ONRUS RIVER WETLAND STABILIZATION

DESIGN REPORT

(INCLUDING METHOD STATEMENT)

Final - 2025 10 27

HansKingSRS (Pty) Ltd

Sustainable River Stabilization

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Hans King Pr Eng

Hans studied civil engineering at the University of Cape Town and completed his BSc in 1981. In 1991 he completed a Graduates Diploma in Engineering at the University of Cape Town.

After working for a construction company for 8 years, he took up employment with the Department of Agriculture for the next 30 years. Here he was responsible for the design of many soil conservation structures including weirs, as well as the development of the use of groyne structures for riverbank stabilization in the Western Cape. He has since presented several papers on the use of groyne structures. In 2016 he was one of a team of authors who produced a Water Research Commission report on the rehabilitation of rivers and wetlands in South Africa. Currently he is part of a team producing a second river rehabilitation report for the WRC.

In 2019, he started his own consultancy HansKingSRS (Pty) Ltd and focuses on the planning of river stabilization projects.

As a private consultant he has planned many river stabilization projects across South Africa. A notable feature with his work is his attempt to reduce the number of engineered structures required for a project by actively reintroducing indigenous wetland vegetation.

Hans is a Fellow of the South African Institute of Civil Engineers (SAICE) as well as a Fellow of the South African Institute of Agricultural Engineers (SAIAE).

Environmental Authorizations

Please note that reports from HansKingSRS (Pty) Ltd are frequently in support of applications for environmental authorization, they do not constitute authorization.

It is the responsibility of the applicant to ensure that valid authorization has been obtained prior to river stabilization work commences.

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SECTION 1- INTRODUCTION

The Onus wetland is located a few kilometres north-west of the town Hermanus. The wetland is part of the Onrus River and is situated in the Hemel and Aarde valley. A short distance upstream of the wetland is the De Bos Dam which supplies the town of Hermanus and farms in the Hemel and Aarde valley with water.

Figure 1 The location of the Onrus wetland in the Hemel and Aarde valley northwest of Hermanus

The wetland had already been damaged by erosion prior to 2023, but the widespread severe flooding of 2023 and 2024 made the erosion suddenly much worse.

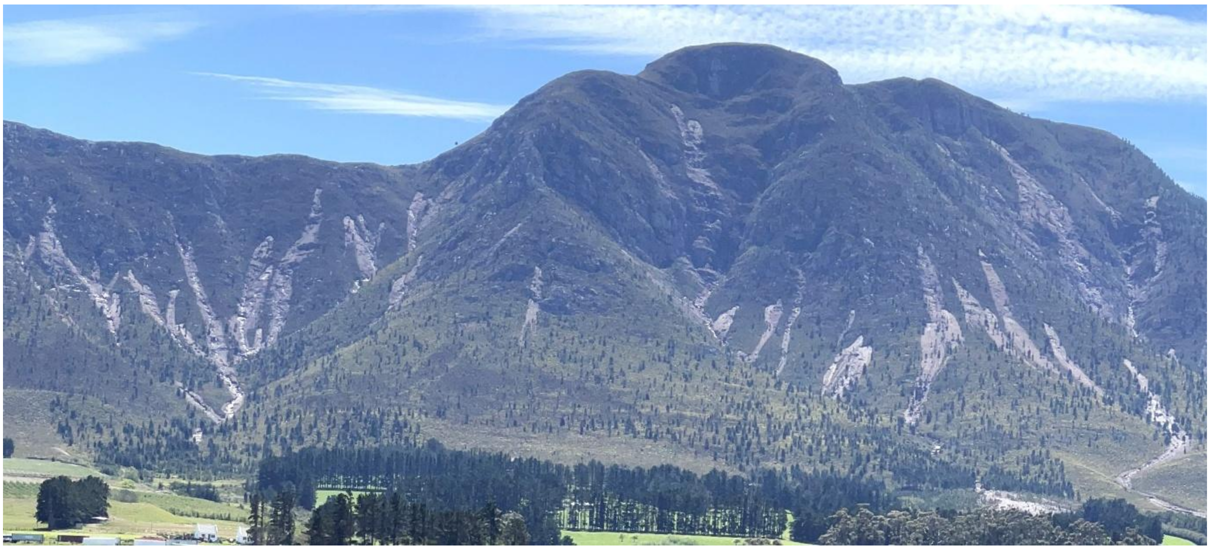

Figure 2 Landslides in the Bot River catchment 2023/2024 indicate the intensity of rainfall that was experienced in the area

The wetland is a peat wetland, which typically is covered mainly by Palmiet Reed (*Prionium Serratum*) and has deep organic peat soils. Under natural conditions these peat wetlands are hardy and resistant to erosion. After fires and floods which often strip all visible vegetation, the palmiet reed resprouts leaves and stems from the parts of the plant which remained buried in the peat.

These wetlands are not only important sources of ecological biodiversity but also help retard the flow of water after rain and enhance the higher base flow in rivers, which in turn supports the ecosystems downstream.

When the high water table which led to the formation of the peatland are removed, the wetland (soil plus vegetation) which has formed over many thousands of years, can become extremely degraded, or disappear completely within a few years. An example of this is the Tierkloof wetland (tributary of the Goukou River) which seems to have completely disappeared post erosion starting in 2003.

Figure 3 Erosion headcut in the Tierkloof wetland - Goukou River (2004). This wetland has now disappeared completely.

The erosion of the Onrus wetland began sometime before 2020. The exact cause of the initiation of the erosion is uncertain, but man-made disturbances like the drying out of the wetland post the construction of the De Bos Dam upstream (on the Karwyderskraal Road), and the proliferation of alien vegetation (mainly black wattle *Acacia mearansii*) played significant roles. After the erosion had begun, a fire started in the wetland by cable thieves ignited the dried-out peat which burned underground for many months before finally being extinguished. The underground burning of the peat most likely created underground chambers which collapsed during the flooding of 2023 and exposed the wetland to the severe erosion which took place later in 2023 and 2024.

Figure 4 Looking upstream to the headcut in the wetland just before the flood 2023

Figure 5 Looking upstream over where the headcut had been in August 2023. The gulley is now about five times wider and several meters deeper.

SECTION 2 – CONSIDERATIONS WHEN STABILIZING PALMIET WETLANDS

OBJECTIVES

The Onrus wetland has suffered enormous erosion damage in the 2023/2024 flooding. Some 25% of the indigenous wetland vegetation has been lost, the majority of which was palmiet reed. The objective of this project can be described as a combination of:-

- To prevent further soil loss
- To restore water table as far as possible, and so protect the remaining indigenous wetland vegetation from damage due to the drying out of the wetland
- To restore the indigenous wetland vegetation as far as possible.
- The solution must be proven and durable.

ALTERNATIVE SOLUTIONS

There are alternative solutions to achieve the given objectives, but they do not all fulfil all the requirements of the project.

