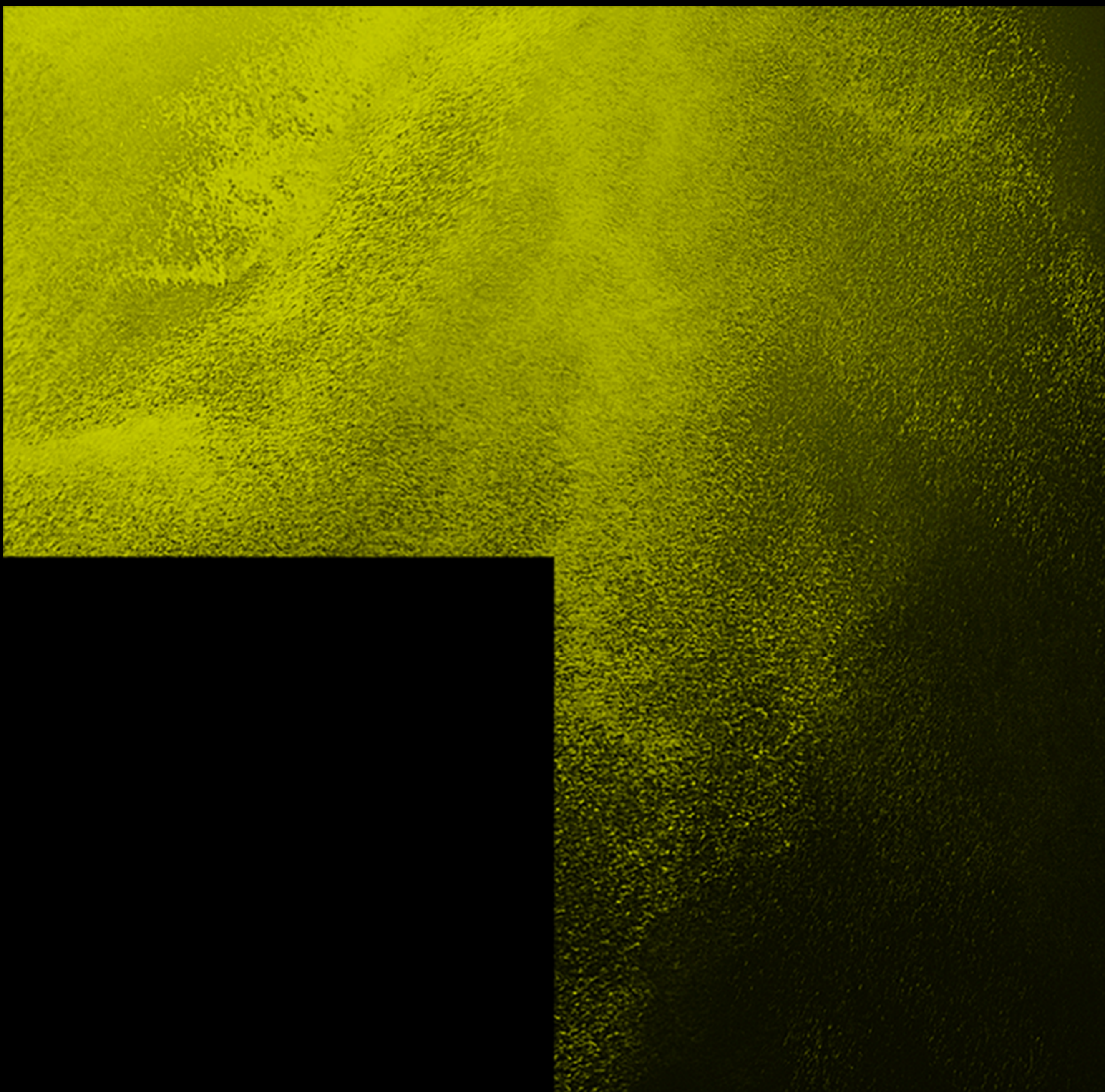
BEACHLANDS SOUTH



DOCUMENT CONTROL RECORD

CLIENT	Beachlands South Limited Partnership
PROJECT	Beachlands South
HG PROJECT NO.	A2001228.00
HG DOCUMENT NO.	
DOCUMENT	Beachlands South ESCP Report

ISSUE AND REVISION RECORD

DATE OF ISSUE	21 December 2021
STATUS	Final
ORIGINATOR	Campbell McGregor
REVIEWED	Daniel Scott
APPROVED FOR ISSUE	Campbell McGregor
OFFICE OF ORIGIN	Auckland
TELEPHONE	+64 9 917 5000
EMAIL	

CONTENTS

1.0 EXECUTIVE SUMMARY

This report has been prepared by Harrison Grierson Consultants Limited on behalf of Beachlands South Limited Partnership (BSLP) in support of a structure plan and private plan change application. The structure plan area covers approximately 307 hectares and is informally referred to in this report as “Beachlands South”. The addresses of the properties owned by BSLP are 110 Jack Lachlan Drive, 620 Whitford Maraetai Road, and 712 Whitford Maraetai Road. The BSLP landholding is approximately 254ha of the total 307ha plan change area.

The plan change will establish an urban pattern of land use, transport, and infrastructure etc. which will require modification to the existing landform through bulk earthworks activities. These bulk earthworks activities will require an overall earthworks framework and management strategy to avoid and minimise sediment discharge effects on the environment.

FIGURE 1: ILLUSTRATIVE MASTERPLAN

This report sets out the overall framework and strategy for erosion and sediment controls in support of this application to rezone the land enabling opportunities for urban development.

The general principle is to ensure earthworks will be undertaken in a manner to minimise sediment runoff into the receiving environments. Earthworks will be undertaken in stages to prevent a large area being left open at any one time, which can increase the chances of sediment runoff. Earthworks will also be conducted in a manner that applies best practice mitigation and control strategies as a minimum standard.

To mitigate the adverse effects of the earthwork activities, we have recommended wherever possible the implementation of Sediment Retention Ponds, given their effectiveness at removing sediment runoff, especially when combined with chemical treatment to assist with sediment particle coagulation. Both Gleams modelling and Universal Soil Loss Equation calculations have been provided, to assess the quantum of sediment discharge that may potentially occur from the earthwork activities in any given earthworks season. This information has then been used by Tonkin and Taylor (Water Quality and Sediment Modelling of the Whitford Embayment) to assess the deposition of sediment within the receiving environments.

Rather than solely rely on the suggested design performance from these calculations and the resulting sediment discharge, we have also provided analysis of stormwater runoff flows from the site utilising historic rainfall data. This approach has led us to modifying the maximum catchment and relative pond size criteria to provide a greater level of stormwater capture within active catchments, thereby reducing the likely volume of sediment discharge from the development.

Ponds are recommended to be sized for 3.75% of the catchment area with a maximum contributing catchment of 4ha, as opposed to 2 or 3% and 5ha catchments as prescribed by GD05. Increasing the size of the pond relative to the exposed catchment means statistically on average only 5.3 storm events would exceed the dead storage of the pond and 0.95 events exceed the pond live storage (assuming the pond is empty) in any earthworks season.

While the sediment discharge and the level of deposition has been quantified under GD05 conditions, we consider the increase in storage volume within each pond provides a level of further protection against sediment discharge given the larger quantum of rainfall that will be captured and treated prior to discharge. Utilising this approach in combination with other best practice strategies such as catchment stabilisation, minimising exposed catchment areas, and works staging, we consider the adverse impacts of the earthworks' activities during construction on the receiving environment can be mitigated.

In addition to the outlined controls, we have recommended a testing and monitoring regime to confirm the assumed performance of the erosion and sediment control devices, but also ensure the efficacy of devices is maintained through regular monitoring.

