – Sector 6



Clifton Beach – Sector 6

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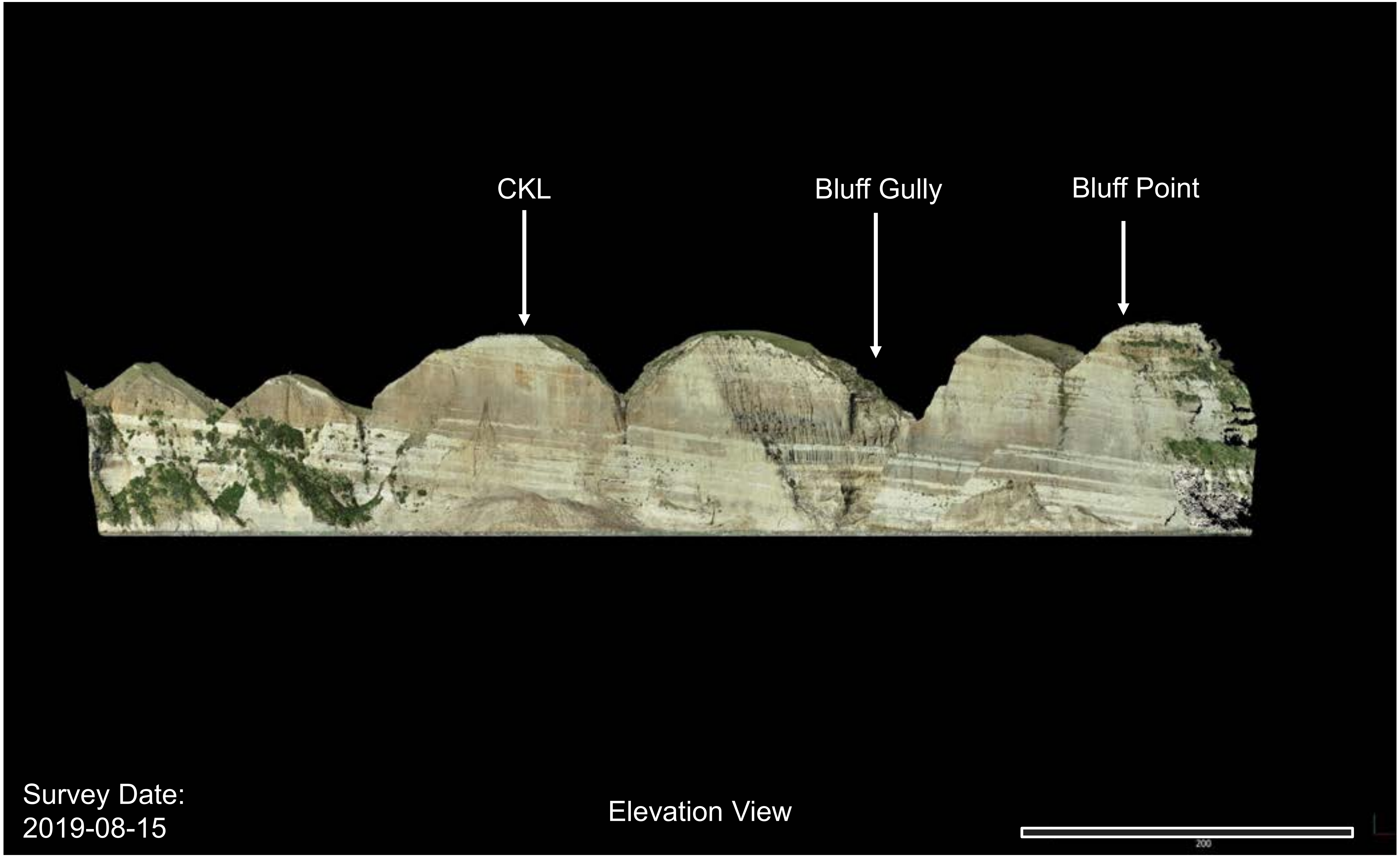
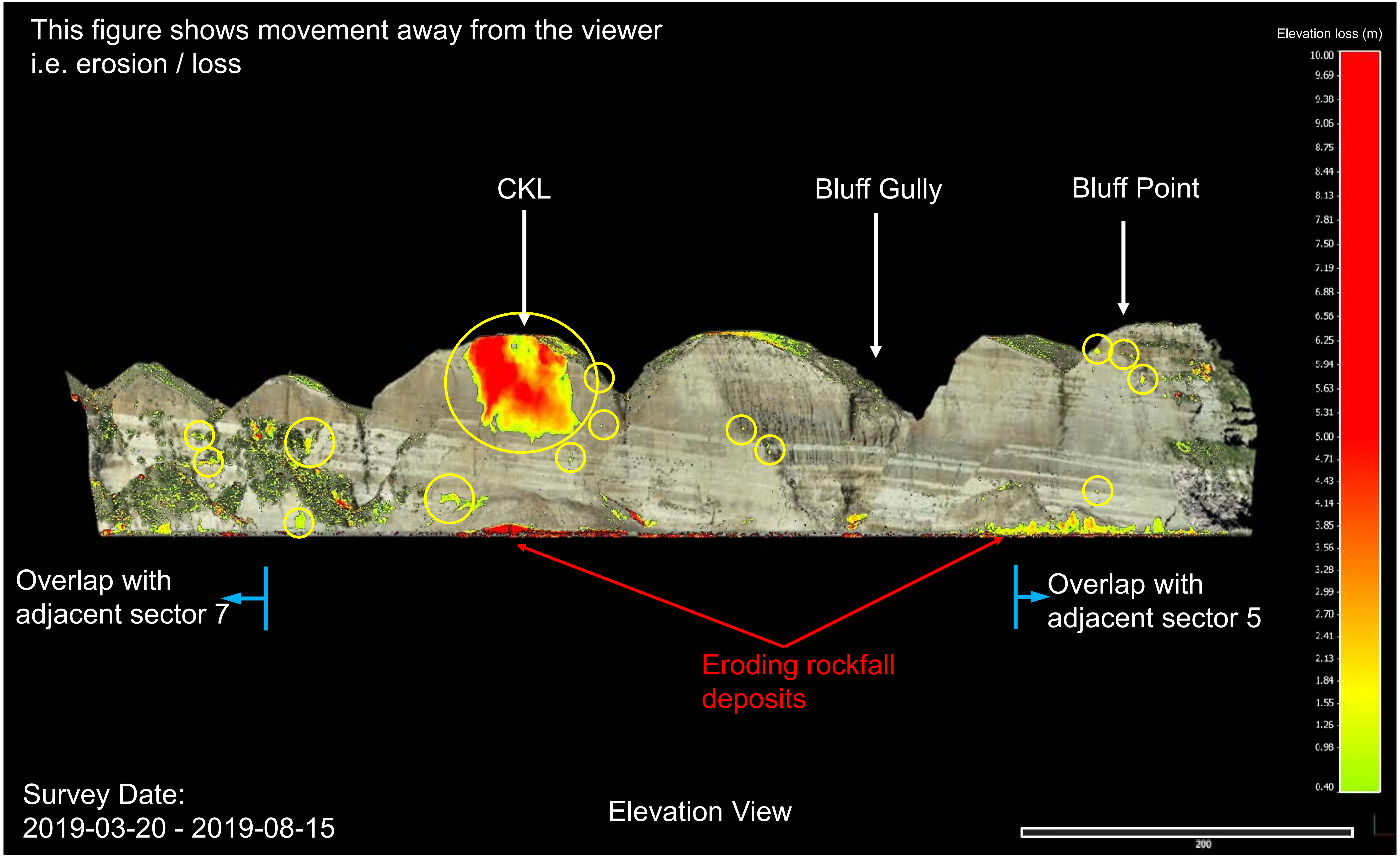
Your Subdivision Professionals



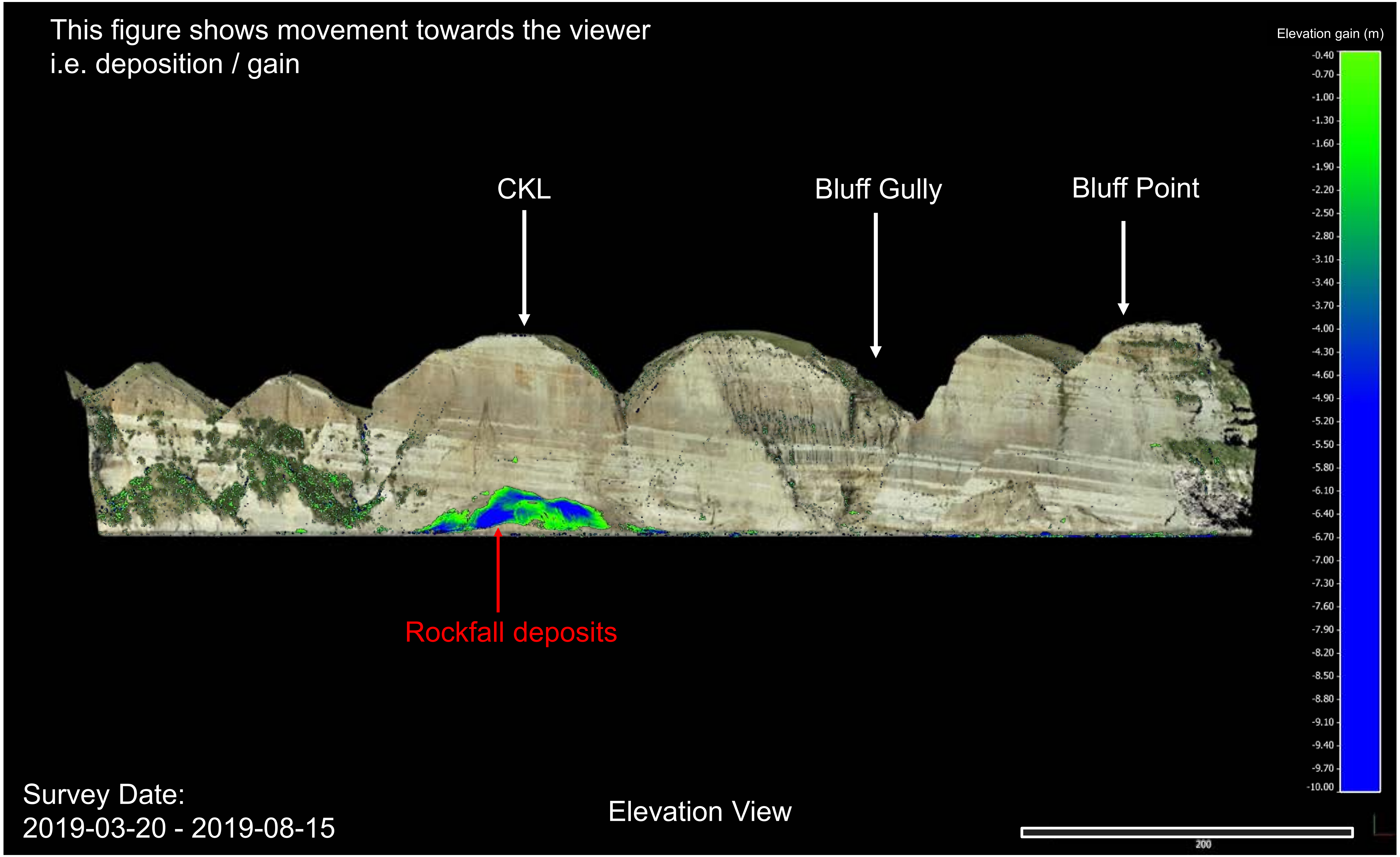
HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 6