ALTERNATIVE 1

Simply collapsing the gulley sides, landscaping the soil to a gentle slope ,and replanting, could be considered as an alternative solution.

The attractiveness of this approach is that it is free of expensive and unsightly engineered structures.

The main problem with this approach is that the slope of the wetland is too steep to have a reasonable expectation that the re-established vegetating will be mature and strong enough to prevent soil erosion during the normal winter storm runoff. The vegetation usually takes 2-3 years to become established, and even longer to properly cover the rehabilitated area. Additionally, this alternative would allow the water-table to permanently drop to a new level, and the existing remnants of the original wetland vegetation will be at a great risk of diminishing because of drought conditions (refer to Figure 6).

This solution would be more appropriate to a shallow gully in a very flat wetland.

ALTERNATIVE 2

A canal (concrete-lined or gabion lined) offers a possible solution.

Such a canal could be constructed such that it would capture expected floods and safely discharge them, satisfying the requirement to prevent soil erosion. Such a canal could possibly assist with trapping a high water-table in the adjacent soil and thereby support the wetland vegetation.

Apart from being obviously in-appropriate for a natural wetland (because it is over-engineered), canals such as this have extremely high construction costs and would not be seen as a viable alternative solution.

ALTERNATIVE 3

A cascade of weirs (the chosen alternative) is also a possible solution. With this solution a group of weirs are planned to create steps in the eroded channel, as well as lift the channel as much as is possible.

The advantage of such a system is that the steps in the channel reduce the slope of the channel, thus flow velocities as well as the tendency for soil erosion to occur. The system also provides for some lifting the water-table which may be beneficial to the remaining original wetland vegetation.

The disadvantage of the system is that the weirs must be constructed such that they can accommodate large floods, this makes the structures large and costly. Another concern is that the wing-walls of the weirs may inhibit the seepage of water down the wetland. With proper design, these issues can be addressed.

Examples of such cascades of weirs are given in

APPENDIX 7 : EXAMPLE SIMILAR PROJECTS.

This option has been chosen for it's superior offering in terms of soil stabilization as well as water-table management.

APPROACH TO SOLUTION

The current slope of the wetland varies between 3% and 1%. To re-establish wetland vegetation, it is necessary to flatten the slope of the eroded channel so that the flow velocity during floods is reduced and it is level less likely that soil erosion will occur. The flattening of the river slope is achieved by creating steps in the river. These steps are made permanent by the construction of a series of weir structures (referred to as a "cascade of weirs"). The whole system (the weir structures plus the channel between them) is designed to discharge given design flood peak flows with an overall reduction of flow energy, and so create conditions most conducive to the re-establishment of the pre-erosion environment.

<u>Weir drop heights:</u>

The choice of weir height has significant impacts on the project. The higher the drop height of the weirs, fewer weirs are needed, and this saves costs. The downside of this is that the rehabilitated channel becomes deeper, and the restoration of the water table is less. Alternatively with lower weir drop heights, a more desirable shallow rehabilitated channel can be achieved, but the cost of this is that the number and cost of stilling basins increases. When all factors are considered, there is an optimal weir drop height, number or weirs, and rehabilitated channel depth. Experience has shown that practical weir drop height is around 2 or 3 meters.

The number and spacing of weirs

Various factors guide the planning of a cascade of weirs. These are:-

- The level of the undisturbed ground at the upper end of the gulley. If the weir cascade stops before the spillway level of the uppermost weir reaches the natural ground level, the possibility of the erosion continuing with the next flood remains.
- The downstream location where a stable riverbed is reached. Finding a stable section of river is important to prevent the undermining of eh lowest weir's foundation by erosion. Ideally a weir cascade would end at a rock outcrop (which is very secure) but failing that a section of river with natural flat slope will suffice.
- The allowable slope between the weirs. As previously mentioned, the slope of the channel strongly influences the flow velocity in the channel during floods. By keeping the slope of the channel flat (ie less than 0,5 percent) with an appropriate channel cross section, the flow velocity can be kept to below 2 meters/second and in a well vegetated channel this should be safe from soil erosion.
- A practical drop height for weirs. Too small a drop height means the number of weirs and hence the number of stilling basins will be greater. Stilling basins are necessary components downstream of weirs where water spilling over the spillway falls, to prevent soil erosion. Too great a drop height means the depth of the rehabilitated gulley downstream of the weir will be great and excessively draw down the water-table. Practical weir heights are usually 2-3 meters.

The rehabilitated channel:

The choice of rehabilitated channel slope is of great significance to the design.

- A steeper rehabilitated channel slope has the benefit is that fewer weir structures are required to drop the water over a given distance, which on face value seems to be a cost saving. Unfortunately, a steeper slope implies a higher flow velocity which may make managing soil erosion in the channel difficult or impossible.

- A shallower slope on the other hand, requires more weirs to drop the water over a given distance (which increases the cost), but the lower slope enables slower flow velocities, and this makes the management of soil erosion a lot easier. Additionally, when very flat slopes are chosen, water downstream of a weir backs up onto the stilling basin of the weir, creating a cushion for water falling over the weir to land on. This can reduce the energy of the falling water and so the size and cost of the stilling basin downstream of the weir.
- A rehabilitated channel slope of 0.5% has often been found to be an appropriate point of balance.

At the Onrus River wetland, the depth of the gulley varies between 4 and 8 meters. Depending on how much fill material can be sourced for the eroded gulley, the introduction of weir structures and the filling in of the gulley, can result in the depression caused by the gulley to be reduced to 2 to 3 meters deep. The benefit of making the depression as shallow as possible is that the restoration of the pre-erosion water-table will be the greatest (see Figure 6). This will provide most benefit to the wetland as an environment. To aid the restoration of the water-table, where structures are constructed below ground level, the upstream face will be lined with a water-proof barrier to seepage and force the water table to rise to the spillway level.