In conclusion we consider the measures and methods outlined in the report provide a suitable framework under which earthworks activities can be undertaken, which can be further developed as part of future individual consenting processes. The measures are both practical and achievable in the management of the earthworks activities and in our opinion are appropriate should the plan change be granted.

2.0 INTRODUCTION

2.1 PROJECT OVERVIEW

This report has been prepared by Harrison Grierson Consultants Limited on behalf of Beachlands South Limited Partnership (BSLP) in support of a structure plan and private plan change application. The plan change area covers approximately 307 hectares and is informally referred to in this report as "Beachlands South". The addresses of the properties owned by BSLP are 110 Jack Lachlan Drive, 620 Whitford Maraetai Road and 712 Whitford Maraetai Road. The BSLP landholding is approximately 254ha of the total 307ha plan change area.

All other properties included in the structure plan and plan change are not in the applicant's ownership but include 680 – 702 Whitford Maraetai Road and 722 – 770 Whitford Maraetai Road.

The purpose of this report is to outline an overall management framework and strategy for erosion and sediment control consistent with best practice, to achieve the overarching objective to avoid and minimise the effects during construction of sediment generation and sedimentation on sensitive receiving environments at Beachlands South.

It is intended that this report will inform the development of an Erosion and Sediment Control Management Plan (ESCMP) or plans associated with any future resource consents in the plan change area following rezoning.

2.2 PROJECT DESCRIPTION

This report is intended to support the structure plan and plan change for rezoning, which will enable opportunities for urban development in the future. The plan change will establish an urban pattern of land use, transport and infrastructure etc. which will require modification to the existing land form through bulk earthworks activities.

These bulk earthworks activities will require an overall earthworks framework and management strategy to avoid and minimise sediment discharge effects on the environment.

The plan change will allow for the construction of a mixture of residential housing typologies, schools, employment areas, a village centre, community facilities and social areas such as parks, playing fields, walkways, and cycleways.

2.3 SCOPE OF THE REPORT

This report sets out the overall framework and strategy for erosion and sediment controls in support of this application to rezone the land enabling opportunities for urban development. The report focuses on the construction phase of the project, this being the greatest potential source for erosion and the highest source of sedimentation loads. The report also provides guidance for the controls and their design with reference to the Auckland Council Guidance Document 05, for Land Disturbing Activities in the Auckland Region (GD05). The report should be read in conjunction with the erosion and sediment control plans (Appendix 1) and the erosion and sediment control calculations (Appendix 2).

This report has also been prepared in coordination and consultation with NIWA, who have completed sediment discharge modelling and Tonkin & Taylor (T&T), who have completed modelling of sediment deposition within the Whitford Embayment.

2.4 SITE DESCRIPTION

The site at 110 Jack Lachlan Drive and 620 Whitford-Maraetai Road, Beachlands (refer to Figure 1) make up a substantial portion of the plan change area. The site at 110 Jack Lachlan Drive is currently referred to as the Rydges Formosa Golf Resort. The site is also located near the Pine Harbour Marina, as well as existing residential developments to the North.

The total plan change area is approximately 307ha. The other properties within the plan change area are rural blocks with single residential dwellings. The topography varies, but generally falls gently towards the coastal edge before dropping steeply to the coastal marine area. Several water tributaries flow from the site with all surface water flowing to these tributaries or directly to the coastline itself (refer to figure 2). The existing site topography typically has slopes of 1-4%, with the elevations ranging from RL71 to RL15.

The presence of these streams within the structure plan and plan change area and the site locality immediately adjacent to an ecologically significant coastal marine area, is such that a robust management framework for earthworks is required to ensure that adverse effects on the environment arising from urbanisation of the land is avoided or minimised.

2.5 DEVELOPMENT STAGING

While the framework and strategy for erosion and sediment controls is applicable across any stage of development, what is proposed for this plan change is a live zone area in the north of the site and Future Urban Zone (FUZ) in the southern portion of the site. This is illustrated in Figure 2 below.

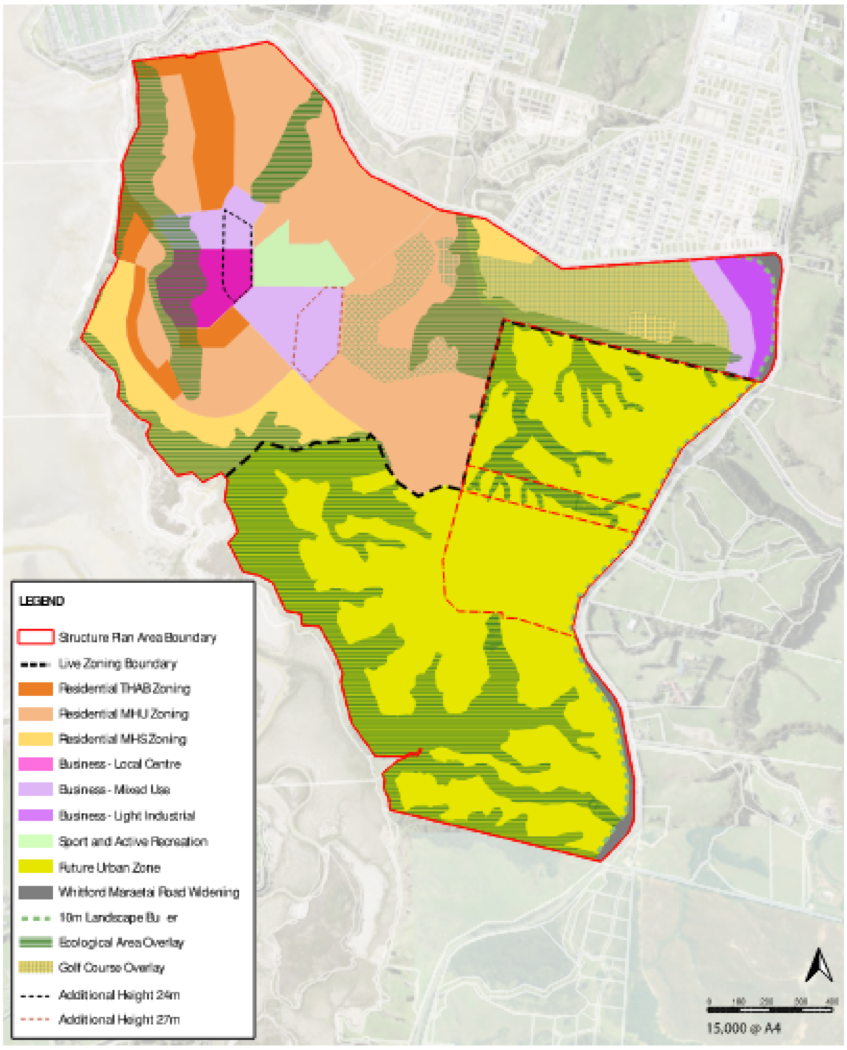


FIGURE 2: PLAN CHANGE ZONING (EXTRACT FROM GOOGLE MAPS, 2021)

FIGURE 3: EXTENT OF PLAN CHANGE AREA & BOUNDARY (EXTRACT FROM GOOGLE MAPS, 2021)

