ARQ
CONSULTING
ENGINEERS

Our reference: 8144/16663

14 June 2018

Royal Haskoning DHV (Pty) Ltd
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For the attention of **Mr. Mervyn Bosworth-Smith**

Dear Sir

SANI PASS ROAD - DESIGN OF GROYNES AT MKONOZANA RIVER CHAINAGE 14 380 TO 14 520

1. BACKGROUND

In 2007, a joint venture consisting of SSI Engineers and Environmental Consultants (SSI), Ndizani Civil Works (Ndizani) and Semenya Furumele Consulting (SFC) was awarded Phase 2 of the upgrading of road P318. This involved the redesign, partial realignment and surfacing of 19 km of existing gravel road extending to the top of Sani Pass on the Lesotho Border.

The Mkonozana River drains the valley leading down from the Sani Pass and runs parallel to the Sani Pass road P318 for several kilometres. A Gabion retaining wall is required between chainage 13900 m and 14800 m to ensure stability of the road fill. The main river bed channel is very close to this longitudinal structure, and detailed hydraulic analysis (ARQ 2017) indicated extremely high flow velocities against the proposed wall. Combined with a high impinging angle onto the proposed wall, the potential scour at the wall was estimated as severe and cannot be adequately managed with the mere introduction of reno mattresses.

The introduction of groynes was consequently proposed. These groynes will decrease the velocity and impinging angle on the gabion wall by effectively directing the main river flow away from the proposed gabion wall.

According to the road floodline study report (SSI, 2009), the 20 year return period flood was adopted as the design flood for this section of the P318 road. Accordingly, all relating levels, velocities and resulting scour depths were required to be determined with this design flood. The resulting water surface elevation was to be selected to ensure that the Q_{2T} flood (40 year return period) elevation at any given location is lower than the shoulder break point to ensure the required freeboard is maintained.

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2. THIS LETTER REPORT

As noted in the Detailed Hydraulic Analysis Report (ARQ, 2017), the impinging angle, the flow velocity and the flow depth all have a large influence (other than the material) on the depth of the estimated scour. The section between chainage 14 520 and 14 380 proved to experience high velocities together with high impinging angles, accordingly resulting in extremely deep estimated scour depths. While it is accepted that the material properties of the riverbed and on the river banks cannot be changed, other contributing components can be improved.

To that effect, the introduction of groynes was evaluated and its effect on the velocity against the gabion wall analysed. ARQ Dams were consequently appointed to verify these velocities and undertake the concept design of these structures if proved to be efficient.

This letter forms part of the Phase II deliverables described in ARQ's proposal letter, reference 8144/16265. The design and evaluation described in this letter covers:

- Planning and recommendations of suitable structures
- Hydraulic analysis and evaluation of the structures under the 20 year return period
- Structural design and details of suitable structures. Drawings will only indicate concepts and construction drawings are not included in the scope of this report.

3. THE SITE

The area under investigation extends some 500m along the Sani Pass road (P318) and Mkonozana River, and specifically between chainage 14 520 and 14 380 as shown in Figure 1 below.

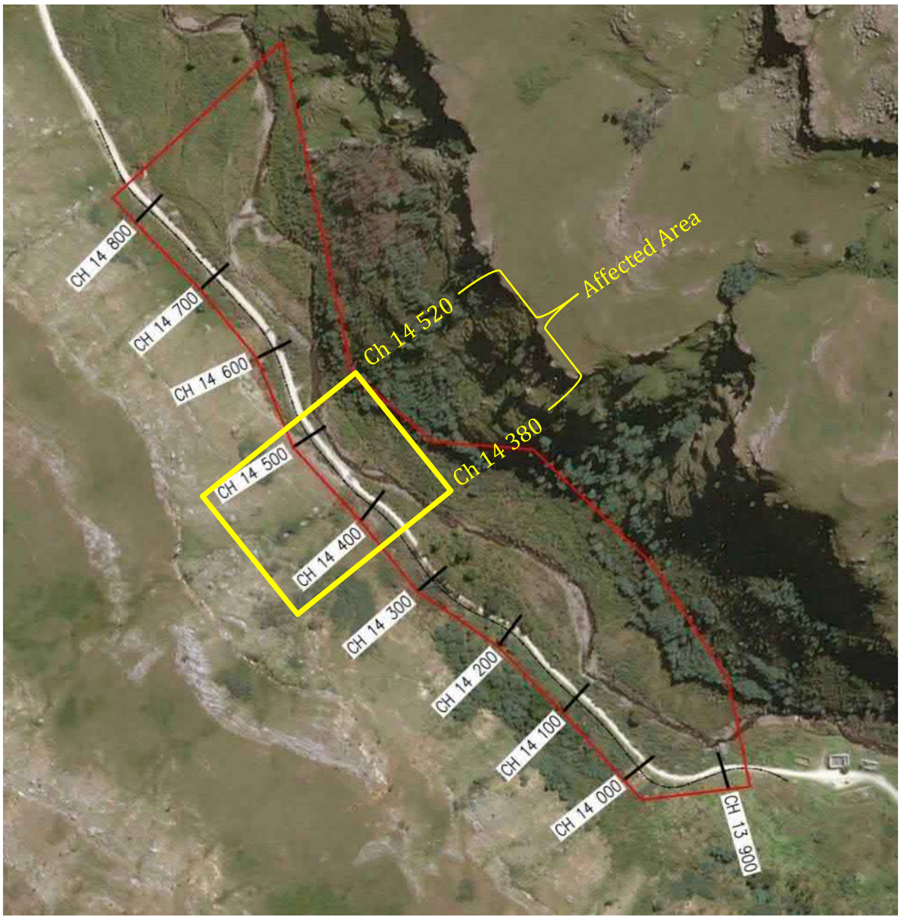

Figure 1 Site Layout of P318 Road and Mkonozana River

4. FLOOD HYDROLOGY AND FLOOD USED FOR ANALYSIS

Flood hydrology in the Mkonozana River was studied by SSI in December 2009. As described in ARQ 2017, the hydrology study area was divided into various sub catchments. The study area for this review is located in the downstream of the catchment number 9. The representative flows extracted from the SSI report for the various return periods in this catchment which were used for the hydraulic analysis are summarised in Table 1.

Table 1 Summarised Design Flows for Catchment number 9 (According to SSI, 2009)

	Flow (m³/s)					
Return Period	**1:5**	**1: 10**	**1:20**	**1:40 ***	**1:50**	**1:100**
9	111	199	300	410	454	585

* Interpolated from existing data

5. DESIGN AND EVALUATION METHODOLOGY

5.1. PROBLEM AREA IDENTIFIED DURING INITIAL ANALYSIS

From the previous analysis, the velocity and impinging angle were identified as the main factors contributing to extremely deep scour depths. As shown in Figure 2, high velocities coupled with a high impinging angle onto the gabion wall at Chainage 14 520 to 14 380 were identified.

With flow velocities ranging between 2.75 m/s to 3.76 m/s impinging onto the gabion wall, extremely high scour depths ranging between 4.2 m to 6.1 m were calculated.

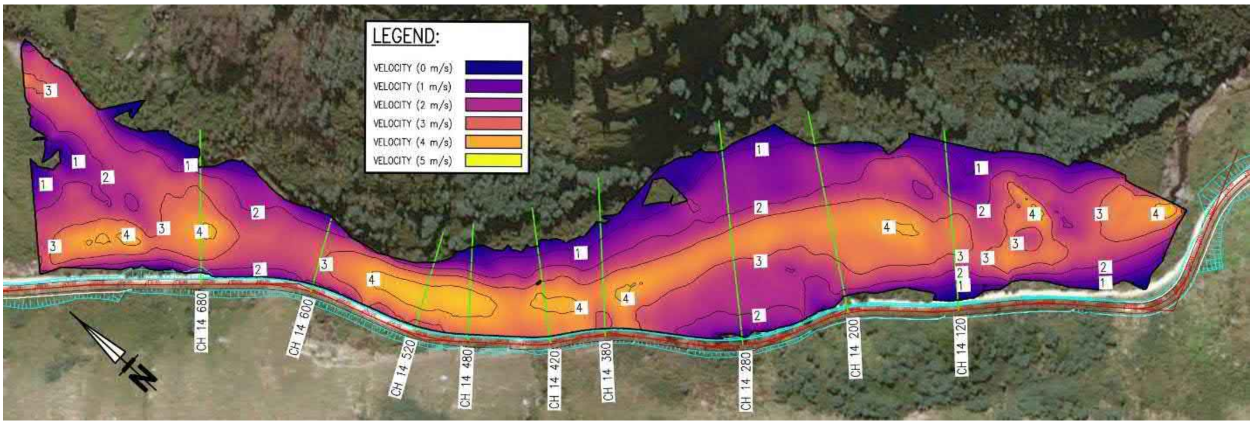

Figure 2 Flow Velocity Distribution Plot for the 1:20 Year Flood (Without Groynes)

It will not be possible to manage this scour depth with the provision of reno-mattresses, and an alternative method to deviate the flow away from the wall was consequently recommended. As groynes can be used to deflect flowing water away from critical zones, the inclusion of this type of structure was recommended.

Ideally, the introduction of groynes will indicate a much lower velocity against the proposed gabion wall which will accordingly decrease the anticipated scour depth.

5.2. USE OF GROYNES TO DEFLECT FLOW FROM CRITICAL PATH

A groyne roughens the bank on which it is constructed and, in doing so, creates a zone of lower flow velocity where the tendency for erosion to occur is less, and that of deposition greater.

A groyne orientated perpendicular to the flow direction of the river keeps the main current (flow) more or less parallel and away from the riverbank. Groynes do not deflect water in the same way that a ball would bounce off a wall, but the main body of water flowing past the groyne is rather directed away from the bank by the slowly rotating pool of water trapped between the groynes as indicated in Figure 3.

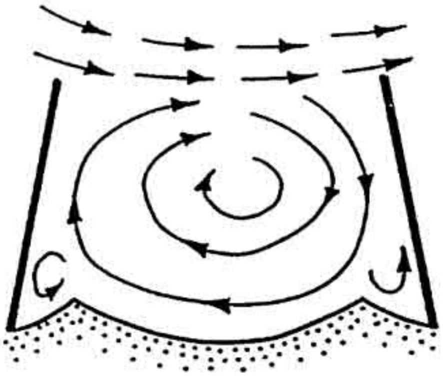

Figure 3 Idealized Flow between Groynes that are not submerged

Groynes offer a solution that is more stable than longitudinal river bank protection in that the energy of the water flowing along the bank is reduced, and in so doing decreases the scour potential against critical structures at the river bank.

6. INTRODUCTION OF GROYNES AT MKONOZANA RIVER

6.1. LOCATION AND ORIENTATION OF GROYNES

As shown in **Error! Reference source not found.**, a curved flow path in the river with an approximate radius of 92.3 m was estimated to provide a suitable deviation of the edge of the main flow in the river. This allows for a translation of approximately 5 m minimum from the existing road/river edge.

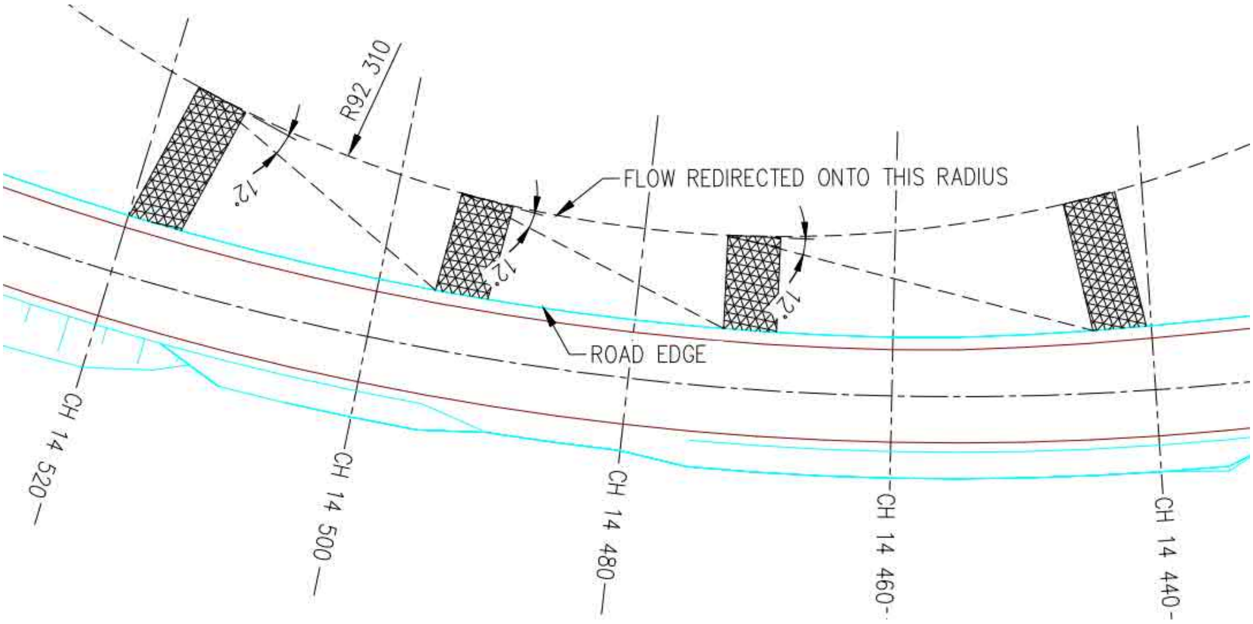

Figure 4 Simplified Plan Layout of Groynes

A configuration of four groynes was then selected utilising the guidelines described by King (2015). These include:

- Groynes are placed on the outside bank of a bend

- The upstream line of the groyne is placed at right angles to the tangential line of the planned flow direction.
- The nose of each groyne is placed on the outer edge of the planned base of the river.

As indicated Figure 4, the spacing of the groynes were determined by projecting a ray from the first groyne to the rehabilitated bank, tangential to the planned river base at the nose of the groyne diverging at 12 degrees.

7. HYDRAULIC ANALYSIS INPUT

7.1. HEC-RAS 5.0 (2D) BACKGROUND

The United States Army Corps of Engineers River Analysis software HECR-RAS 5.0 was employed in the determination of the flow conditions. HEC-RAS 5.0 was specifically developed to enhance the capabilities of the software, specifically modelling in areas that required a higher level of hydrodynamic fidelity such as flood plains where the watercourse is less defined. Modelling in two dimensions provides an analysis where water can flow in any direction. This allows a more natural model that allows inundation and stagnant water, and consequently a more accurate model. In the case of this design, eddy's formed between the groynes will be indicated by the flow vectors.

7.2. MANNING VALUE REGIONS

As presented in the Detailed Hydraulic Analysis Report (ARQ,2017), Bing Satellite Imagery along with photos taken on site were used as reference to identify and evaluate different roughness regions which was consequently used to develop a hydraulic roughness map of Manning values.

The groynes were modelled as structures in the river with its associated roughness coefficients.

7.3. HYDRAULIC PARAMETERS

The analysis was based on steady flow conditions. This required both upstream and downstream boundary conditions, where a constant inflow hydrograph (design flow) was assigned as the upstream boundary condition. An energy grade of s = 0.067, based on the ground topography along the downstream end of the model was used as a normal slope boundary and the downstream boundary condition.

2D HEC-RAS inherently includes expansion and contraction coefficients within the 2D areas and therefore it was not required to be set manually. It is only at hydraulic structures where the expansion and contraction coefficients should still be set manually, which was not necessary in this case.

The groynes were modelled as changes in the topography effectively blocking the flow, with their associated roughness coefficients.

8. ANALYSIS RESULTS

8.1. WATER SURFACE ANALYSIS

The resulting water depth at steady state for the 1:20 year flood is presented in Figure 5.

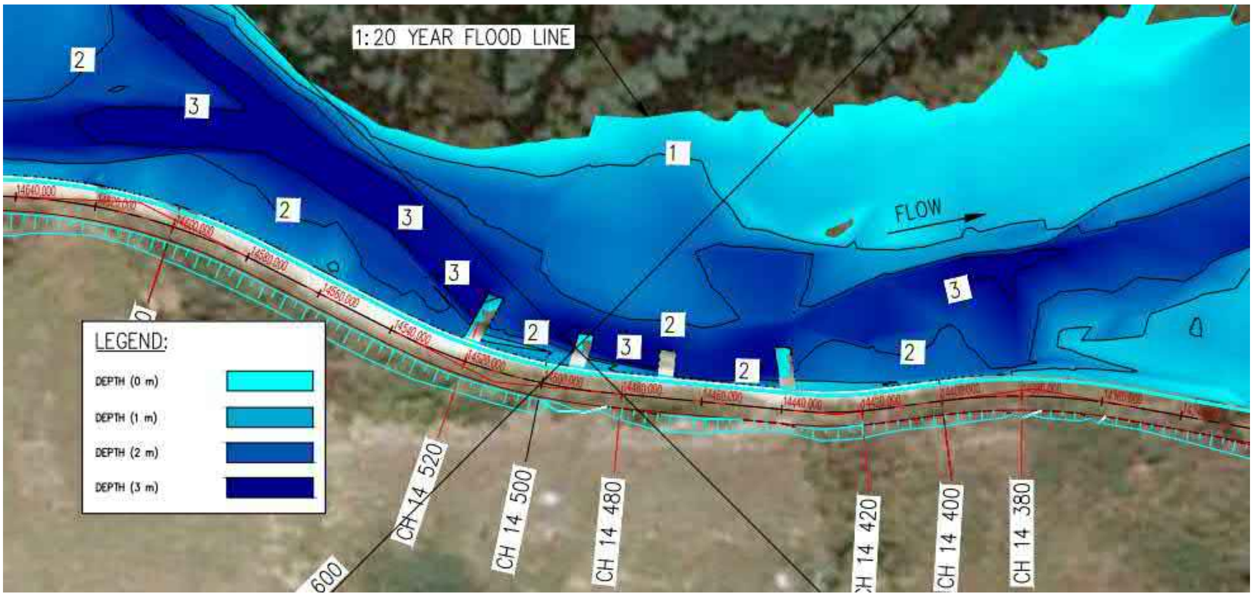

Figure 5 Water Depth Plan for the 1:20 Year Flood

When comparing the initial flow depth (before the inclusion of groynes) with these deviated flow depths, it is clear that the water depth in the modified configuration higher than without the inclusion of the groynes.

This increase in depth is to be expected with the decrease in flow area, but the river flow is still contained within the river banks and does not overtop the road. However, to ensure that the required freeboard is maintained, the 1:40 year flood level must be kept below the shoulder break point. A long section taken on the road is shown in Figure 6, which confirms that this is the case.