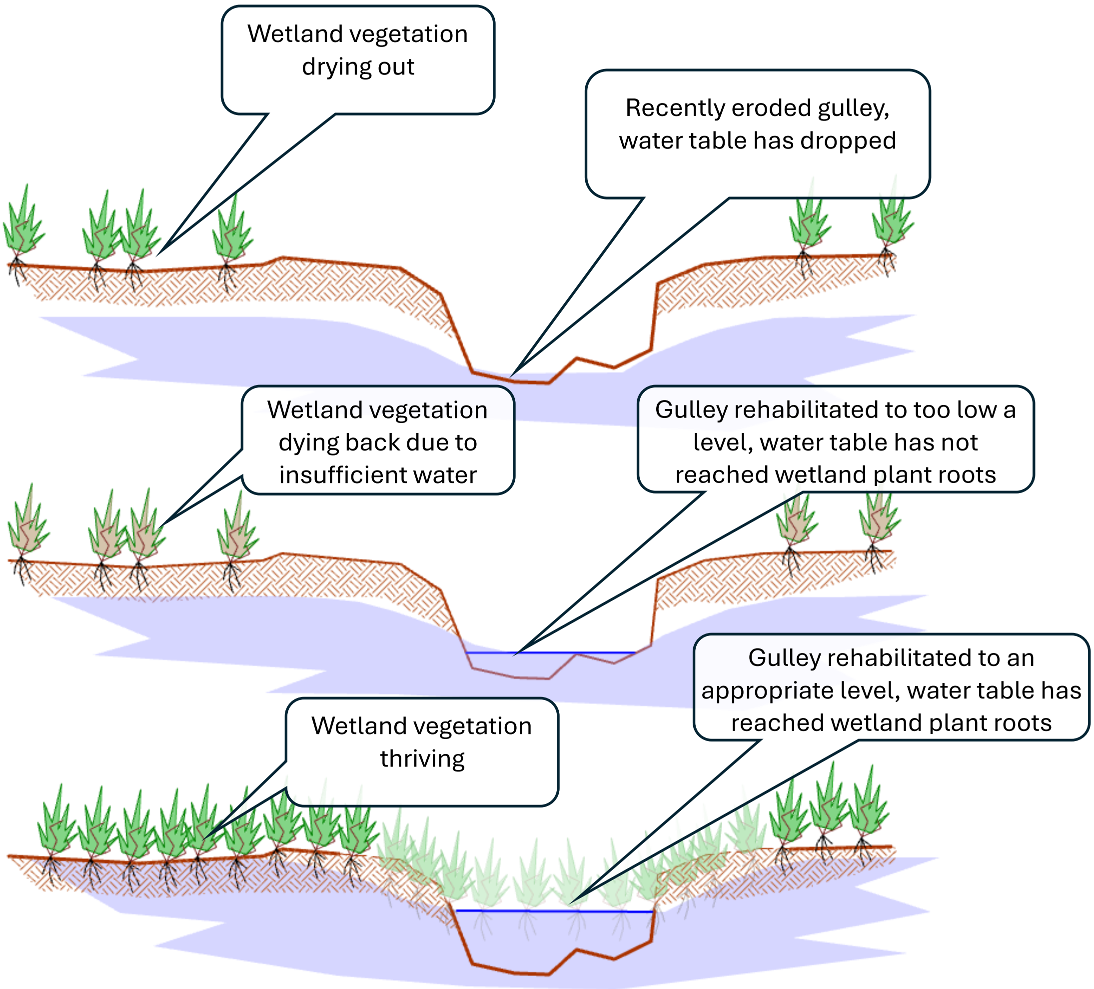

Figure 6 The benefit of selecting an appropriate rehabilitated channel depth

When designing the capacity of the rehabilitated channel consideration must be given to the revegetation of the channel itself as it influences the design. The re-introduction of indigenous wetland vegetation to degraded and eroded areas not only improves ecological biodiversity, but improves resistance to erosion, and increases hydraulic roughness which causes floodwater to flow slower and deeper.

THREATS TO THE USE OF WEIRS FOR WETLAND STABILIZATION

<u>Outflanking</u>

The size of the opening of a weir largely determines how much water the weir can flow over the weir before it is forced to seek an alternative path around the weir. This is referred to as the discharge capacity of the weir. If a weir's discharge is less than the flow rate of a flood being experienced, water will flow over or around the wing walls, and probably in an area where provision has not been made to prevent soil erosion. Should erosion take place the level of the gulley formed may be close to or lower than that of the weir spillway level, and the weir is technically “outflanked”, as the flowing water has created a route bypassing the weir. To guard against failure by outflanking, the discharge capacity must be enough to accommodate at least the 1:50 year flood if not more. In addition to this, a pragmatic design would incorporate some sort of provision to accommodate floods larger than that expected – for instance establishing erosion resisting vegetation in the area where surplus water is expected to flow when the design discharge capacity is exceeded.

Foundation stability

Weirs must be designed to withstand forces which cause them to overturn or to slide. Of these two the sliding is usually a greater problem, and the most common solution is to add a “shear key”, in other words the spillway is partially extended down into the foundation where it presses against the downstream soil and helps resist the forces causing the structure to slide.

In peat soils the settlement of the foundation could be a problem, but this is managed by keeping the load of the structure on the subsoil less than what existed prior to the erosion of the wetland. Keeping the foundation of the weir broad is very helpful in spreading the load of the structure and reducing the tendency for settlement of the foundation to occur.

The formation of tunnels under a weir by flowing water poses a serious threat to the stability of a weir. To prevent the formation of tunnels in the soil two actions can be taken. The first is to use a “shear key” (first mentioned above) to lengthen the flow path of water and so reduce the risk for seepage and tunnel formation. The second is to stabilize the foundation material with cement, and so prevent it from being washed away.

Channelizing of flow

When constructing a cascade of weirs, if the flow of water through the wetland is all concentrated down the rehabilitated channel, the wetland downstream of the weir wing-walls may suffer drought conditions and become degraded. Especially if the wing-walls are long, it may be advisable to provide pipes through the wing-walls at regular intervals to low-flow enable water to flow down the wetland as naturally as possible.

SECTION 3 : THE PLANNING OF THE ONRUS WETLAND INTERVENTIONS

CHALLENGES WITH THE INTERPRETATION OF THE SURVEY DATA

When hydraulic modelling of a landscape is done, amongst other data, it is based on a topographic survey of the area. These surveys are usually done using a hand-held gps, photogrammetry or lidar.

The hand-held gps has the advantage of having centimetre accuracy, but this is limited to discreet points which are measured. The rest of the survey is interpolated between these points.

Photogrammetry (a survey deriving heights from multiple stereo-images covering a site's extents, connected to gps measured control points) has slightly lower accuracy at individual points than a hand-held gps offers, but significantly improved detail overall. The disadvantage of photogrammetry is that if the camera cannot see the ground beneath vegetation, photogrammetry cannot give the height of the ground.

Lidar surveys (an aerial ground scanner, also connected to gps measured control points) has better accuracy between the control points than photogrammetry, and has the added benefit of a better chance of picking up ground heights underneath vegetation.

Surveying ground heights in palmiet-wetlands has always been challenging. It is most reliably measured with a hand-held gps but walking through a palmiet wetland to do this is practically impossible. With the density of foliage in palmiet wetlands, both photogrammetry and lidar can only measure the top of the palmiet.

Figure 7 Access to palmiet wetlands make them extremely challenging to survey

The terrain at Onrus was first surveyed using a hand-held gps plus drone based photogrammetry. Later a Lidar survey of the wetland became available, and this was used as well.