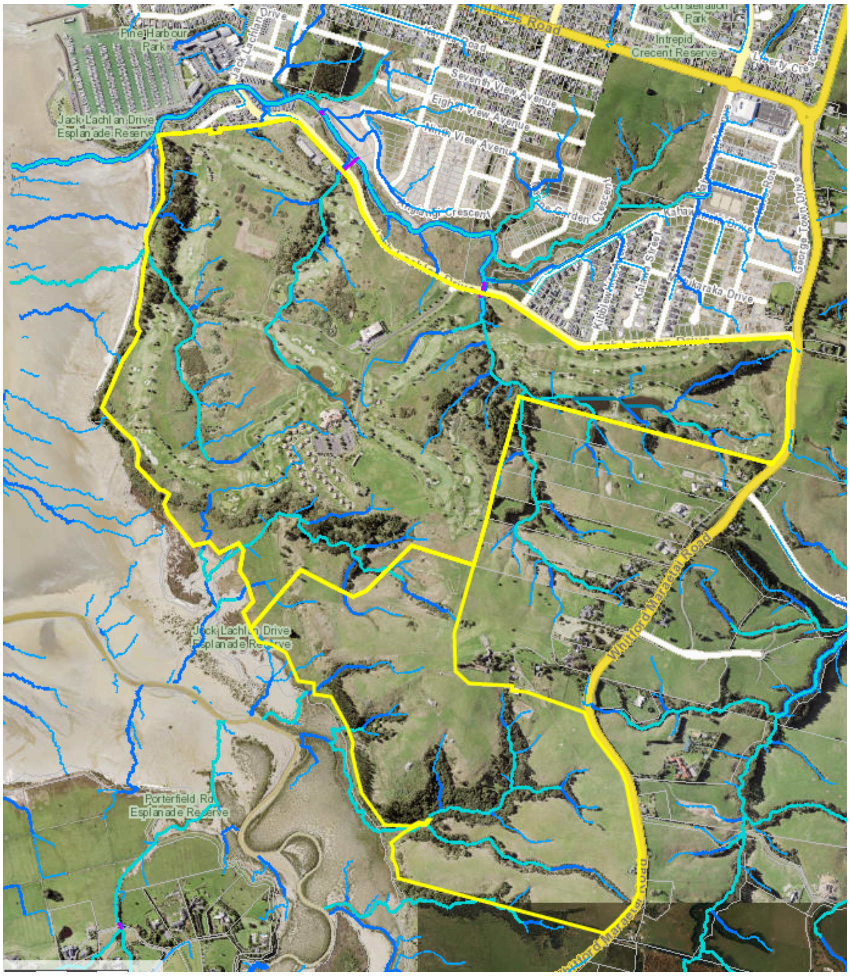


FIGURE 4: EXISTING SITE FLOW PATHS (EXTRACT FROM AUCKLAND COUNCIL GEOMAPS, 2017)

3.0 EARTHWORKS

Earthworks are required to form road corridors, superlot platforms and stormwater management devices, as well as to allow for the installation of drainage and utilities.

The general principle is to ensure earthworks will be undertaken in a manner to minimise sediment runoff and discharge into the receiving environments. Earthworks will be undertaken in stages to prevent a large area being left open at any one time, which can increase the chances of sediment runoff. Earthworks will be conducted in a manner that applies best practice Auckland Council GD05 (Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Regions) mitigation and control strategies as a minimum standard.

The existing site topography will inherently require modification to repurpose the landform for future urban development. The principles outlined in section 4.0, are to provide confidence that there are suitable and robust management options to minimise sediment discharge to the sensitive downstream receiving environments.

3.1 EXISTING CATCHMENTS

There are five (5) catchment areas and discharge locations (A to E), that cover the plan change area. These are illustrated in Figure 3 below and form the basis for the modelling and reporting that has been completed in relation to sediment discharge (NIWA Gleams Modelling) and deposition (T&T Water Quality and Sediment Modelling in the Whitford Embayment).

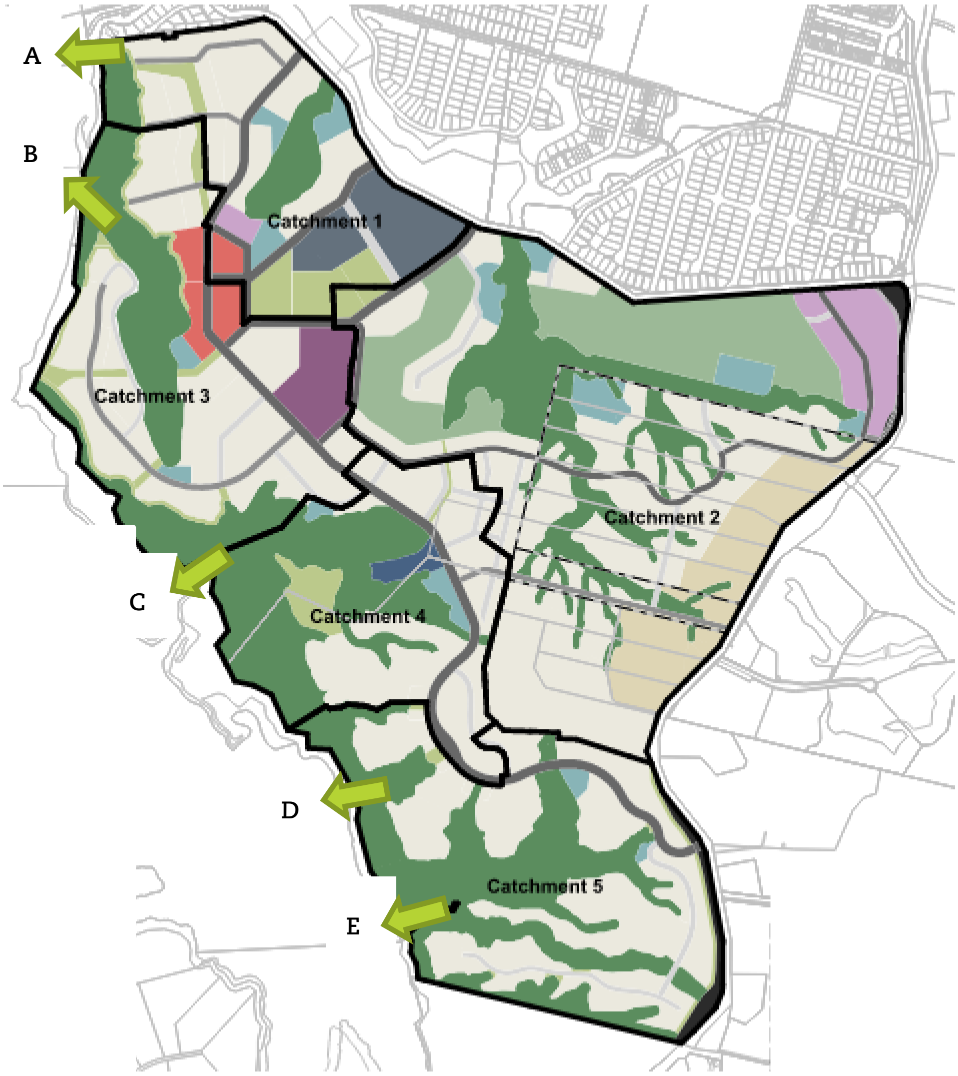


FIGURE 5: PROPOSED PLAN CHANGE AREA AND DISCHARGE LOCATIONS

3.2 EARTHWORK CATCHMENTS

As part of our earthworks assessment, we have developed an indicative Erosion and Sediment Control plan including sub-catchments within these larger catchment areas. For the purposes of this indicative plan, we have focused on the live zone and likely earlier stages of development that will occur.

This ESCP is provided in Appendix 1. This plan has been developed to illustrate the scale of catchment and suggests how the earthworks might be conducted. While some catchments are indicated as larger than 4ha, only 4ha would be disturbed at a time as discussed further in section 4.

4.0 EROSION AND SEDIMENT CONTROL PRINCIPLES

4.1 GD05 PRINCIPLES

Design of sediment retention devices in the Auckland region predominantly relies on the implementation of Auckland Council's GD05 guidelines "Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region. Chapter E11 Land Disturbance - Regional of the Auckland Unitary Plan also refers to best practice in Auckland generally being deemed to be compliance with Auckland Council 'Guidance Document 2016/005 Erosion and Sediment Control Guideline for Land Disturbing Activities (GD05)' or similar design.