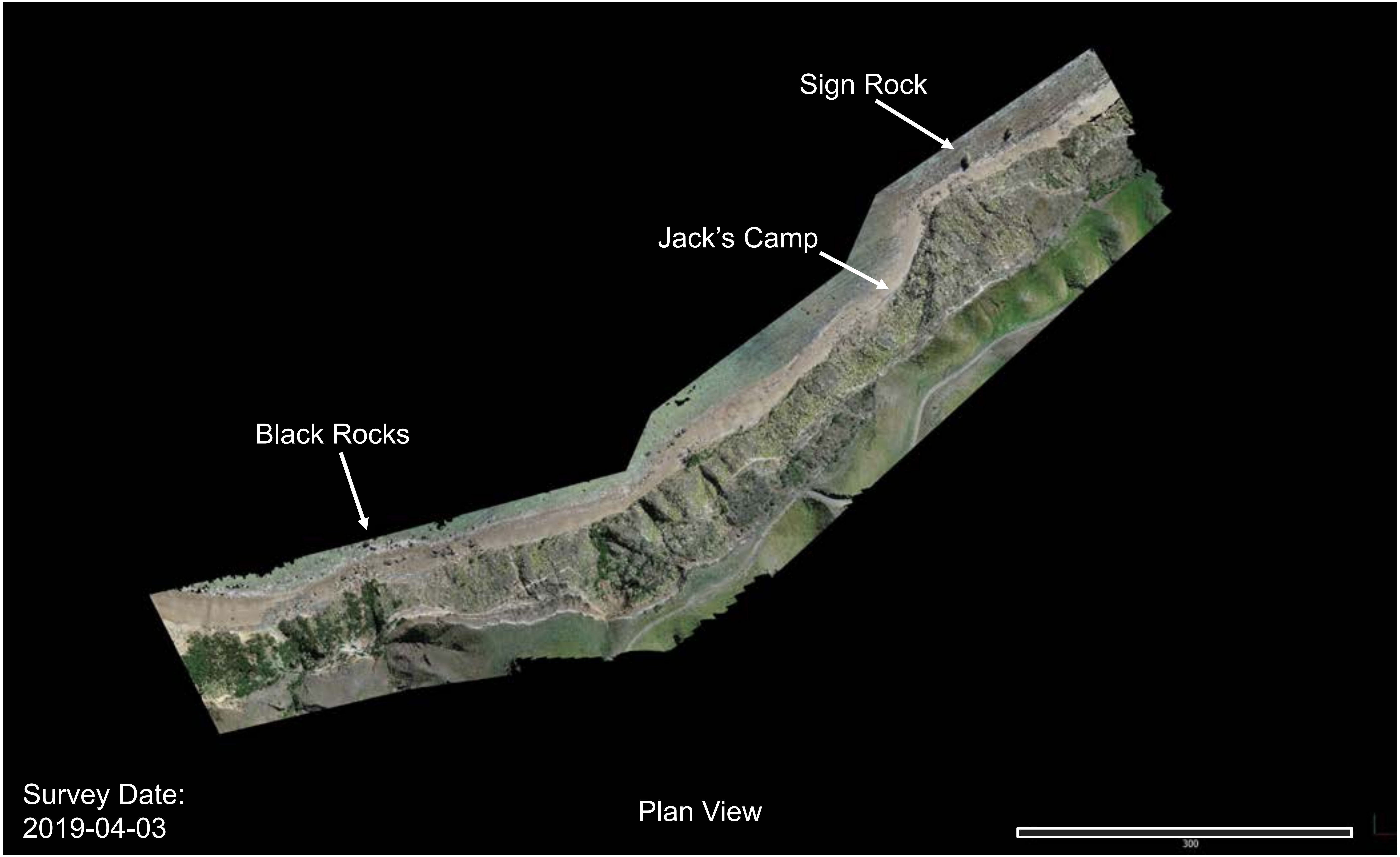
Stantec



Clifton Beach – Sector 6

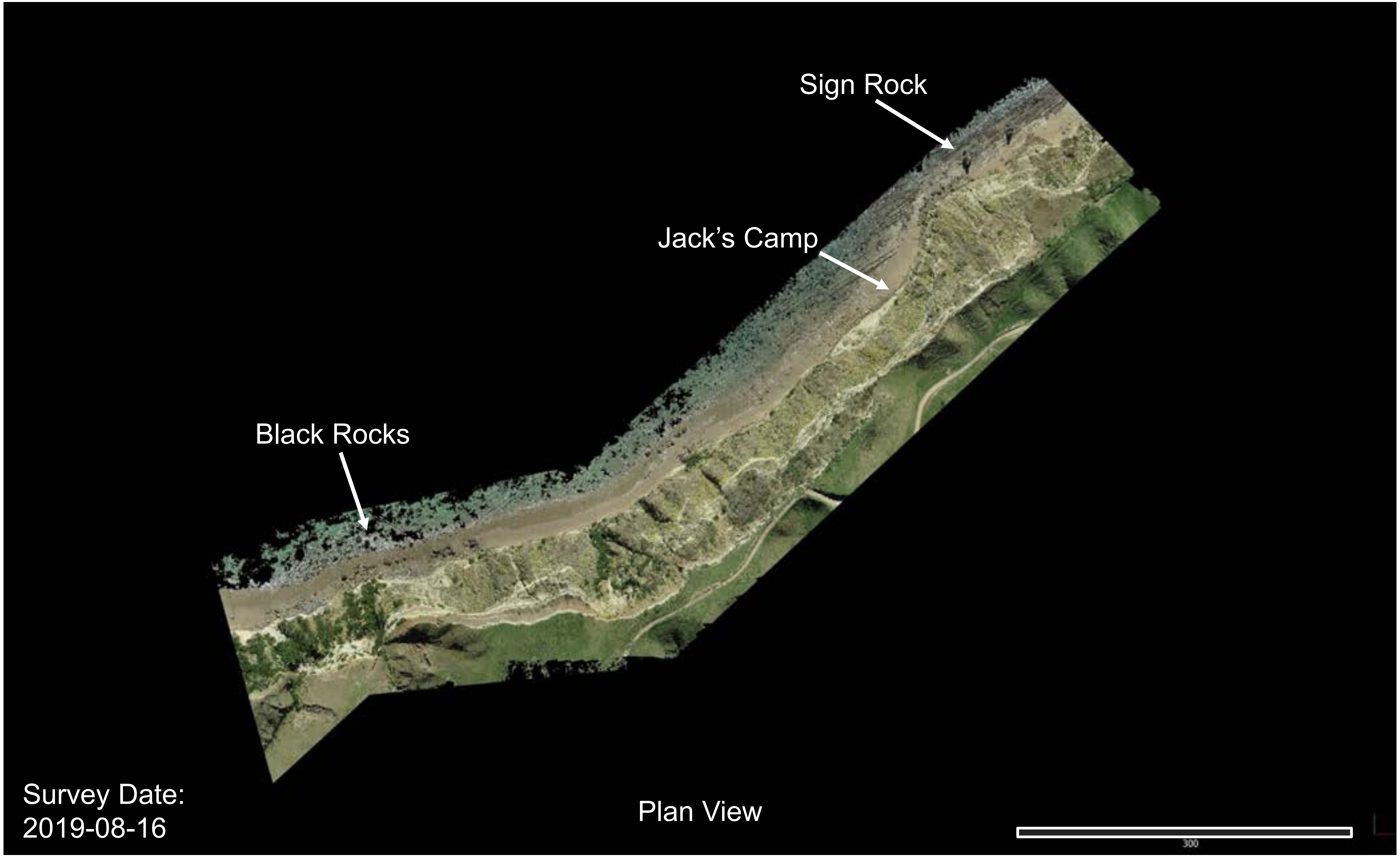


Clifton Beach – Sector 6



Clifton Beach – Sector 7

The Surveying Company
Your Subdivision Professionals



HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 7

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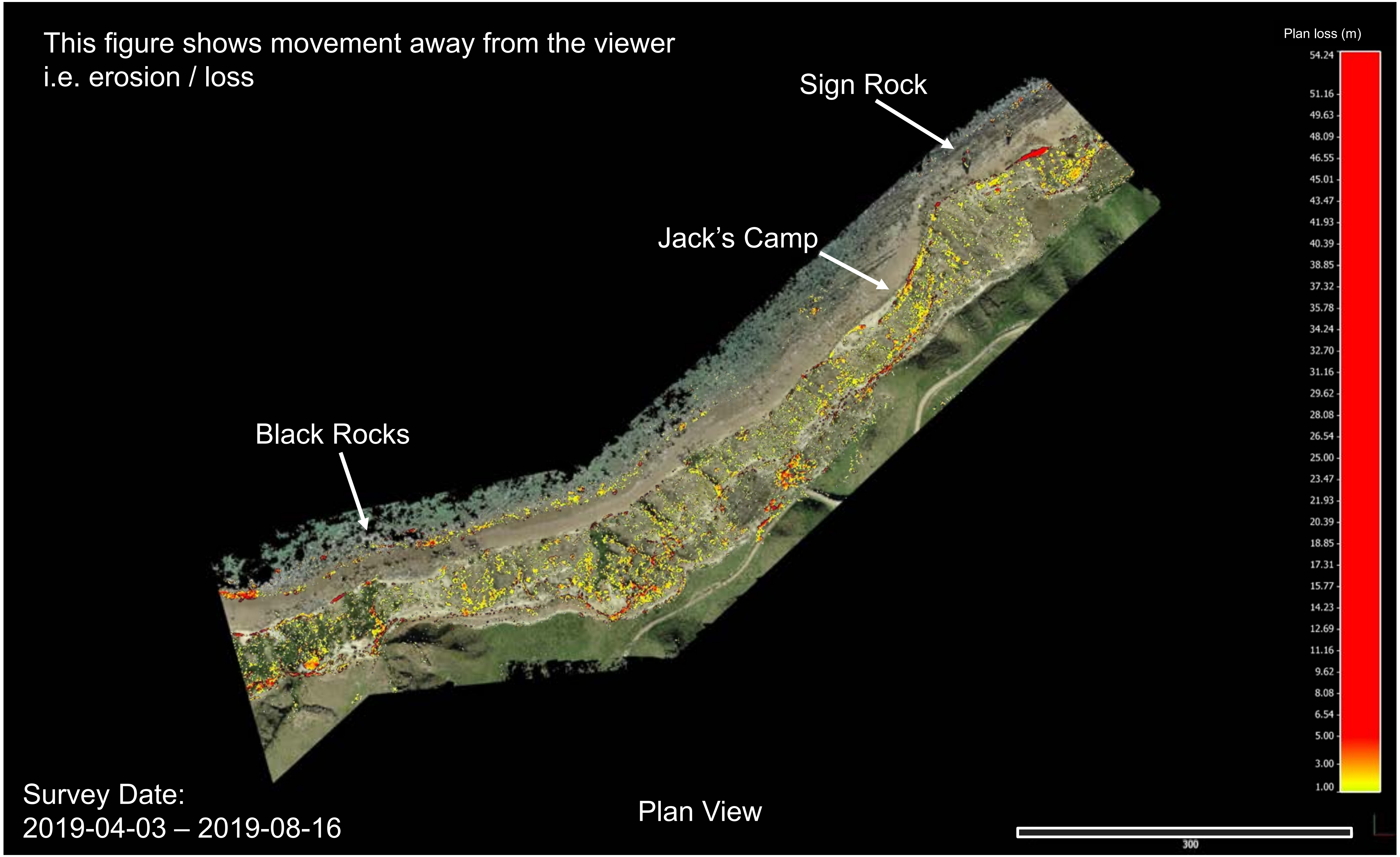
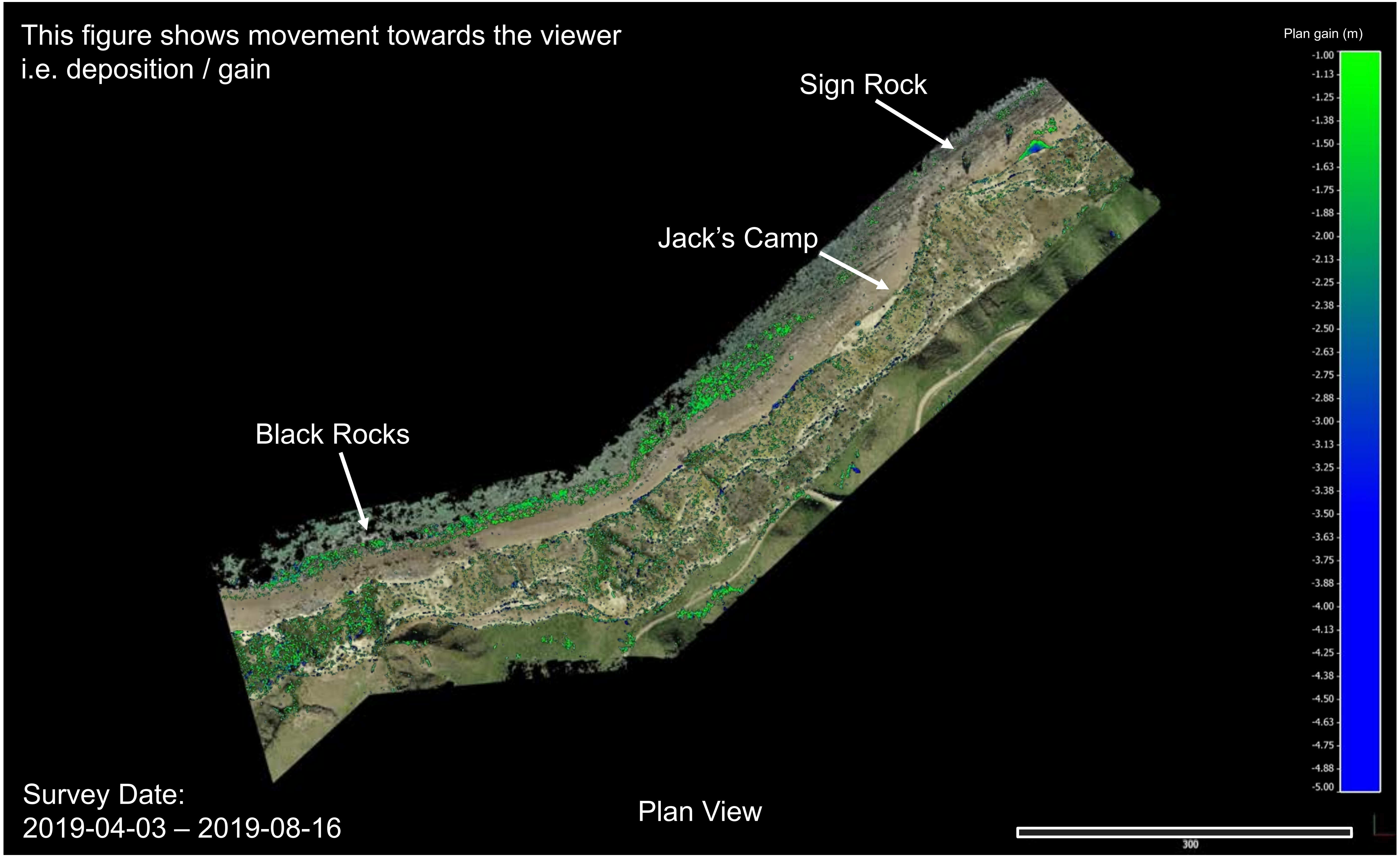
THE SURVEYING COMPANY
YOUR SUBDIVISION PROFESSIONALS



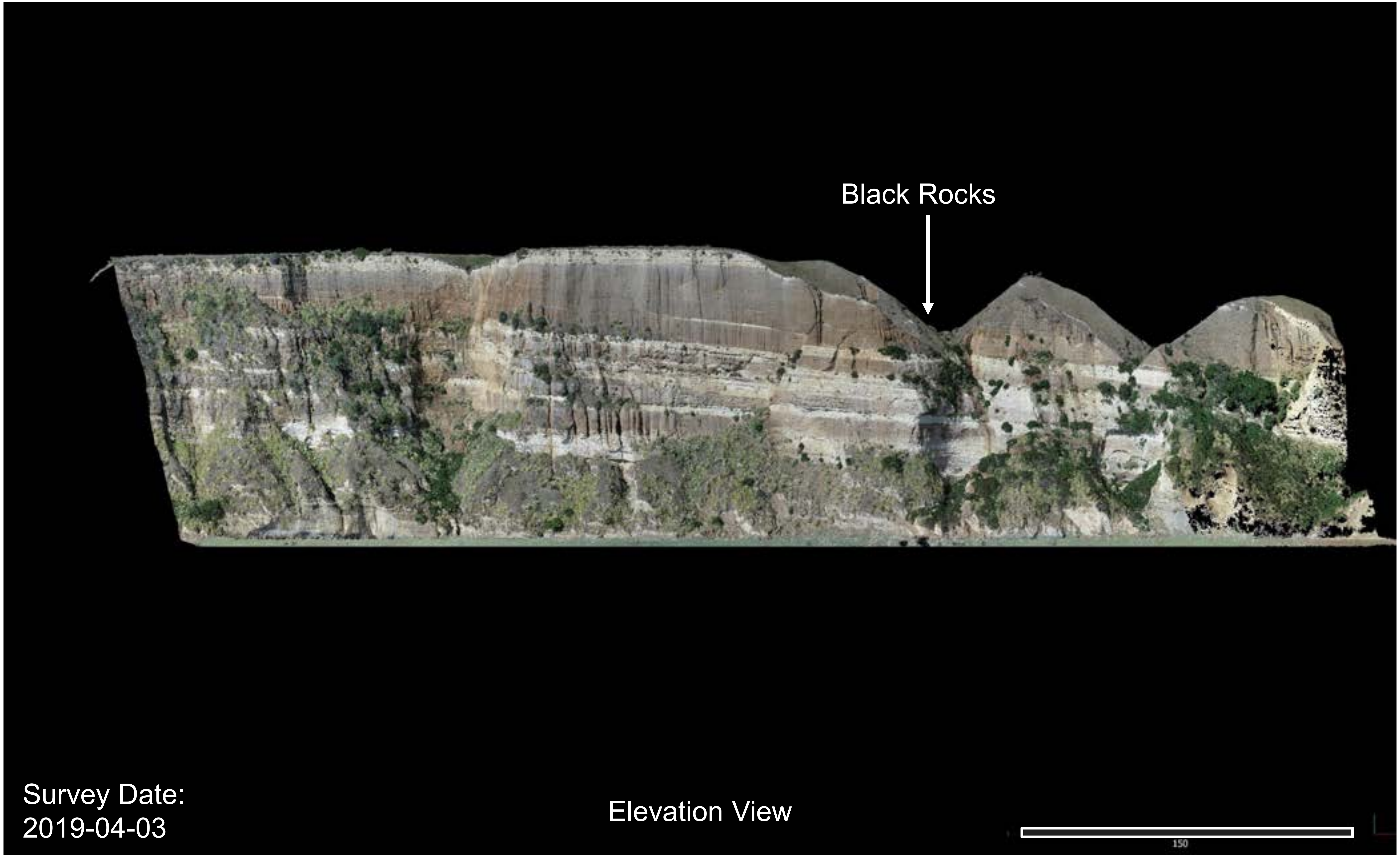
HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 7

Stantec



Clifton Beach – Sector 7



Clifton Beach – Sector 7a

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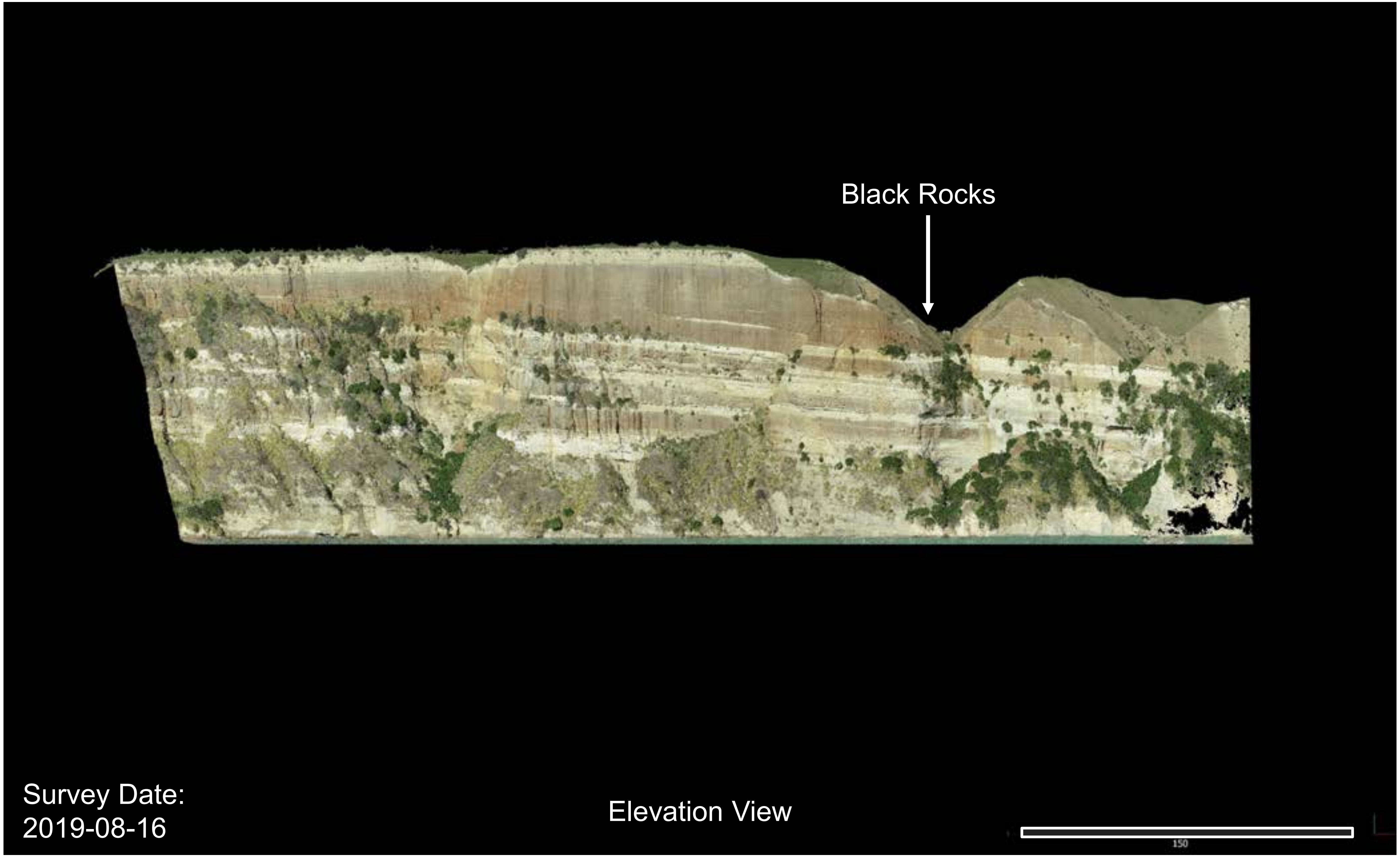
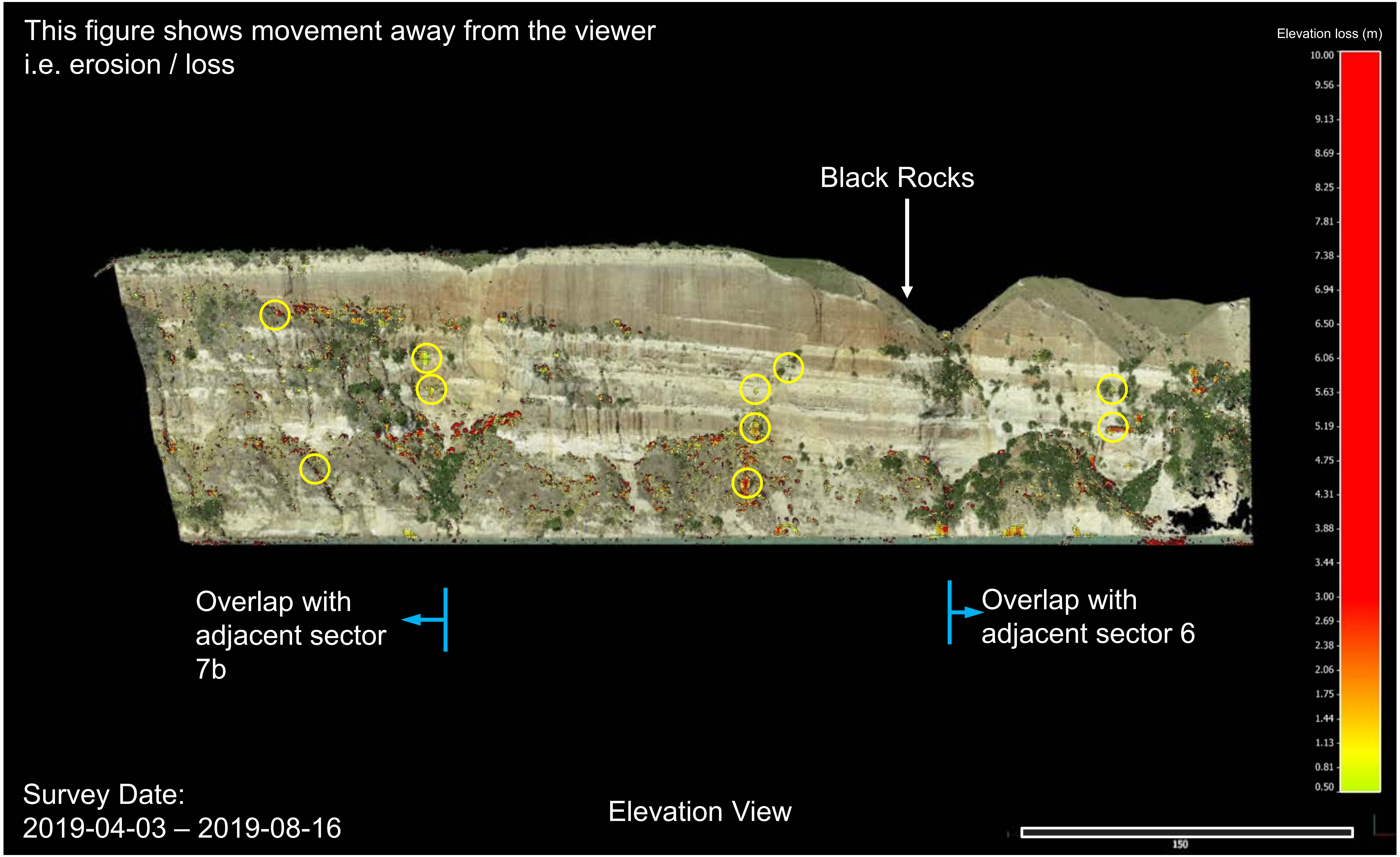
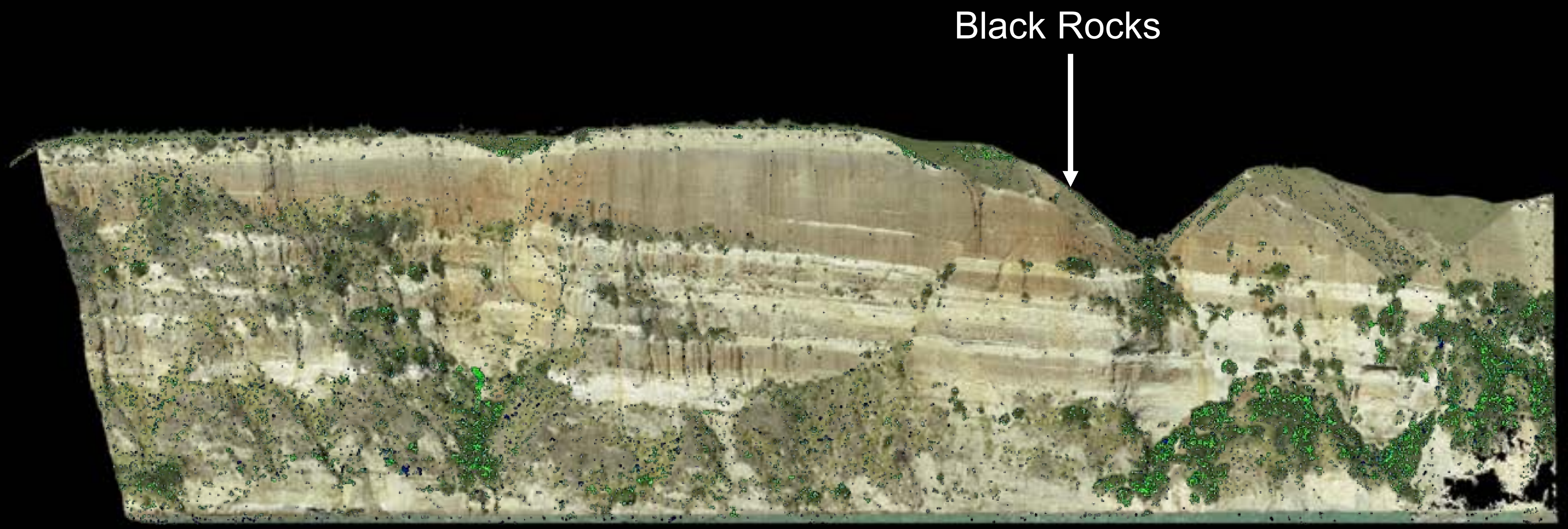


Clifton Beach – Sector 7a



Clifton Beach – Sector 7a

This figure shows movement towards the viewer
i.e. deposition / gain



Elevation gain (m)

-0.30, -0.38, -0.47, -0.55, -0.64, -0.72, -0.81, -0.89, -0.98, -1.06, -1.14, -1.23, -1.31, -1.40, -1.48, -1.57, -1.65, -1.73, -1.82, -1.90, -1.99, -2.07, -2.16, -2.24, -2.33, -2.41, -2.49, -2.58, -2.66, -2.75, -2.83, -2.92, -3.00