Apart from the survey of palmiet wetlands being challenging, the interpretation of the data is as well, especially when modelling the behaviour of floods in the wetland. The palmiet-reed is usually 1-1,5 meters tall. During floods the height of the vegetation changes depending on the intensity and duration of the flood.

- During low flows, water flows between the palmiet-reed stems, and the height of the reed does not change. The resistance to flow is great due to the convoluted flow path the water must follow between the tangled palmiet-reed stems.
- As the flow rate increases, the stems of the palmiet-reed get pushed flat, and the water generally starts flowing over them. At this stage the height of the palmiet-reed is less, around 0,5-1 meters. The resistance to flow reduces.
- As the flow rate increases further, or if the water flows at a high level for a long time, the leaves of the palmiet-reed get shredded from the stems, and the volume of palmiet-reed material decreases. The height of the palmiet-reed mass now decreases further, again altering the hydraulics of the terrain.

The HECRAS 2D modelling software does not accommodate this sort of terrain alteration during a flood so during the design stage it was seen as necessary to recognise the problem and to accommodate it.

It was considered to delineate the palmiet area on the orthophoto, and then to reduce that portion of the terrain by a nominal amount (probably 0,75 meter) to allow for the palmiet-reed bending over during higher floods. One problem with this approach is that some of the palmiet-reed beds have varying amounts of other vegetation in them (like phragmytes) and this makes it difficult to delineate all of the palmiet-reed. Should only part of the palmiet-reed be delineated and reduced in height, this would negatively impact on the modelling process and so it would probably be better to not reduce the height of the palmiet reedbed at all.

The drone photogrammetry survey was used for the hydraulic modelling, as the Lidar data was not available at that time. The Lidar survey was eventually used during the design of the structures to model the terrain so that excavation quantities would be most realistic.

THE NUMBER AND SPACING OF THE WEIRS

At the Onrus wetland it was determined that at the lower end of the Camphill Village property, the slope of the river is governed by a downstream rock outcrop crossing the river. It was then felt that the area opposite the small dam next to the Caledon Road would be secure enough to place the lowest weir.

After an inspection of a long section of the river, five weirs with heights between 2 and 3 meters were deemed to be adequate for the project. This was done by drawing in the 0.5 % slope (representing the base of the rehabilitated gulley) from a spillway, upstream, until the channel was just deep enough to fit another weir into the terrain. This process was repeated until the upper end of the gulley was reached. The slopes and weirs positions and weir heights were revised to get the best fit to the terrain. The slope of the rehabilitated channel between the weirs ranged between 0,3 percent and 0,5 percent. A site inspection with the project team was had to discuss the position and spillway level of the structures, and agreement was reached on this.

When the functioning of these weir sizes and positions was simulated in a hydraulic model various shortcomings were highlighted.

1. Firstly, it was felt that the weirs were too low and could perform better in terms of raising the water table (providing soil could be found to fill the channel).
2. The second problem was that at the upper end of the gulley. There was a previously unidentified narrow but steep side-gulley in which the flow velocity during floods would be very high and would certainly erode actively. If unchecked, this gulley could precipitate the further erosion of the upstream wetland. This side-gulley had not been identified originally because of the difficulty of getting there and vegetative cover made it hard to see from the air. The hydraulic model using the photogrammetry-based survey data identified the problem.

To address these problems, the levels of the five initially proposed weirs were revised, and a sixth weir was added.

THE WEIR DESIGN

Spillway capacity

The spillways have been designed to accommodate peak storm discharge of 120 m^3/sec with provision for freeboard. To limit the energy of water falling over the spillways, it has long been customary within the Department of Agriculture to limit the flow depth approaching the weir to around 1 meter. With an assumed approach velocity of 2 m/sec the broad crested weir formula was used to determine a spillway length required to discharge the design flood. The length obtained was 60 meters. This could have been planned as a straight spillway but for various reasons this spillway shape was changed to a horseshoe spillway (with inside dimensions 30 meters x 15 meters). These reasons were:-.

- Economy of stilling basin – there could be savings in the stilling basin arrangement.
- Width of valley disturbed – A 60-meter-long straight spillway would have necessitated constructing deep into yet undisturbed wetlands.
- Less total force causing the structure to slide down the slope

Spillway levels

The spillway levels have been debated when the team met on site.

From the point of view of reducing the amount of landscaping cost, lower spillway heights would be more appropriate. As discussed in the previously in the text, low spillways would have very limited benefit for the remnants of the pre-existing vegetation in the wetland because the water-table would still be far below that which originally existed, and the vegetation would suffer drought conditions.

From the point of view of maximising the water-table restoration, the higher spillway levels would be most desirable. The difficulty at the Onrus River wetland will be finding the soil to fill the rehabilitated channel to at least close to the spillway level. There is a possibility of importing soil dredged from the downstream estuary, or from in the De Bos dam upstream. It is quite likely that should the higher spillway levels be used and there is not enough soil to landscape the channel to the spillway levels, depressions in the channel will occur and the formation of ponds is likely.

It is not unreasonable to prioritise the spillways in terms of which should be fitted with higher spillways if funds or the availability of fill material will not allow all to be constructed to the higher level. The greater proportion of existing palmiet reed beds that are in good condition, are in the middle to upper section of the wetland, and to protect these, the upper 3 or 4 weirs should be first considered as locations for the higher spillways.

Weir	Spillway elevation (notch elevation if present)	Top of Stilling basin counter-weir	Spillway height	Distance to downstream weir	Slope of rehabilitated channel
1	72.0	69.5	3	180 m	0.28%
2	69.0	66.5	3	200 m	0.25%
3	65.75	63.25	3	200 m	0.25%
4	62.5 (61.5)	60	3	440 m	0.17%
5	59.0 (58.0)	56.5	3	900 m	0.08%
6	55.0 (54.0)	52.5	3		

Figure 8 Spillway levels and rehabilitated channel slopes (assuming all spillways 3m high)

(Weir 1 is the most upstream weir)