This guidance aims to:

- provide an understanding of Erosion Sediment Controls (ESC)
- provide user friendly technical advice on ESC methodologies/ technologies that are current best practice, proven and practical
- provide guidance on how to select and implement ESC practices during design, construction, operation, maintenance, and decommissioning, within the Auckland context.

While for most projects, the design of erosion and sediment controls can rely on the practice guidance provided by GD05, given the sensitivity of the discharge environments for the Beachlands South project we have utilised GD05 as a minimum standard. We have then made our device selection and modified device sizing to achieve a higher performance standard and mitigate the risk of larger sediment discharges.

4.2 BEACHLANDS SOUTH PROJECT PRINCIPLES

The erosion and sediment controls principles recommended to be applied to Beachlands South are as follows:

- Undertake works during the earthworks season, between October and April, where the likelihood of larger rainfall and/or persistent rainfall events is lower.
- Undertake the works over multiple stages to reduce exposed areas.
- Stabilise and reduce exposed catchment areas in advance of significant rainfall events.
- Divert flows from external catchments away from exposed working areas, using clean water diversions.
- Ensure all works are generally in accordance with Auckland Council GD05 requirements as a minimum standard.
- Ensure all site generated runoff is conveyed to primary treatment devices such as Sediment Retention Ponds (SRP) for treatment, which afford the greatest level of sediment capture. Water shall be conveyed using dirty water diversions.
- Utilise Sediment ponds as the primary form of treatment device. SRP's are a preferred treatment device as they achieve a greater level of sediment retention performance for treating sediment laden flows. SRP's for this development are proposed to be sized to provide a greater level of service, providing greater storage volume than required by GD05 to reduce the risk of sediment discharge given the sensitivity of the receiving environment.

- Decanting earth bunds will be used in minor catchment areas where required. As works proceed, exposed areas where works have been completed will also be stabilised, to reduce the area contributing towards the site generated flows.
- Undertake testing to confirm design assumptions and pond performance and undertake monitoring of pond discharges.

4.3 EROSION AND SEDIMENT CONTROLS

We recommend the following control devices listed below are implemented for bulk earthwork activities carried out at Beachlands South. All devices shall be constructed in accordance with GD05 best practice. SRPs shall be utilised as primary treatment device wherever practicable, given the greater sediment retention efficiency when compared with other devices. Other measures (reference in bracket cross references GD05) that shall be used either for smaller catchments or in conjunction with SRPs are:

- “Clean Water” Diversion Channels and Bunds – (E2.1)
- “Dirty Water” Diversion Channels and Bunds – (E2.2)
- Check Dam – (E2.4)
- Stabilised Entranceways – (E2.6)
- Topsoiling and Grass Seeding – (E3.1)
- Hydroseeding – (E3.2)
- Mulching – (E3.4)
- Sediment Ponds – (F1.1)
- Decanting Earth Bunds – (F1.2)
- Silt Fences – (F1.3)
- Super Silt Fences – (F1.4)
- Silt Socks – (F1.5)

4.4 BEACHLANDS SOUTH EROSION SEDIMENT CONTROL STRATEGY

As noted above, stormwater discharges conveyed from the site will discharge to sensitive ecological environments. While sediment discharge can occur pre-development, during development and post-development from urbanisation of the land, this report focuses on the development phase and earthworks being the potential source for erosion and highest source of sedimentation.

In order to mitigate the adverse effects of the earthworks activities, we recommend the implementation of Sediment Retention Ponds, given their effectiveness at removing sediment runoff, especially when combined with chemical treatment to assist with sediment particle coagulation.

While both Gleams modelling and Universal Soil Loss Equation calculations have been provided, rather than solely rely on the suggested design performance from these calculations and the resulting sediment discharge, we have also provided analysis of stormwater runoff flows from the site utilising historic rainfall data. This approach has led us to modifying the maximum catchment and relative pond size criteria to provide a greater level of stormwater capture within active catchments, thereby reducing the likely volume of sediment discharge from the development.

Utilising this approach in combination with other best practice strategies such as catchment stabilisation, minimising exposed catchment areas, and works staging, we consider the adverse impacts of the earthworks' activities during construction on the receiving environment can be mitigated.

4.4.1 STORM ANALYSIS AND RAINFALL VOLUMES

To inform our design and device sizing, we have undertaken analysis of stormwater flows resulting from the site during the earthworks season. Taking statistical rainfall over the past 20 years, reveals the following results.

TABLE 1 - 20 YEAR HISTORICAL RAINFALL DATA (SOURCE: NIWA VCSN DATA)

Year	Total Rain Days (>5mm) Sept - May	Total Rain Days (<5mm) Sept - May	Total Rain Days (>5mm) Oct - Apr	% Rain Days (>5mm) Oct - Apr	% Rain Days (>5mm) Sept - May	Total Rain Days (>36mm) Oct - Apr	Max. Rainfall Volume (mm in a day)	Max Cumulative over 3 days (mm)
2000/01	41	54	28	10%	15%	5	88.1	98.4
2001/02	57	41	46	17%	21%	2	62.1	62.1
2002/03	46	49	34	12%	17%	1	39.1	74.9
2003/04	52	43	34	12%	19%	3	81.2	92.2
2004/05	44	43	28	10%	16%	2	37.4	52.9
2005/06	52	41	35	13%	19%	4	71.7	75.9
2006/07	38	26	35	13%	14%	3	95	121.4
2007/08	40	38	27	10%	15%	1	51.1	57.6
2008/09	43	48	32	12%	16%	2	39.1	74.9
2009/10	31	40	18	7%	11%	1	43.2	79.4
2010/11	46	47	31	11%	17%	6	142.2	142.2
2011/12	51	38	41	15%	19%	3	60.9	62.9
2012/13	40	48	21	8%	15%	0	35.6	48.6
2013/14	39	39	29	11%	14%	3	51.7	63
2014/15	51	43	30	11%	19%	1	42.9	61.6
2015/16	44	35	29	11%	16%	4	50.1	66.1
2016/17	51	42	36	13%	19%	7	134.6	150.1
2017/18	51	51	31	11%	19%	2	62.5	88.2
2018/19	38	38	30	11%	14%	1	47.6	91
2019/20	29	44	14	5%	11%	0	34.3	44.8
Average	44	42	31	12%	16%	2.6	64	80

The following annualised rainfall storm event has been utilised in undertaking the Stormwater Hydrological modelling for the site.

TABLE 2 – 24HR ANNUALISED RAINFALL (SOURCE: NIWA VCSN DATA)

Storm Event	Annualised 24hr Rainfall Depth (mm)
95^{th} Percentile	36
1 in 2-year	79
1 in 10-year	136
1 in 100-year	208

From the statistical data provided above we make the following observations:

- The number of days where greater than 5mm of rainfall occurred ranges between 5 and 17% with an average of 12%
- Extending the earthworks season into the shoulder months of September and May increases the number >5mm rainfall events by 3 – 8%, or by an average of 33%.
- Assessing 2-year rainfall events over the 20-year period, exceedance of the 2-year storm event occurred 8 times, with no exceedance event occurring in 15 of the 20 years of data.
- Assessing 10-year rainfall events, exceedance of the 10-year storm occurred only once in 2010/11.
- In two (2) years (2010/11 – 142mm & 2016/17 – 150mm) events occurred which on a 3-day rainfall cumulation, exceeded the 1 in 10-year event rainfall of 136mm.
- The number of events greater than the 95^{th} percentile storm is between 0 – 7 with an average of 2.6 events per year over the 20-year period.