Survey Date:
2019-04-03 – 2019-08-16

Elevation View

150

Clifton Beach – Sector 7a

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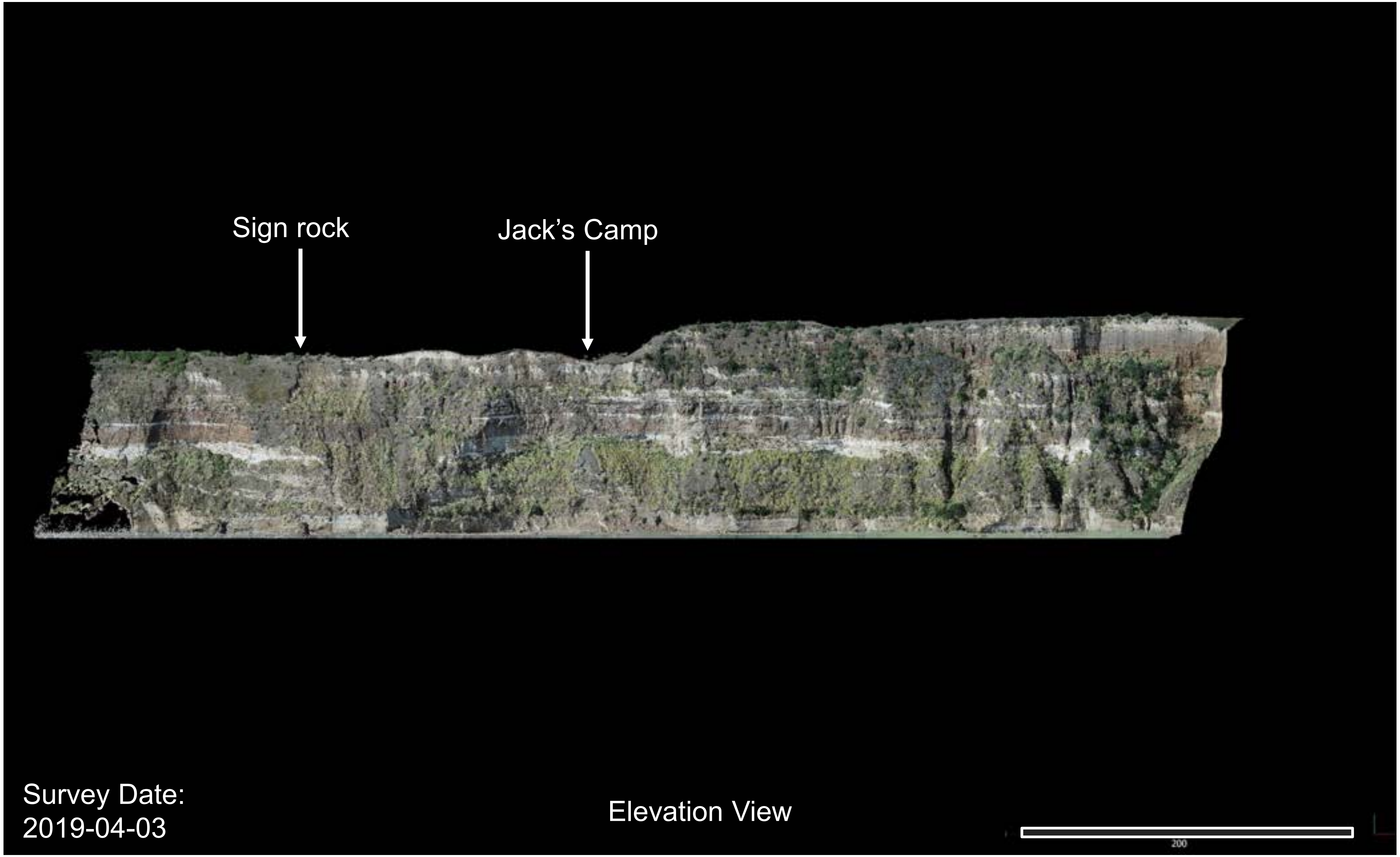
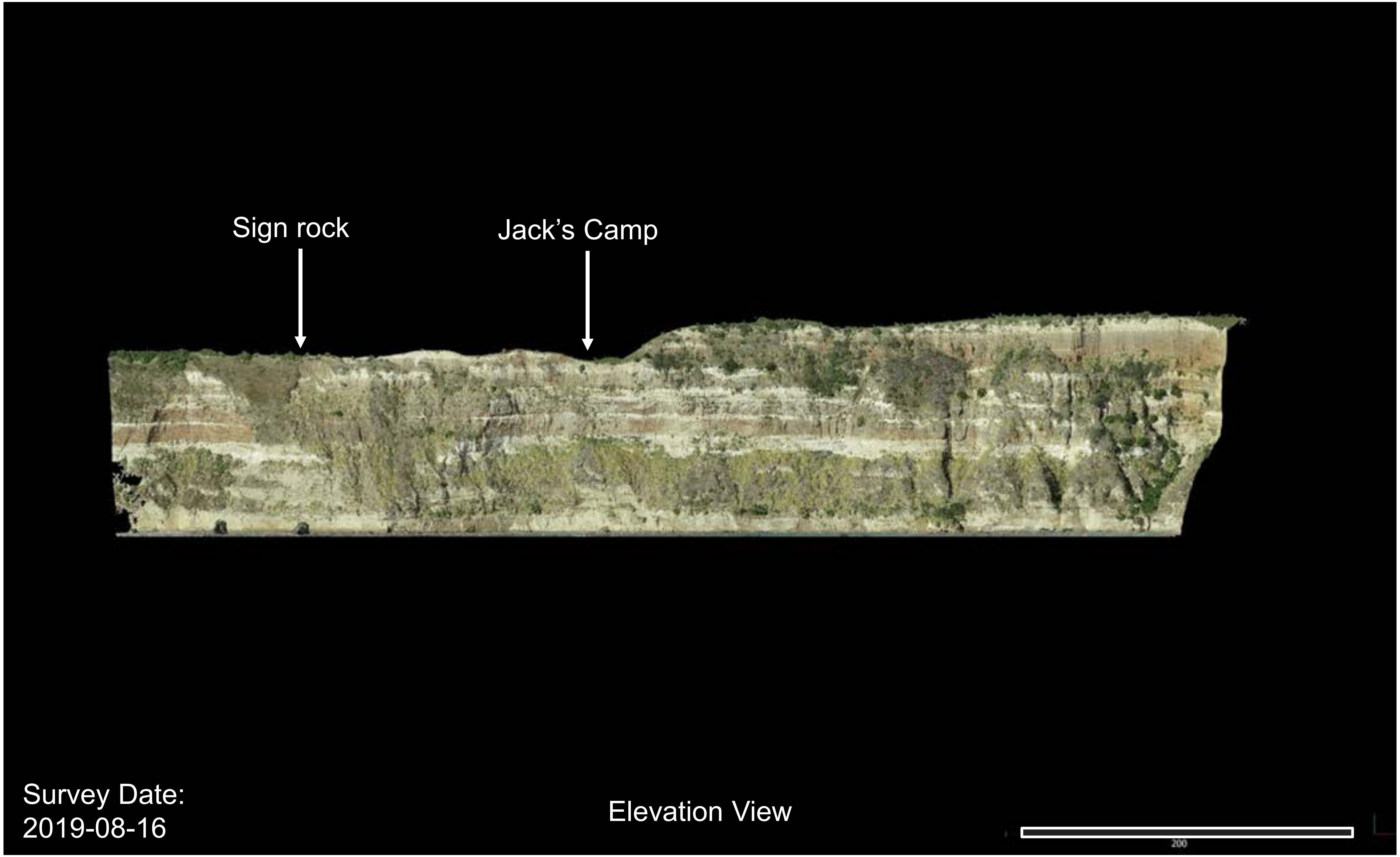


Hastings District Council

Clifton Beach – Sector 7b

Stantec



Clifton Beach – Sector 7b

THE SURVEYING COMPANY
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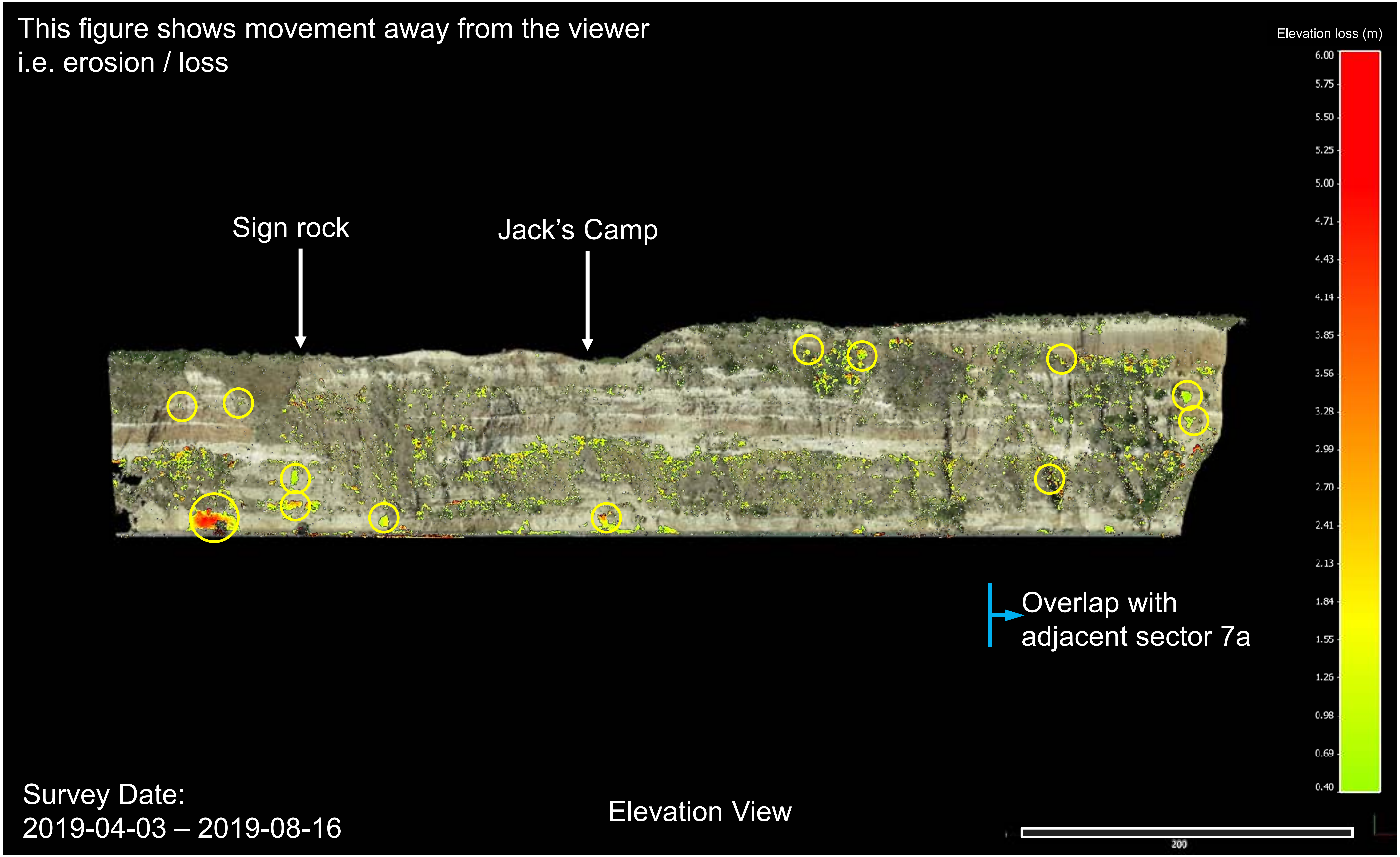
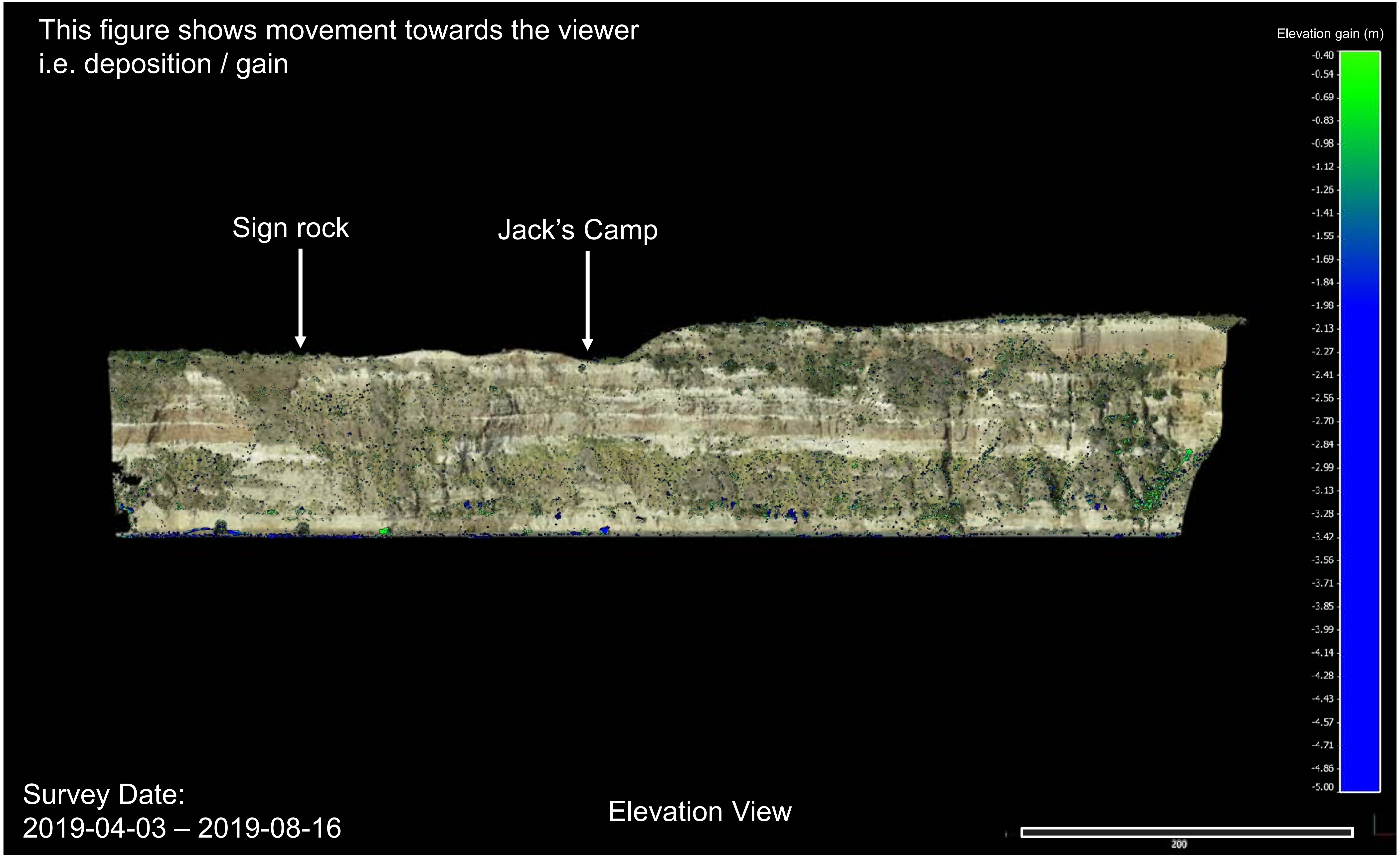