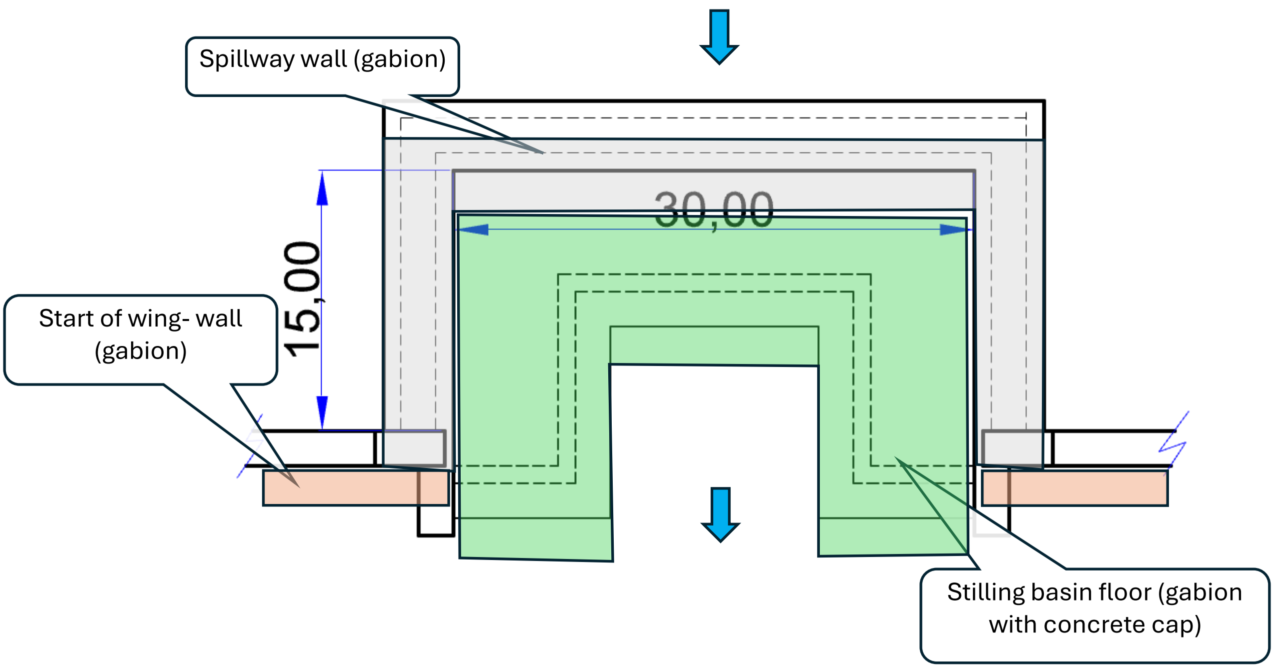

Figure 9 The proposed Onrus weir - plan view

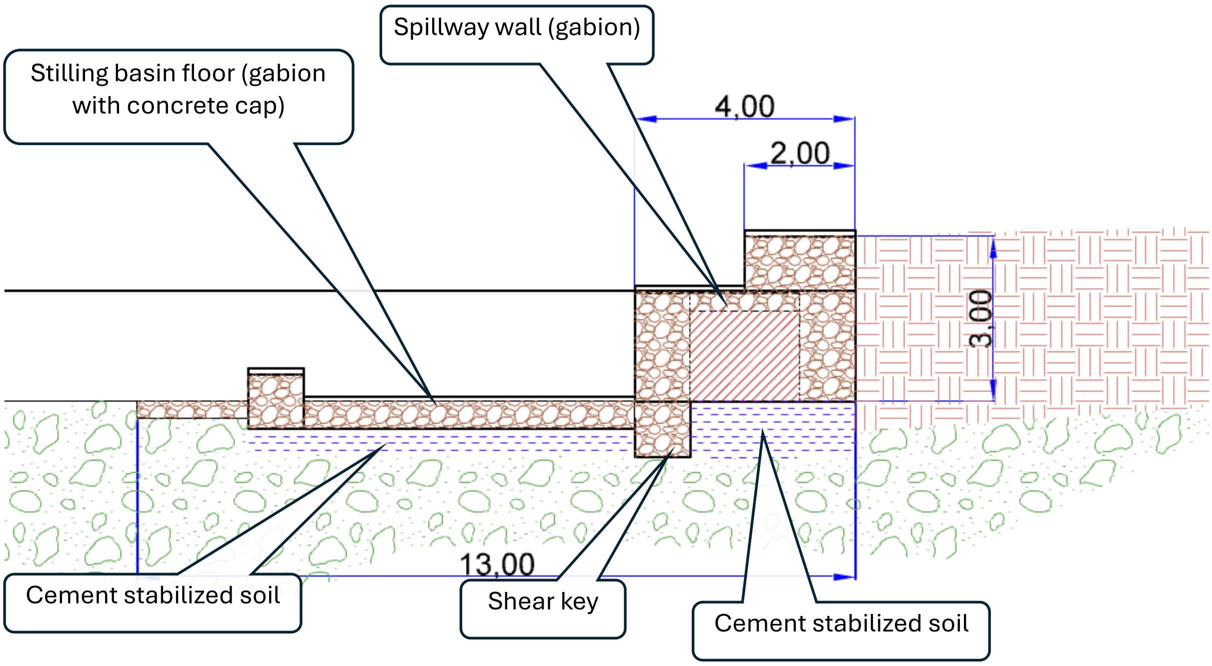

Figure 10 Proposed cross section for the Onrus weirs

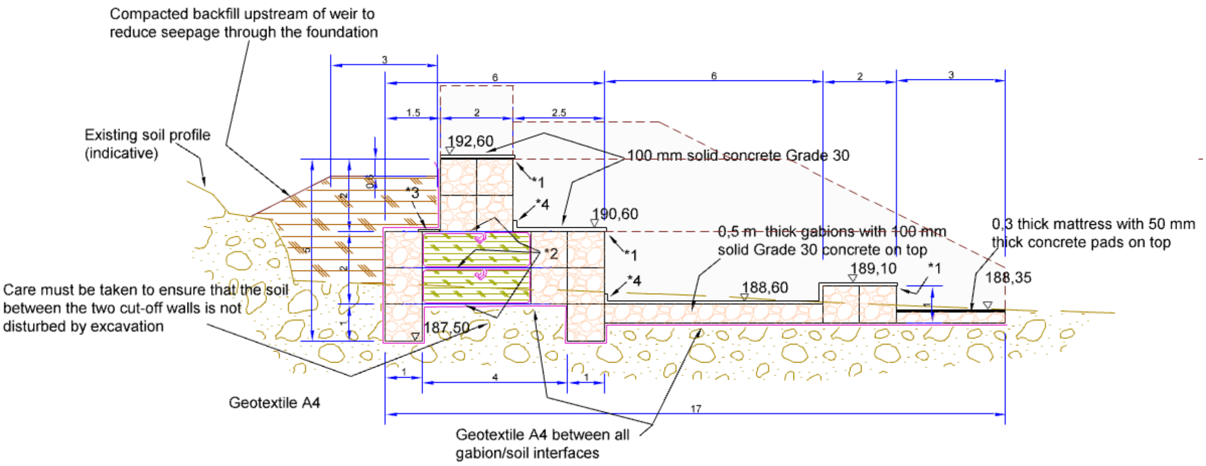

Figure 11 The Tesselaarsdal weirs cross-section (note that this was for dropping water through 4 meters)

SECTION 4: THE MODELLING OF THE DESIGN

The behaviour of water flowing over the site has been simulated using the HECRAS 2D software. The conditions simulated included: -

- A variety of expected peak flood flows (1:10, 1:20, 1:50 and 1:100 - year floods)
- A variety of topographical options, including the “as surveyed” terrain, and the terrain with a range of proposed weir locations and spillway heights.
- A variety of channels between the weirs have also been modelled.