4.4.2 RAINFALL ANALYSIS OUTCOMES

We summarise the following outcomes from this analysis.

- The frequency of rainfall events that occur in the shoulder season months of September and May are statistically significant and therefore any works conducted in these periods should be minimised and focus on setup or close out of disturbed site areas.
- Events over and above the 95^{th} percentile storm are low.
- Exceedance events beyond a 2-year event are very low.

4.5 PROPOSED SEDIMENT RETENTION POND (SRP) SIZING VS GD05

A specific catchment analysis of the proposed earthwork areas is recommended at the time of any bulk earthwork application. For the immediate purposes of this plan change, we have conducted a scenario analysis based on the exposed catchment area within any wider catchment at any one time.

We provide a summary of what is proposed in terms of SRP sizing for Beachlands South, compared with what is considered best practice by GD05.

GD05 requires ponds to be sized based on 2% or 3% of the contributing catchment area with a maximum catchment area of 5 hectares. For Beachlands South we are recommending that the sizing of ponds is increased to 3.75% with a maximum catchment area of 4 hectares.

Ultimately this means the maximum pond size remains the same between GD05 and the recommended approach, but the contributing catchment is reduced.

The stormwater runoff volumes have been calculated using the TP108 method utilising a SCS curve number of 91 for the disturbed catchment area.

The pond storage volumes and stormwater runoff volumes are tabulated below.

TABLE 3 - POND VOLUMES/SIZING

Area (HA)	Pond Volume %	Dead Volume m3	Live Volume m3	Total Volume m3	2yr Storm Volume	10yr Storm Volume	95th Percentile Storm Volume	Rainfall Depth stored by Dead Storage (mm)	Rainfall depth treated by pond (mm)
3	5	450	1050	1500	1657	3298	514	33.3	73.3
4	3.75	450	1050	1500	2260	4447	735	26.6	58.3
5	3	450	1050	1500	2824	5558	918	23.3	49.8

What this means in terms of volumetric control is for a 4ha catchment the sediment pond will provide dead storage for 61% of the 95th percentile storm event and total storage for 66% of 1 in 2-year events, and 33% for 1 in 10-year events (assuming the pond is empty).

The 450m^3 of dead storage means no discharge will occur in any rainfall event smaller than 26.6mm for a 4ha catchment (again assuming the pond is empty at the time of rainfall). The pond will afford a total storage (assuming no discharge) for all storms to a rainfall depth of 58.3mm.

Based on a 3ha, 4ha and 5ha catchments and the 20 years of statistical rainfall data this means approximately 3.3, 5.3 or 7.2 events per season will exceed the dead storage capacity of the sediment pond.

The live storage is exceeded 0.5, 0.95 or 1.35 times respectively. However, given the notice these types of events would provide, other measures to reduce exposed areas and minimise flow paths can be utilised in conjunction with the primary devices to mitigate the effects of such events.

For the purposes of sediment discharge modelling and calculations, we have assumed 15 hectares of earthworks can be completed within any single catchment, with a maximum of 5 hectares of disturbed area at any time. While for assessment purposes we have suggested 15 hectares within a single catchment over an earthworks season, provided a maximum exposed catchment is maintained we don't consider a limit need be applied to the overall catchment area that might be earthworked in any particular earthwork season. A summary of the results is provided in section 5 of this report.

5.0 SEDIMENT LOSS CALCULATIONS

HG has formulated an earthworks catchment scenario for carrying out the Gleams modelling and USLE calculations which assumed three (3) 5ha catchments were disturbed during an earthworks season within any particular catchment, but no more than 5ha was disturbed at any given time. This scenario was then utilised to complete sediment loss or Total Suspended Solid (TSS) analysis on a range of slopes between 0 to 3°, 3-6°, 6-9° and 9-12°.

TABLE 4 – EXPOSED EARTHWORKS AREAS SCENARIO

Season	Month	EW1 (%)					EW2 (%)					EW3 (%)				
		Existing	Open	Mulched	Stabilized	Treatment	Existing	Open	Mulched	Stabilized	Treatment	Existing	Open	Mulched	Stabilized	Treatment
1	Oct	70	30	0	0	SRP	100	0	0	0	SRP	100	0	0	0	SRP
	Nov	0	80	10	10	SRP	100	0	0	0	SRP	100	0	0	0	SRP
	Dec	0	40	30	30	SRP	70	30	0	0	SRP	100	0	0	0	SRP
	Jan	0	20	40	40	SRP	0	80	0	20	SRP	100	0	0	0	SRP
	Feb	0	0	70	30	SRP	0	60	20	20	SRP	60	40	0	0	SRP
	Mar	0	0	70	30	SRP	0	0	70	30	SRP	0	80	10	10	SRP
	Apr	0	0	70	30	SRP	0	0	0	0	SRP	0	20	50	30	SRP
	May–Sep	0	0	0	100	SRP	0	0	0	100	SRP	0	0	0	100	SRP

We then assessed the existing earthwork surface and determined the percentage of area within each slope category. The slope assessment can be found in Appendix A but is also tabulated below.

TABLE 5 – SLOPE % OF DEVELOPABLE AREA

Catchment Reference	Slope % of Developable Area				
	0-3°	3-6°	6-9°	9-12°	>12°
1	31.6	38.9	15.9	10.2	3.4
2	36.0	33.1	16.8	7.6	6.5
3	18.0	29.9	22.2	12.6	17.3
4	28.2	33.2	18.4	8.6	11.6
5	10.8	40.0	25.4	10.9	12.7

This information was then utilised to determine the sediment loss across each catchment area by NIWA in calibration of their Gleams model.

5.1 GLEAMS MODELLING

Gleams modelling has been carried out by NIWA, the results of which are provided in Appendix B.

Load reduction factors applied in the modelling for the storm events were as follows:

2 year – 0.95
10 year – 0.85
100 year – 0.65

As the load reduction factors (even when applied in relation to the performance of a GD05 SRP) are relatively high, we consider that it is not appropriate to assume a higher level of performance as a result of increasing pond size.

Therefore, further Gleams modelling for the revised pond to catchment ratio has not been performed. Rather we have taken what we consider is a more holistic approach in assessing the total rainfall against the storage afforded by the pond to assess the device’s efficacy, as outlined in sections 4.3 & 4.4.

TABLE 6 – GLEAMS SEDIMENT DISCHARGE 95TH PERCENTILE & 2 YR RESULTS

	Sediment Discharge			
	Existing		Proposed (with Flocculation)	
Catchment Reference	95th Percentile	2 yr	95th Percentile	Gleams (tons)
1	1.02	2.95	2.41	9.96
2	0.75	2.12	2.19	8.92
3	2.38	7.07	4.83	20.24
4	2.59	8.49	4.09	17.67
5	5.85	12.54	18.1	26.9

This data indicates sediment discharge (TSS) is likely to be approximately 3 times the existing discharge in a 1 in 2-year event while the 95th percentile storm represents an approximately two times increase.

What this means in terms of sediment deposition is summarised in section 5.3 of this report and described in detail as part of the T&T report.

We note the same load reduction factor has been used for both the 95th percentile storm and 2-year event. However, given the increased storage volume within the volume and likely smaller discharge, you could anticipate a better level of performance than that indicated by the results. It is proposed that actual results will be tested for and monitored as outlined in section 6 of this report.

5.2 USLE CALCULATIONS

The Universal Soil Loss Equation (USLE) method has been used to determine the sediment loss that will occur over the exposed earthworks area for an earthworks season, based on the 2-year annual rainfall event. This analysis has been completed in addition to the Gleams Modelling (conducted by NIWA), to provide comparison to those results established by NIWA. A summary of these results in comparison to the NIWA figures is tabulated below, the full results of which are provided in Appendix A.