HASTINGS
DISTRICT COUNCIL

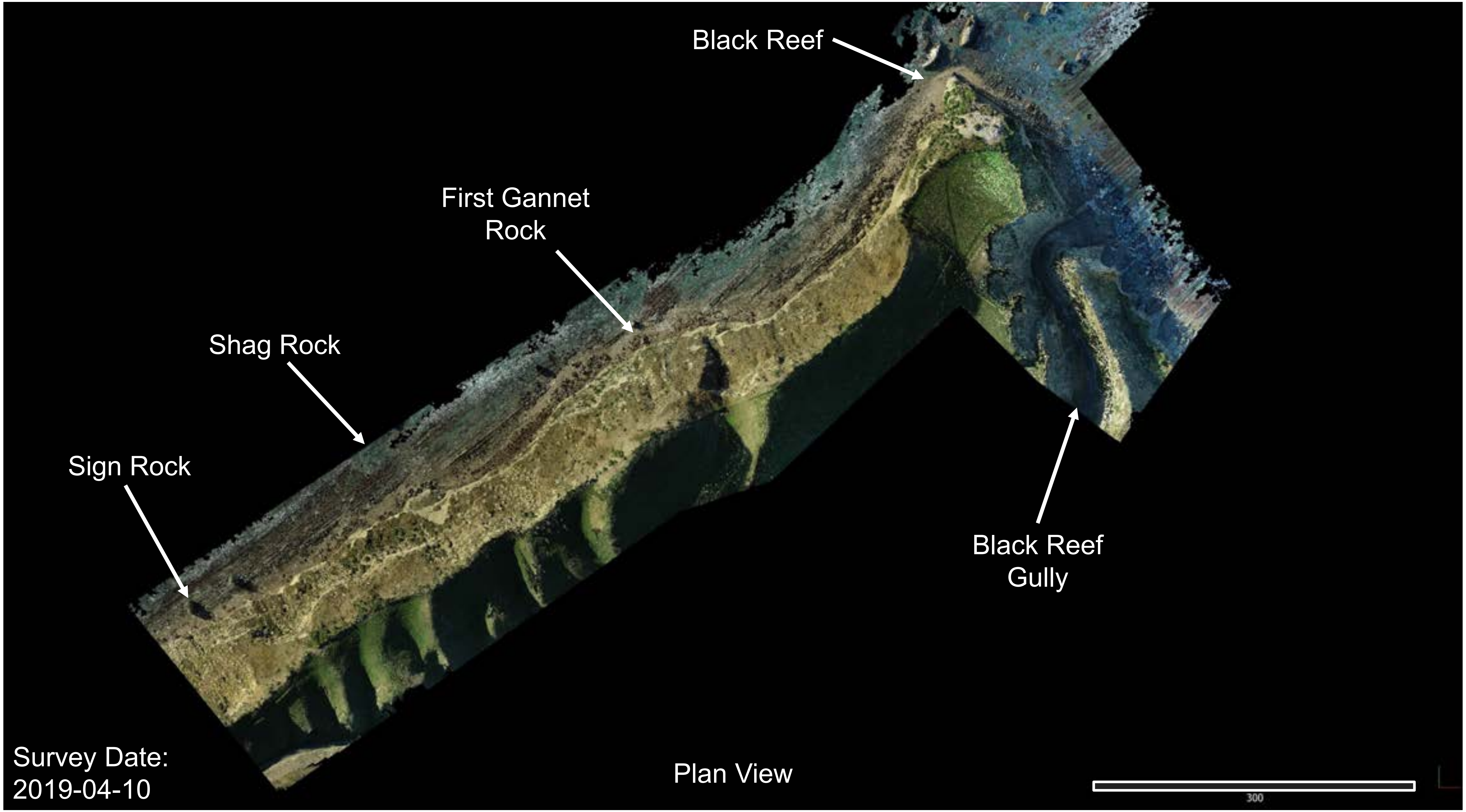
Clifton Beach – Sector 7b

Stantec



Clifton Beach – Sector 7b

The Surveying Company
Your Subdivision Professionals



Hastings District Council

Clifton Beach – Sector 8

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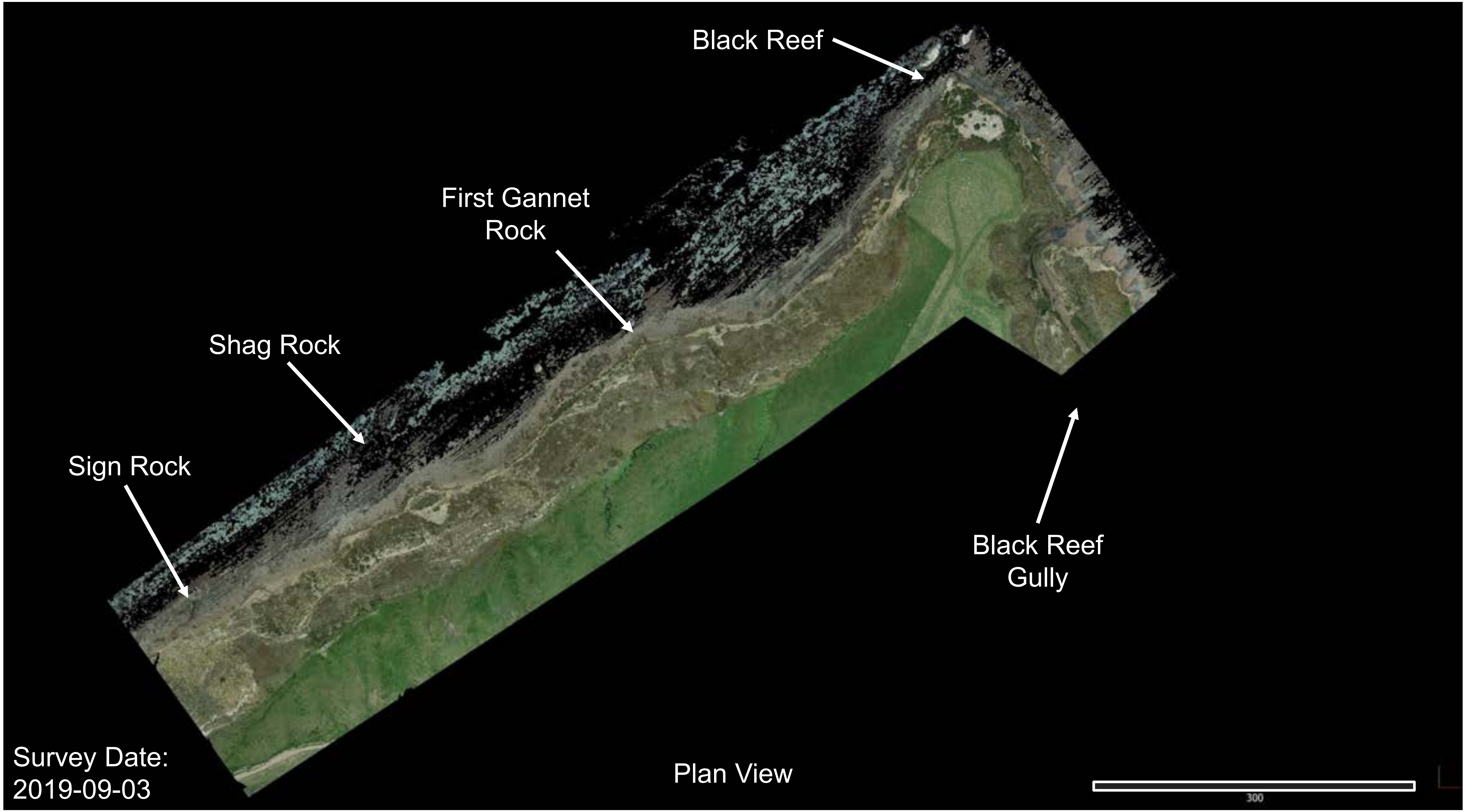
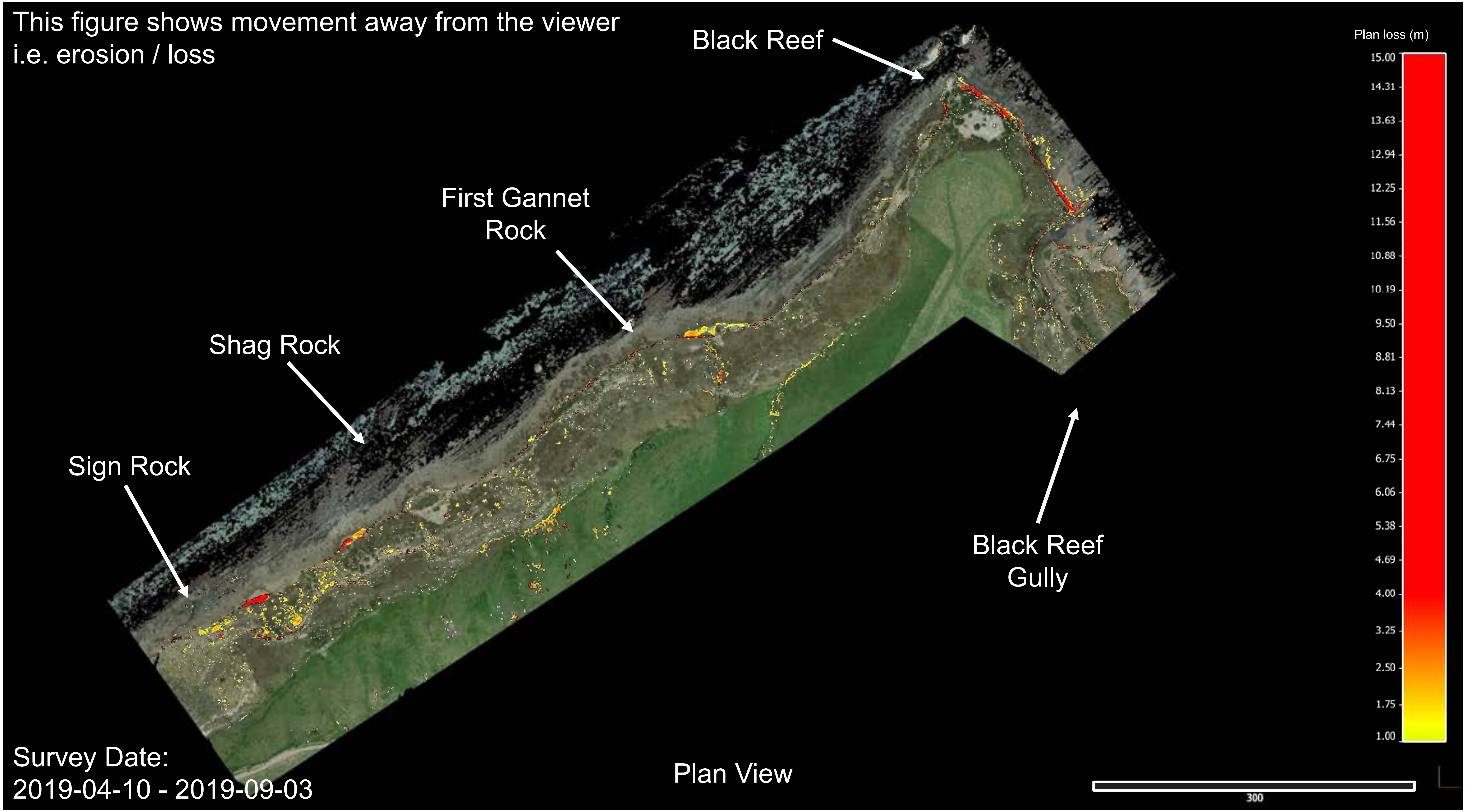


Clifton Beach – Sector 8



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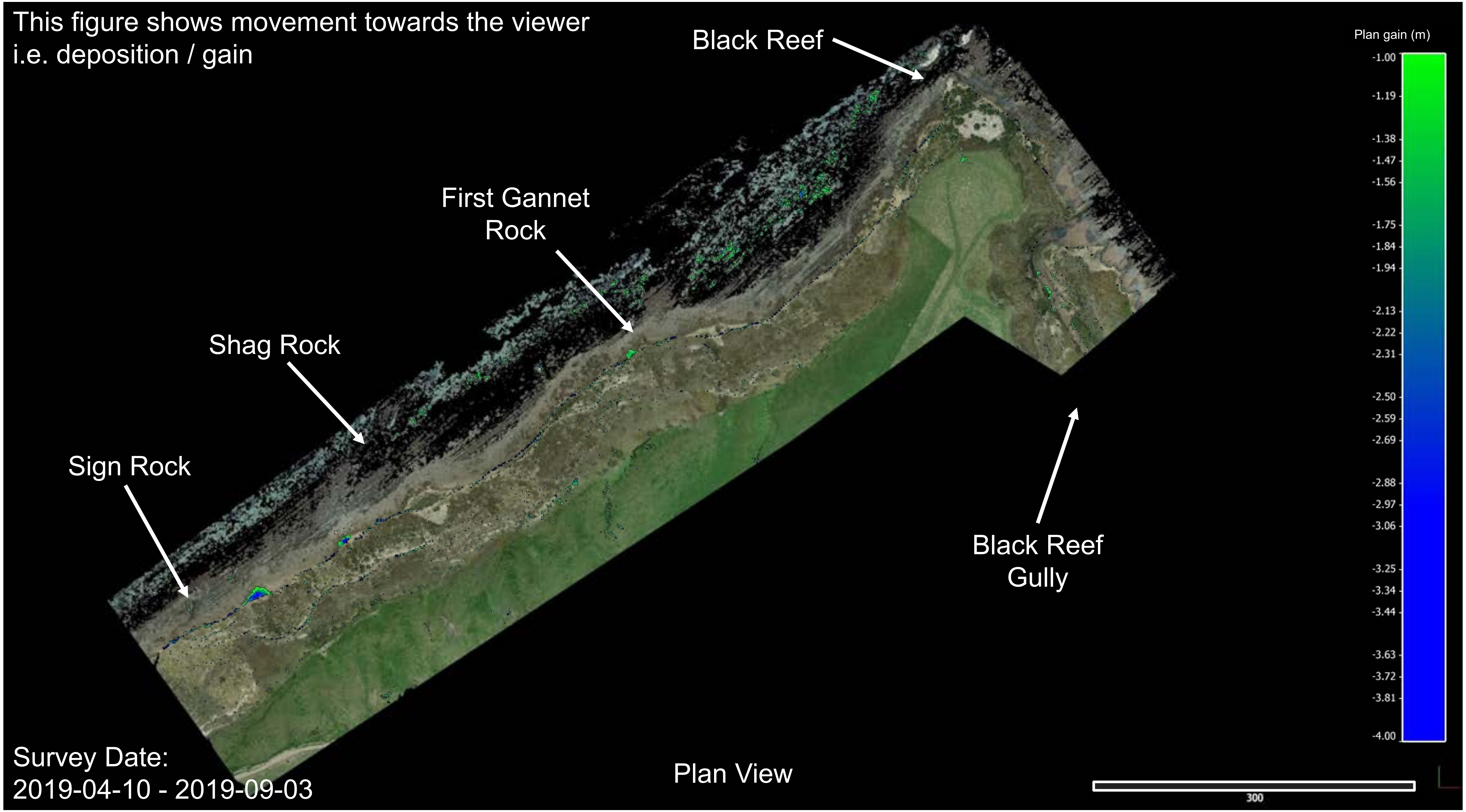
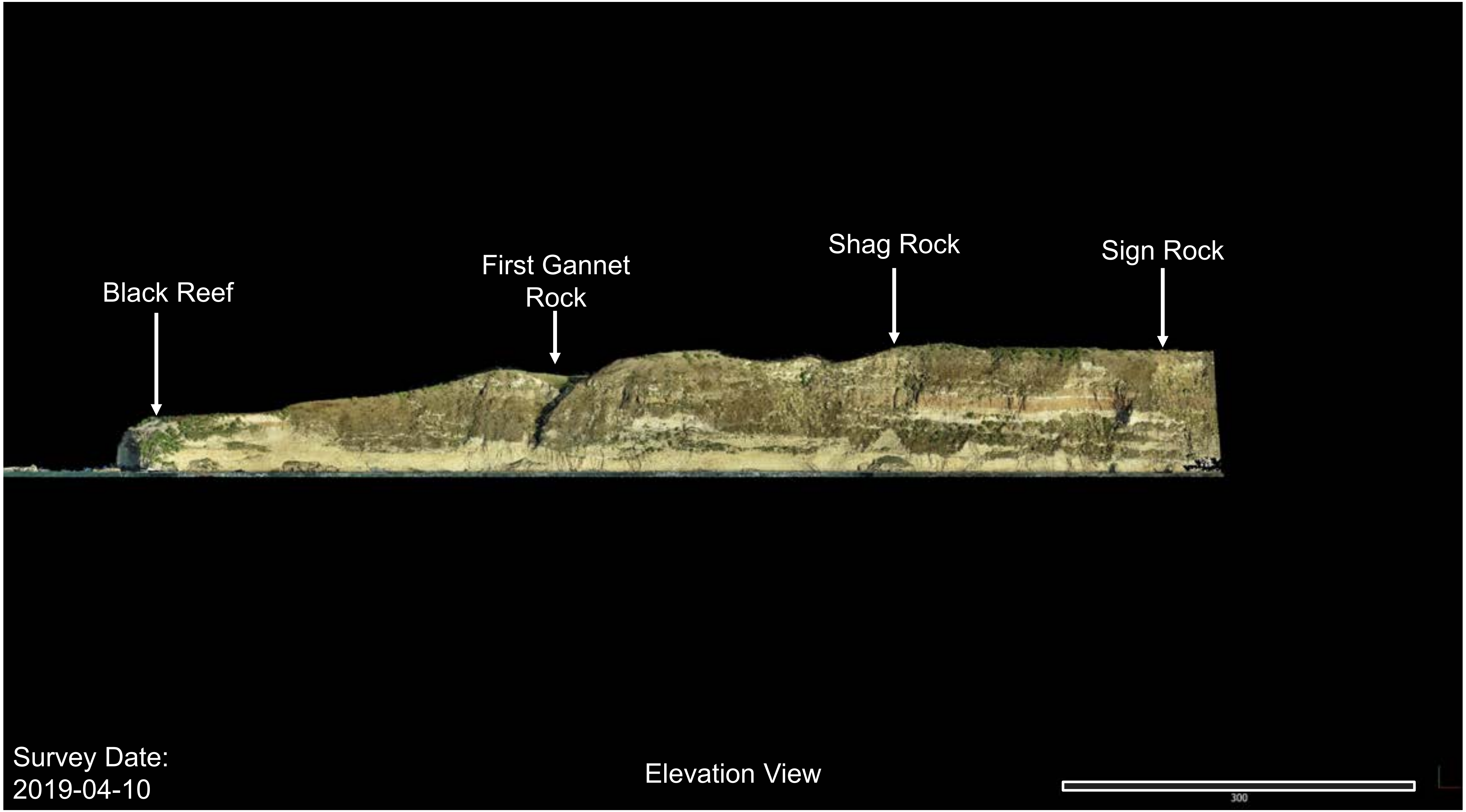
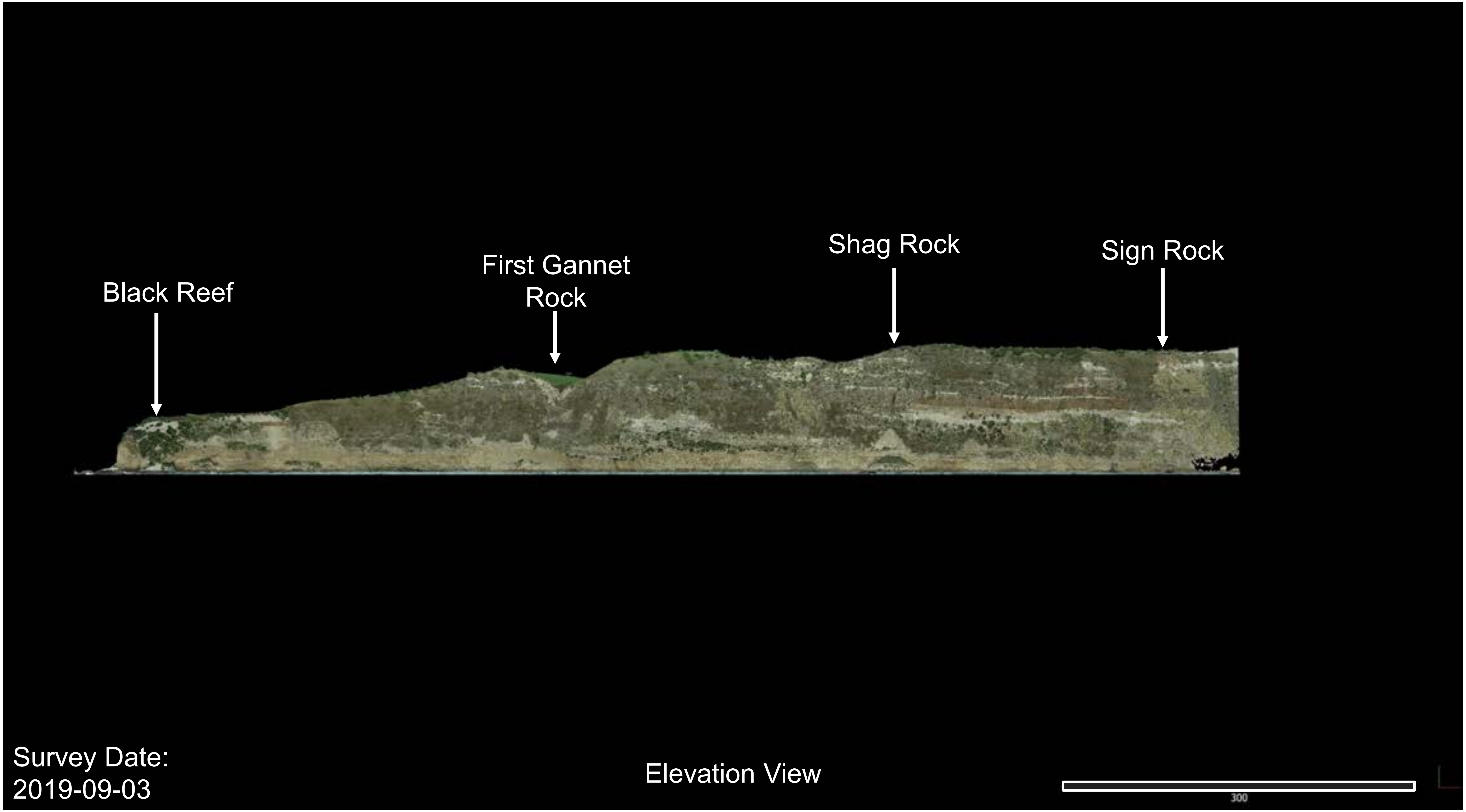


Clifton Beach – Sector 8



Clifton Beach – Sector 8



Clifton Beach – Sector 8

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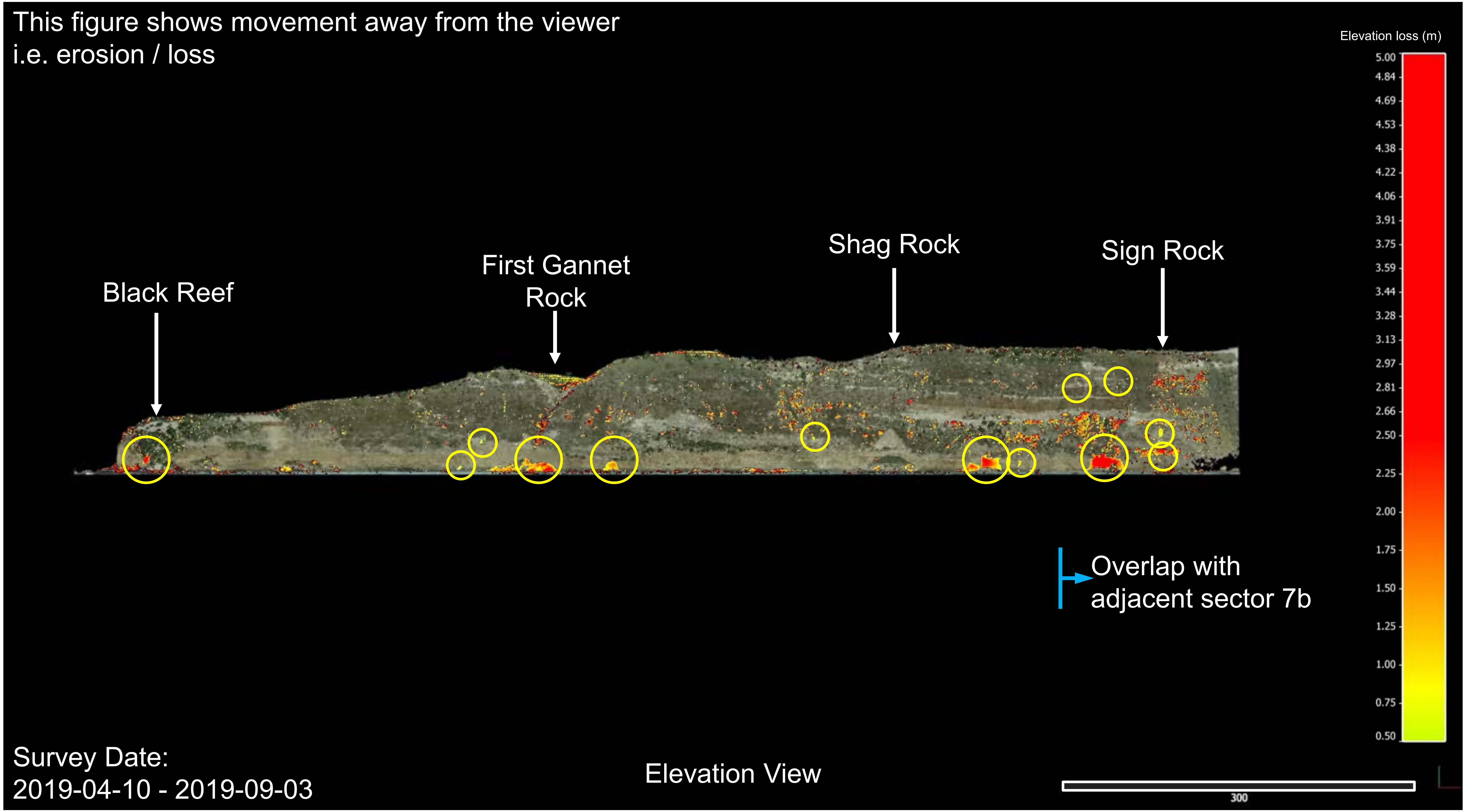

HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 8

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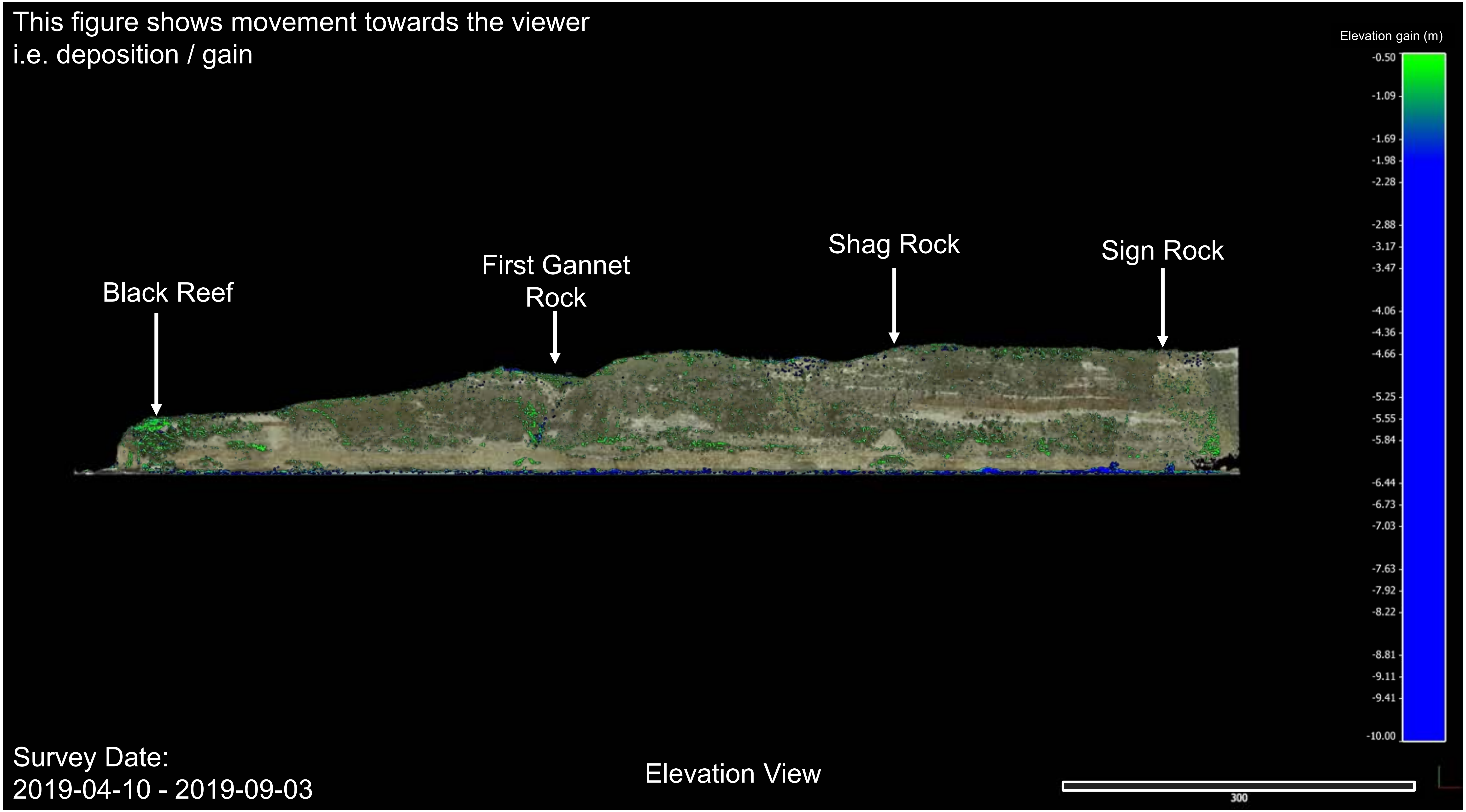

HASTINGS
DISTRICT COUNCIL

Clifton Beach – Sector 8

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Clifton Beach – Sector 9a

Clifton Beach – Sector 9a

The Surveying Company
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HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 9a

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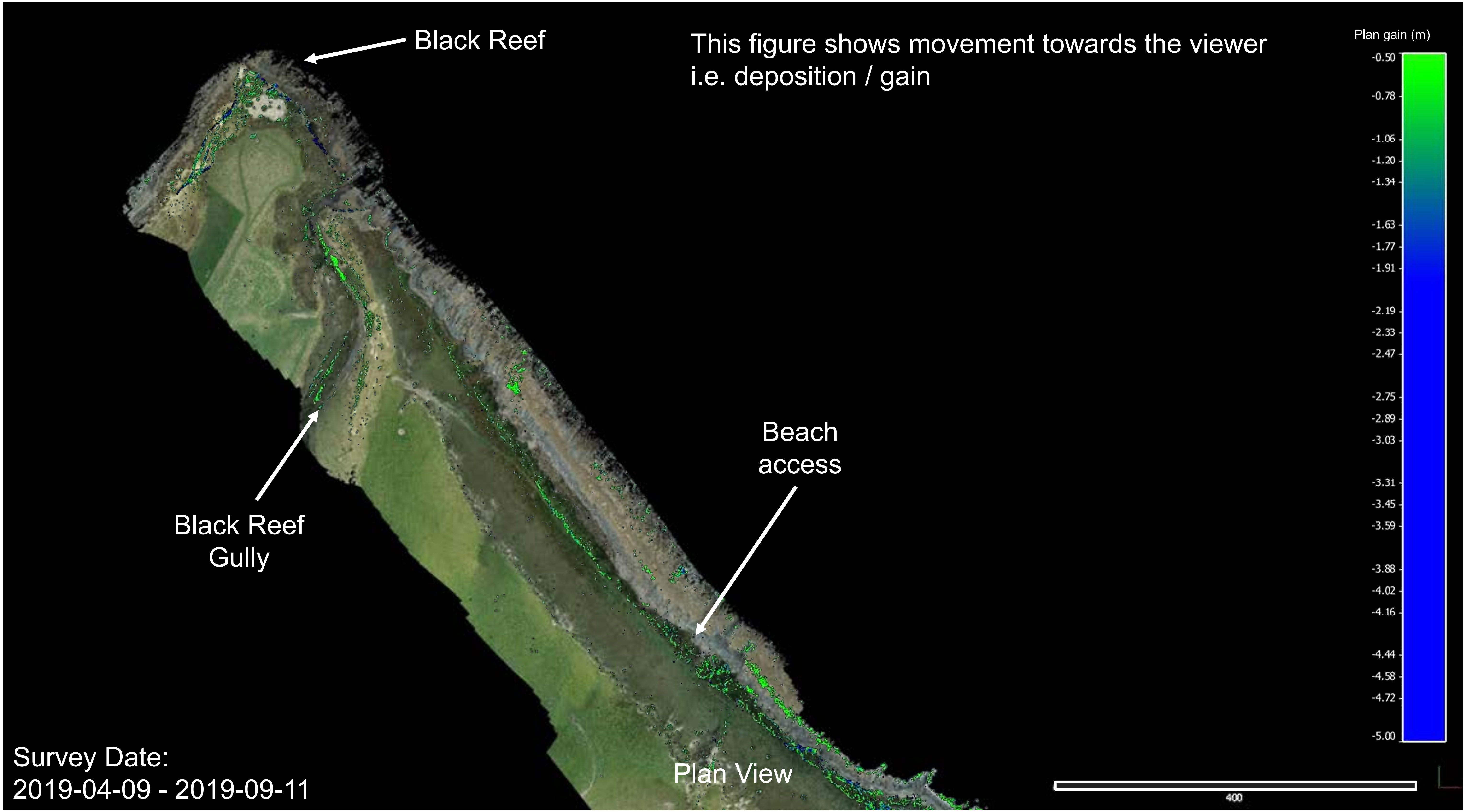
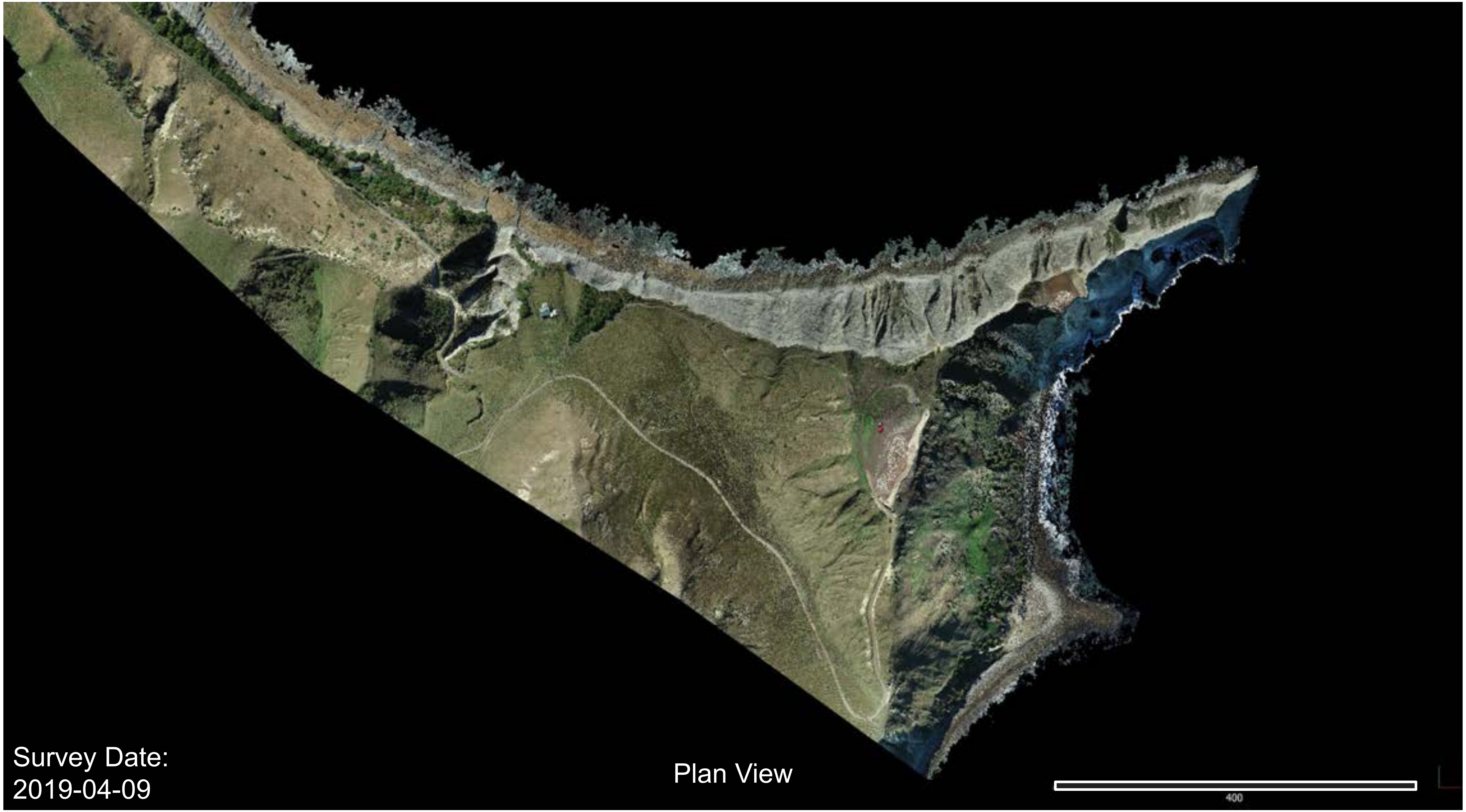


Clifton Beach – Sector 9a



Clifton Beach – Sector 9b

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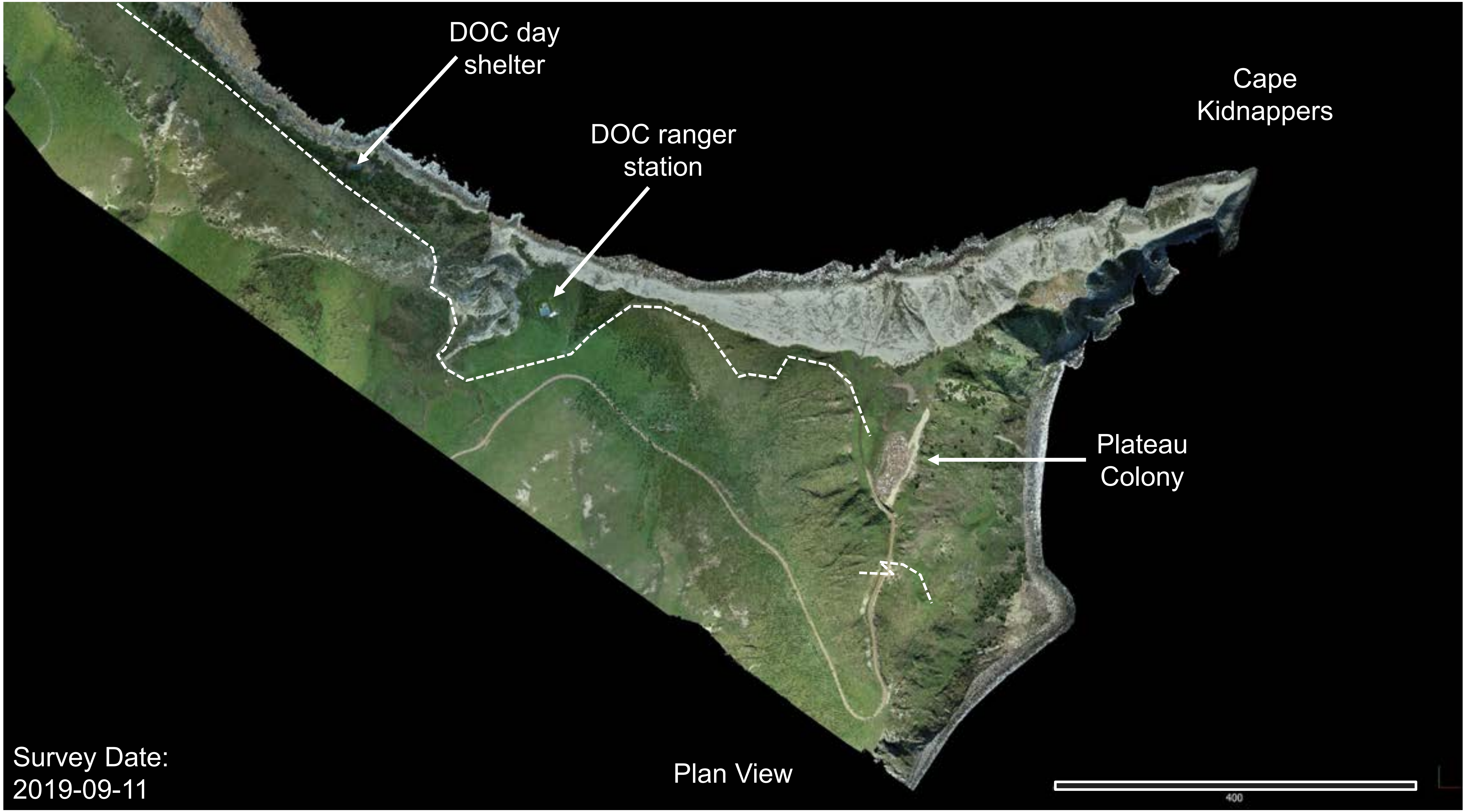

HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 9b

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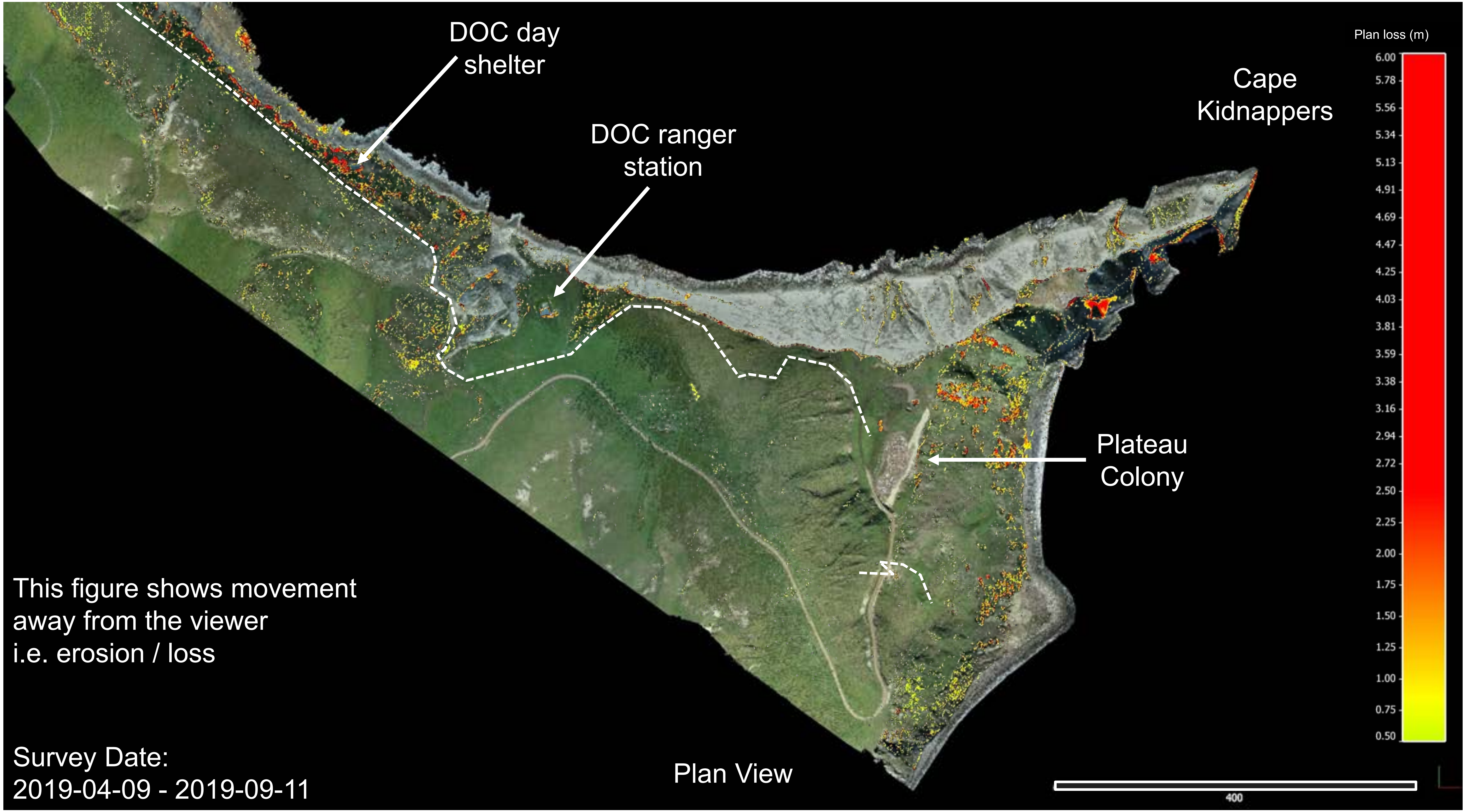