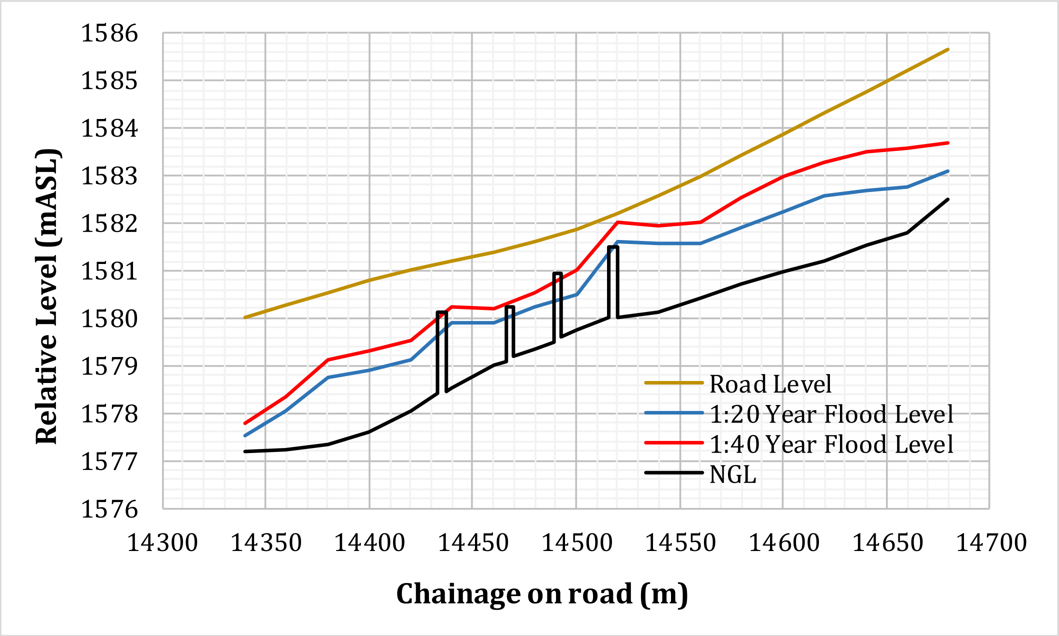

Figure 6 Long Section on Road Indicating the Water Surface Elevation

8.2. FLOW VELOCITY DISTRIBUTION

Velocity is one of the more important input parameters into the scour calculations, and it is with this parameter that a major alteration is necessary. The velocity against the gabion needs to be decreased to prevent excessive scour depths which could influence the stability of the wall in the long term. The velocity for the modified configuration at steady state for the 1:20 year flood is presented in Figure 7.

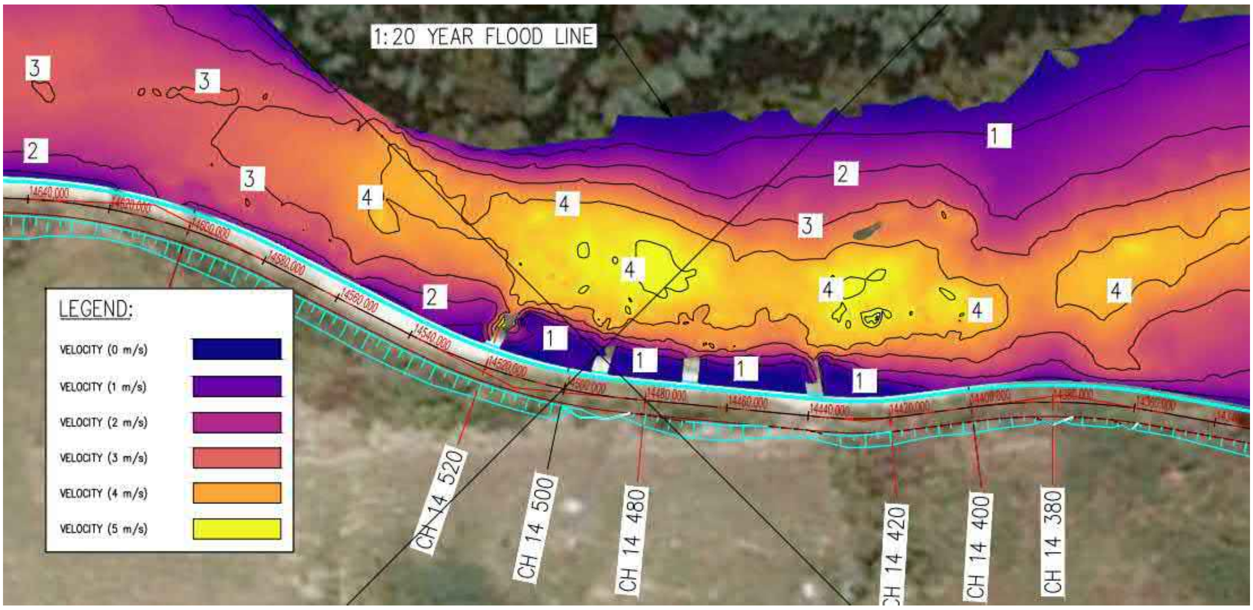

Figure 7 Flow Velocity Distribution Plot for the 1:20 Year Flood at Critical Area

While the unmodified velocity against the wall was around 3.7 m/s at the affected area, it is clear that the addition of the groynes decreases this substantially. An average flow velocity of 0.15 m/s is expected against the gabion wall, with a maximum of 0.7 m/s.

The velocity at the nose of the groynes varies from 3.2 m/s to 2.4 m/s from the upstream to downstream groyne respectively. This is very similar to the initial distribution of velocity in the main river channel. The groynes will be structurally design to both withstand this flow and possible scouring at the toe.

The resulting water surface elevation and flow velocity at various sections along the gabion wall are summarised in Table 2.

Table 2 HEC-RAS Results at Specific Sections along the Gabion Wall

Section Chainage *	1:20 Year Water Surface Elevation at Gabion Wall	Velocity at the Gabion Wall	Velocity at groyne nose
m	Msal	m/s	m/s
14340	1577.525	0.708	N/A
14360	1578.050	1.339	N/A
14380	1578.750	0.555	N/A
14400	1578.905	1.388	N/A
14420	1579.104	0.283	N/A
14437	1579.888	0.070	2.369
14460	1579.901	0.083	N/A
14470	1580.251	0.178	2.261
14480	1580.220	0.561	N/A
14493	1580.506	0.037	1.792
14500	1580.505	0.081	N/A
14520	1581.600	0.802	3.197
14540	1581.583	1.084	N/A

* Road Chainage

Not only does the velocity distribution change, but also the flow pattern. As presented in Figure 8, eddies will form between the groynes which effectively directs the flow towards the new required position. The velocity in these eddies is also much reduced which decreases the scour potential at the gabion wall. The flow pattern is very close to the idealised flow pattern described above.

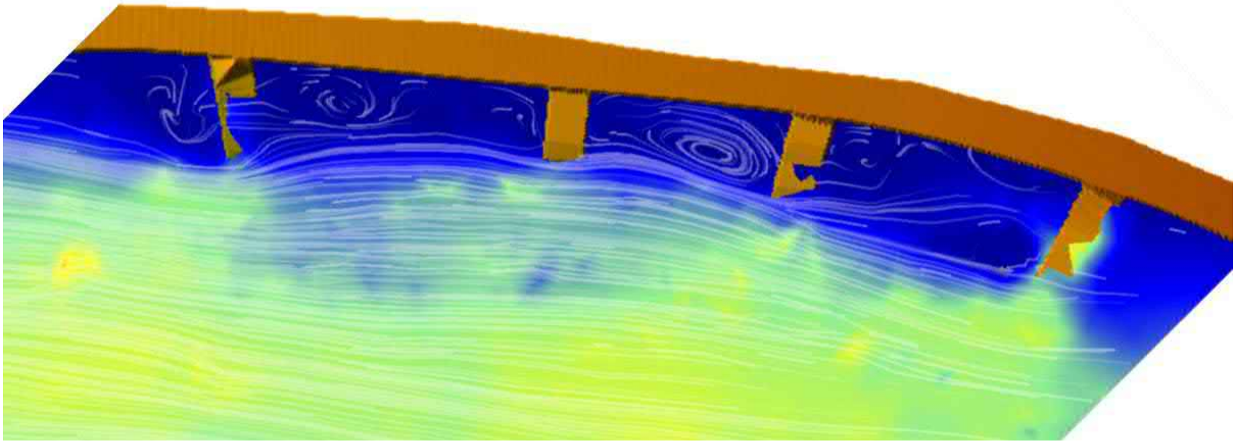

Figure 8 Flow pattern at Groynes at Sani Pass

8.3. MANNING VALUE SENSITIVITY ANALYSES

The roughness coefficient of natural beds depends on many factors, the most significant of those being the corresponding basic bed roughness, the irregularity of the cross section shapes, the occurrence of gullies in the bed and the wearing away of alluviums. The roughness coefficient does not only change along the bed, but also when water level changes occur.

It is therefore important to evaluate the effect of a changed hydraulic roughness regime on both the velocity and more importantly the water surface elevation. A substantial increase in water surface elevation may result in the overtopping of the road or a decreased available freeboard.

A sensitivity analyses was conducted to assess the influence of changes in the hydraulic roughness to the model. The manning values were consequently increased and reduced by 15% in the hydraulic model. The results at Chainage 14 480 is summarised in Figure 9.

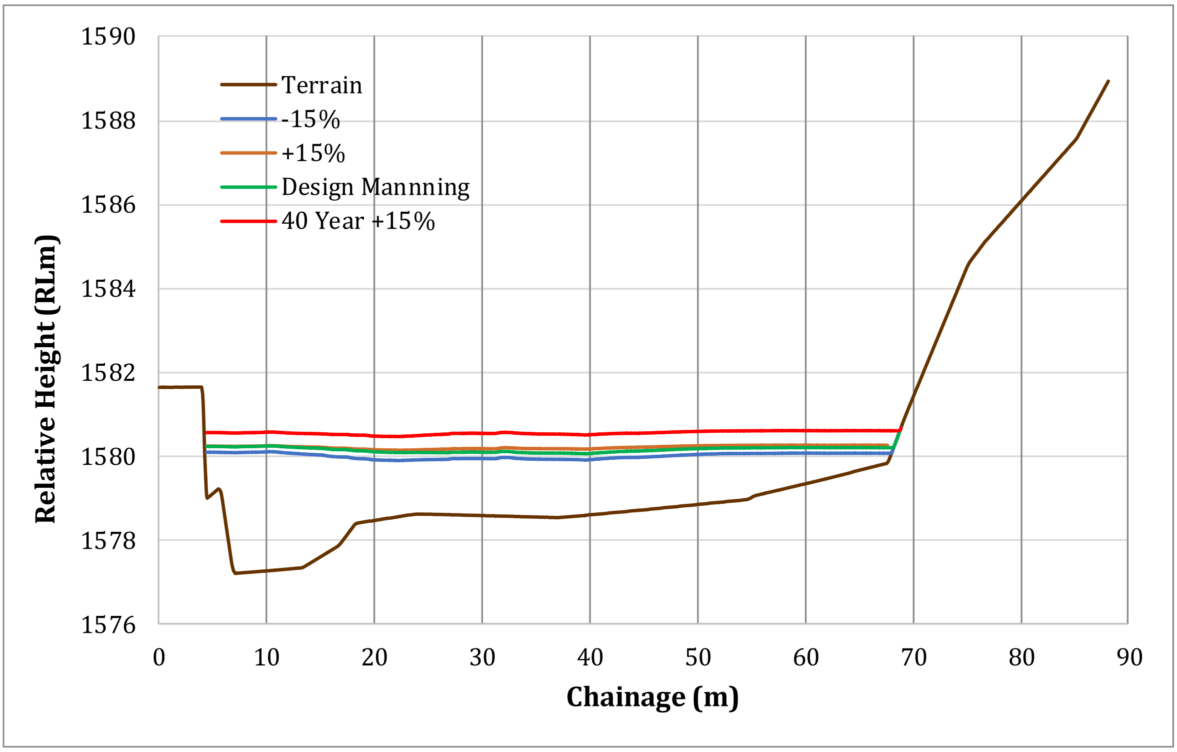

Figure 9 Sensitivity Analyses Results of Adjusting the Manning values by 15%

It can be seen that the change in Manning values has an insignificant influence on the water surface elevation, with the peak simulated water surface elevation deviating from the base analyses by approximately 7.5 %. With the difference being less than the sensitivity adjustment it can be accepted that the model is not prone to erratic variability due to slight changes in the hydraulic roughness in the river.

The insignificant effect of the variance in roughness coefficient is collaborated by the results of the 1:40 year flood with increased Manning values as presented in Figure 9. The required freeboard is maintained even with increased roughness coefficients.

9. SCOUR DEPTH ESTIMATION

9.1. GENERAL

According to NCHRP (2017), river scour is defined as the removal by hydrodynamic forces of granular bed material in the vicinity of the structure. Typically, the gabion wall at the P318 road will constrict the flow under flood conditions and accelerate the flow causing scour at the gabion wall and associated reno mattresses. Centrifugal action will cause scour on the outside of this bend (against the gabion wall), and deposition of soil on the inside bend. The introduction of the groynes will decrease the velocity at the critical area, but a significant velocity is still evident at the nose of the most upstream groyne, and potential for significant scouring can still occur here.

Typically, three types of scour mechanisms can develop at this critical area, namely scour along the longitudinal gabion wall, scour underneath the reno mattresses and scour at the groyne nose.

9.2. MATERIAL PROPERTIES AT STRUCTURE FOUNDATION LEVELS

Material tests were performed both on the material where the reno-mattresses will be founded at the base of the gabion wall and at the nose of the groynes more into the riverbed.

Material tests performed on material samples extracted from Chainage 14200 to 14600 at the proposed gabion wall generally confirmed black silty sand material. Test results (attached herewith in **Appendix A**) indicated that approximately 40% of the founding material passes the 0.075mm sieve. As no other testing was performed on the samples, the material could not be classified.

Four test pits were excavated at approximately the groyne nose positions.

Photos of the main river channel show that the channel is lined with coarse surface material including relatively large boulders. The tests pit profiles at these four test pits (mostly in the riverbed) however indicate that finer material is present below the upper gravel-boulder layer. Test results on material extruded from the test pits revealed a general average particle size (D_{50}) of 13mm at the surface and 40mm some 1m below the surface. While scour will initiate from the surface and larger particle size along the depth of the soil profile will decrease the estimated scour depth, it is clear that the riverbed is moveable material. The smallest particle size will consequently be used for scour estimation calculations to account for this moveable material.

The test results are included in **Appendix A**.

9.3. SCOUR ALONG LONGITUDINAL GABION WALL

The most commonly utilized scour depth prediction near longitudinal walls, are the empirical formulations described in the Hydraulic Engineering Circular No 23 (HEC 23). The Transportation Research Board of National Academies (NCHRP) extended these investigations to include certain vital parameters which were overlooked by HEC 23. These parameters included the properties of the flow, sediment and waterway geometry.

Considering that HEC 23 is still extensively used in the industry, both these methods were employed to estimate the potential scour at the base of the gabion wall on the P318 road. The review is described hereunder.

This scour depth evaluation was only conducted along the critical area of Ch 14 520 to Ch 14 380. The velocity against the gabion wall along this extent will be substantially decreased, but the scour depth was still evaluated for comparison purposes. The scour depth along the rest of the wall as described in ARQ (2017) will still generally be valid.

9.3.1. SCOUR DEPTH ESTIMATION USING HEC 23

As noted in the Detailed Hydraulic Analysis Report (ARQ,2017), the natural flow of the Mkonozana River is characterised by various bends along its length. The main river flow at the bend between chainage 14 400 and chainage 14 500 impinges straight onto the gabion wall with a relatively high velocity. The introduction of the groynes will eliminate the impinging angle, decrease the velocity substantially, and should accordingly decrease the scour depth.

The scour depths estimated using HEC 23 are summarised in Table 3. As listed in this table, the elimination of the impinging angle (together with the decrease in velocity against the wall) will decrease the scour to manageable depths. Certain uncertainties still exist in terms of the selected impinging angles and resulting velocities, and HEC 23 recommends a minimum embedment depth of 0.6 m as a safety factor below the predicted scour depth to be considered as the equilibrium scour depth.

Although the HEC 23 prediction methodology is only a first approximation of the estimated scour depth, it is clear that the introduction of the groynes decreases the estimated scour substantially. The scour was initially estimated to be at its most critical at Chainage 14 480 at approximately 6.7 m, but this is decreased to a manageable 1.58 m. The inclusion of reno-mattresses will effectively manage these estimated scour depths.

Table 3 Scour Depth Estimation along the Gabion Wall using HEC 23

Section Chainage (m)	Estimated Impinging Angle (°)	Scour depth (m) Initial Condition	Estimated Scour Depth(m) Modified with groynes		
		At Impinging Angle	At Impinging Angle	+ 5 ° on Impinging Angle	- 5 ° on Impinging Angle
14680	0	1.70	1.84	2.44	N/A
14600	1	1.40	1.04	1.33	0.97
14520	0	3.71	1.52	2.02	N/A
14480	0	6.13	1.27	1.58	N/A
14450	0	-	1.35	1.50	N/A
14420	1	2.11	1.91	2.27	1.83
14400	0	1.99	1.95	2.55	N/A

9.3.2. SCOUR DEPTH ESTIMATION ACCORDING TO NCHRP

NCHRP (2017) extended the HEC 23 relations by carrying out a series of experimental (large and small scale) investigations and develop more comprehensive relationships for estimating the total scour depth along the base of longitudinal walls. These studies included the effect of turbulence, sediment material, roughness and river geometry.

Two relationships were developed for predicting the maximum scour at the base of longitudinal walls by considering most of the effective flow, sediment, and waterway parameters including sediment particle median grain size, mean- flow velocity, mean-flow depth, angle of installation, effective roughness of longitudinal wall and sinuosity of the waterway. These equations estimate the maximum scour due to both local scour and general scour processes. A linear combination of the two scour depths yields the total scour at the base of the longitudinal walls.

The laboratory results from the samples taken at the four test pits excavated at the groynes were used as input values for the estimation of the scour. The D_{50} particle sizes varied from 13 to 35 mm, and the lowest value of 13 mm was selected as, a conservative but most appropriate value. These scour depths along the length of the road are summarized in Table 4.

Table 4 Estimated Scour Depths along Gabion Wall according to NCHRP (2017)

Section Chainage (m)	Estimated Scour Depth (m)			
	D_{50} =13.0 mm	D_{50} =15 mm	D_{50} =8 mm	D_{50} =20 mm
14680	0.284	0.220	0.680	0.24
14600	0.133	0.102	0.318	0.19
14520	0.250	0.193	0.597	0.39
14480	0.06	0.047	0.144	0.57
14420	0.044	0.034	0.106	0.52
14400	0.273	0.211	0.651	0.48

9.4. SCOUR AT THE GROYNE END

When obstructions such as the groynes are introduced to the river, the scour depth increases locally. The estimation of the scour depth at the nose of the groyne can be estimated with the Niell formula (Niell and Yeremko, 1989).

As per this formula, the scour depth estimation at the nose of the groyne is mainly governed by the particle size (D_{50}), the flow depth and the discharge per metre width. The estimated scour depth at the nose of the four groynes are listed in Table 5.