The model has been rebuilt several times, in addition to inspecting the impact of different weir configurations, different methods of modelling the weirs themselves were tested.

A reduced number of plots are shown in the report for the sake of brevity, but more are available on request. Only the 1in 10 and 1in 100 year plots are shown in the report, so that the reader can see the different impacts of frequently repeating floods and more extreme floods.

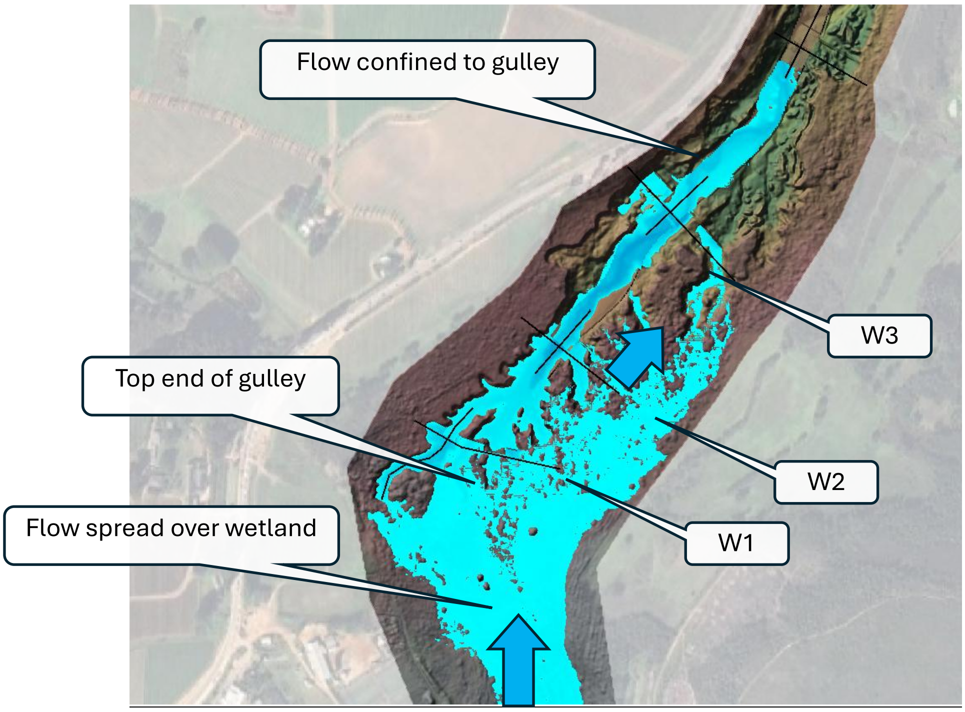

Figure 12 The model clearly demonstrates how water flowed before and after the development of the gulley. In the wetland upstream of the gulley, flow is distributed over a wide area, once the gulley forms the flow is restricted to the narrow channel

Flood flows:

The peak flood flows were determined using the Rational method (as adapted by the Western Cape : Department of Agriculture) – see Appendix 1.

Before simulating a flood flow, the model was "primed" with a nominal flow of 20 m^3/s to "wet" the model.

Floods were modelled as triangular hydrographs of duration of 2 x t_c (the time of concentration – 2 hours). The flood would rise to the design peak flow in the time = t_c and then subside over a period = 1xt_c (2 hours).

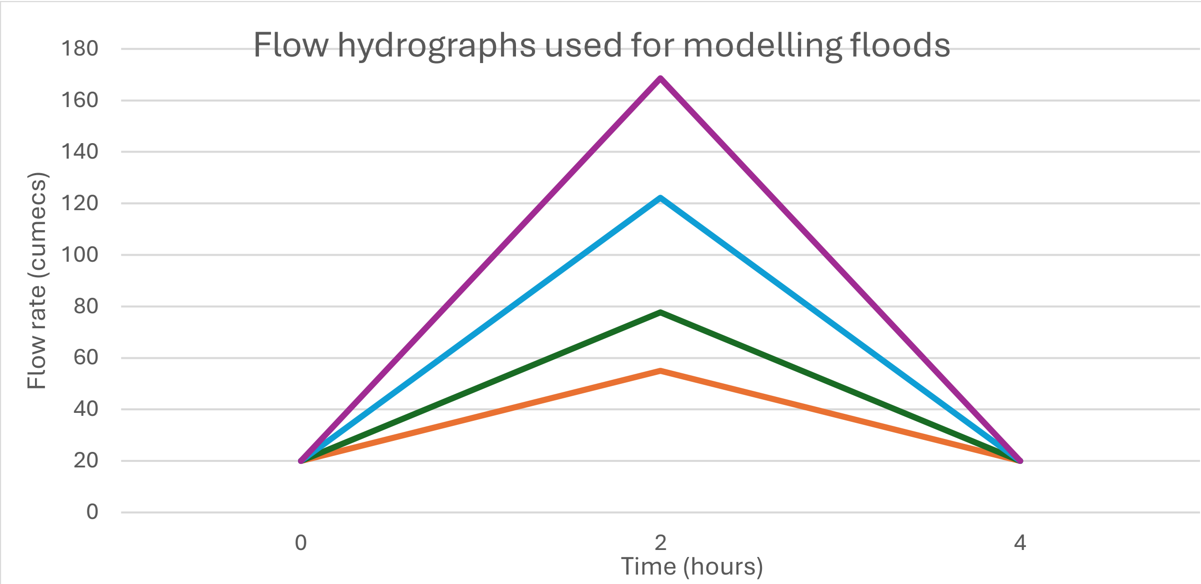

Figure 13 Hydrographs used for the modelling of different return period floods

Manning roughness:

The Manning Roughness for various areas in the models were determined using USGS report WSP 2339, 1989, "Guide for selecting Mannings roughness coefficients for natural channels and flood plains". Polygons of areas of similar hydraulic roughness were digitized in QGIS, saved as shapefiles and exported to HECRAS.

The Manning roughness factors used were as follows:-

ZONE / CONDITION	MANNING ROUGHNESS
Natural channel (sinuous, with frequent changes in width and direction}	0.155
Rehabilitated channel (straighter, consistent width and gradual bends)	0.075
Wetland outside of channel (varying vegetation height, frequent undulations)	0.120

Please refer to the comments made in section 3 “Challenges with the interpretation of the survey data“ regarding the difficulty modelling the hydraulic roughness and elevation of palmiet reed beds.

Modelling of the rehabilitated channel:

The centreline of the rehabilitated channel was planned on a CAD layout and was then exported as a shapefile to HECRAS. Similarly, the positions of the weirs were planned in CAD and exported to HECRAS as shapefiles.