Clifton Beach – Sector 9b

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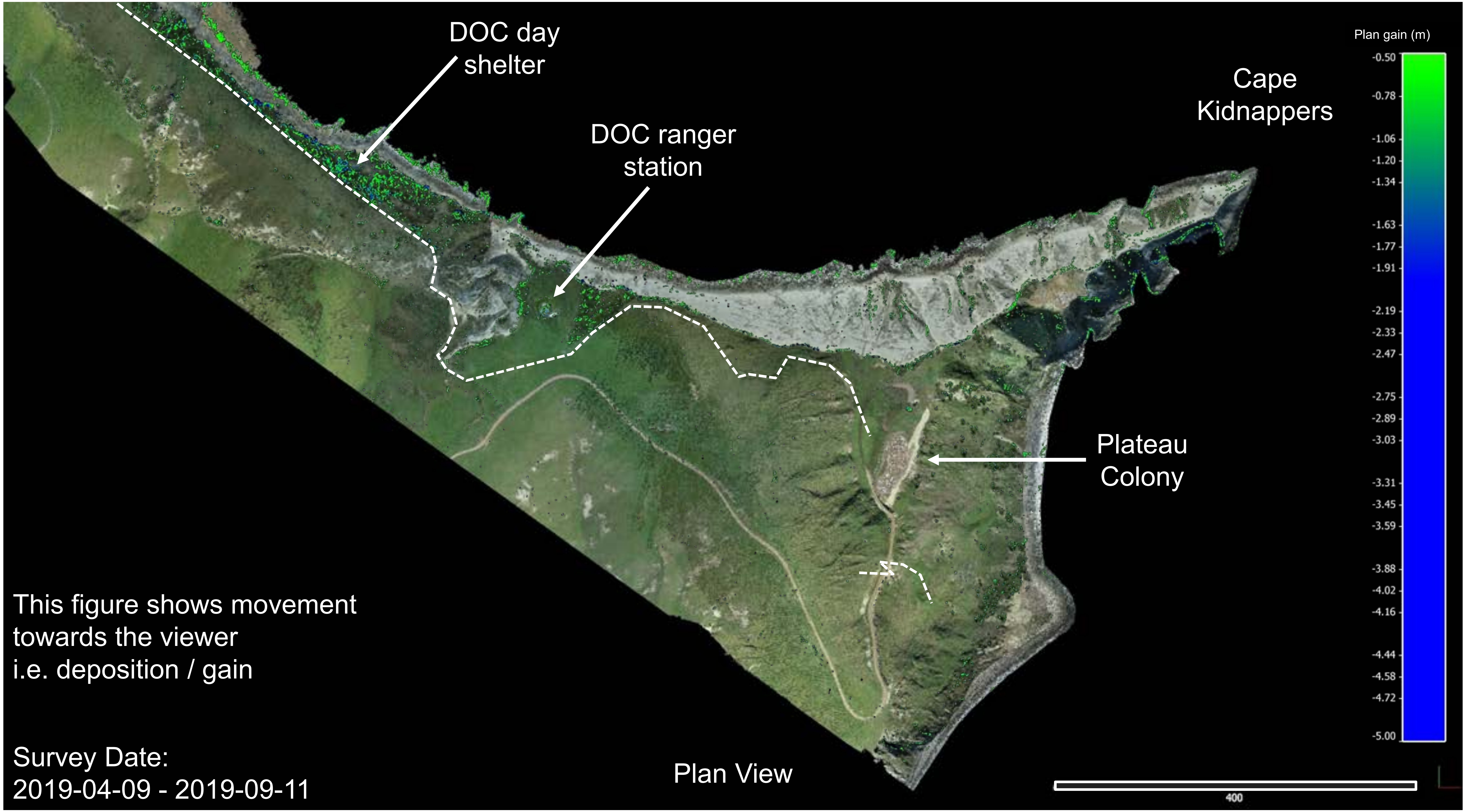
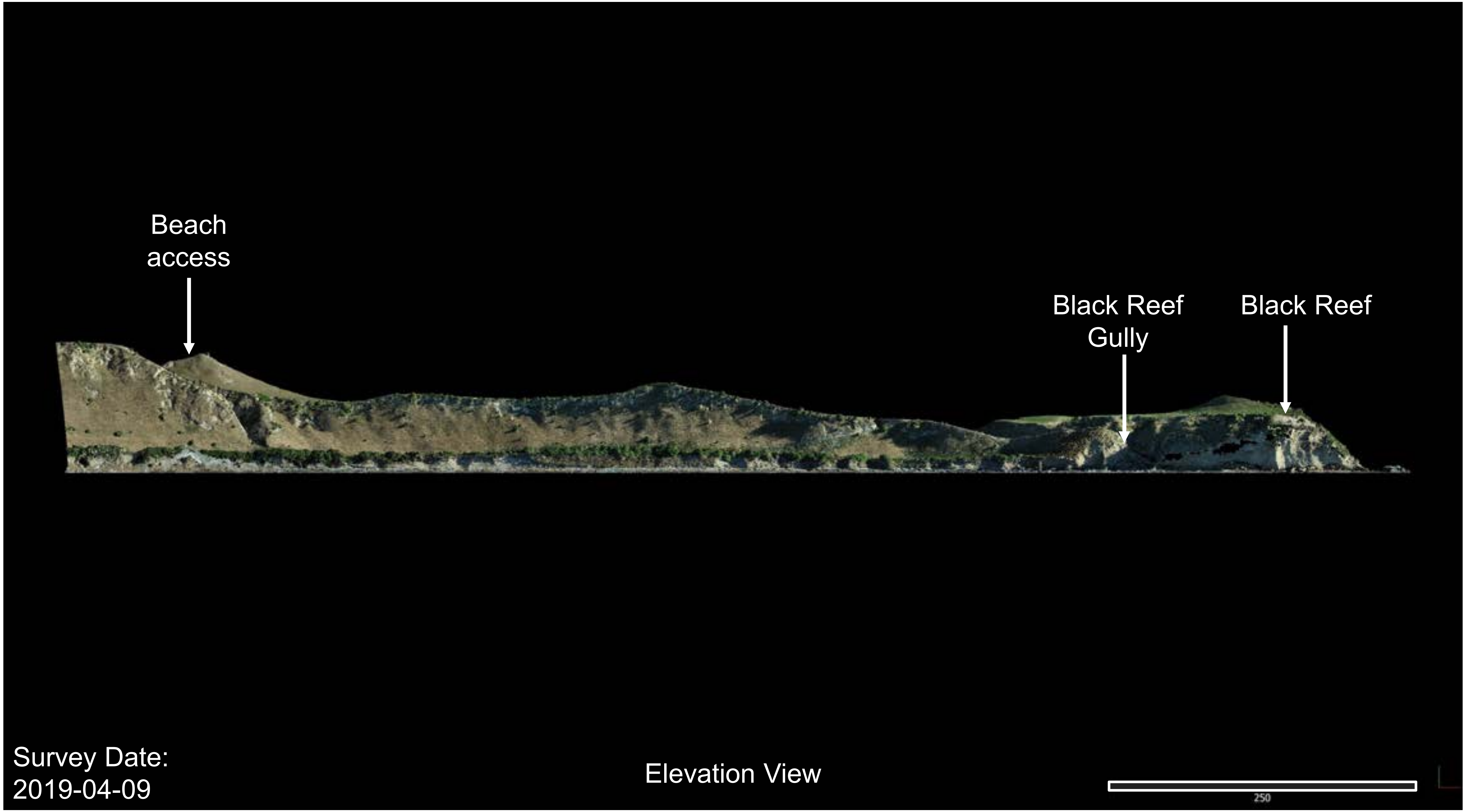


Clifton Beach – Sector 9b



Clifton Beach – Sector 9a

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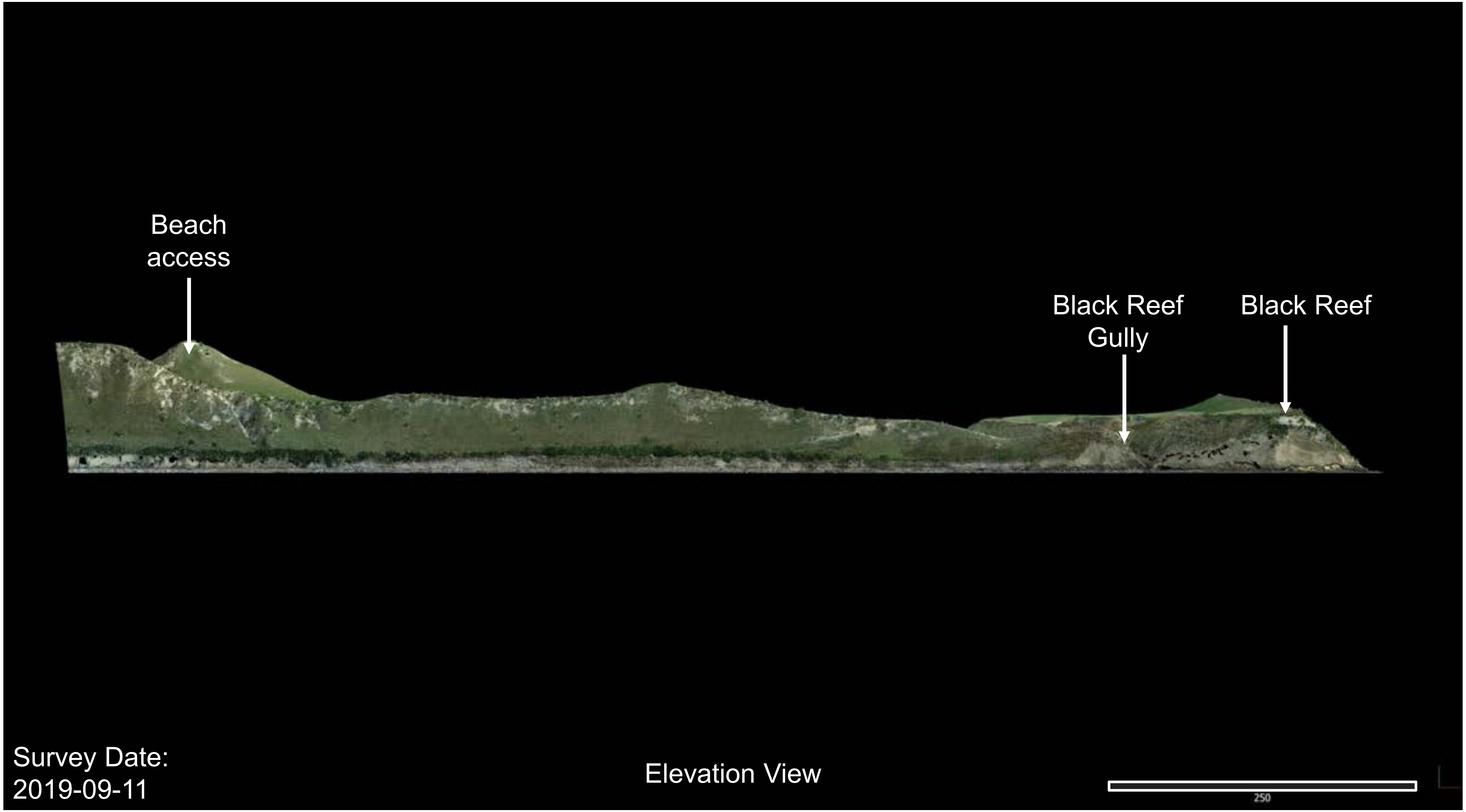

HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 9a

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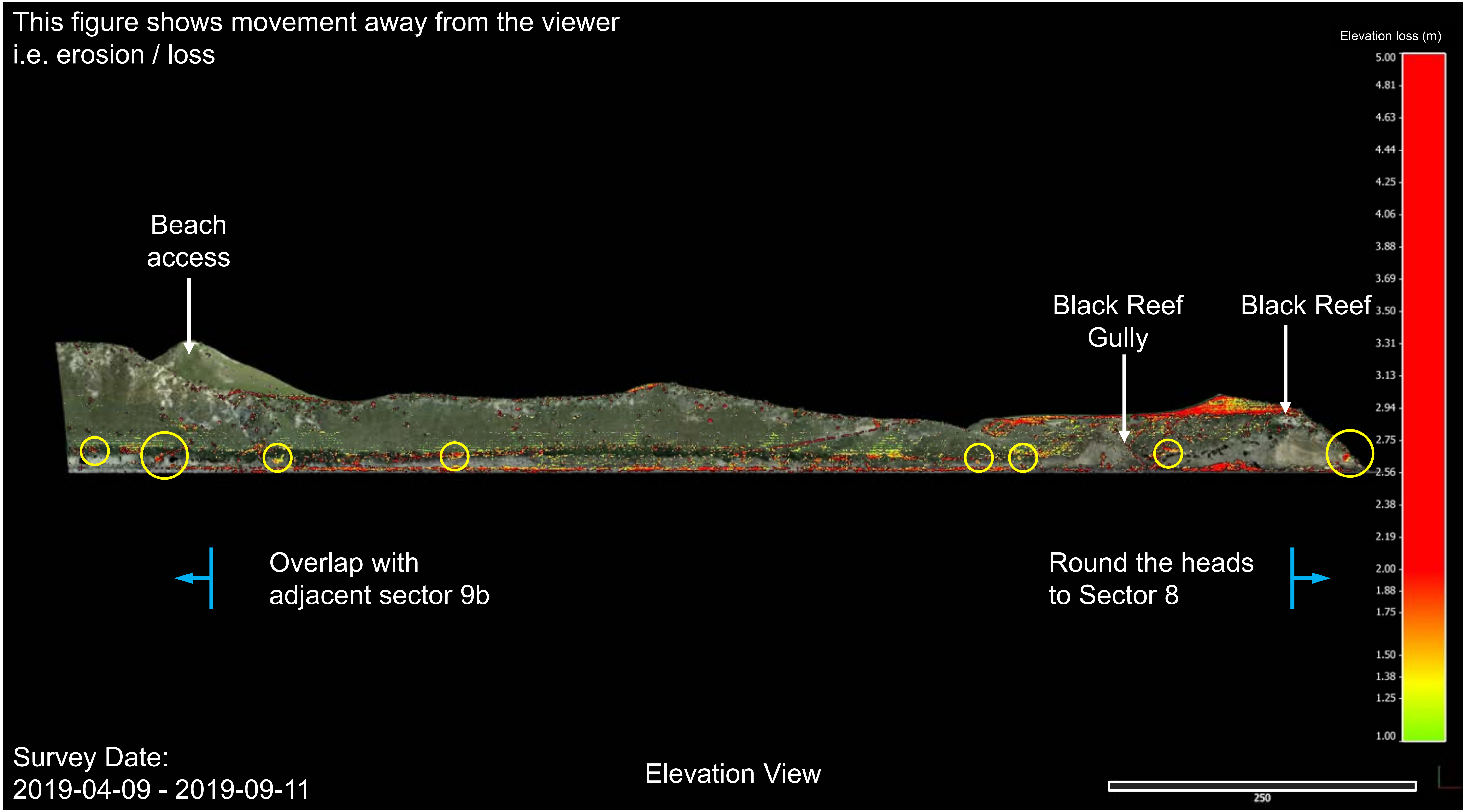
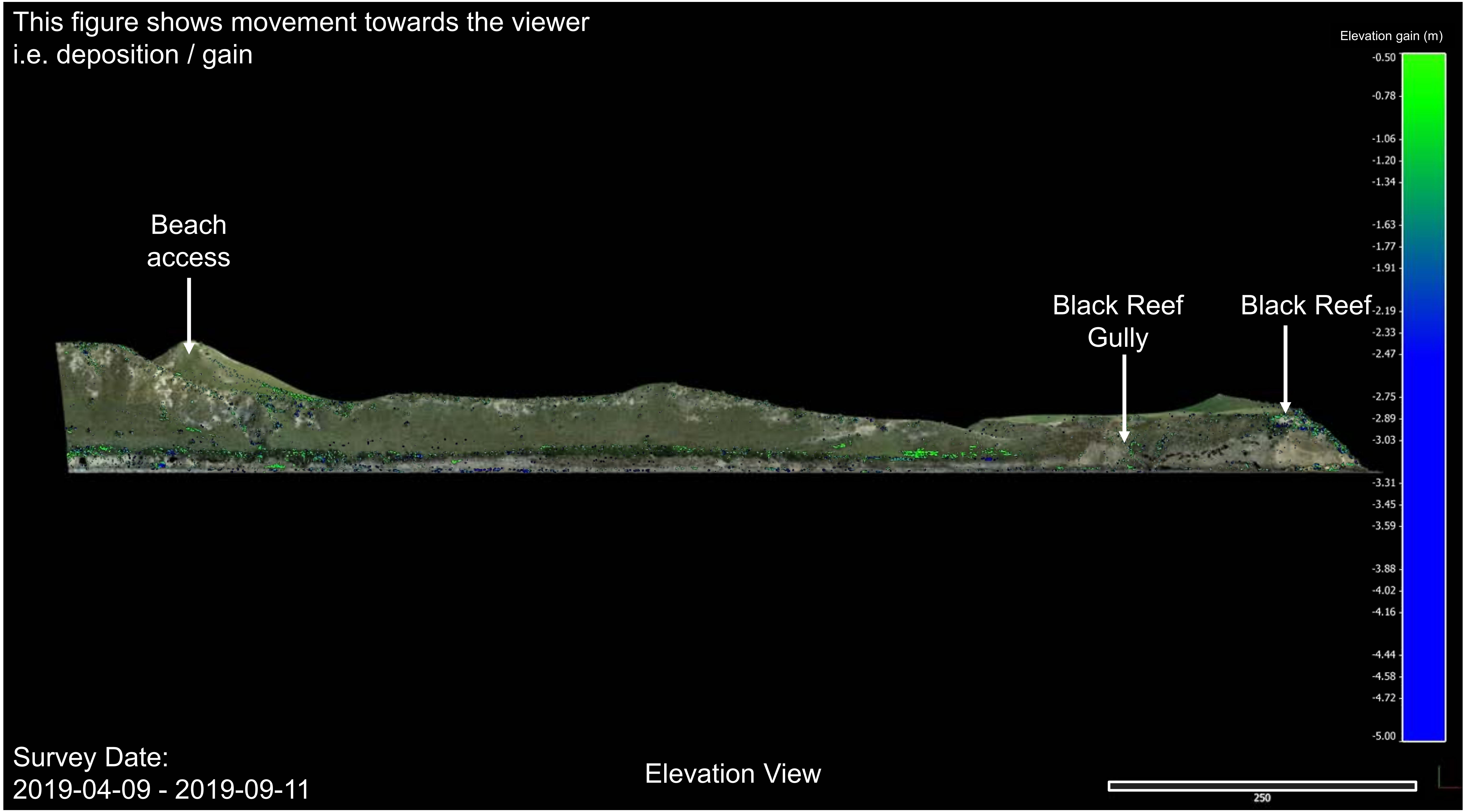
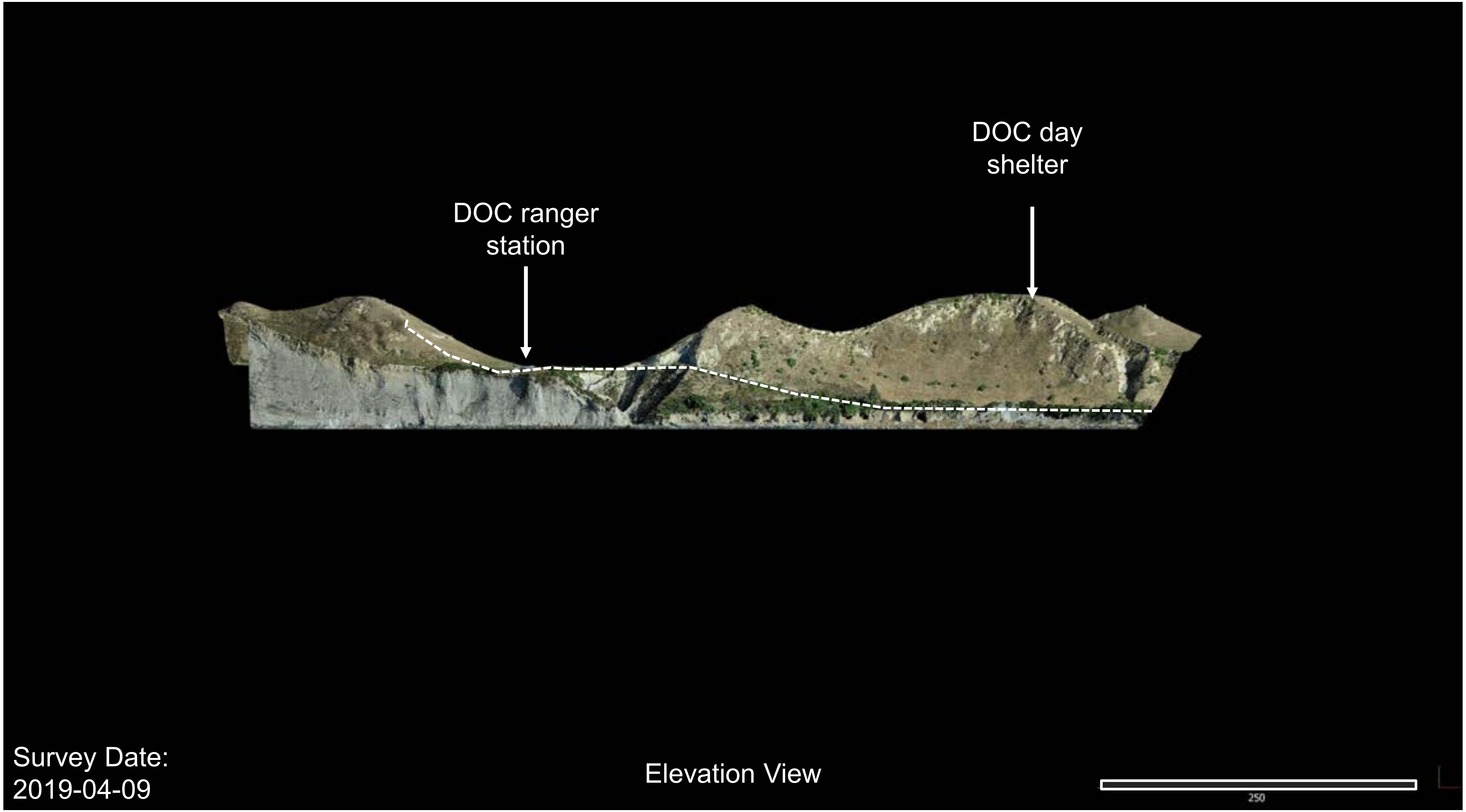