Table 5 Scour Depth Estimation at Groyne Nose

Groyne Number	Estimated D_{50} particle size (mm)	Discharge per m ($m^3/s/m$)	Flow Depth (m)	Estimated scour depth (m)
01	13	5.37	3.1	0.789
02	19	5.06	2.8	0.830
03	35	4.77	2.9	0.765
04	15	4.88	2.8	0.817

The nose of the groynes will consequently be founded below the estimated scour depth, with a safety margin of a nominal 0.3 m. In this case all the groynes will be founded at 1.1 m below the river bed level.

10. STRUCTURAL STABILITY OF GROYNES

10.1. SECTIONAL STABILITY

As indicated on the typical long section of the proposed groyne structures in Figure 10, it is necessary to reduce vertical (stepped) faces as far as possible. The horizontal and sloped faces will prevent additional vortices which can erode the riverbed. In order to ensure minimum impact on the environment, different parts of the groyne need to be constructed at various heights. The main body of the groyne was designed at a convenient height between the 1:10 and 1:20 year flood height, while the shoulder of the groyne was designed to prevent overtopping by the 1:20 year flood at the proposed gabion wall.

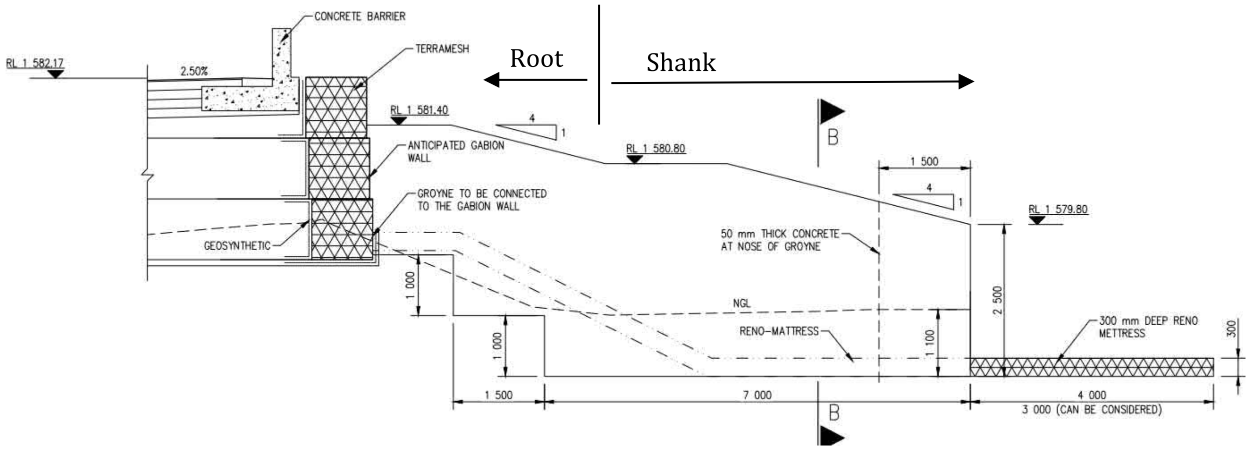

Figure 10 Typical Section through Groyne

It is common practice to make the shank 4 m thick to ensure the groynes stability under all conditions. To save gabion costs, it is recommended that the outside is constructed with gabions while the space between the two gabions is filled with a compacted gravel sausage contained above and below with gabion mesh fastened to the exterior gabion walls. The thicker shank will ensure stability of the structure under shock loading (tree stumps striking the structure) and will ensure structure stability when local scour holes develop.

Refer to Drawing No 81444-013-016 (in Appendix B) for conceptual sections and details on the groynes and specifically cross sections through the shank.

10.2. PROTECTION AGAINST SCOUR AND EXTERNAL FORCES

To prevent the nose of the groyne settling into a scour hole, the following protection methods are recommended:

- The foundation level of the structure must be at the estimated scour depth, with an additional nominal 0.3m for safety. In this case, the groynes will be founded 1.1 m below the river bed level.
- There must be no additional unnecessary vertical faces on the long section that can cause vortices.
- A 4 m wide reno mattress is normally provided around the base of the entire structure to protect the foundation material against floods. The complete effect of scouring at the gabion nose is not completely known, and the shortening of the reno mattresses can be considered. These mattresses must be at founding level around the nose and shank and can then be landscaped up to the top of the bank.

In order to protect the wires of the baskets against tearing from rolling rocks and floating tree stumps, all exposed wires and gabions around the nose of the structure must be covered with 50 mm concrete. The concrete layer is placed with open joints at 500 mm in both directions to allow some flexibility of the structure.

11. MONITORING AND REPAIR

Monitoring of the groynes forms an integral part of its life cycle. A regular structural forcing monitoring programme enables structures to be evaluated for safety, condition and functionality. This allows for timely planning of repair and replacement activities and can provide an adequate understanding of failure mechanisms and damage trends.

Major failures arising from storm action are easily identified, but without monitoring small changes may go undetected and they may ultimately result in the failure of the groynes or unacceptable large settlements. Quantitative description of the condition of the structure needs to relate to the potential failure modes, focusing on those that have been identified as the most likely and should be able to identify these responses.

Structural condition monitoring at regular intervals are consequently recommended through the lifetime of the groynes. Condition monitoring of the groynes provides the information necessary to make an updated evaluation of the structure integrity, either periodically or after extreme events, so that the appropriate maintenance action can be carried out. Structure conditions always involves visual inspection and, in some cases, includes measurements to evaluate the current structure condition relative to the baseline condition. After initial structure adjustment and settlement, most significant changes occur during storm events. The monitoring plan should provide enough flexibility in scheduling to accommodate the irregularity of severe storms.

12. RISK ASSESSMENT

As various input factors could influence the estimated scour depths, a simple risk assessment was undertaken and is summarized in Table 6.

Table 6 Risk Assessment

Input	What does it affect?	Actions Performed to mitigate the risk	Further Actions Required
Roughness Coefficient – Manning's values	Velocity and height of water in channel	Sensitivity analysis Performed	Sensitivity adequate
Material Particle size distribution	Scour depth	Sensitivity range analysis performed	Particle size distribution required from additional test results
Flow > Q_{20}	Flow depth and velocity and potential scour depth	None- Evaluation was based on the required design flood	Accept that potential scour can occur and repair scour damage after flooding

13. CONCLUSIONS

State of the art design procedures were used to confirm and design impermeable groyne structures such that only eddies will form between the groynes, an in so doing decrease both the impinging flow angle and velocity.

The formation of the eddies at the groynes directed the main river flow away from the proposed gabion wall. . These eddies will decrease the velocity against the proposed gabion wall substantially, and the estimated scour depth will consequently decrease within manageable limits. Scour will be effectively managed with the design of a conventional revetment structure in the form of reno-mattresses between the groynes.

Yours faithfully

MBlaeser

Michelle Blaeser
For **ARQ (Pty) Ltd**

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US Department of Transportation. 2009. Fe*deral Highway Administration Bridge Scour and Stream Instability Countermeasures*. Hydraulic Engineering Circular No 23. Publication No FHWA-NHI-09-111.

Hans King. 2015. *2015 State of the art: The use of groynes for riverbank erosion protection*.

APPENDIX A
TEST RESULTS

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY
Reg. No : 1965 / 009585 / 07
25 WESTMEAD ROAD - WESTMEAD P.O.BOX 15318 WESTMEAD 3608 KWAZULU - NATAL
TELEPHONE : 031 7004325 TELEFAX : 031 7001909 email : soilslab@mweb.co.za

Project : Sani Pass P318 Phase 2
Client : D O T (KZN)
Contractor : Leomat
tested by : Site Laboratory

Request No. : 1011
Request by : V.Mkhize
Date Received : 09-11-2017
Date Reported : 17-11-2017

MATERIALS TEST REPORT

Laboratory Number	* 420	* 421	422	423	424
Field Number	A	B	C	D	E
Section In Field	14+020 - 17+170 (RHS + LHS)				
Layer Tested	Sampling for Materail Classification (Gabions & Terramesh)				
Position in field	14+040 RHS	14+130 RHS	14+840 RHS	15+020 RHS	15+080 LHS
Source of Material	Insitu	Insitu	Insitu	Insitu	Insitu
Depth (mm)	+/- 1500	+/- 1500	+/- 1500	+/- 1500	+/- 1500
Sample Description	Dk. Br. Silty Sand	Dk. Br. Silty Sand	Lt Br. Silty Sand + Shale.	Dk Br Silty Sand	Dk Br Greyish Silty Sand +Clay
Stabilising Agent	Natural	Natural	Natural	Natural	Natural

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

100,0	mm	Percentage Passing					
75 0	mm				100		
63 0	mm				73		
53,0	mm				73		
37 5	mm				63		
26,5	mm		100	100	61		
19,0	mm		98	98	55		
13,2	mm		97	97	48		
4,75	mm		95	95	41	100	
2.0	mm		92	91	36	99	100
0.425	mm		77	79	30	98	99
0.075	mm		56	57	18	89	93
Grading Modulus			0,75	0,72	2,16	0,59	0,08

Mechanical Analysis TMH1 - Method A5

Coarse Sand	(%)	15	13	18	10	1
Coarse - Fine Sand	(%)	6	6	8	9	1
Medium - Fine Sand	(%)	7	7	9	14	2
Fine - Fine Sand	(%)	10	11	16	13	4
Silt and Clay	(%)	61	63	50	55	93

Atterberg Limits - TMH1 - Methods A2, A3, A4

Liquid Limit	(%)	29	33	24	27	50
Plasticity Index	(%)	10	12	4	9	17
Linear Shrinkage	(%)	5,6	6,3	2,1	4,0	8,7
Classification Group Index		A6	A6	A-2-4	A-4	A-7-5
COLTO Classification	#	**G10**	**G10**	**G7**	**G9**	**N/A**
TRH 14 Classification (1985)	#	**G10**	**G10**	**G7**	**G9**	**N/A**

Maximum Dry Density and Optimum Moisture Content - TMH1 - Method A7

Maximum Dry Density	(kg/m3)	1734	1706	1895	1744	1638
Optimum Moisture Content	(%)	17,3	18,9	12,4	18,2	20,7

California Bearing Ratio - TMH1 - Method A8

CBR	@	100 %	Compaction	11	8	59	13	2
CBR	@	98 %	Compaction	6	5	45	11	2
CBR	@	95 %	Compaction	4	3	26	10	2
CBR	@	93 %	Compaction	3	3	16	8	2
CBR	@	90 %	Compaction	3	3	8	6	1
Swell	@	100 %	Compaction	0,20	0,28	0,12	0,52	0,35

The above test results are pertinent only to the samples received and tested at the laboratory. This report shall not be reproduced, except in full, without the prior consent of Soilco Materials Investigations Pty Ltd. # Opinions and interpretations expressed herein are Outside the Scope of SANAS Accreditation.

The Colto / TRH 14 Classifications are only based on the above results. Further testing may be required.

Remarks : - ____________________

For Soilco : - ________ **Date :-** 22.11.2017 **Engineer : -** ________ **Date : -** 22/11/2017

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

Reg No. : 1965 / 009585 / 07
25 WESTMEAD ROAD - WESTMEAD P.O. BOX 15318 WESTMEAD 3608 KWA ZULU - NATAL
TELEPHONE : 031 7004325 TELEFAX : 031 7001909 email : soilslab@mweb.co.za

Client : KZN (D.O.T)
Project : P318 Sani Pass Phase 2
Contractor :
Tested By : Site Laboratory

Req . No. Katy
Date Received 06-06-2018
Date Tested 06-06-2018
Date Reported 11-06-2018

AGGREGATE TEST REPORT

Laboratory No.	1168	1169	1170	1171	1172
Field No.	1 - Top	2 - Top	2 - Bottom	3 - Top	3 - Bottom
Section Tested	14+437 - 14+520 RHS				
Position in Field	14+520 (Top)	14+493 (Top)	14+493 (Btm)	14+470 (Top)	14+470 (Btm)
Source	In situ	In situ	In situ	In situ	In situ
Layer Tested	-	-	-	-	-
Material Description	River Sand With Large Boulders	River Sand With Large Boulders	River Sand With Large Boulders	River Sand With Large Boulders	River Sand With Large Boulders

Sieve Analysis (% Passing) SANS AG 1

Sieve Aperture	100,0	mm	94	100	93	100	81
	75,0	mm	80	92	80	84	78
	63,0	mm	78	89	74	72	78
	50,0	mm	72	79	66	59	64
	37,5	mm	65	63	57	41	52
	28,0	mm	62	57	54	37	45
	20,0	mm	58	51	50	33	37
	14,0	mm	51	46	47	28	32
	10,0	mm	46	41	43	25	29
	7,1	mm	42	37	39	22	25
	5,0	mm	38	33	35	20	23
	2,0	mm	28	23	25	14	17
	1,0	mm	17	16	17	9	12
	0,600	mm	11	13	13	6	10
	0,425	mm	9	11	11	5	9
	0,300	mm	6	8	8	4	7
	0,150	mm	4	5	6	3	5
	0,075	mm	3	3	4	3	3

Material Characteristics

Fineness Modulus			SANS PR 5					
Flakiness Index		(%)	SANS AG 4					
Average Least Dimension		(mm)	SANS AG 2					
Aggregate Crushing Value		(%)	SANS AG 10					
10% Fact	(Dry)	(Kn)						
	(Wet)	(Kn)						
	Wet / Dry Ratio	(%)						
pH Value	*	(%)	TMH 1 A20					
Organic Impurity			TMH 1 B6					
Apparent Density		(kg / m^3)	SANS AG 22					
Methylene Blue		(%)	SANS 1243					
Los Angeles Abrasion	*	(%)						
Water Absorption		(%)	SANS AG 20 or 21					
Bulk Density		(kg / m^3)						
Apparent Density		(kg / m^3)						

Remarks :

For Soilco :

Date: 11.06.2018

Engineer: KBrien

Date: 11/06/2018

SOILCO MATERIALS INVESTIGATIONS (PTY) LTD

CIVIL ENGINEERING MATERIALS TESTING LABORATORY

SOILCO
Reg No. : 1965 / 009585 / 07
25 WESTMEAD ROAD - WESTMEAD P.O. BOX 15318 WESTMEAD 3608 KWA ZULU - NATAL
TELEPHONE : 031 7004325 TELEFAX : 031 7001909 email : soilslab@mweb.co.za

Client : KZN (D.O.T)
Project : P318 Sani Pass Phase 2
Contractor :
Tested By : Site Laboratory

Req . No. Katy
Date Received 06-06-2018
Date Tested 06-06-2018
Date Reported 11-06-2018

AGGREGATE TEST REPORT

Laboratory No.	1173	1174			
Field No.	4 - Top	4 - Bottom			
Section Tested	14+437 - 14+520 RHS				
Position in Field	14+437 (Top)	14+437 (Btm)			
Source	In situ	In situ			
Layer Tested	-	-			
Material Description	River Sand With Large Boulders	River Sand With Large Boulders			

Sieve Analysis (% Passing) SANS AG 1

Sieve Aperture	**100,0**	**mm**	100	100			
	75,0	**mm**	94	63			
	63,0	**mm**	90	54			
	50,0	**mm**	76	46			
	37,5	**mm**	66	38			
	28,0	**mm**	61	35			
	20,0	**mm**	55	32			
	14,0	**mm**	49	29			
	10,0	**mm**	44	28			
	7,1	**mm**	40	26			
	5,0	**mm**	35	24			
	2,0	**mm**	24	18			
	1,0	**mm**	14	12			
	0,600	**mm**	9	8			
	0,425	**mm**	8	6			
	0,300	**mm**	6	3			
	0,150	**mm**	4	2			
	0,075	**mm**	3	1			

Material Characteristics

Fineness Modulus			**SANS PR 5**					
Flakiness Index		**(%)**	**SANS AG 4**					
Average Least Dimension		**(mm)**	**SANS AG 2**					
Aggregate Crushing Value		**(%)**	**SANS AG 10**					
10% Fact	**(Dry)**	**(Kn)**						
	(Wet)	**(Kn)**						
	Wet / Dry Ratio	**(%)**						
pH Value	*	**(%)**	**TMH 1 A20**					
Organic Impurity			**TMH 1 B6**					
Apparent Density		**(kg / m^3)**	**SANS AG 22**					
Methylene Blue		**(%)**	**SANS 1243**					
Los Angeles Abrasion	*	**(%)**						
Water Absorption		**(%)**	**SANS AG 20 or 21**					
Bulk Density		**(kg / m^3)**						
Apparent Density		**(kg / m^3)**						

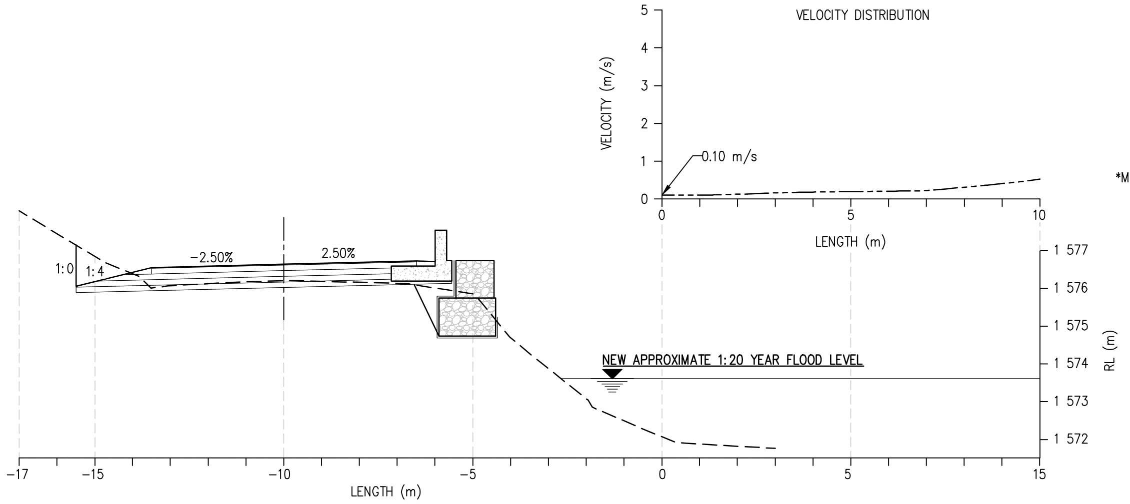
Remarks :

For Soilco : Date: 11.05.2018 Engineer: OBrien Date: 11/06/2018

APPENDIX B
CONCEPTUAL DRAWINGS

LEGEND:

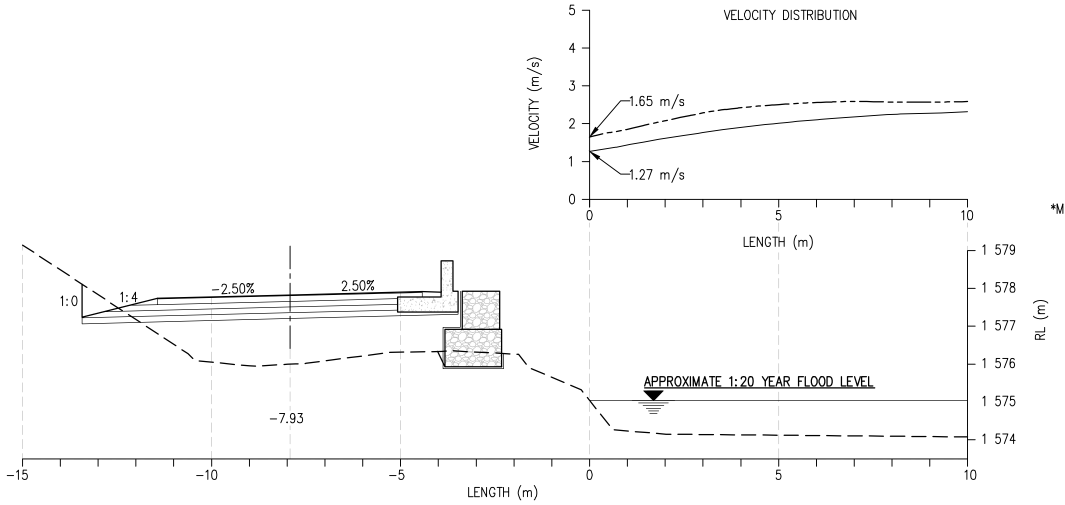
WATER VELOCITY WITH GROYNES	— · — · —
WATER VELOCITY WITHOUT GROYNES	———



CHAINAGE 14 120
SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	N/A
MODIFIED	1 573.61

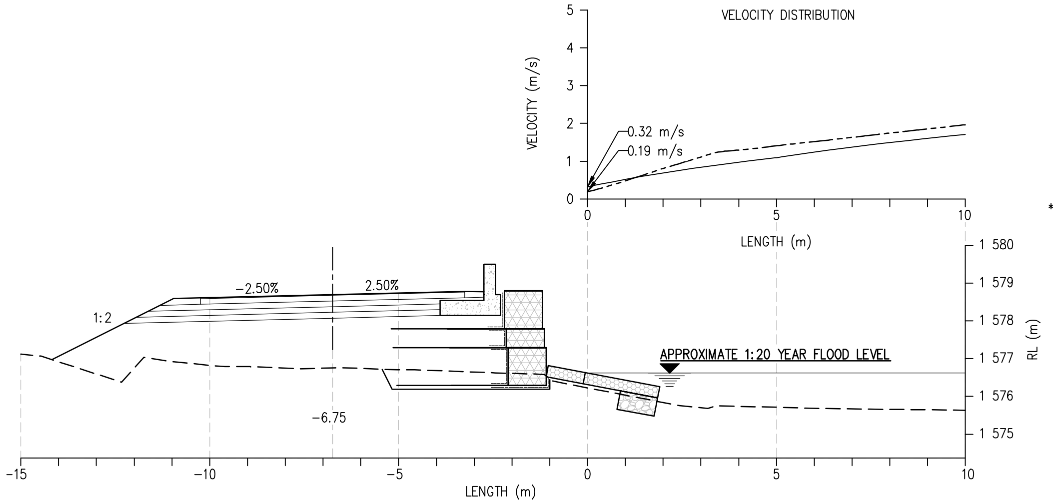
*MODIFIED WITH ADDITION OF GROYNES



CHAINAGE 14 200
SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	1 575.04
MODIFIED	1 575.10

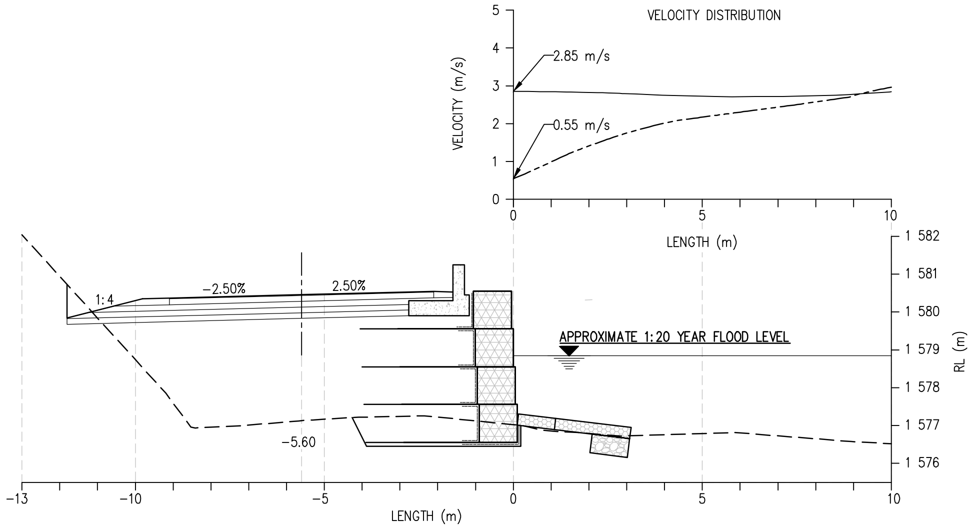
*MODIFIED WITH ADDITION OF GROYNES



CHAINAGE 14 280
SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	1 576.62
MODIFIED	1 576.54

*MODIFIED WITH ADDITION OF GROYNES



CHAINAGE 14 380
SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	1 578.85
MODIFIED	1 578.78

*MODIFIED WITH ADDITION OF GROYNES

NOTE:

WATER SURFACE ELEVATION AND VELOCITY WAS BASED ON TOPOGRAPHICAL SURVEY RECEIVED FROM SITE.

No.	DATE	REVISION	APPROVED
A	14/06/18	DESIGN REPORT	
00	17/01/18	EVALUATION REPORT	

LIST OF ASSOCIATED DRAWINGS

SHEET	DESCRIPTION	DWG. No.
2/5	VELOCITY AND DEPTH DISTRIBUTION PLAN	8144-003
1/5	WATER SURFACE FLOOD LINE	8144-002

ARQ (PTY) LTD.
6 DAVENTRY STREET
LYNNWOOD MANOR
0081 RSA
TEL : 012 348 6668
FAX : 012 348 6669
EMAIL : dams@arq.co.za

CONSULTING ENGINEERS

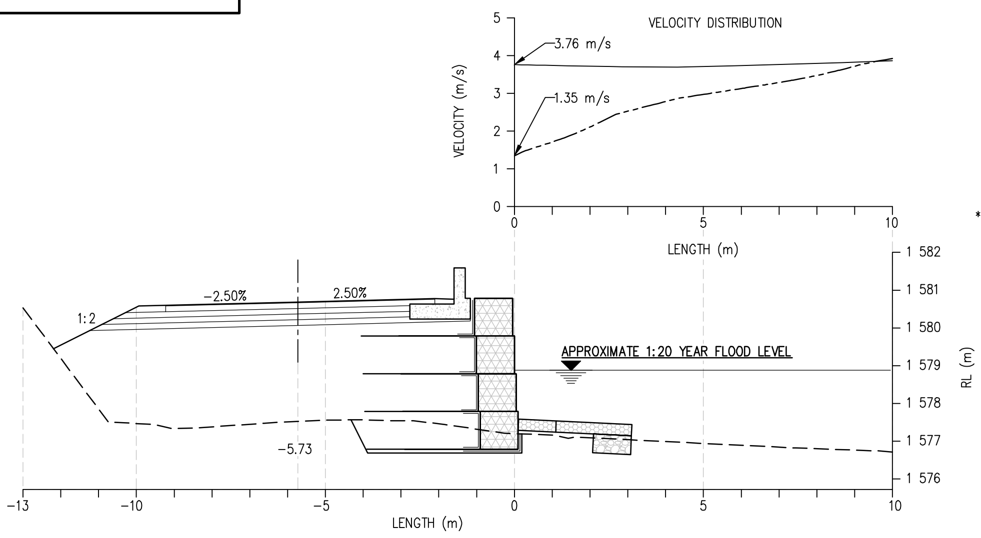
THE MASTER HELD AT THE ARQ HEAD OFFICE, BEARS THE ORIGINAL SIGNATURE OF APPROVAL

CLIENT: Royal HaskoningDHV Enhancing Society Together

PROJECT: SANI PASS HYDROLOGY	DRAWN: GS	SHEET SIZE: A1	SHEET No: 3/5
TITLE: HYDROLOGY CROSS SECTIONS: VELOCITY & FLOOD LEVELS CH 14 120 – CH 14 380	DESIGNED: MB	DATE: 14/06/2018	REV No: A
	CHECKED: DCE	DRAWING No: 8144–004	

LEGEND:

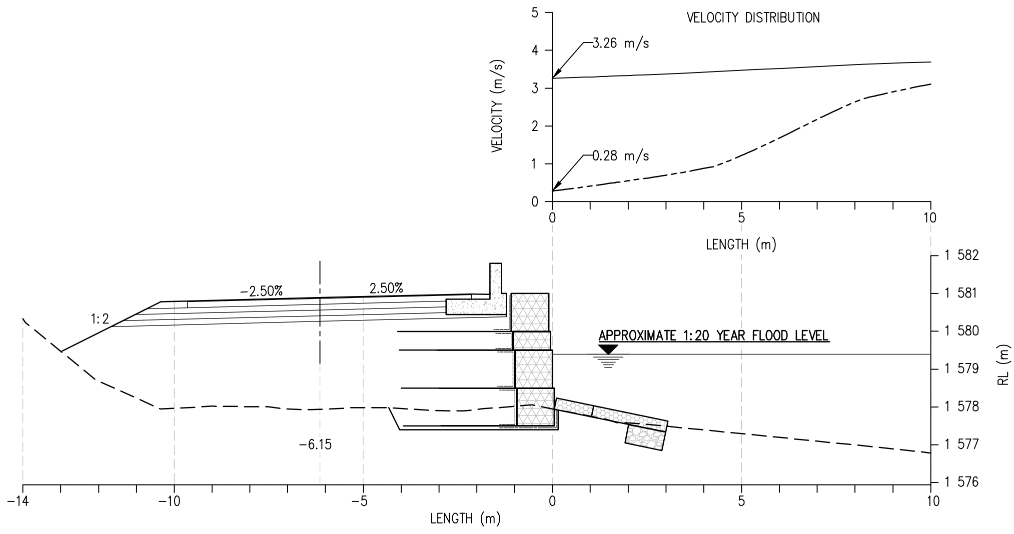
WATER VELOCITY WITH GROYNES	— · — · —
WATER VELOCITY WITHOUT GROYNES	———



DESCRIPTION	LEVEL (m)
INITIAL	1 578.88
MODIFIED	1 578.92

*MODIFIED WITH ADDITION OF GROYNES

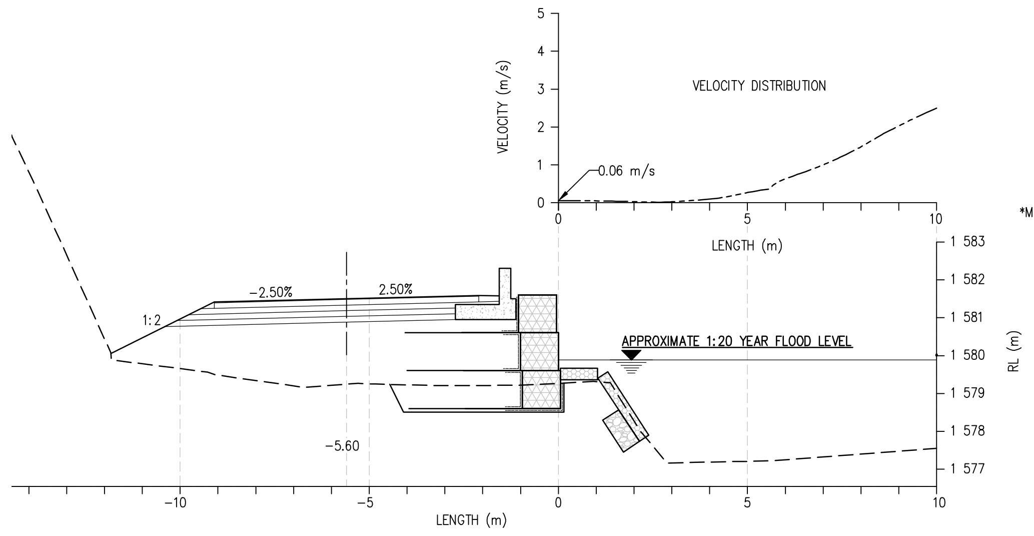
CHAINAGE 14 400
SCALE 1:100



DESCRIPTION	LEVEL (m)
INITIAL	1 579.39
MODIFIED	1 579.10

*MODIFIED WITH ADDITION OF GROYNES

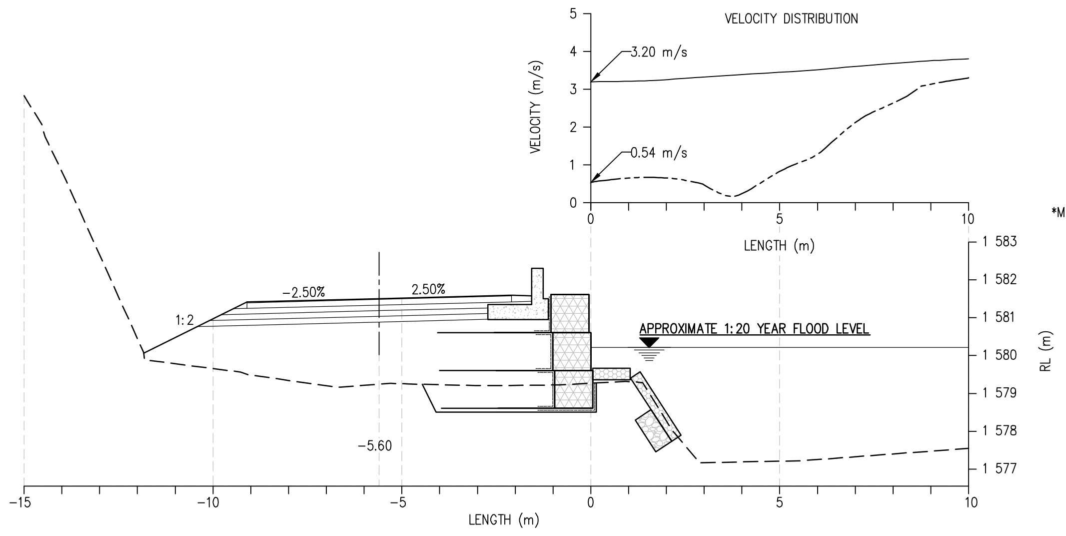
CHAINAGE 14 420
SCALE 1:100



DESCRIPTION	LEVEL (m)
INITIAL	N/A
MODIFIED	1 579.89

*MODIFIED WITH ADDITION OF GROYNES

CHAINAGE 14 460
SCALE 1:100



DESCRIPTION	LEVEL (m)
INITIAL	1 580.22
MODIFIED	1 580.20

*MODIFIED WITH ADDITION OF GROYNES

CHAINAGE 14 480
SCALE 1:100

NOTE:

WATER SURFACE ELEVATION AND VELOCITY WAS BASED ON TOPOGRAPHICAL SURVEY RECEIVED FROM SITE.

No.	DATE	REVISION	APPROVED
A	14/06/18	DESIGN REPORT	
00	17/01/18	EVALUATION REPORT	

LIST OF ASSOCIATED DRAWINGS

SHEET	DESCRIPTION	DWG. No.
2/5	VELOCITY AND DEPTH DISTRIBUTION PLAN	8144-003
1/5	WATER SURFACE FLOOD LINE	8144-002

ARQ CONSULTING ENGINEERS

ARQ (PTY) LTD.
6 DAVENTRY STREET
LYNNWOOD MANOR
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TEL : 012 348 6668
FAX : 012 348 6669
EMAIL : dams@arq.co.za

THE MASTER HELD AT THE ARQ HEAD OFFICE, BEARS THE ORIGINAL SIGNATURE OF APPROVAL

CLIENT: Royal HaskoningDHV Enhancing Society Together

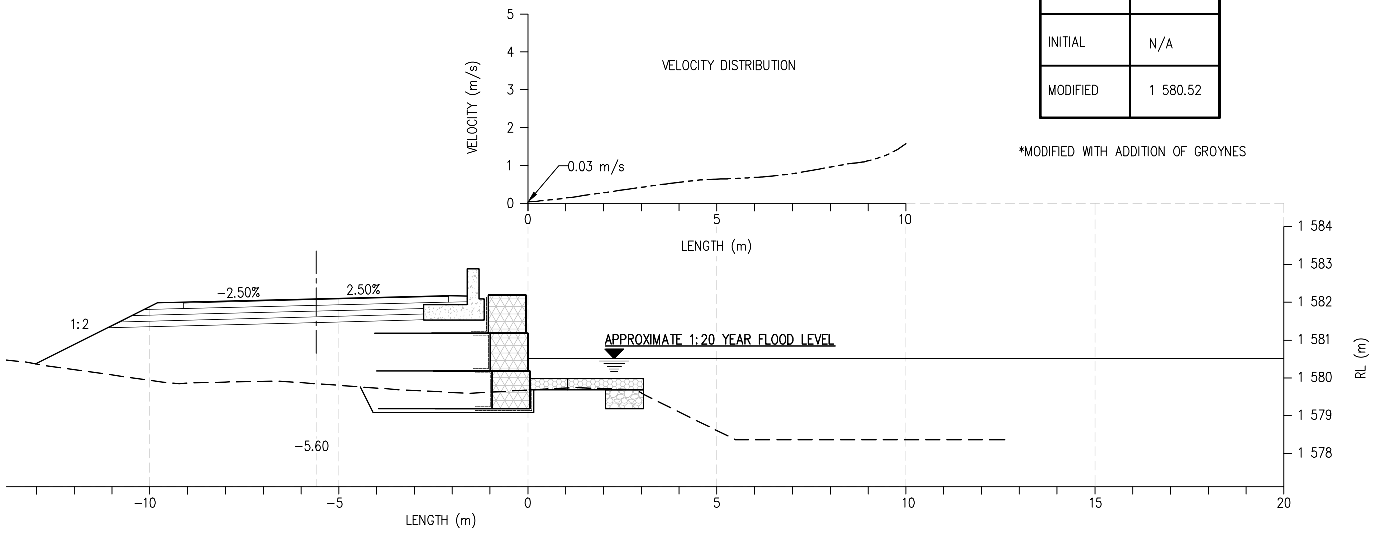
PROJECT: SANI PASS HYDROLOGY

TITLE: HYDROLOGY
CROSS SECTIONS: VELOCITY & FLOOD LEVELS
CH 14 400 – CH 14 480

DRAWN: GS	SHEET SIZE: A1	SHEET No: 4/5
DESIGNED: MB	DATE: 14/06/2018	REV No: A
CHECKED: DCE	DRAWING No: 8144-005	

LEGEND:

WATER VELOCITY WITH GROYNES	– · – · –
WATER VELOCITY WITHOUT GROYNES	——

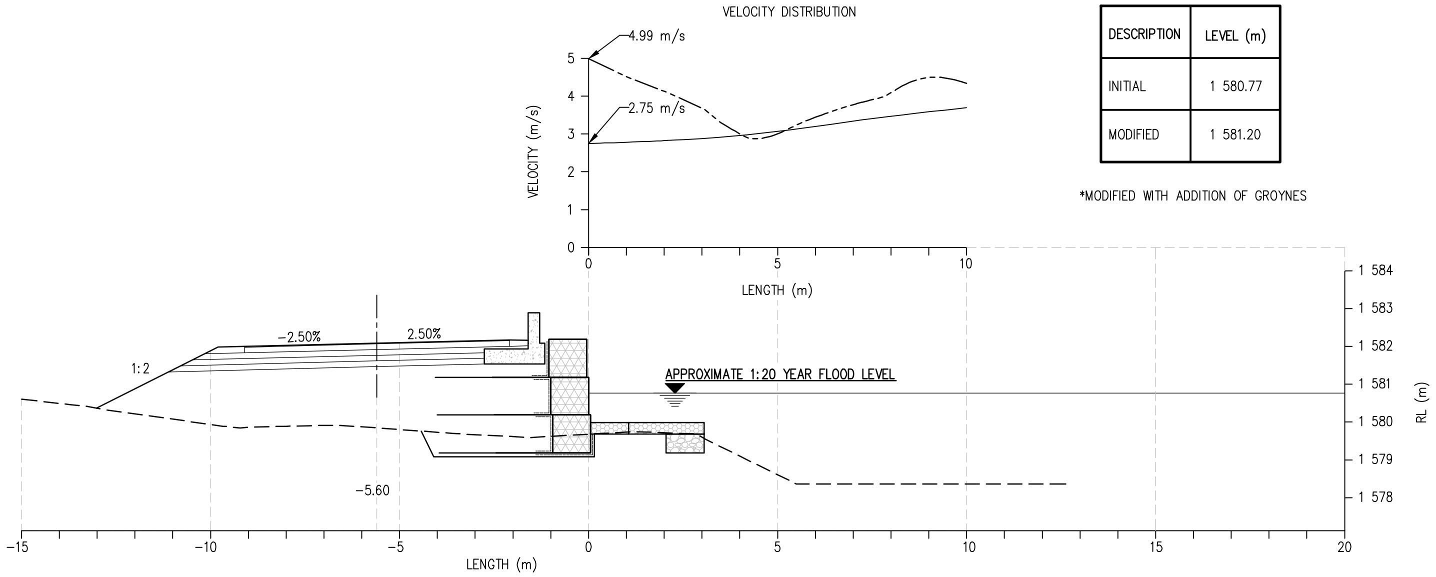


CHAINAGE 14 505

SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	N/A
MODIFIED	1 580.52

*MODIFIED WITH ADDITION OF GROYNES

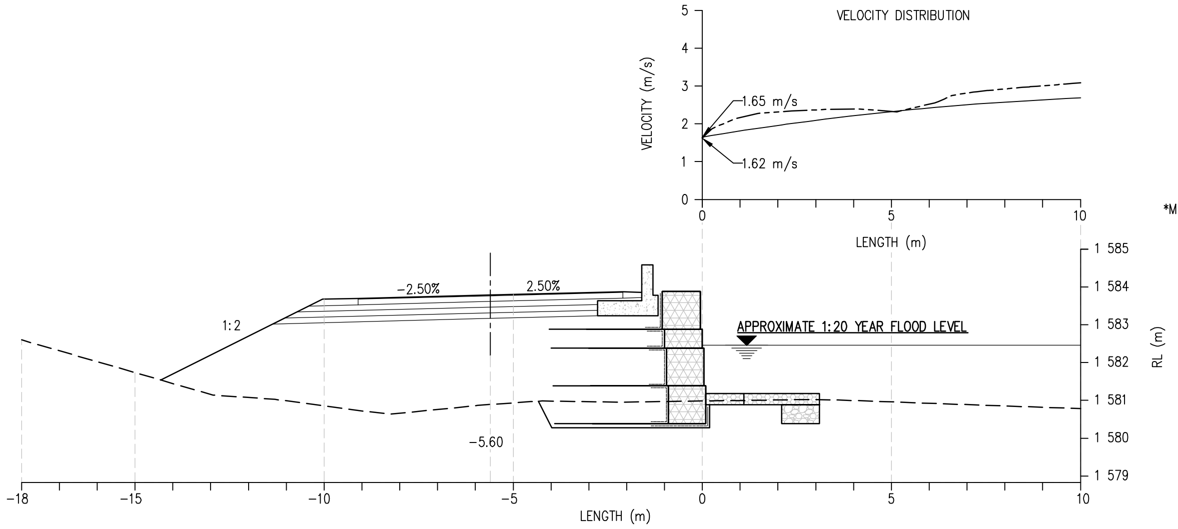


CHAINAGE 14 520

SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	1 580.77
MODIFIED	1 581.20

*MODIFIED WITH ADDITION OF GROYNES

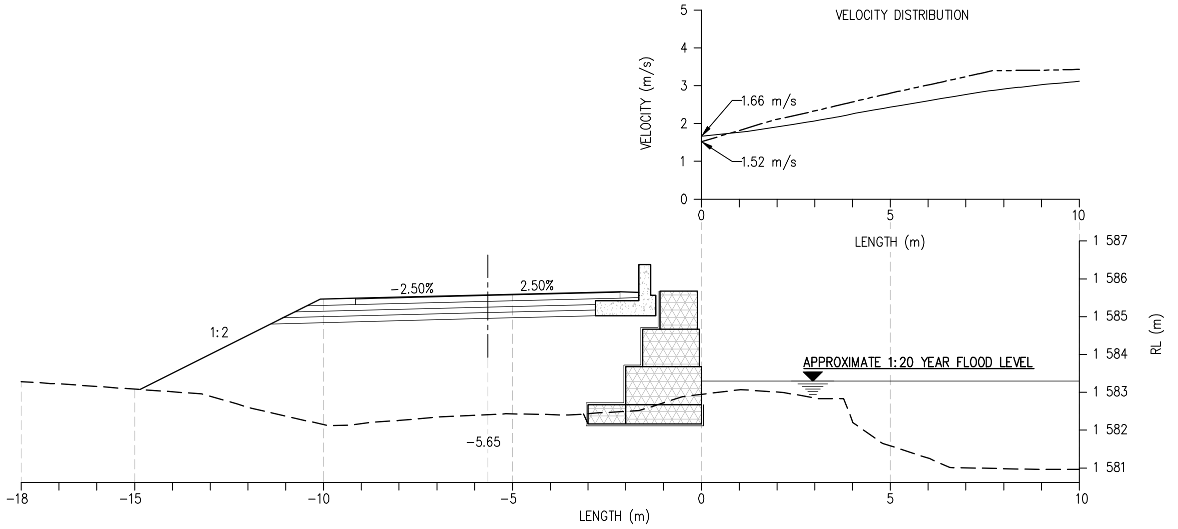


CHAINAGE 14 600

SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	1 582.46
MODIFIED	1 582.25

*MODIFIED WITH ADDITION OF GROYNES



CHAINAGE 14 680

SCALE 1:100

DESCRIPTION	LEVEL (m)
INITIAL	1 583.30
MODIFIED	1 583.10

*MODIFIED WITH ADDITION OF GROYNES

NOTE:

WATER SURFACE ELEVATION AND VELOCITY WAS BASED ON TOPOGRAPHICAL SURVEY RECEIVED FROM SITE.

No.	DATE	REVISION	APPROVED
A	14/06/18	DESIGN REPORT	
00	17/01/18	EVALUATION REPORT	

LIST OF ASSOCIATED DRAWINGS

SHEET	DESCRIPTION	DWG. No.
2/5	VELOCITY AND DEPTH DISTRIBUTION PLAN	8144−012
1/5	WATER SURFACE FLOOD LINE	8144−011

ARQ CONSULTING ENGINEERS

ARQ (PTY) LTD.
6 DAVENTRY STREET
LYNNWOOD MANOR
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TEL : 012 348 6668
FAX : 012 348 6669
EMAIL : dams@arq.co.za

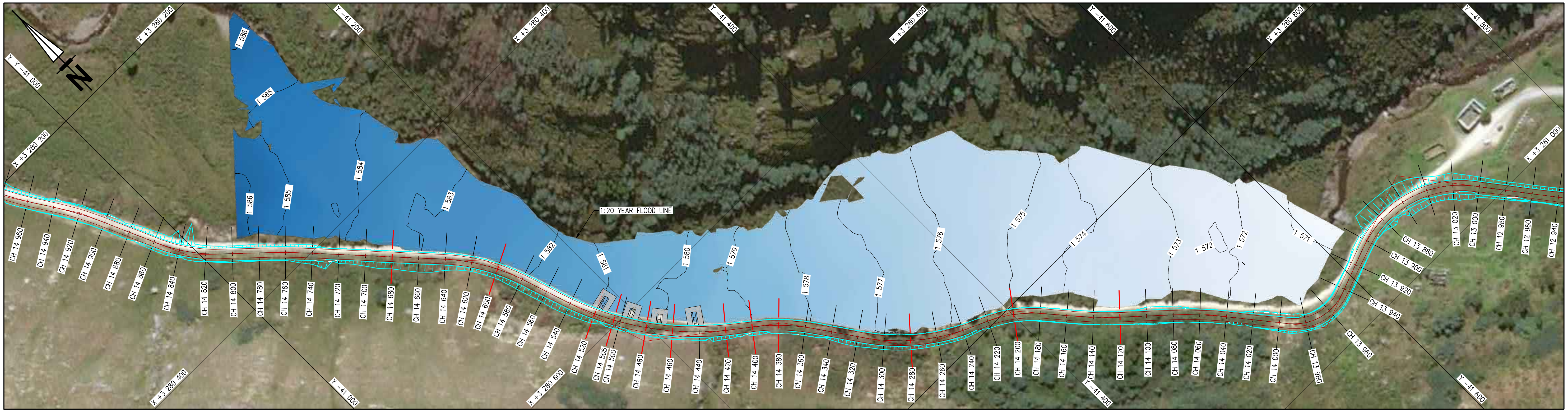
THE MASTER HELD AT THE ARQ HEAD OFFICE, BEARS THE ORIGINAL SIGNATURE OF APPROVAL

CLIENT:
Royal HaskoningDHV
Enhancing Society Together

PROJECT: SANI PASS HYDROLOGY

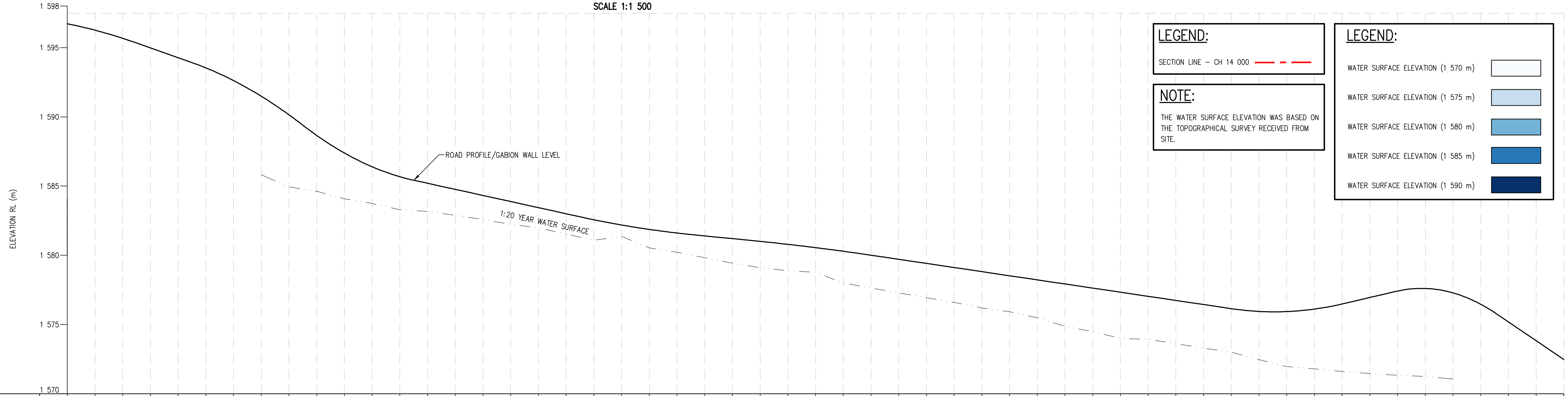
TITLE:
HYDROLOGY
CROSS SECTIONS: VELOCITY & FLOOD LEVELS
CH 14 505 AND CH 14 680

DRAWN: GS
DESIGNED: MB
CHECKED: DCE
SHEET SIZE: A1
DATE: 14/06/2018
DRAWING No: 8144−006
SHEET No: 5/5
REV No: A



1:20 YEAR WATER SURFACE ELEVATION

SCALE 1:1 500



LEGEND:

SECTION LINE – CH 14 000

NOTE:

THE WATER SURFACE ELEVATION WAS BASED ON THE TOPOGRAPHICAL SURVEY RECEIVED FROM SITE.

LEGEND:

WATER SURFACE ELEVATION (1 570 m)	
WATER SURFACE ELEVATION (1 575 m)	
WATER SURFACE ELEVATION (1 580 m)	
WATER SURFACE ELEVATION (1 585 m)	
WATER SURFACE ELEVATION (1 590 m)	

CHAINAGE ON ROAD (m)	14 920	14 900	14 880	14 860	14 840	14 820	14 800	14 780	14 760	14 740	14 720	14 700	14 680	14 660	14 640	14 620	14 600	14 580
FREEBOARD (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.303	2.651	2.380	2.035	1.878	1.729	1.425	1.456
1:20 YEAR WATER SURFACE ELEVATION (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1 585.812	1 584.943	1 584.620	1 584.084	1 583.741	1 583.295	1 583.165	1 582.882	1 582.591	1 582.228	1 581.984
GABION LEVEL (m)	N/A	N/A	N/A	N/A	1 594.269	N/A	N/A	N/A	N/A	N/A	1 587.387	1 586.392	1 585.675	1 585.200	1 584.760	1 584.320	1 583.880	1 583.440

CHAINAGE ON ROAD (m)	14 560	14 540	14 520	14 500	14 480	14 460	14 440	14 420	14 400	14 380	14 360	14 340	14 320	14 300	14 280	14 260	14 240	14 220	14 200
FREEBOARD (m)	1.465	1.486	1.421	1.330	1.503	1.579	1.765	1.608	1.909	1.704	2.298	2.370	2.421	2.476	2.179	2.618	2.598	2.738	2.885
1:20 YEAR WATER SURFACE ELEVATION (m)	1 581.535	1 581.082	1 581.366	1 580.538	1 580.219	1 579.821	1 579.435	1 579.104	1 578.879	1 578.748	1 577.993	1 577.636	1 577.288	1 576.936	1 576.573	1 576.200	1 575.923	1 575.486	1 574.876
GABION LEVEL (m)	1 583.000	1 582.568	1 582.188	1 581.868	1 581.608	1 581.400	1 581.200	1 581.000	1 580.788	1 580.551	1 580.291	1 580.006	1 579.709	1 579.412	1 579.115	1 578.818	1 578.521	1 578.224	1 577.926

CHAINAGE ON ROAD (m)	14 180	14 160	14 140	14 120	14 100	14 080	14 060	14 040	14 020	14 000	13 980	13 960	13 940	13 920	13 900	13 880	13 860	13 840
FREEBOARD (m)	3.147	3.338	3.105	3.159	N/A	N/A	3.475	3.971	4.314	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1:20 YEAR WATER SURFACE ELEVATION (m)	1 574.482	1 573.994	1 573.930	1 573.610	1 573.299	1 573.003	1 572.467	1 571.961	1 571.798	1 571.606	1 571.460	1 571.338	1 571.247	1 571.068	N/A	N/A	N/A	N/A
GABION LEVEL (m)	1 577.629	1 577.332	1 577.035	1 576.738	N/A	N/A	1 575.942	1 575.932	1 576.112	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

LONGITUDINAL SECTION

SCALE 1:1 500

No.	DATE	REVISION	APPROVED
A	14/06/18	DESIGN REPORT	

LIST OF ASSOCIATED DRAWINGS

SHEET	DESCRIPTION	DWG. No.
5/5	CROSS SECTIONS: CH 14 505 – CH 14 680	8144–006
4/5	CROSS SECTIONS: CH 14 400 – CH 14 480	8144–005
3/5	CROSS SECTIONS: CH 14 120 – CH 14 380	8144–004

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EMAIL : dams@arq.co.za

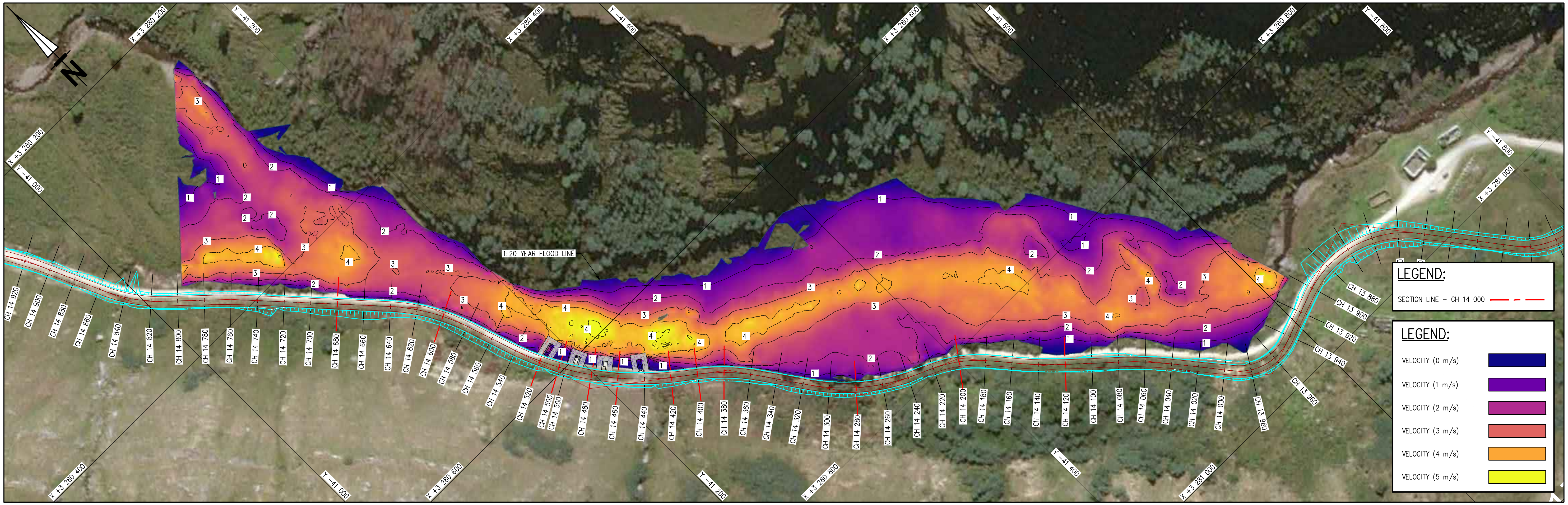
THE MASTER HELD AT THE ARQ HEAD OFFICE, BEARS THE ORIGINAL SIGNATURE OF APPROVAL