The shapefile centreline was used to guide the insertion of a channel – “Terrain modification” into the HECRAS model. Of the various channel modelling options available, the first option (use the “Replace terrain” option) was found to work best, with the proviso that the total channel width (channel plus side slopes) had to be limited.

The channel was modelled with a 30 m wide base, 1:4 side slopes, and a total structure width of 40 m (in other words the side slopes were limited to 5m each horizontally) – although in practise flatter side slopes were eventually used to generate more fill material.

Modelling of the weirs:

The design spillway length was determined using a discharge of 120 m^3/s (refer to Section 3 – “Weir design”) and a overflow depth of 1m (a long-standing norm with the Department of Agriculture to distribute the energy of water spilling over the spillway). For various reasons the weir was changed from a straight to a horseshoe weir. To enable water to utilize the whole length of the weir, it was necessary to flare the channel base from 30 m to 40m wide in the vicinity of the weirs.

The widened portion of the channel at the weir could not be modelled with a "channel" in HECRAS because "channel" terrain modifications must have a constant width. The landscaped area around the weir, including the weir spillway, was modelled as a "multi point polygon" terrain modification where the top surface was level (at the height of the spillway). To improve the calculation of the water profile as it falls over the structure, a "breakline" was placed on the downstream edge of the structure. This created conditions for the correct application of the broad crested weir formula.

General comments regarding the different models that have been tested:

1. The inundation plots show the area inundated during different return period floods, and for different structural configurations (ie as surveyed, with 6 weirs). The plots all show clearly how the entire valley was inundated even at the 1:10 year flood level (see Figure 20 Inundation plot t=3hours 1:10 year flood (terrain as surveyed)), but now with the gulley this does not happen (see Figure 20 Inundation plot t=3hours 1:10 year flood (terrain as surveyed)). This leads to a lowering of the water table, and the dying back of the wetland habitat
2. The flow velocity plots give a good indication of where serious soil erosion will take place during floods. The average flow velocity is indicated by colour – the key relating colour to flow velocity is in the lower right-hand corner of each plot.
   For most sands, flow velocities less than 1m/s are safe with respect to soil erosion. With the help of vegetation, these sands can still be stable to around 2 m/s for short periods of time. Hence the flow areas shaded blue (less than 1m/s) are safe wrt soil erosion, and shaded yellow, safe for short periods of time.
   Areas indicated orange and red are certainly areas where soil erosion will take place – and probably migrate upstream (as headcuts). These areas where soil erosion takes place, lead to the deepening of the gulley, and the dying back of the wetland, so they need to be resolved.
   When comparing the flow velocity plots "as surveyed" with "six weirs", the plots with the "six weirs" may have more yellow area than the "as surveyed" plots, but not the several areas highlighted orange and red.

3. There were initially 5 weirs planned, but the flow velocity plot identified high flow velocities upstream of the upper weir, so an additional weir had to be added.
4. The layout of the site with the six proposed weirs and rehabilitated channel are shown on Figure 24.
5. Plan views, cross sections, and long section of flow passing over each weir are given in Figures 22 to 43. Please note that the cross sections do not show the gabion wing-walls which are at least 1m higher than the spillways.

SECTION 5: CONCLUSION OF THE DESIGN

In general, the beneficial impacts of the wetland rehabilitation include:-

- The control the flow velocity in the river so that extremely high flow velocities and the related soil erosion have been avoided.
- The raising of the water table by as much as 3 m or more.
- The sustainable re-establishment of indigenous wetland vegetation over a wide area.
- The halting of the upstream migration of the erosion gulleys.
- The halting of the flow of sediment from the wetland to the downstream estuary.

The need for the proposed work is great. In the 2023/24 flooding, the gulley in the wetland extended upstream by almost 1,5 km, and if nothing is done about it, this will happen again. In addition, a lot of the peat soil and palmiet reed beds adjacent to the gulley are drying out. Should there be a fire the peat and the palmiet reed will all burn and disappear completely. By re-purposing the peat soil and remains of the vegetation, the material can be put to good use recreating the wetland at a lower level.

An estimate of the construction cost of the project has been made and is summarised in Appendix 6. The projected cost is just below R 40 million (vat included), but as described in the Appendix, this makes provision for R5 million for various contingencies. The cost estimate is based on a one-year construction period.

SECTION 6 – METHOD STATEMENT FOR PROPOSED WORK

ORDER OF WORK

- The construction of weirs will tend drown upstream work areas, so the six weirs will be constructed from the upstream end first, working downstream.
- Once a weir is close to being completed, the landscaping and planting of the channel upstream of the weir will be done. While the landscaping and planting is being done, a temporary drainage facility at the weir will be provided – this will be either a pipe through the weir, a gap left in the spillway, or a sump upstream of the spillway from which water will be pumped over the spillway. Once the landscaping is complete, the construction of the weir will be finalised.

HOW THE WORK WILL BE DONE

For each weir:

- An access road will be created by the shortest possible route through the wetland. This will be done by rescuing indigenous wetland plants along the route, to a temporary storage facility. Three main access routes are likely –
    - From upstream of the Hamilton-Russel vineyards – just upstream of Weir 1
    - Opposite Weir 4 - in the middle of the project
    - From the dam att the lower end of the project – opposite Weir 6.
- The demarcated work zone will be cleared of vegetation, which will be rescued for re-planting.
- The foundation area (spillway wall, stilling basin and wing walls) will be stabilized with 5% cement (the footprint will have cement spread over it, then mixed mechanically and compacted). Where the existing channel is deeper than the future foundation, this layer of cement stabilizing will be deeper, to ensure that there is no development of water tunnels under the structure.
- The spillway structure gabions will be installed – leaving a narrow gap for the management of water, which will be kept open until the bulk of the upstream channel landscaping has been completed, after which it will be closed.
- The concrete capping (where required) will then be placed.

For each section of channel between the weirs:

- The sideways extents of the channel will be pegged out (considering the rehabilitated channel width, floor level, and minimum side slope).

- The indigenous vegetation in this area will be rescued for replanting later.
- A temporary drainage channel (about 5m wide) will most likely be used by the contractor to drain the wetland until the landscaping is complete, then as the temporary opening in the downstream weir is being closed, the channel will be closed up as well.