While there are differences between the Gleams and USLE values, each method does utilise different calculations and so some level of variance is not unexpected. We note though that the level of variance as a percentage of the gross sediment volume (250 – 400t depending on catchment) is relatively small (up to 2%)

TABLE 7 – USLE VS GLEAMS SEDIMENT DISCHARGE 2YR RESULTS

	Sediment Discharge with Flocculation (2yr storm)		
	Existing	Proposed	
Catchment Reference	Gleams (tons)	USLE (tons)	Gleams (tons)
1	2.95	13.5	9.96
2	2.12	13.4	8.92
3	7.07	18.8	20.24
4	8.49	15.5	17.67
5	12.54	18.1	26.9

5.3 COASTAL SEDIMENT DISCHARGE

Tonkin & Taylor have completed a coastal sediment discharge and water quality assessment based on the stormwater discharge and efficacy of the proposed sediment discharges to determine the potential effects of sediment deposition and movement within the wider coastal environment.

They have conducted their assessment utilising sediment deposition thresholds immediately following a single rainfall event of:

- 20mm thick deposition, remaining for longer than five days
- 5mm thick deposition, remaining for longer than 10 days
- 2mm/yr accumulation above the natural annual sedimentation rate.

In summary utilising the sediment discharge data provided by NIWA, the T&T modelling and analysis has considered several scenarios which provide the following conclusions:

- in a 1 in 2.33-year event more than 5mm of accumulated sediment persisting for longer than 10 days may occur during construction over an area of <0.1ha at each of the five identified discharge locations.
- For discharges A&B when considering the rate of sediment removal through natural re-erosion effects even in the worst case 100-yr scenario over the 10-year construction duration less than 2mm sediment accumulation rate (SAR) is expected over this period.
- For discharges C, D & E of the existing 3mm SAR it is anticipated the development would contribute approximately 1mm of this total. SAR in the area of these discharges is anticipated to increase two to three times in more frequent events during construction which therefore as the potential to add 2mm of accumulated sediment above existing background rates. This would only occur over the limited construction direction and only over areas that would be subject to long term deposition in the existing scenario. While this increase would occur during construction, it is anticipated a net reduction in silt content would occur following development of the land.

Further information regarding the depth and area over which sediment deposition is likely to occur within the coastal environment is provided in the T&T report. What the increase in sediment means for ecology and ecological processes is addressed in the T&T Ecological Report.

From this analysis we note while 1 in 2-year or larger storms result in increases in sediment discharge and sediment deposition, the number of events of this scale or larger are low with only 1 or 2 events exceeding this scale in any given year and in 15 of the last 20 years no events of this scale have occurred.

6.0 TESTING AND MONITORING

To ensure the erosion and sediment controls proposed achieve and maintain the desired objectives and performance criteria testing and monitoring of their performance, forms a critical part of any strategy. While the testing and monitoring criteria can be developed further as part of future consents, they are a key component to ensure the intended design outcomes are achieved. Initial criteria as to what testing and monitoring might be required is provided below.

6.1 BASELINE & FRESHWATER TESTING AND MONITORING

An Adaptive Management approach is recommended for baseline testing and freshwater monitoring requirements. This is discussed further by Tonkin & Taylor in their Freshwater & Wetland Ecological Assessments.

6.2 EROSION AND SEDIMENT CONTROL DEVICE MONITORING

The following requirements are recommended to be stipulated by the ESCMP or through an appropriate management plan.

6.2.1 SITE INSPECTIONS

As a requirement for site management, regular site inspections shall be undertaken throughout the project works. This shall include a hierarchy of inspections covering regular maintenance inspections as well as pre-rainfall event checks and rainfall trigger inspections. All devices shall be inspected post rainfall events and any threshold exceedance events recorded and reported. Remediation of any causes to exceedance events shall be carried out as soon as practicable.

Any inspection regime shall provide certainty that appropriate measures are being undertaken and compliance with both conditions and consent and GD05 are maintained.

6.2.2 DISCHARGE SAMPLING

Flow monitoring of sediment pond discharges shall be provided along with automated sampling of inflow and outflow of each SRP. Samples shall be collected from both inflow and outflow and analysed for Total Suspended Solids (TSS) at an accredited laboratory to confirm the efficacy and operation of each SRP.

Treatment efficiencies shall be calculated and reported on as part of the ongoing monitoring and compliance of the site.

Additional testing and sampling may be required at the commencement of the proposed earthworks activities, to confirm the intended design outcomes of each device is achieved. Should the device not perform as anticipated a review of the device sizing or contributing catchment may be required.

If a threshold exceedance event occurs, an audit of the applicable device(s) shall be undertaken and any causes contributing to the exceedance remedied.

A set of requirements in relation to triggered monitoring shall also be set as part of the consent to highlight performance in response to larger rainfall events and/or threshold exceedances in SRP efficiency or water quality.

7.0 CONCLUSION

This report has been prepared by Harrison Grierson on behalf of Beachlands South Limited Partnership in support of a private plan change application for the urban development of approximately 307ha of rural land in Beachlands. We have assessed the likely earthwork activities and resulting erosion and sediment that may result from these activities.

We have utilised Auckland Council's GD05 as a basis for mitigating the impacts of sediment discharge from the site to the downstream receiving environments. We have recommended that wherever possible sediment retention ponds should be utilised. Sediment retention ponds provide the highest level of sediment load reduction within the currently applied suite of sediment controls.

Given the sensitivity of the receiving environments we consider it appropriate that the highest practicable level of sediment load reduction be achieved through the earthworks phase of development. We consider this will be achieved by the measures that are proposed.

Both GLEAMS modelling and USLE calculations have been completed to assess the potential quantum of sediment discharging from the site.