CLIENT: Royal HaskoningDHV
Enhancing Society Together

PROJECT: SANI PASS HYDROLOGY

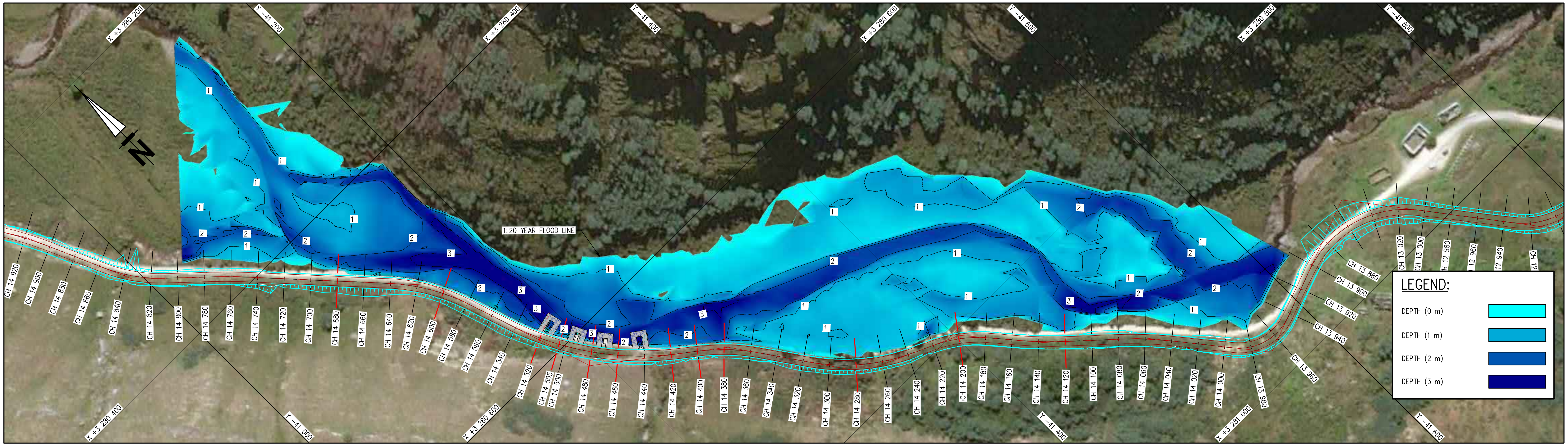
TITLE:
HYDROLOGY
PLAN LAYOUT AND LONGITUDINAL SECTION
WATER SURFACE FLOOD LINE WITH GROYNES

DRAWN: GS	SHEET SIZE: A1	SHEET No: 1/5
DESIGNED: MB	DATE: 14/06/2018	REV No: A
CHECKED: DCE	DRAWING No: 8144–011	



1:20 YEAR VELOCITY

SCALE 1:1 500



1:20 YEAR DEPTH

SCALE 1:1 500

				5/5	CROSS SECTIONS: CH 14 505 – CH 14 680	8144–006
				4/5	CROSS SECTIONS: CH 14 400 – CH 14 480	8144–005
				3/5	CROSS SECTIONS: CH 14 120 – CH 14 380	8144–004
A	14/06/18	DESIGN REPORT		SHEET	DESCRIPTION	DWG. No.
No.	DATE	REVISION	APPROVED	LIST OF ASSOCIATED DRAWINGS		

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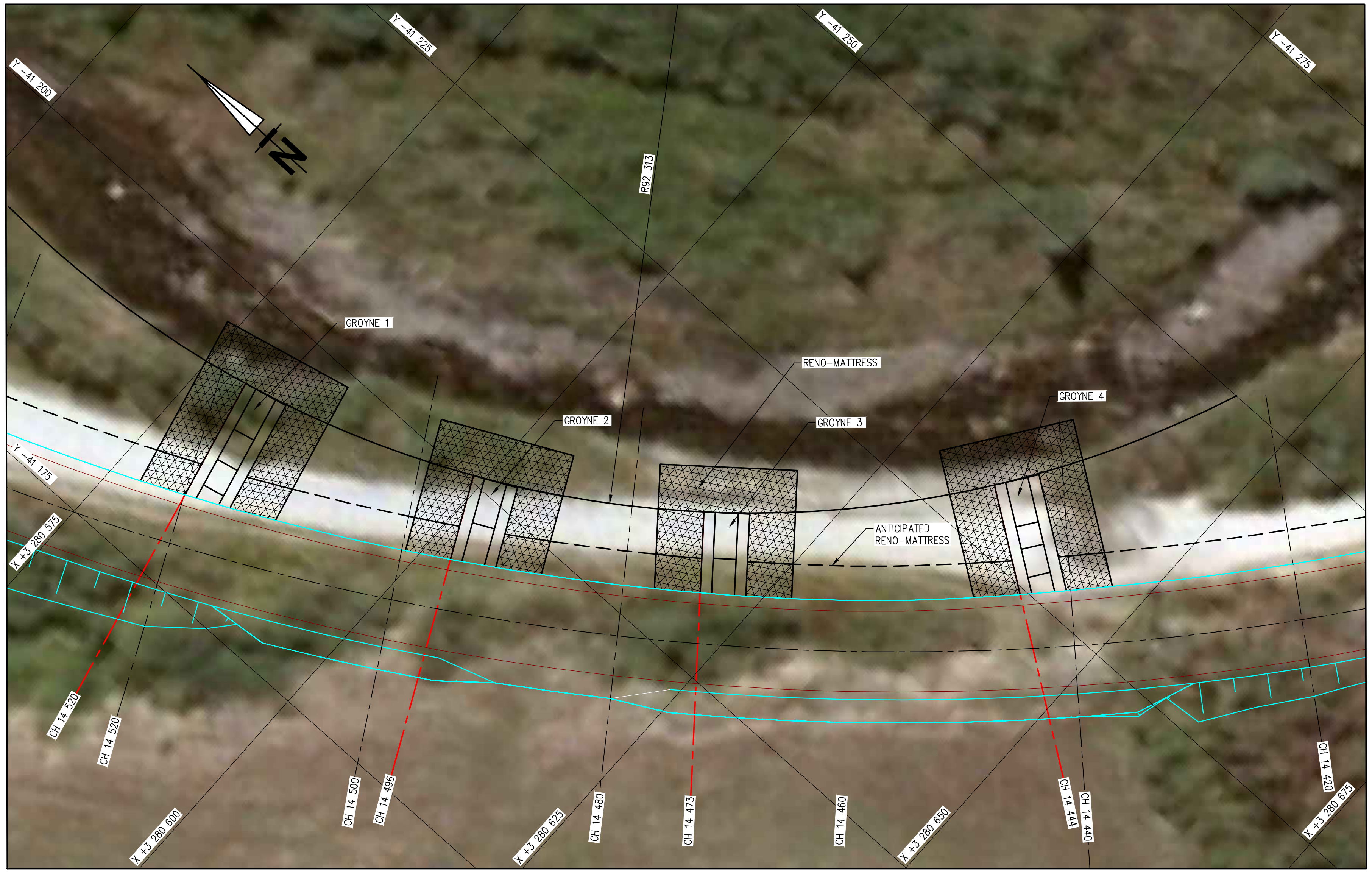
CLIENT:
Royal HaskoningDHV
Enhancing Society Together

PROJECT: SANI PASS HYDROLOGY

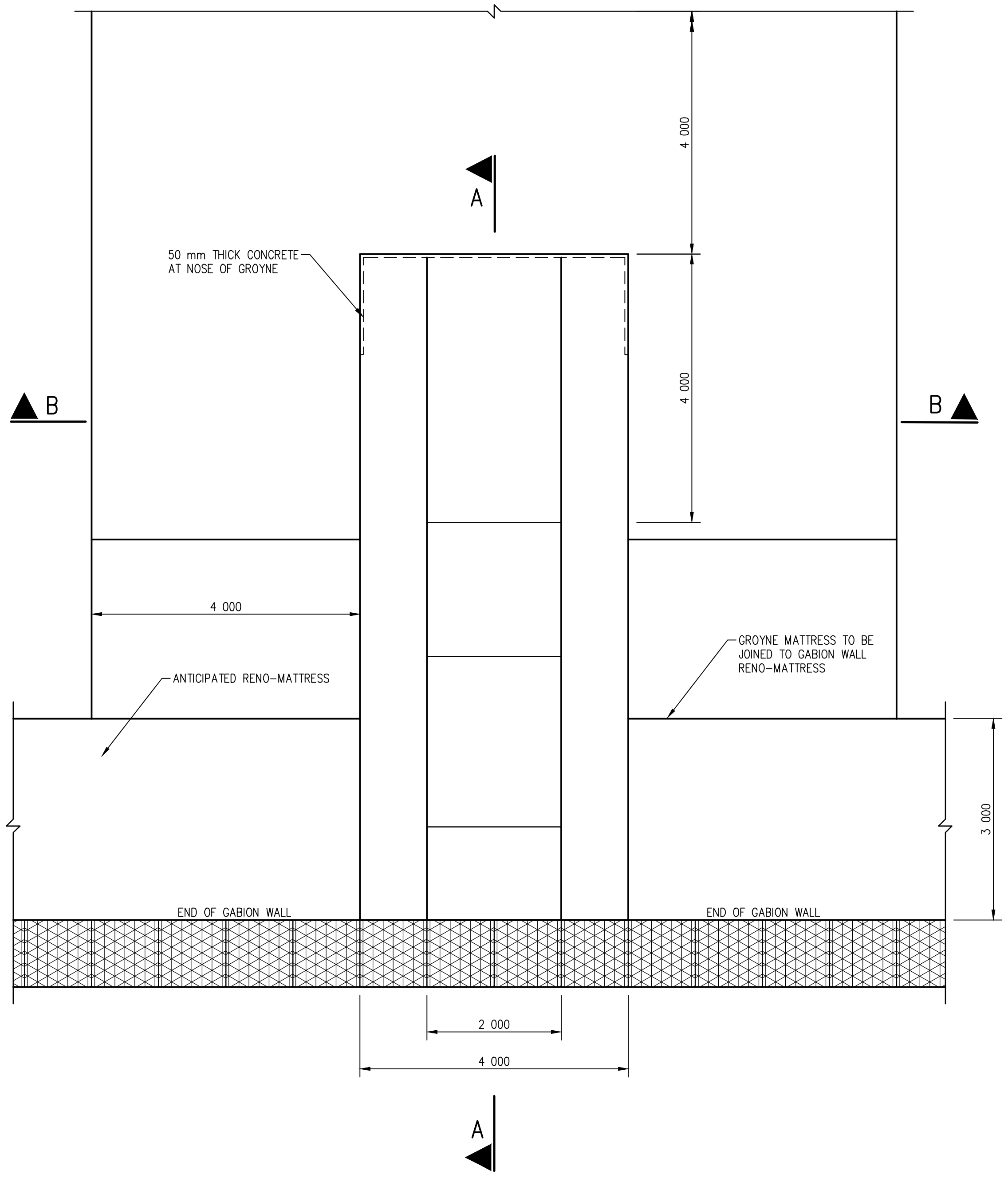
TITLE:
HYDROLOGY
VELOCITY AND DEPTH DISTRIBUTION PLAN
CH 13 840 – CH 14 920 WITH GROYNES