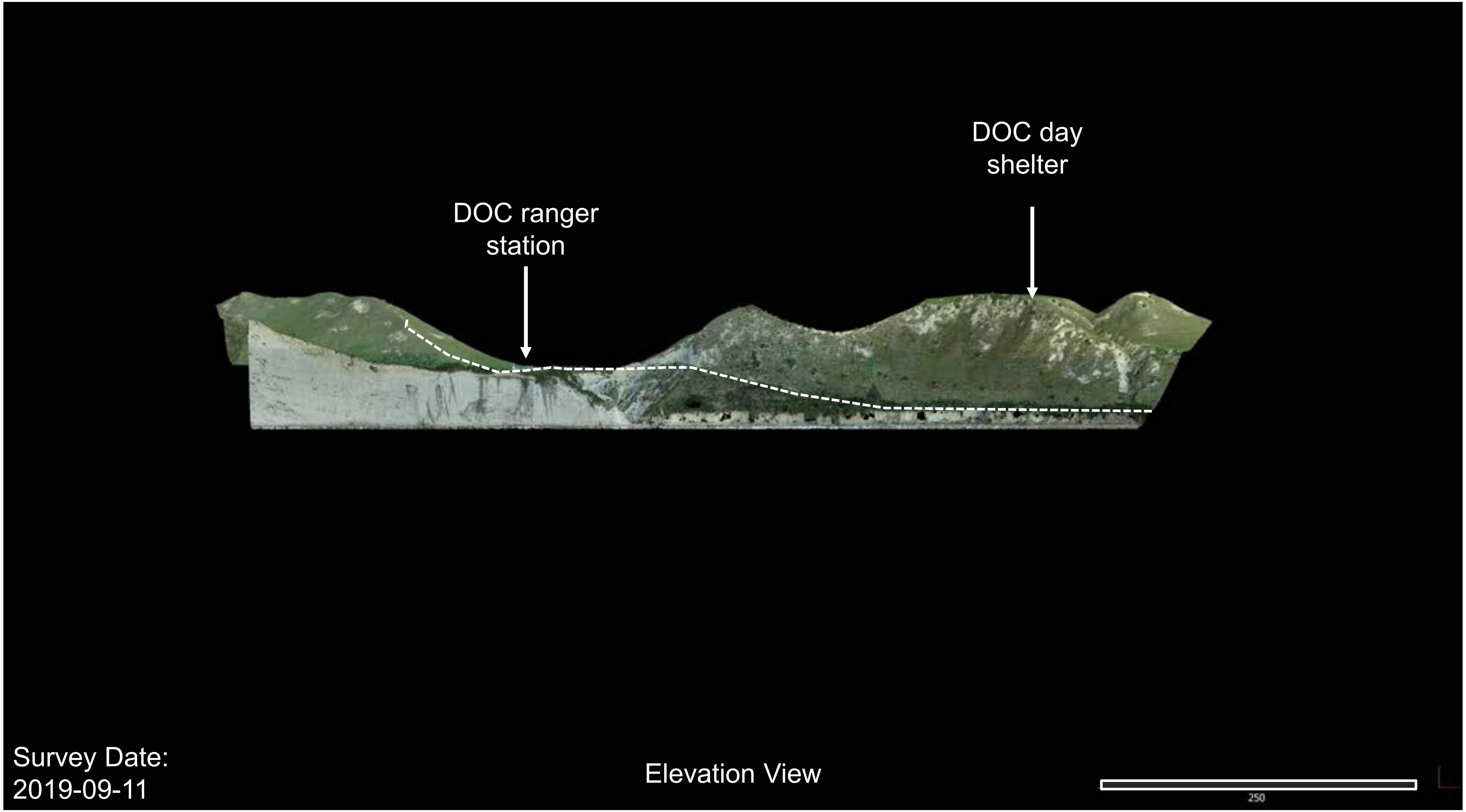
Clifton Beach – Sector 9a



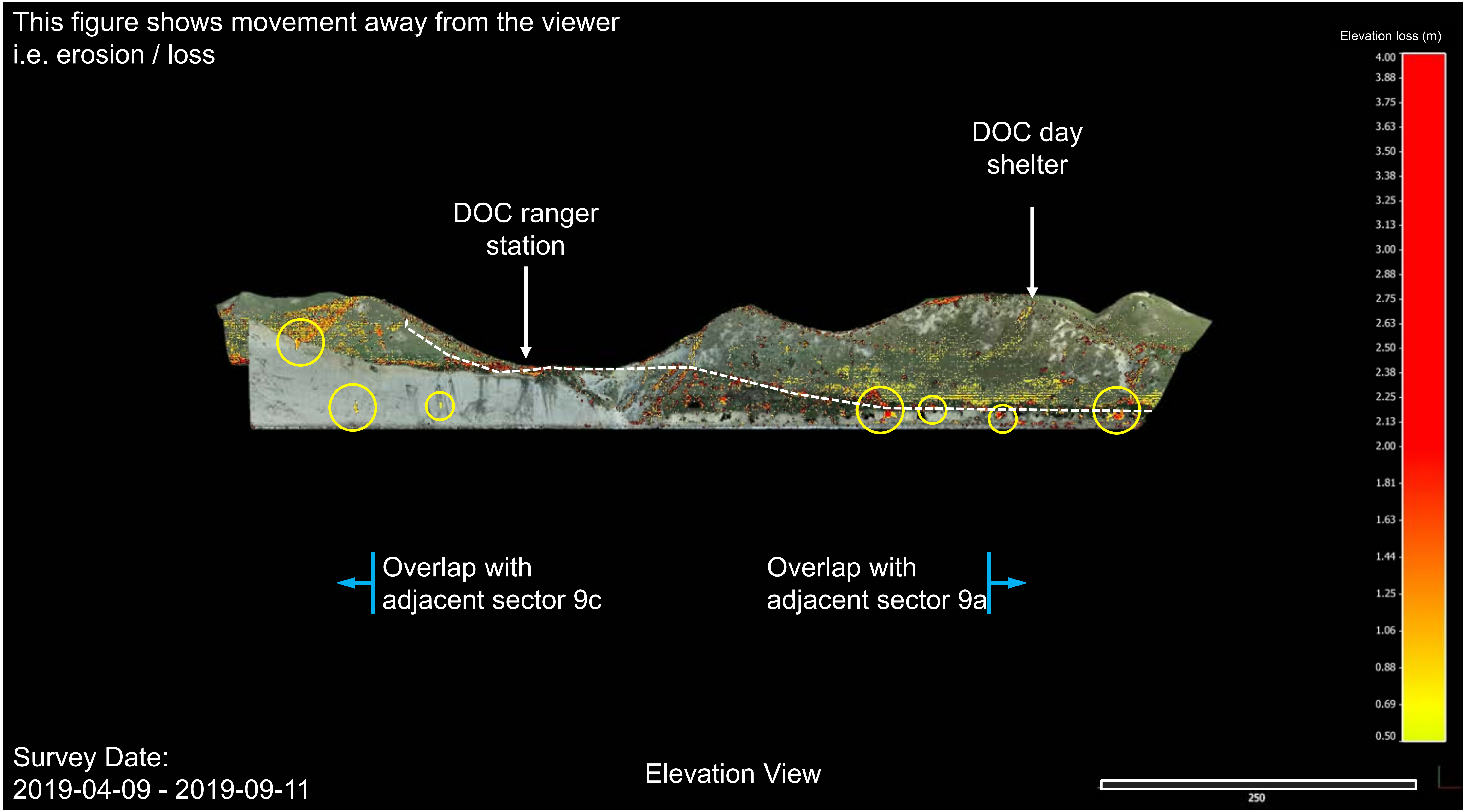
Clifton Beach – Sector 9a



Clifton Beach – Sector 9b



Clifton Beach – Sector 9b



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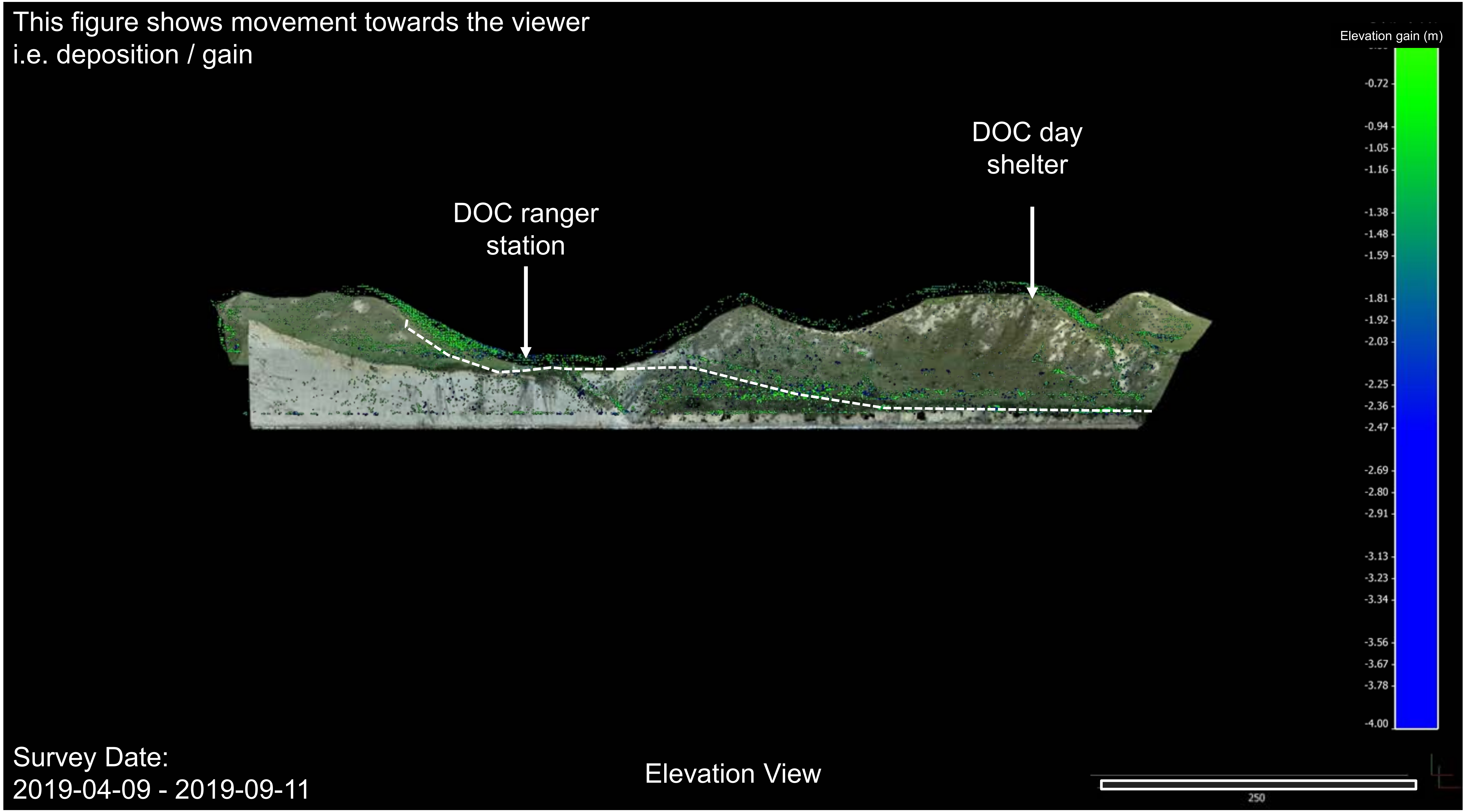

Clifton Beach – Sector 9b

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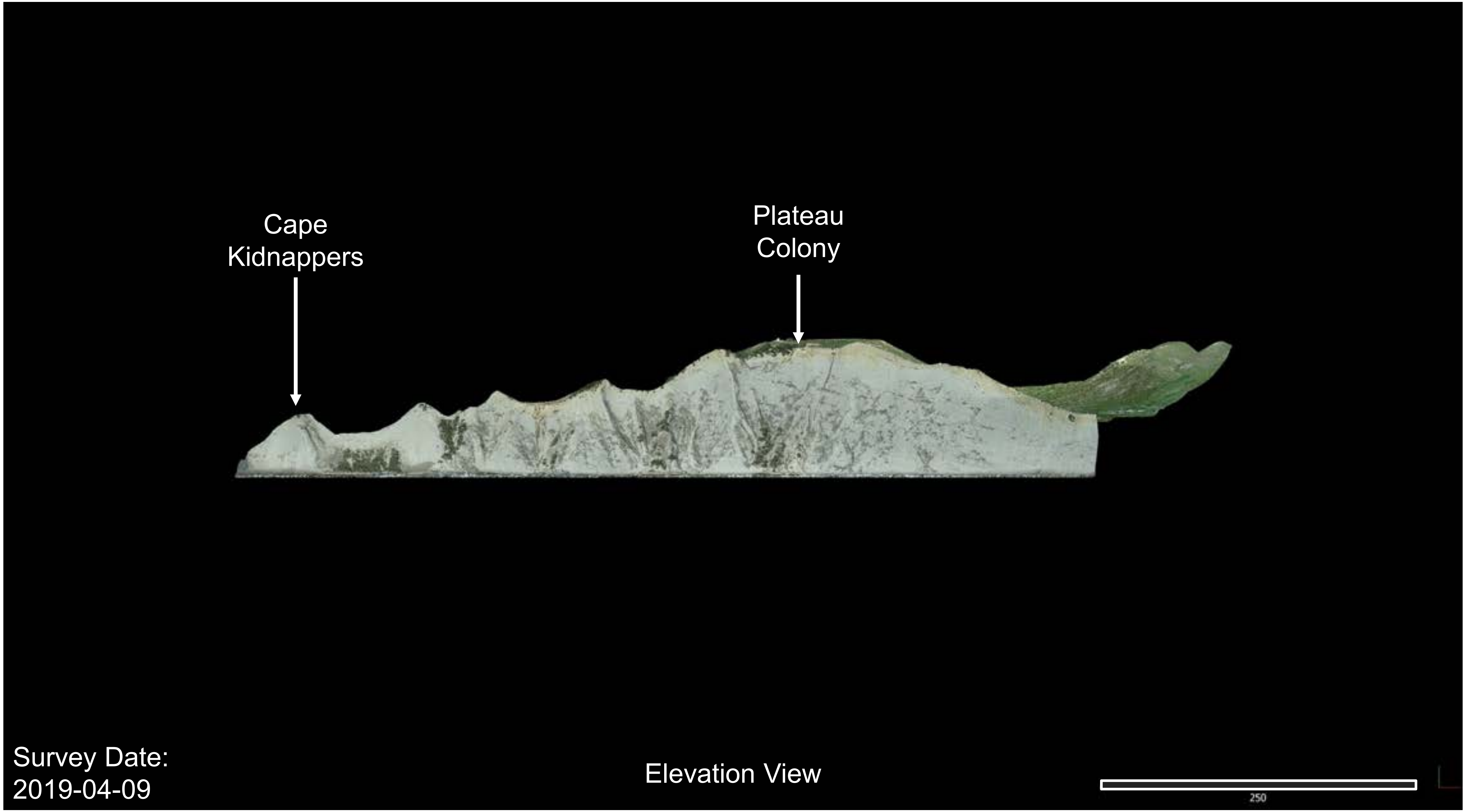
Your Subdivision Professionals



Hastings District Council

Clifton Beach – Sector 9c

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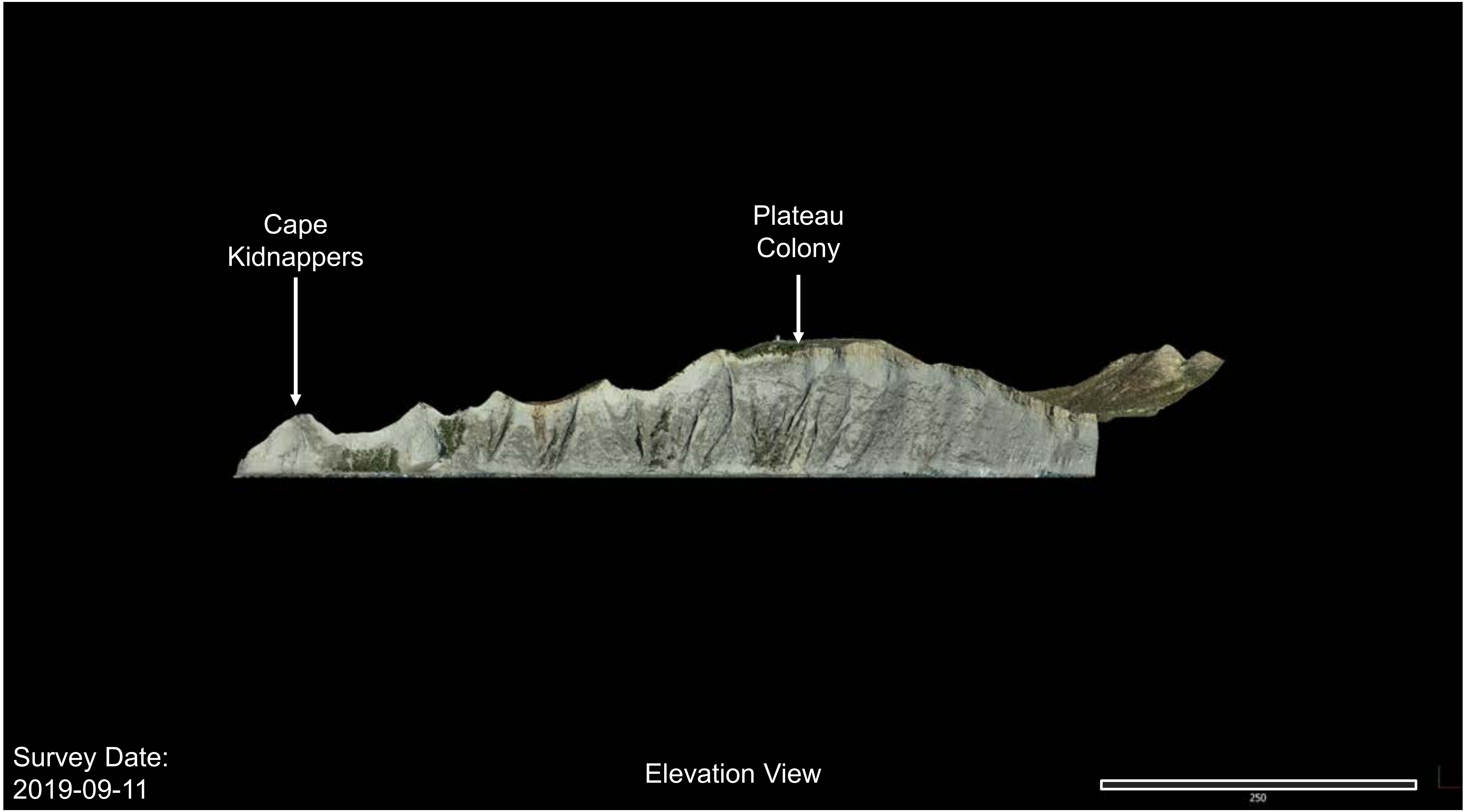

HASTINGS
DISTRICT COUNCIL

Clifton Beach – Sector 9c

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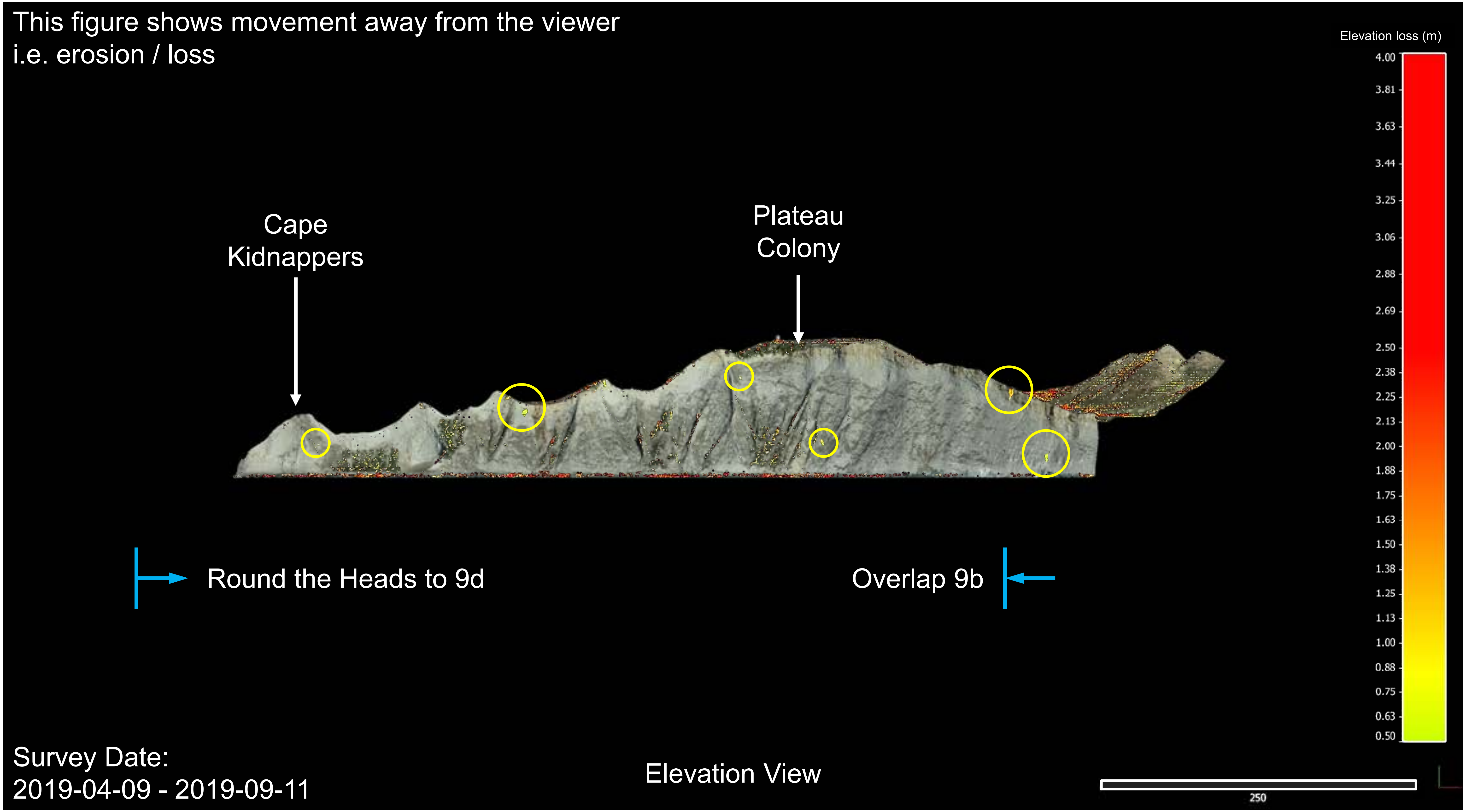

HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 9c

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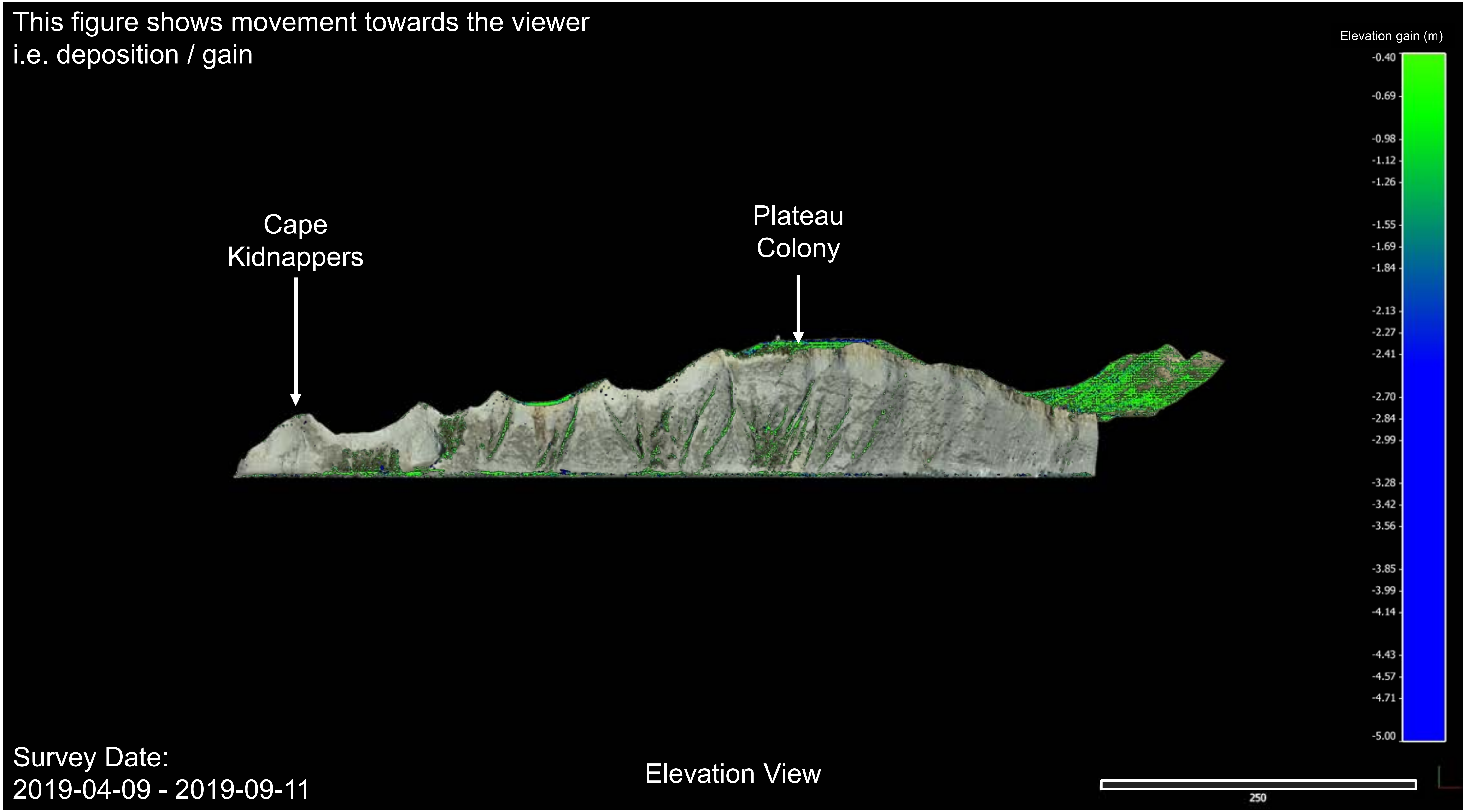
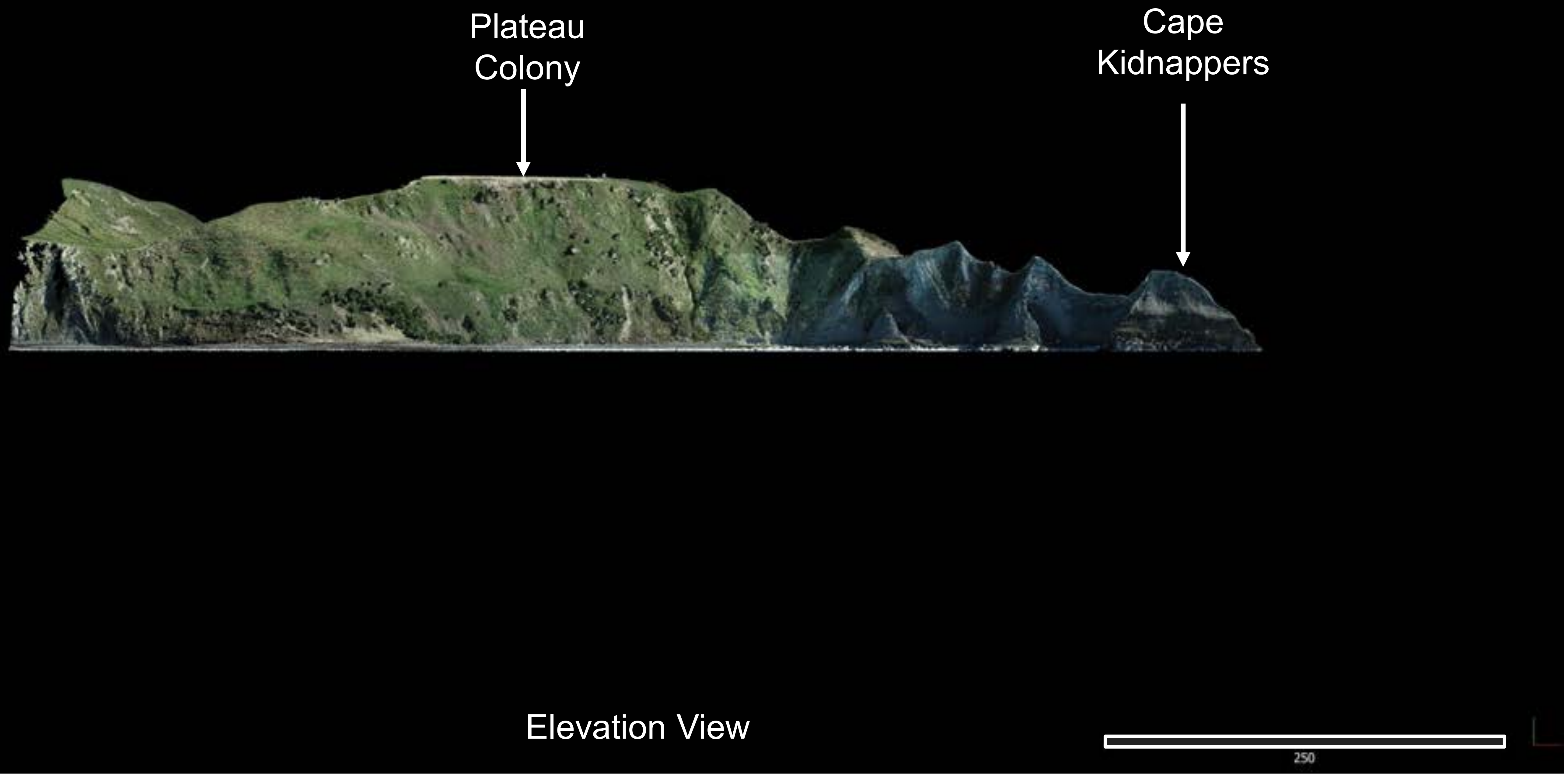


Clifton Beach – Sector 9c



Survey Date:
2019-04-09

Elevation View

Clifton Beach – Sector 9d

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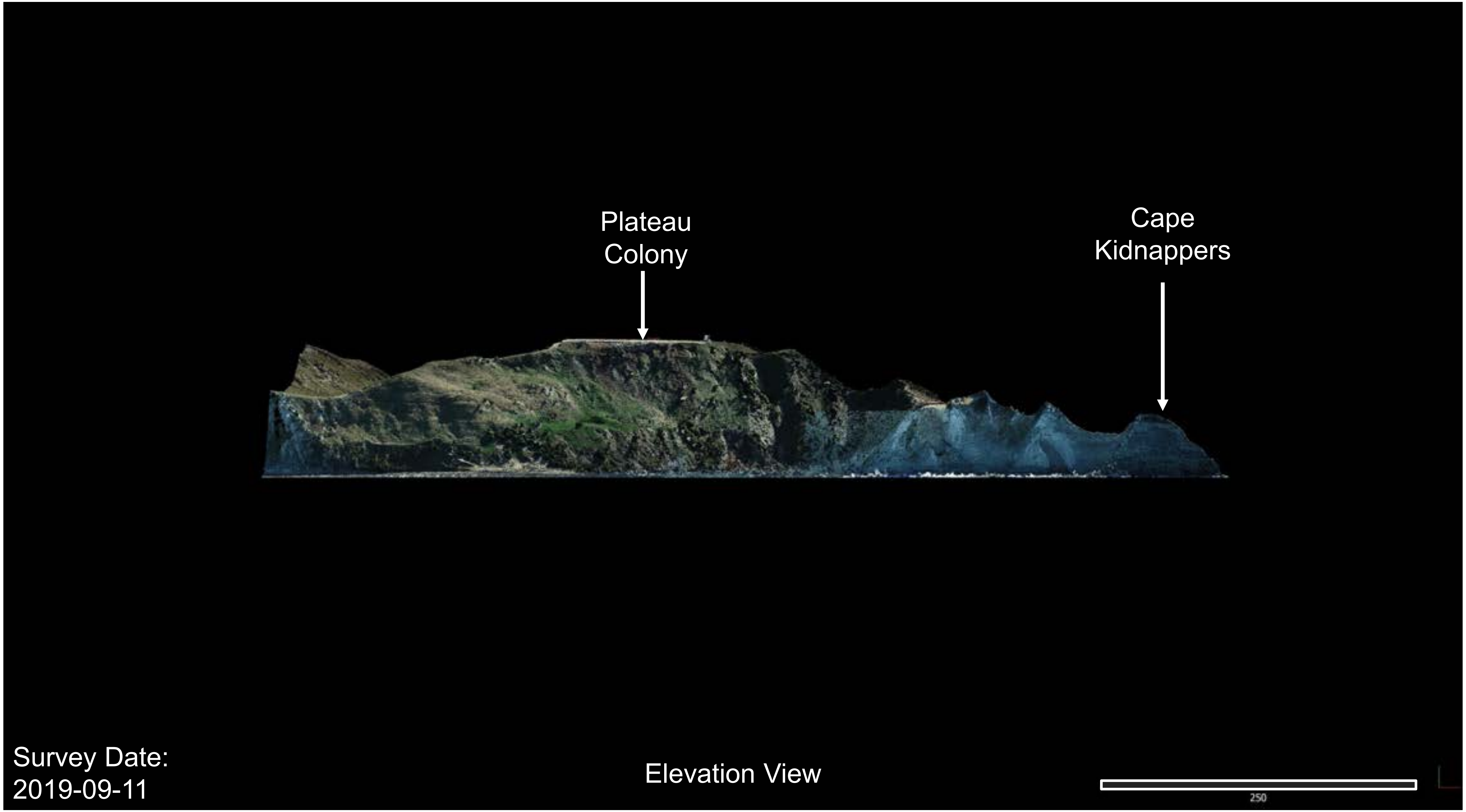
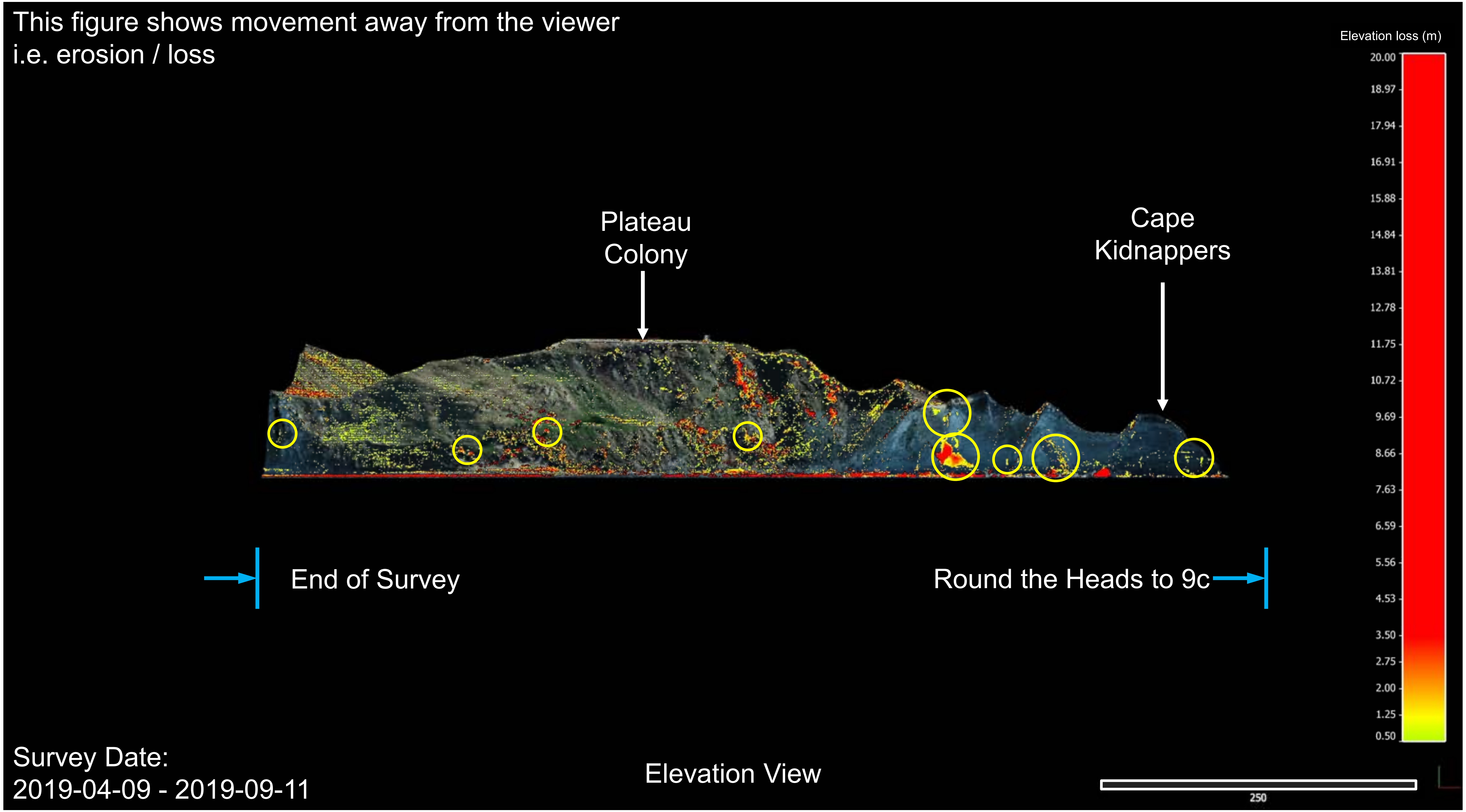


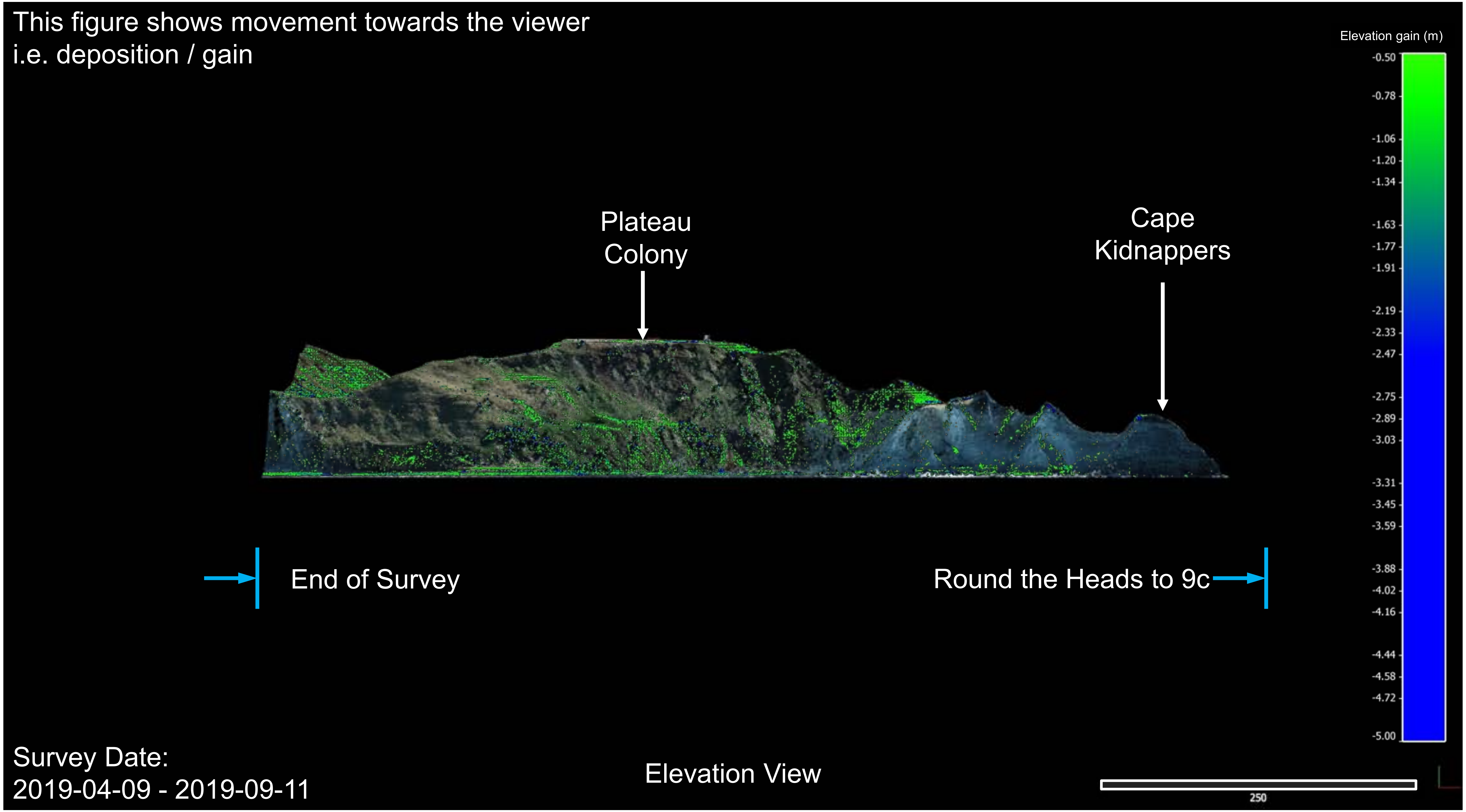
HASTINGS DISTRICT COUNCIL

Clifton Beach – Sector 9d

Stantec



Clifton Beach – Sector 9d



Clifton Beach – Sector 9d

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