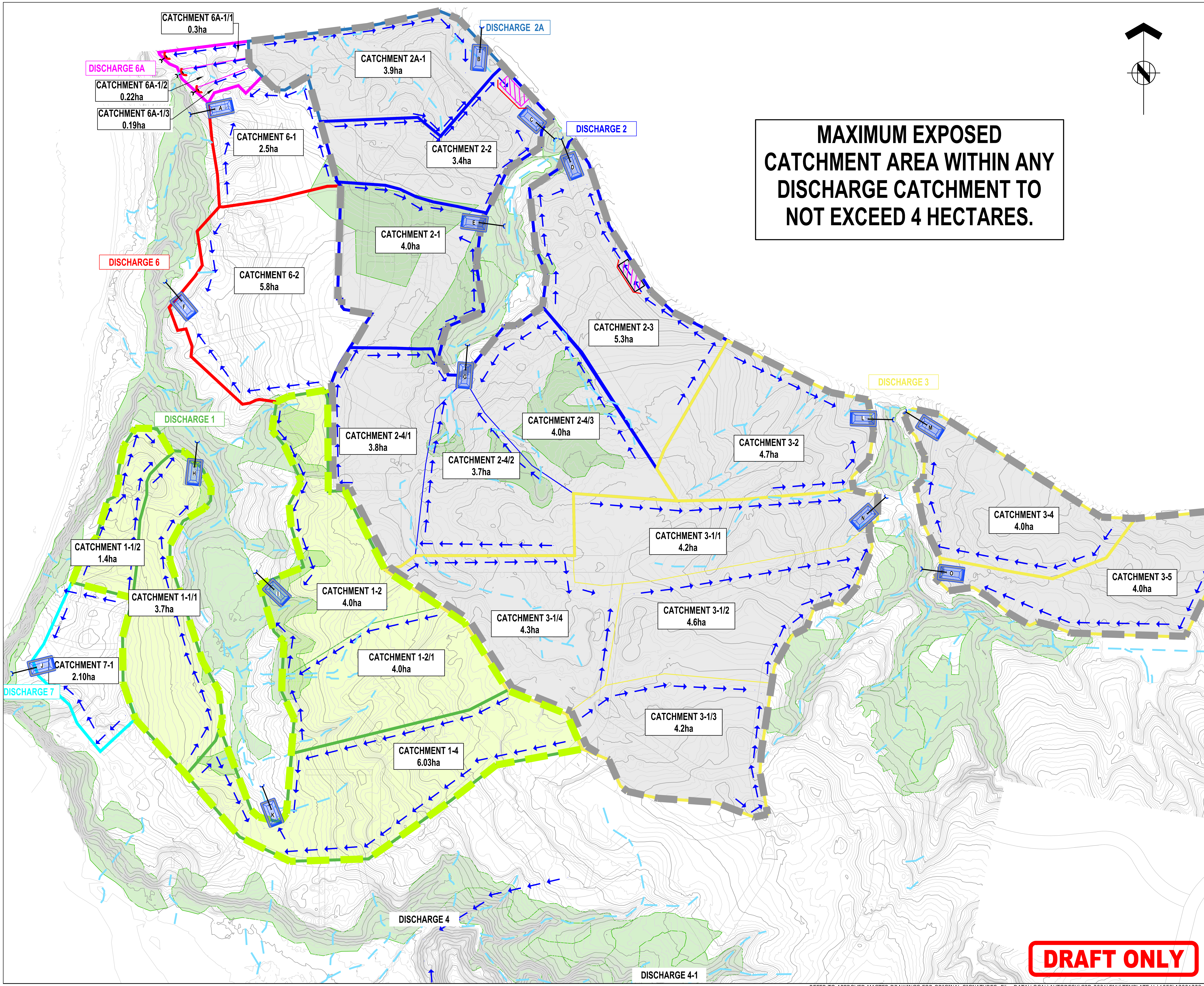
Statistical analysis of rainfall events over the past 20 years during earthworks season has been completed to quantify the volume of runoff from exposed catchment areas and the number of exceedance events that occur, where both the dead and live storage of the proposed sediment ponds is exceeded.

Based on this analysis we have recommended that catchments and ponds be sized to achieve a greater level of service than that prescribed by GD05, i.e. achieve a higher standard than prescribed by current best practice. Ponds are recommended to be sized for 3.75% of the catchment area with a maximum contributing catchment of 4ha, as opposed to 2 or 3% and 5ha as prescribed by GD05. Increasing the size of the pond relative to the exposed catchment means on average only 5.3 events would exceed the dead storage of the pond and 0.95 events exceed the pond live storage (assuming the pond is empty).

We have also recommended a number of testing and monitoring requirements are required during the earthworks' activities. These requirements would be undertaken and recorded as part of an Erosion and Sediment Control Management plan which would allow validation of the sediment discharge and the performance of sediment control devices. This is a commonly accepted approach for managing sites, especially when associated with sensitive receiving environments.

In conclusion we consider the measures and methods outlined in the report provide a suitable framework under which earthworks activities can be undertaken, which can be further developed as part of future individual consenting processes. The measures are both practical and achievable in the management of the earthworks activities and in our opinion are appropriate should the plan change be granted.

APPENDIX 1 EROSION AND SEDIMENT CONTROL PLAN – INDICATIVE SCENARIO



ASSOCIATION OF CONSULTING ENGINEERS NEW ZEALAND

ISO 9001 QUALITY ASSURED

LEGEND:

- RUNOFF DIVERSION CHANNEL
- CATCHMENT AND SUBCATCHMENT BOUNDARY (COLOUR DIFFERS TO MATCH DISCHARGE LOCATION)
- DISCHARGE X — DISCHARGE LOCATION
- SEDIMENT POND
- EXISTING WATERCOURSE
- STABILISED ENTRY
- CULVERT UNDER ACCESS ROAD
- DECANTING EARTH BUND
- ECOLOGICAL AREAS
- EXISTING SURFACE CONTOURS AT 2m INTERVALS
- CATCHMENTS DISCHARGING TO THE NORTH (DISCHARGES 2, 2A, 3)
- CATCHMENTS DISCHARGING TO DISCHARGE 1

AUCKLAND OFFICE
LEVEL 4, 96 ST GEORGES BAY ROAD
PARNELL AUCKLAND 1052
T +64 9 917 5000
W www.harrisongrierson.com

REF	REVISIONS	BY	DATE
R1	ISSUED FOR REVIEW	PZS	22.11.21

PROJECT:

BEACHLANDS SOUTH

TITLE:

EROSION AND SEDIMENT CONTROL PLAN - INDICATIVE NORTHERN CATCHMENT SCENARIO

ORIGINATOR: MNH	DATE:	SIGNED:	PLOT BY: PZS
DRAWN: PZS	DATE:	SIGNED:	PLOT DATE: 29.11.21
CHECKED: DAS	DATE: 29.11.21	SIGNED:	SURVEY BY:
APPROVED: CQM	DATE:	SIGNED:	SURVEY DATE:

ISSUE STATUS: FOR REVIEW

PROJECT No: A2001228 | SCALES: | A1

DRAWING No: A2001228-230 | REV R1

REFER TO APPROVED MASTER DRAWINGS FOR ORIGINAL SIGNATURES File: DATA\LOCAL\AUTODESK\C3D 2021\ENU\TEMPLATE U:\1050\A2001228_A\CAD\CURRENT\A2001228-230-EROSION AND SEDIMENT CONTROL PLAN.DWG

APPENDIX 2 EROSION AND SEDIMENT CONTROL USLE CALCULATIONS

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume
10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.46** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 5.24 %

LS = **0.88** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **0.01** unitless
P = **1** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 0 %

Section	**USLE Parameters**					**A Soil Loss (t/ha/yr)**	**Area (ha)**	**Works Duration (Years)**	**Est. Gross Sediment Yield (tons)**	**Sediment Delivery Ratio**	**Sediment Control Efficiency (%)**	**Net Sediment Loss (tons)**
	R	**K**	**LS**	**C**	**P**							
Pond X	76	0.46	0.88	0.01	1	0.31	4	0.307692	0.38	0.5	0	0.19
Sediment Generation Potential (tons)									**0.38**			
Estimated Total Net Sediment Loss (tons)												**0.19**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume
10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 5.24 %

LS = **0.88** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 75 %

Section	**USLE Parameters**					**A**	**Area (ha)**	**Works Duration (Years)**	**Est. Gross Sediment Yield (tons)**	**Sediment Delivery Ratio**	**Sediment Control Efficiency (%)**	**Net Sediment Loss (tons)**
	R	**K**	**LS**	**C**	**P**	**Soil Loss (t/ha/yr)**						
Pond X	76	0.46	0.88	1	1.32	40.79	4	0.307692	50.20	0.5	75	6.27
Sediment Generation Potential (tons)									**50.20**			
Estimated Total Net Sediment Loss (tons)												**6.27**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P**

where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume
10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 5.24 %

LS = **0.88** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 90 %

Section	USLE Parameters					A	Area	Works	Est. Gross	Sediment	Sediment	Net
	R	K	LS	C	P	Soil Loss (t/ha/yr)	(ha)	Duration (Years)	Sediment Yield (tons)	Delivery Ratio	Control Efficiency (%)	Sediment Loss (tons)
Pond X	76	0.46	0.88	1	1.32	40.79	4	0.307692	50.20	0.5	90	2.51
Sediment Generation Potential (tons)									**50.20**			
Estimated Total Net Sediment Loss (tons)												**2.51**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume
10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.46** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 10.51 %

LS = **2.30** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **0.01** unitless
P = **1** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 0 %