DRAWN: GS	SHEET SIZE: A1	SHEET No: 2/5
DESIGNED: MB	DATE: 14/06/2018	REV No: A
CHECKED: DCE	DRAWING No: 8144–012	



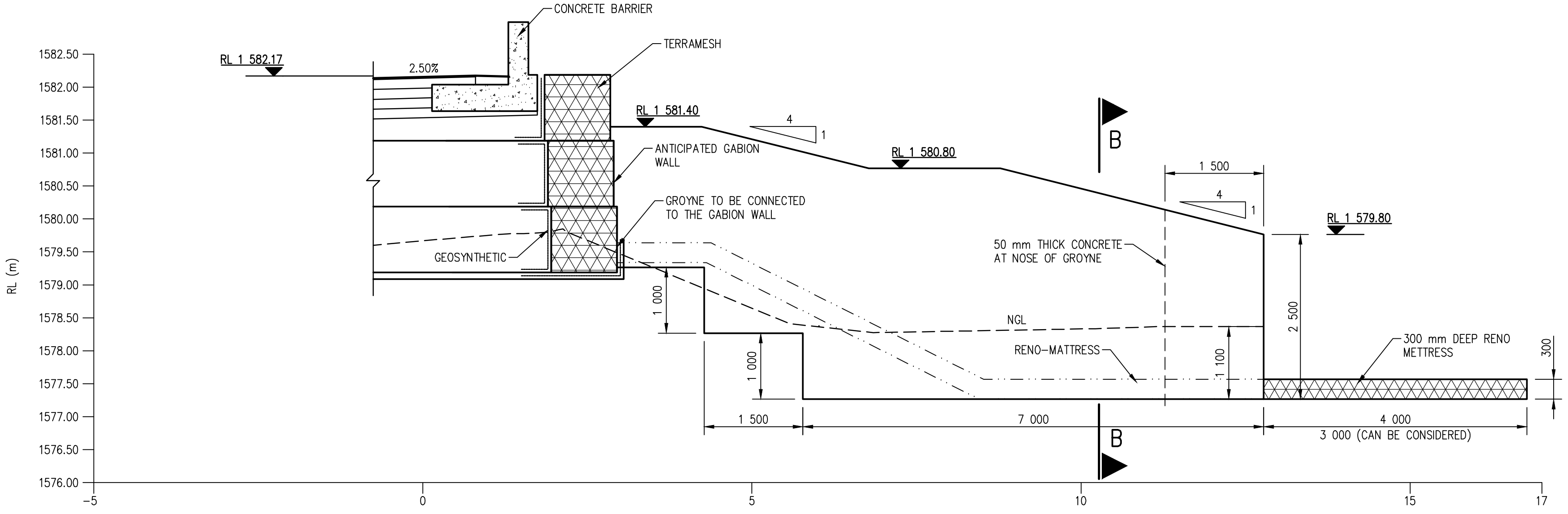
PLAN LAYOUT OF GROYNES

SCALE 1:250



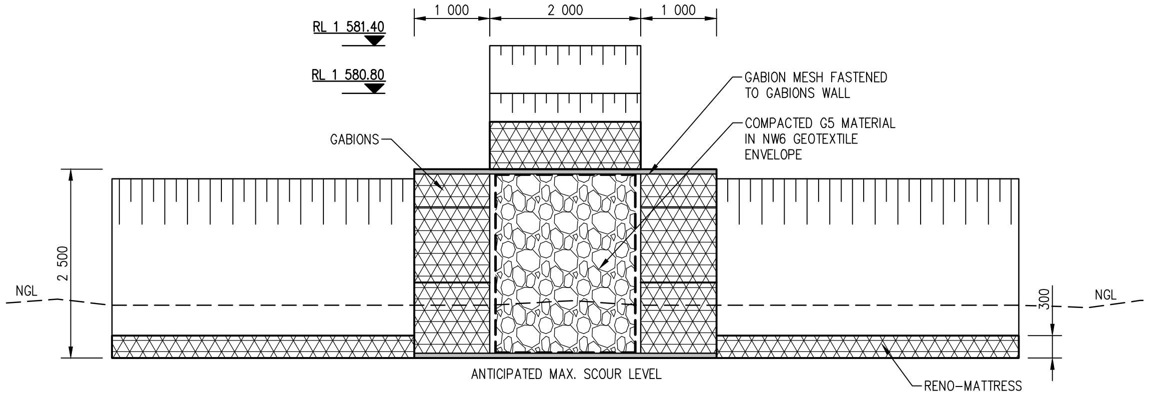
DETAIL PLAN LAYOUT OF GROYNE 1

SCALE 1:50



LONG SECTION A-A THROUGH GROYNE

SCALE 1:50



SECTION B-B THROUGH GROYNE

SCALE 1:50

A	14/06/18	DESIGN REPORT		SHEET	DESCRIPTION	DWG. No.
No.	DATE	REVISION	APPROVED	LIST OF ASSOCIATED DRAWINGS		

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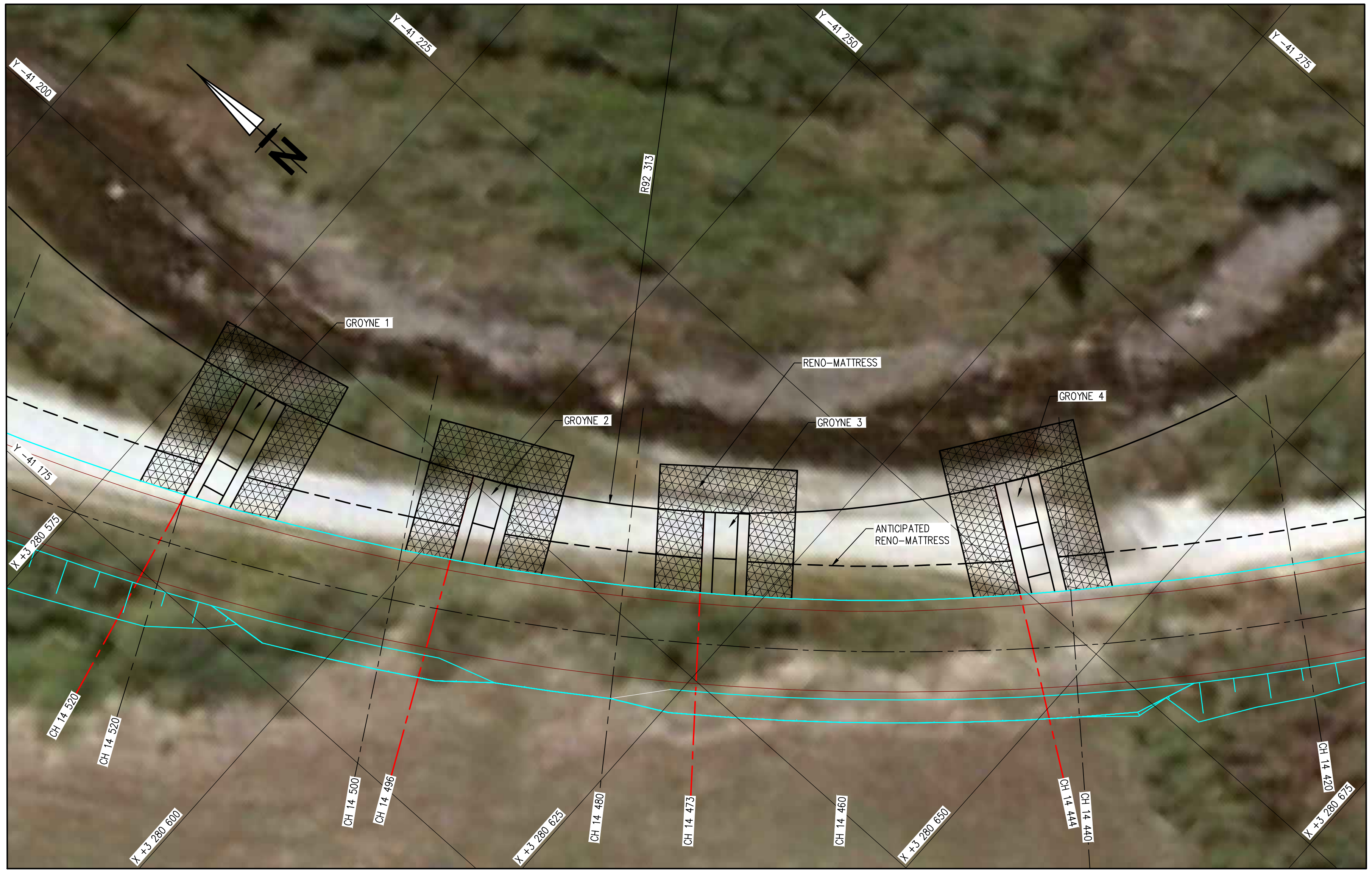
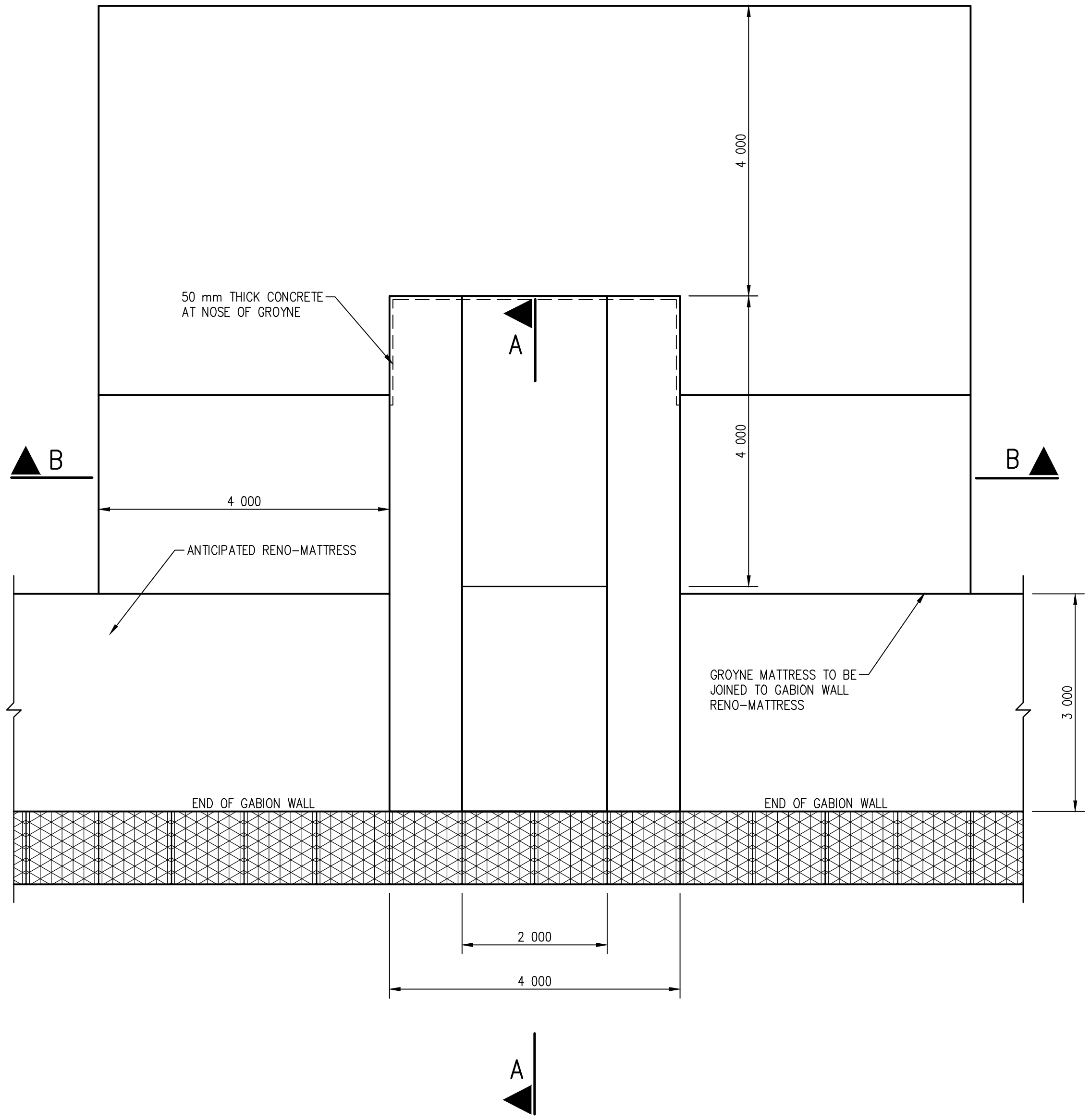
CLIENT: Royal HaskoningDHV Enhancing Society Together

PROJECT: SANI PASS HYDROLOGY	DRAWN: GS	SHEET SIZE: A1	SHEET No: 1/4
TITLE: GROYNES PLAN LAYOUT, SECTIONS & DETAILS GROYNE 1	DESIGNED: MB	DATE: 14/06/2018	REV No: A
	CHECKED: DCE	DRAWING No: 8144-013	



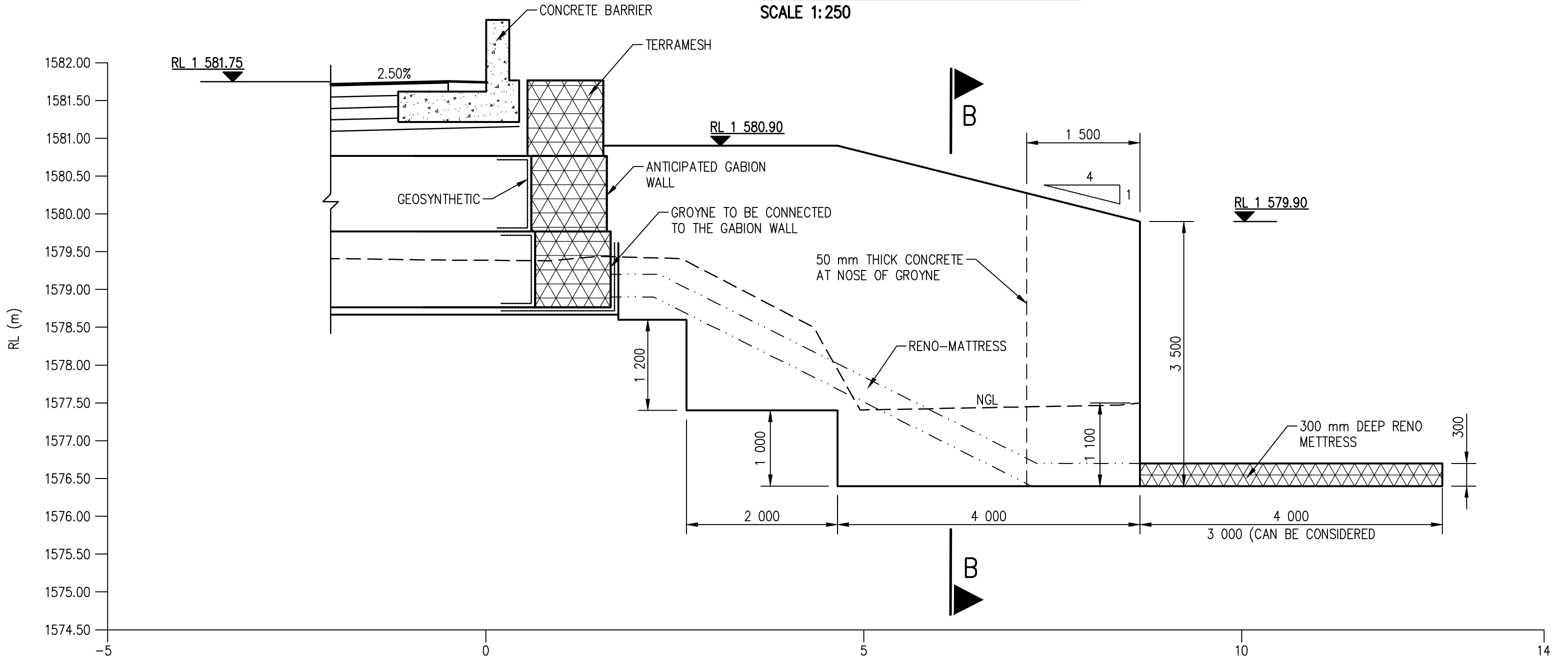
PLAN LAYOUT OF GROYNES

SCALE 1:250



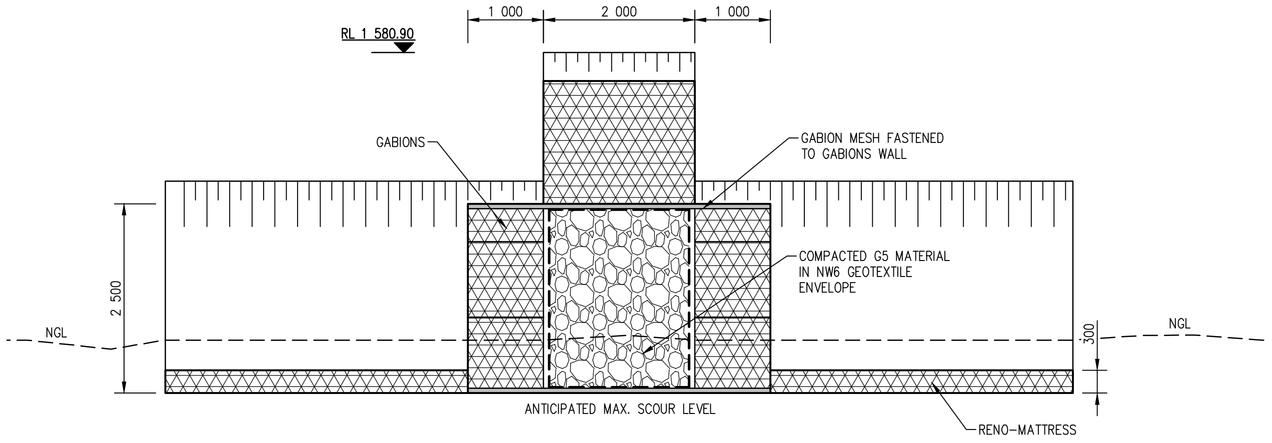
DETAIL PLAN LAYOUT OF GROYNE 2

SCALE 1:50



LONG SECTION A–A THROUGH GROYNE

SCALE 1:50



SECTION B–B THROUGH GROYNE

SCALE 1:50

A	14/06/18	DESIGN REPORT		SHEET	DESCRIPTION	DWG. No.
No.	DATE	REVISION	APPROVED	LIST OF ASSOCIATED DRAWINGS		

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CLIENT:

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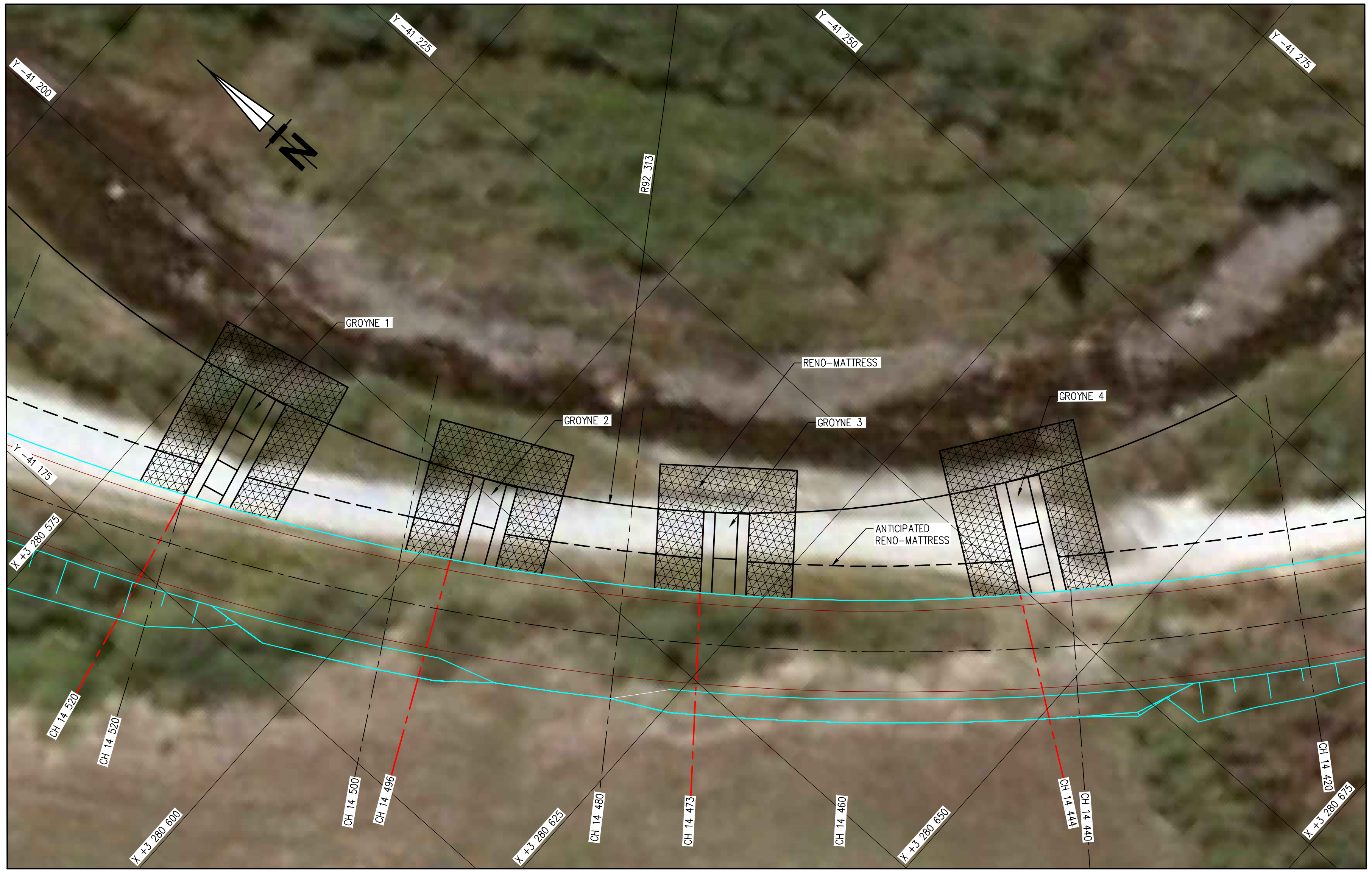
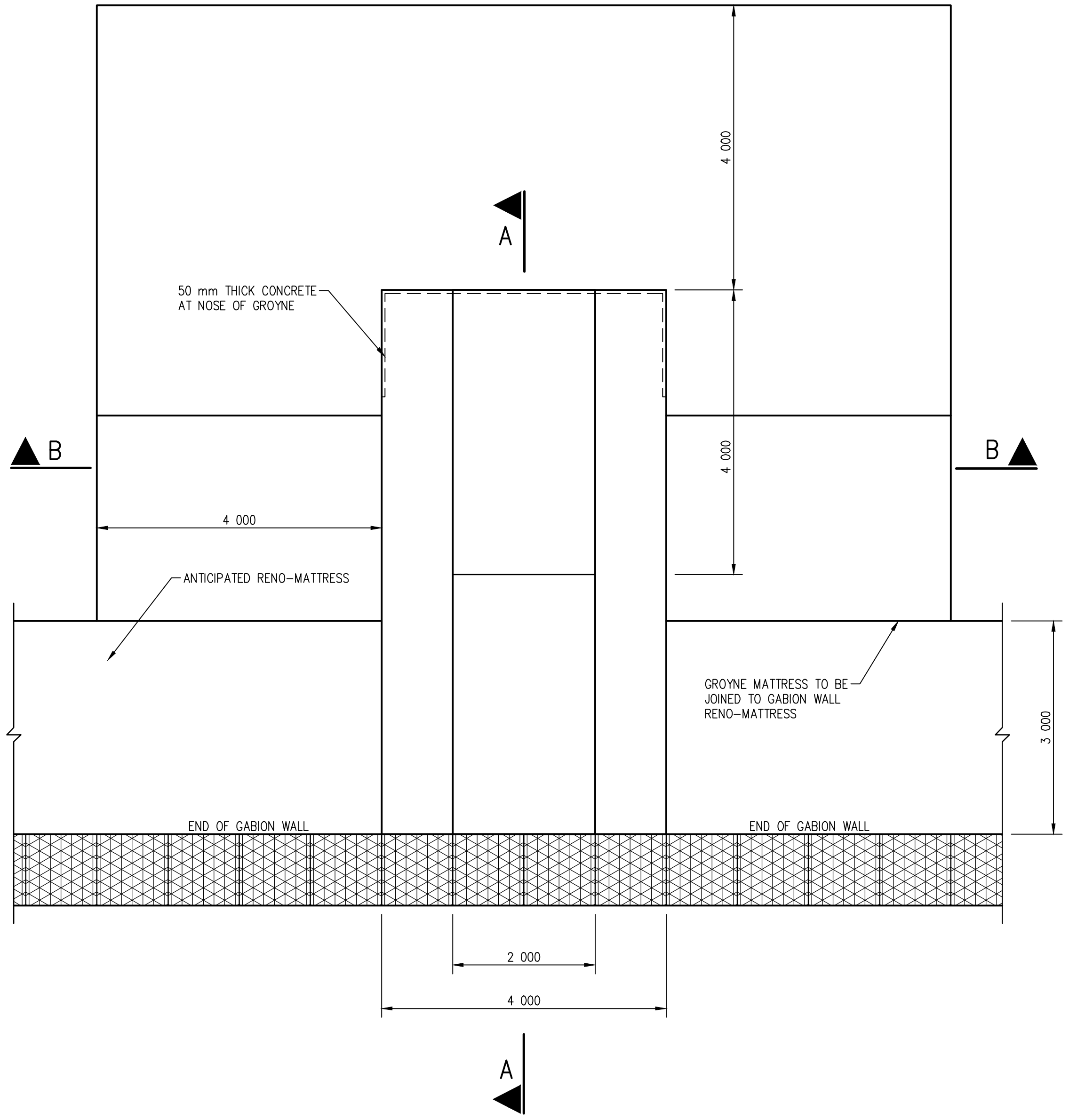
PROJECT: SANI PASS HYDROLOGY	DRAWN: GS	SHEET SIZE: A1	SHEET No: 2/4
TITLE: GROYNES PLAN LAYOUT, SECTIONS & DETAILS GROYNE 2	DESIGNED: MB	DATE: 14/06/2018	REV No: A
	CHECKED: DCE	DRAWING No: 8144–014	



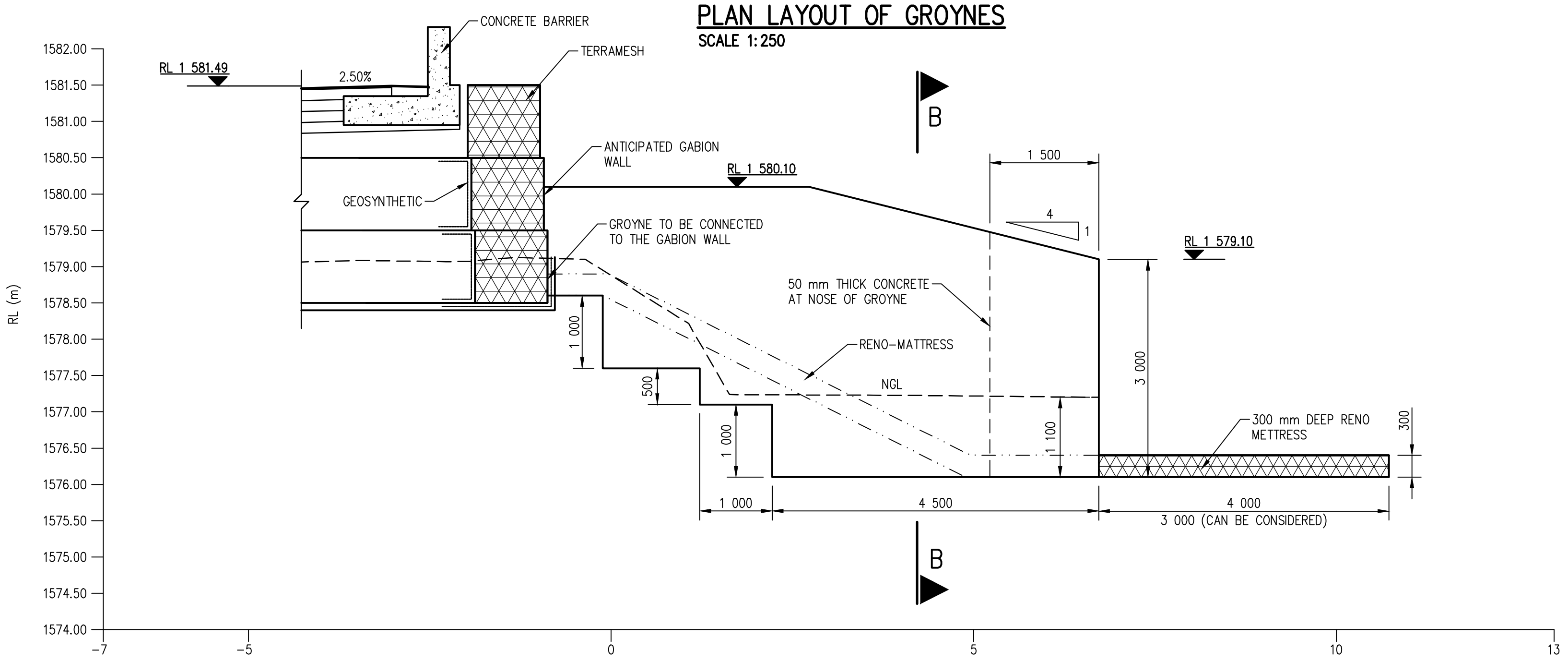
PLAN LAYOUT OF GROYNES

SCALE 1:250



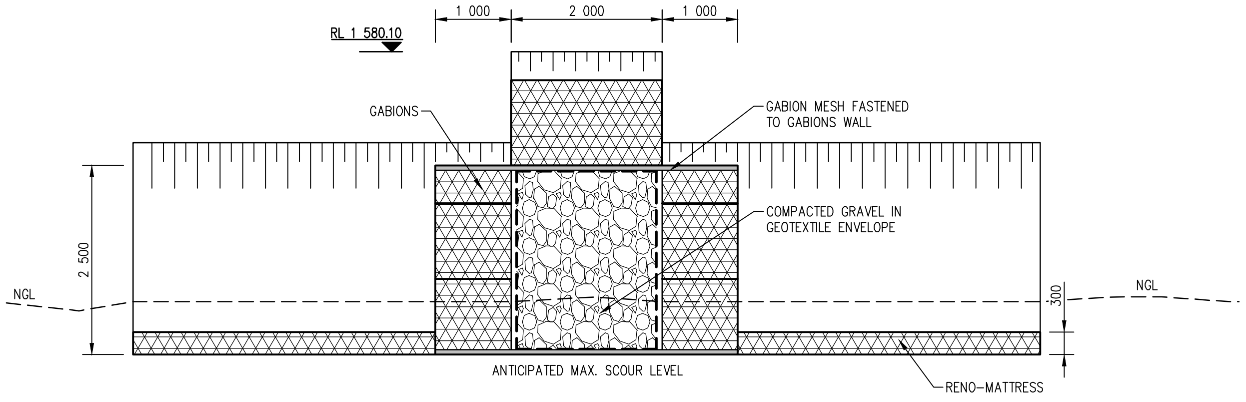
DETAIL PLAN LAYOUT OF GROYNE 3

SCALE 1:50



LONG SECTION A–A THROUGH GROYNE

SCALE 1:50



SECTION B–B THROUGH GROYNE

SCALE 1:50

No.	DATE	REVISION	APPROVED
A	14/06/18	DESIGN REPORT	

SHEET	DESCRIPTION	DWG. No.

LIST OF ASSOCIATED DRAWINGS

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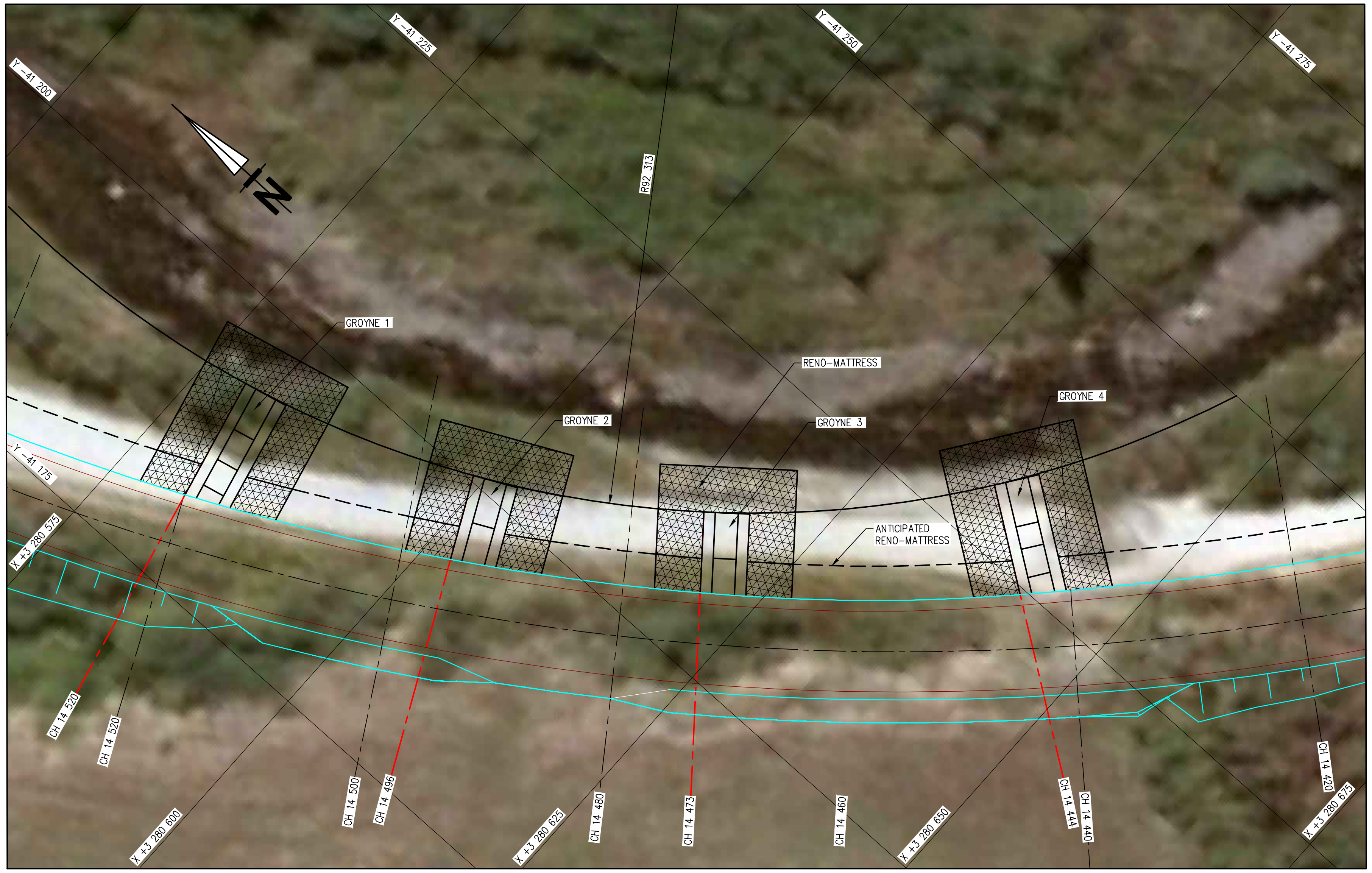
CLIENT:
Royal HaskoningDHV
Enhancing Society Together

PROJECT: SANI PASS HYDROLOGY

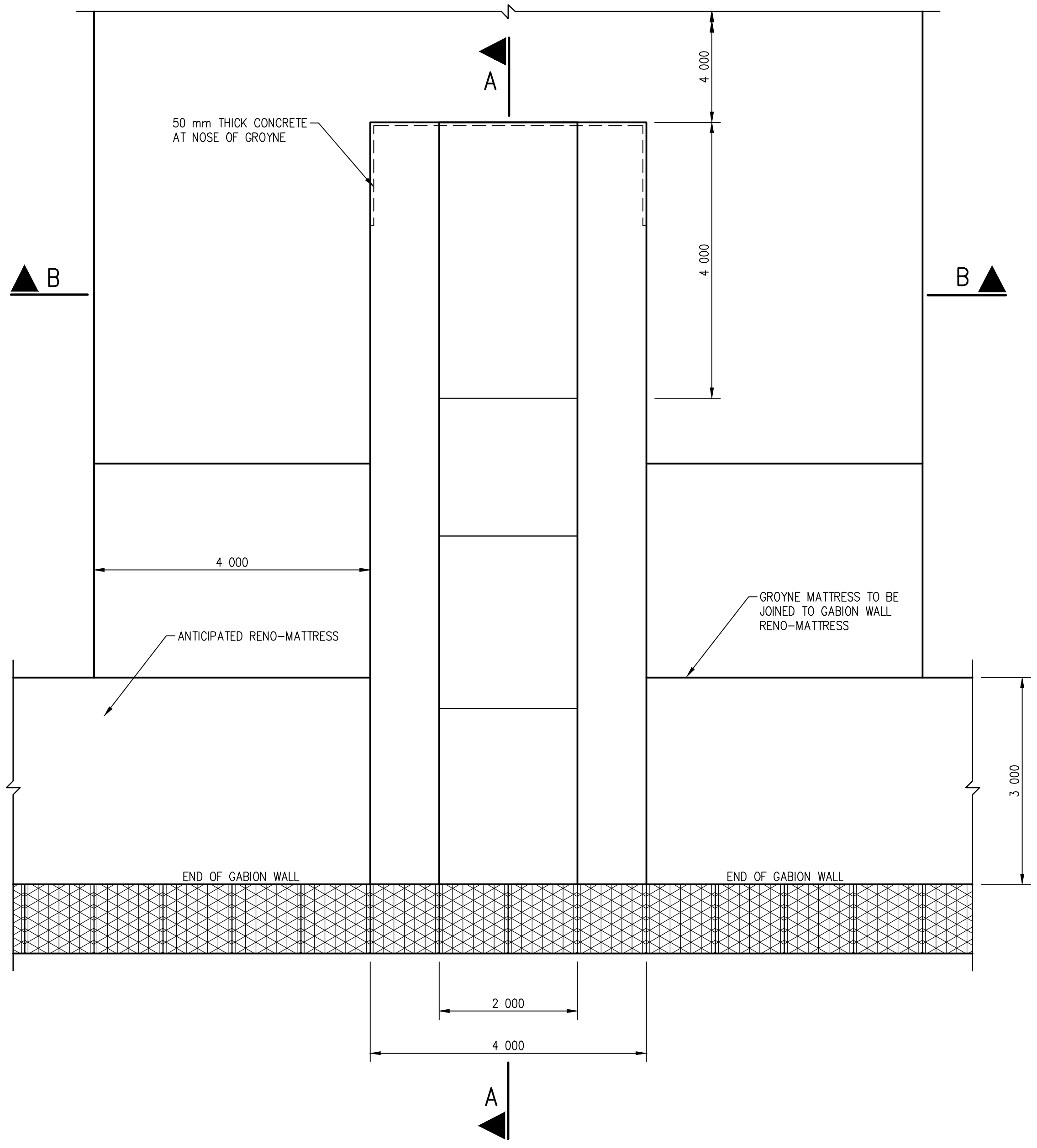
TITLE:
GROYNES
PLAN LAYOUT, SECTIONS & DETAILS
GROYNE 3

DRAWN:	SHEET SIZE:	SHEET No:
GS	A1	3/4
DESIGNED:	DATE:	REV No:
MB	14/06/2018	A
CHECKED:	DRAWING No:	
DCE	8144–015	



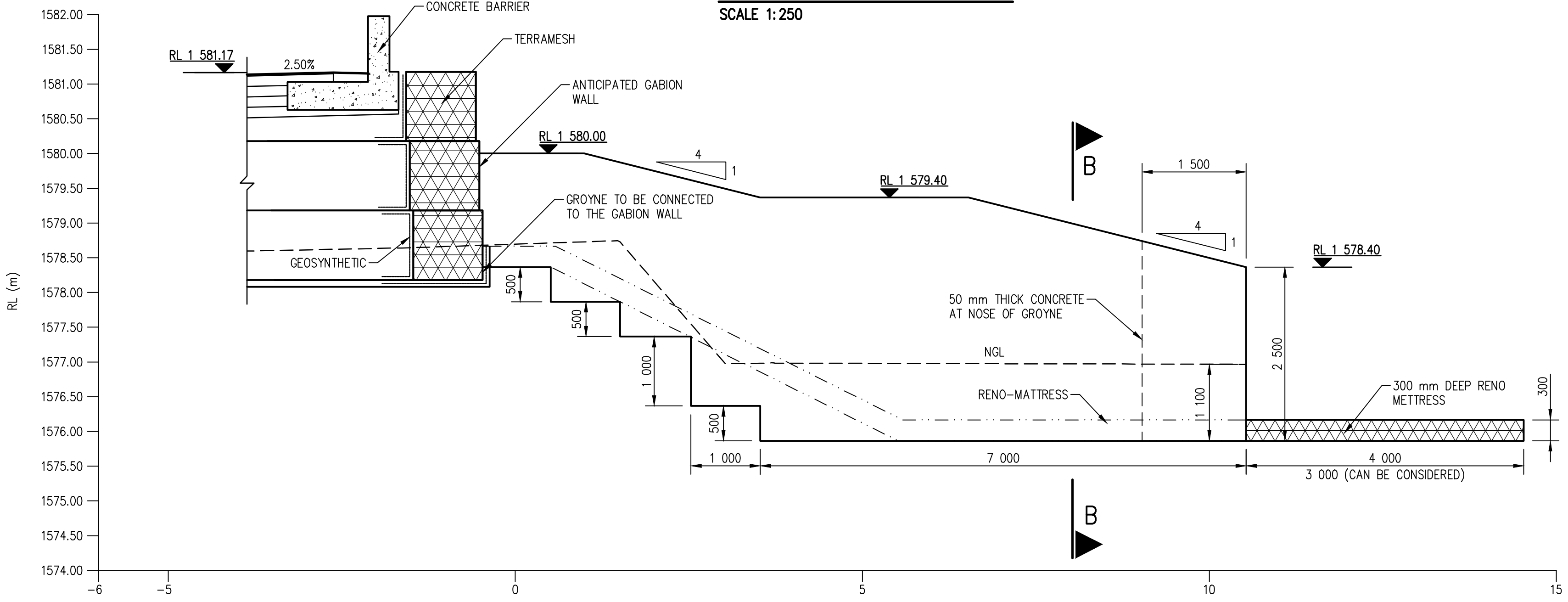
PLAN LAYOUT OF GROYNES

SCALE 1:250



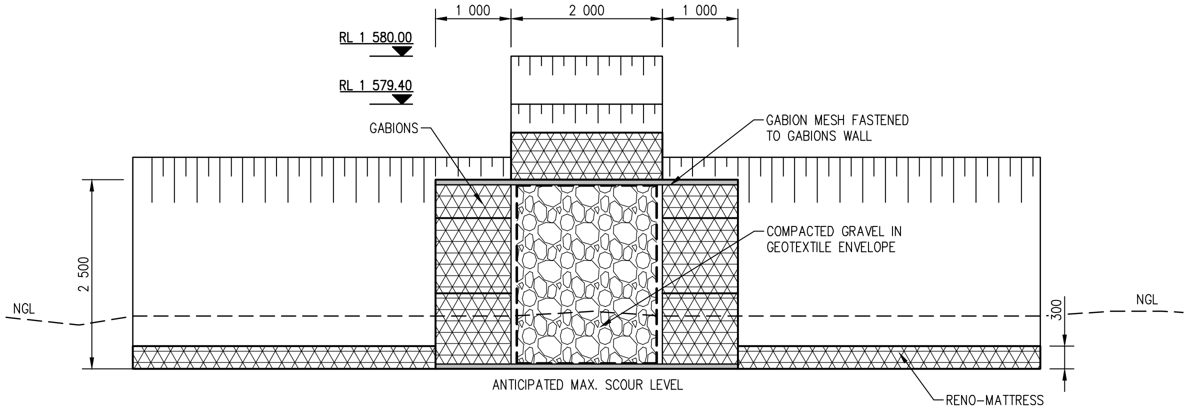
DETAIL PLAN LAYOUT OF GROYNE 4

SCALE 1:50



LONG SECTION A–A THROUGH GROYNE

SCALE 1:50



SECTION B–B THROUGH GROYNE

SCALE 1:50

No.	DATE	REVISION	APPROVED
A	14/06/18	DESIGN REPORT	

LIST OF ASSOCIATED DRAWINGS

SHEET	DESCRIPTION	DWG. No.

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CLIENT: Royal HaskoningDHV

PROJECT: SANI PASS HYDROLOGY

TITLE: GROYNES
PLAN LAYOUT, SECTIONS & DETAILS
GROYNE 4

DRAWN: GS
DESIGNED: MB
CHECKED: DCE
SHEET SIZE: A1
DATE: 14/06/2018
DRAWING No: 8144–016
SHEET No: 4/4
REV No: A