Section	**USLE Parameters**					**A Soil Loss (t/ha/yr)**	**Area (ha)**	**Works Duration (Years)**	**Est. Gross Sediment Yield (tons)**	**Sediment Delivery Ratio**	**Sediment Control Efficiency (%)**	**Net Sediment Loss (tons)**
	R	**K**	**LS**	**C**	**P**							
Pond X	76	0.46	2.30	0.01	1	0.80	4	0.307692	0.99	0.5	0	0.49
Sediment Generation Potential (tons)									**0.99**			
Estimated Total Net Sediment Loss (tons)												**0.49**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume
10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 10.51 %

LS = **2.30** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 75 %

Section	USLE Parameters					A Soil Loss (t/ha/yr)	Area (ha)	Works Duration (Years)	Est. Gross Sediment Yield (tons)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Net Sediment Loss (tons)
	R	K	LS	C	P							
Pond X	76	0.46	2.30	1	1.32	106.14	4	0.307692	130.63	0.5	75	16.33
Sediment Generation Potential (tons)									**130.63**			
Estimated Total Net Sediment Loss (tons)												**16.33**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume
10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 10.51 %

LS = **2.30** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 90 %

Section	**USLE Parameters**					**A**	**Area**	**Works**	**Est. Gross**	**Sediment**	**Sediment**	**Net**
	R	**K**	**LS**	**C**	**P**	**Soil Loss (t/ha/yr)**	**(ha)**	**Duration (Years)**	**Sediment Yield (tons)**	**Delivery Ratio**	**Control Efficiency (%)**	**Sediment Loss (tons)**
Pond X	76	0.46	2.30	1	1.32	106.14	4	0.307692	130.63	0.5	90	6.53
Sediment Generation Potential (tons)									**130.63**			
Estimated Total Net Sediment Loss (tons)												**6.53**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks (assumed as being operational from 01 October to end of Jan)

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume 10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.46** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 15.84 %

LS = **4.36** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **0.01** unitless
P = **1** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 0 %

Section	USLE Parameters					A Soil Loss (t/ha/yr)	Area (ha)	Works Duration (Years)	Est. Gross Sediment Yield (tons)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Net Sediment Loss (tons)
	R	K	LS	C	P							
Pond X	76	0.46	4.36	0.01	1	1.52	4	0.307692	1.87	0.5	0	0.94
Sediment Generation Potential (tons)									**1.87**			
Estimated Total Net Sediment Loss (tons)												**0.94**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume
10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 15.84 %

LS = **4.36** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 75 %

Section	**USLE Parameters**					**A Soil Loss (t/ha/yr)**	**Area (ha)**	**Works Duration (Years)**	**Est. Gross Sediment Yield (tons)**	**Sediment Delivery Ratio**	**Sediment Control Efficiency (%)**	**Net Sediment Loss (tons)**
	R	**K**	**LS**	**C**	**P**							
Pond X	76	0.46	4.36	1	1.32	201.04	4	0.307692	247.43	0.5	75	30.93
Sediment Generation Potential (tons)									**247.43**			
Estimated Total Net Sediment Loss (tons)												**30.93**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume 10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 15.84 %

LS = **4.36** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 90 %

Section	**USLE Parameters**					**A**	**Area (ha)**	**Works Duration (Years)**	**Est. Gross Sediment Yield (tons)**	**Sediment Delivery Ratio**	**Sediment Control Efficiency (%)**	**Net Sediment Loss (tons)**
	R	**K**	**LS**	**C**	**P**	**Soil Loss (t/ha/yr)**						
Pond X	76	0.46	4.36	1	1.32	201.04	4	0.307692	247.43	0.5	90	12.37
Sediment Generation Potential (tons)									**247.43**			
Estimated Total Net Sediment Loss (tons)												**12.37**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks (assumed as being operational from 01 October to end of Jan)

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume 10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.46** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 21.26 %

LS = **7.04** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **0.01** unitless
P = **1** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 0 %

Section	**USLE Parameters**					**A Soil Loss (t/ha/yr)**	**Area (ha)**	**Works Duration (Years)**	**Est. Gross Sediment Yield (tons)**	**Sediment Delivery Ratio**	**Sediment Control Efficiency (%)**	**Net Sediment Loss (tons)**
	R	**K**	**LS**	**C**	**P**							
Pond X	76	0.46	7.04	0.01	1	2.46	4	0.307692	3.03	0.5	0	1.51
Sediment Generation Potential (tons)									**3.03**			
Estimated Total Net Sediment Loss (tons)												**1.51**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume 10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 21.26 %

LS = **7.04** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 75 %

Section	**USLE Parameters**					**A**	**Area**	**Works**	**Est. Gross**	**Sediment**	**Sediment**	**Net**
	R	**K**	**LS**	**C**	**P**	**Soil Loss (t/ha/yr)**	**(ha)**	**Duration (Years)**	**Sediment Yield (tons)**	**Delivery Ratio**	**Control Efficiency (%)**	**Sediment Loss (tons)**
Pond X	76	0.46	7.04	1	1.32	324.60	4	0.307692	399.51	0.5	75	49.94
Sediment Generation Potential (tons)									**399.51**			
Estimated Total Net Sediment Loss (tons)												**49.94**

ESTIMATION OF SEDIMENT YIELD
BY THE UNIVERSAL SOIL LOSS EQUATION
An Empirical Method to Estimate Sheet and Rill Erosion from Land

PREPARED BY HARRISON GRIERSON CONSULTANTS LTD

PROJECT No : A2001228-01 **BY :** KKA **DATE :** 26/08/2021 **CHECKED :** MNH

SITE DESCRIPTION : **Beachlands South**

CATCHMENT AREA: **Pond X** *see drawing XXXXX
EXPOSED AREA: **4** ha
WORK DURATION : **0.31** Years 16.0 Weeks

WORKING EQUATION : **A = R K LS C P** where A = soil loss (tons/ha/year)

1

*A=R*K*LS*C*P*
WHERE:
R=Rainfall Erosion Index
K=Soil Erodibility Factor
LS=Slope Length & Steepness Factor
C=Ground Cover Factor
P=Roughness Factor

- Rainfall erosion index (R)

R = 0.00828 (P)^2.2*1.7 where : P = 49.612 mm

R = **76** Joule/ha

- Soil erodibility index (K)

All Sectors
Assume 10 % Sand
55 % Clay
35 % Silt

0 % granular
0 % organic

K = **0.25**
K corrected = **0.462** tons/unit of R

- Slope length and steepness factor (LS)

Length = 74.13 m
Height top = 45.73 m
Height bot = 43.27 m
Slope = 21.26 %

LS = **7.04** unitless

- Ground cover factor (C) and Roughness factor (P)

Assume : Working Area, Vegetation

C = **1** unitless
P = **1.32** unitless

The USLE predicts the total yield of sediment generated but makes no allowance for that retained on site. A Sediment Delivery Ratio (SDR) must be selected. American sources state that SDR rates range mostly from 0.1 to 0.7 (N.Y. Guidelines for Urban Erosion and Sediment Control).

Assume SDR = 0.5 (average)

Sediment control efficiency = 90 %

Section	USLE Parameters					A	Area	Works	Est. Gross	Sediment	Sediment Control	Net Sediment
	R	K	LS	C	P	Soil Loss (t/ha/yr)	(ha)	Duration (Years)	Sediment Yield (tons)	Delivery Ratio	Efficiency (%)	Loss (tons)
Pond X	76	0.46	7.04	1	1.32	324.60	4	0.307692	399.51	0.5	90	19.98
Sediment Generation Potential (tons)									**399.51**			
Estimated Total Net Sediment Loss (tons)												**19.98**