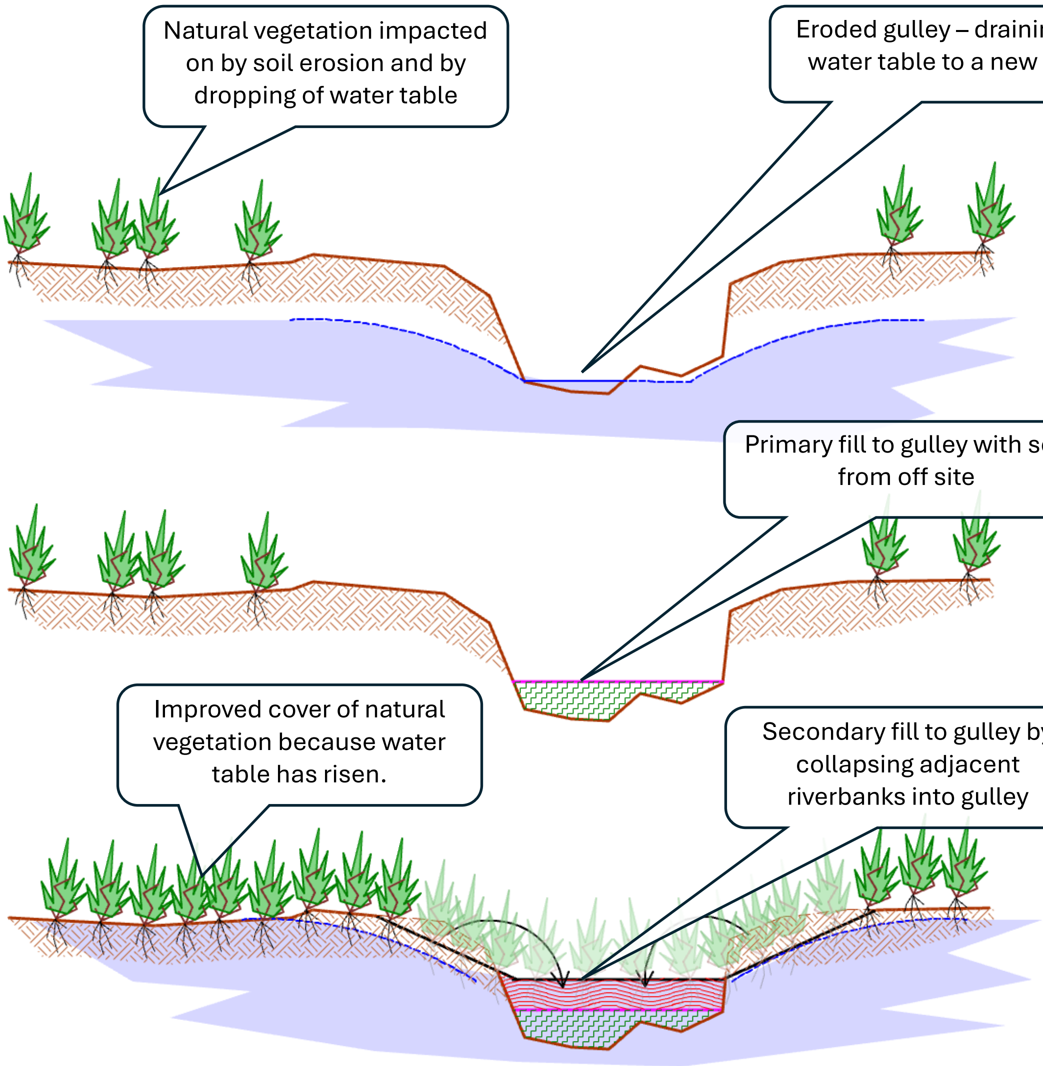

Figure 14 Representation of the stages of work in the gulley

- If sand is available for import (either from the estuary, or the upstream dam) this will be placed first into the gulley up to a level of not more than 500 mm below the final surface of the rehabilitated wetland.
- The gulley walls will be collapsed until the designed minimum rehabilitated channel cross-section profile has been created. This soil will be spread over the rehabilitated channel to fill it to the designed level. The banks of the channel will have a maximum slope of 1:4 to enable the successful planting of vegetation.
- Depending on the conditions of flow in the river, it may be necessary to leave open a narrow drainage trench through the rehabilitated wetland until the bulk of the wetland rehabilitation is complete, and then to close it up at the last moment before the downstream weir is completed.
- Rescued plants will be re-establish across the whole of the rehabilitated channel.

ACCESS ROUTES

- Generally, the disturbance of indigenous wetland areas needs to be minimised, and when it is inevitable, it will be done bearing in mind that it needs to be rehabilitated afterwards.
- Access roads will be a short as possible, and where possible be just upstream of the area already having to be disturbed for the construction of the wing-walls.
- Where possible, access routes will be restricted to areas that will later be disturbed and then rehabilitated.

MANAGEMENT OF INDIGENOUS VEGETATION AND STOCKPILING OF MATERIALS

- At times peat soil will be excavated for the construction of the weirs, and this will have to be stored temporarily. If possible, space will be created in the eroded area to store wetland soil. This may include building a temporary soil filled bulk-bag wall on the river side of the stockpile to prevent it frow washing away. Alternatively, areas not covered with indigenous vegetation outside of the wetland will be sought to temporally store the soil.
- During the construction of access roads and the clearing of work areas for construction, the wetland ecologist will indicate which plants must be brush-cut and which must be lifted entirely for replanting.
- Wetland vegetation (with or without roots) will also need to be stored until needed for the revegetation of the wetland. The project has made provision for the construction of a temporary channel of 200 m (in total) to be used as a nursery on site for the storage of viable palmiet reed rhizomes for later use. These will be rescued simultaneously with the clear and grub operation.

WORK AREA FOOTPRINT

The contractor needs a reasonable space within which to work. There are usually piles of rock for packing in gabions, and excavated soil etc. In addition to these, space is needed for excavators and other equipment to pass the working machines. Contractors often request 10 m all around a structure.

Most of the low-lying area in and around the gulley will be disturbed during the cut-to-fill operation where soil is sourced from outside the gulley to fill it in. In this area the work area required by the contractor is not an issue.

Where the weir wing-walls must be extended into virgin palmiet reed beds then it would be advisable that the contractor be confined to a narrow strip upstream of the wing-wall, as it is desirable lift the soil level to the top of the gabion in this area anyway.

APPENDIX 1 : HYDROLOGY

A detailed hydrological study has been undertaken by Dr Simon Lorentz of SRK. This included a detailed analysis of how much water the catchment yields, as well as a 100 year peak flow estimate.

As is normal for this kind of work, design flood peak flows for a range of return periods were needed to inspect flow conditions at the site. These design peak flows are used to determine the frequency and level of inundation, as well as flow velocity, during different floods. To provide this information flood peak flows were determined using the Rational method (as adapted by the Western Cape Department of Agriculture) has been used. This method is GIS based, is relatively simple and has been widely used. The result of the Rational method study corresponds very well with that determined by Dr Lorentz.

The Rational method indicates a slightly higher 1:100 year flood peak flow at the wetland, and for the sake of the safety of the structures, and concerns about the interpretation of survey data in the palmiet wetland, this larger value has been used.

The following were the peak flow rates used in the hydraulic design of the weirs:-

Flood return period	Peak flow rate
1:10	55
1:20	77.7
1:50	122.2
1:100	168.6

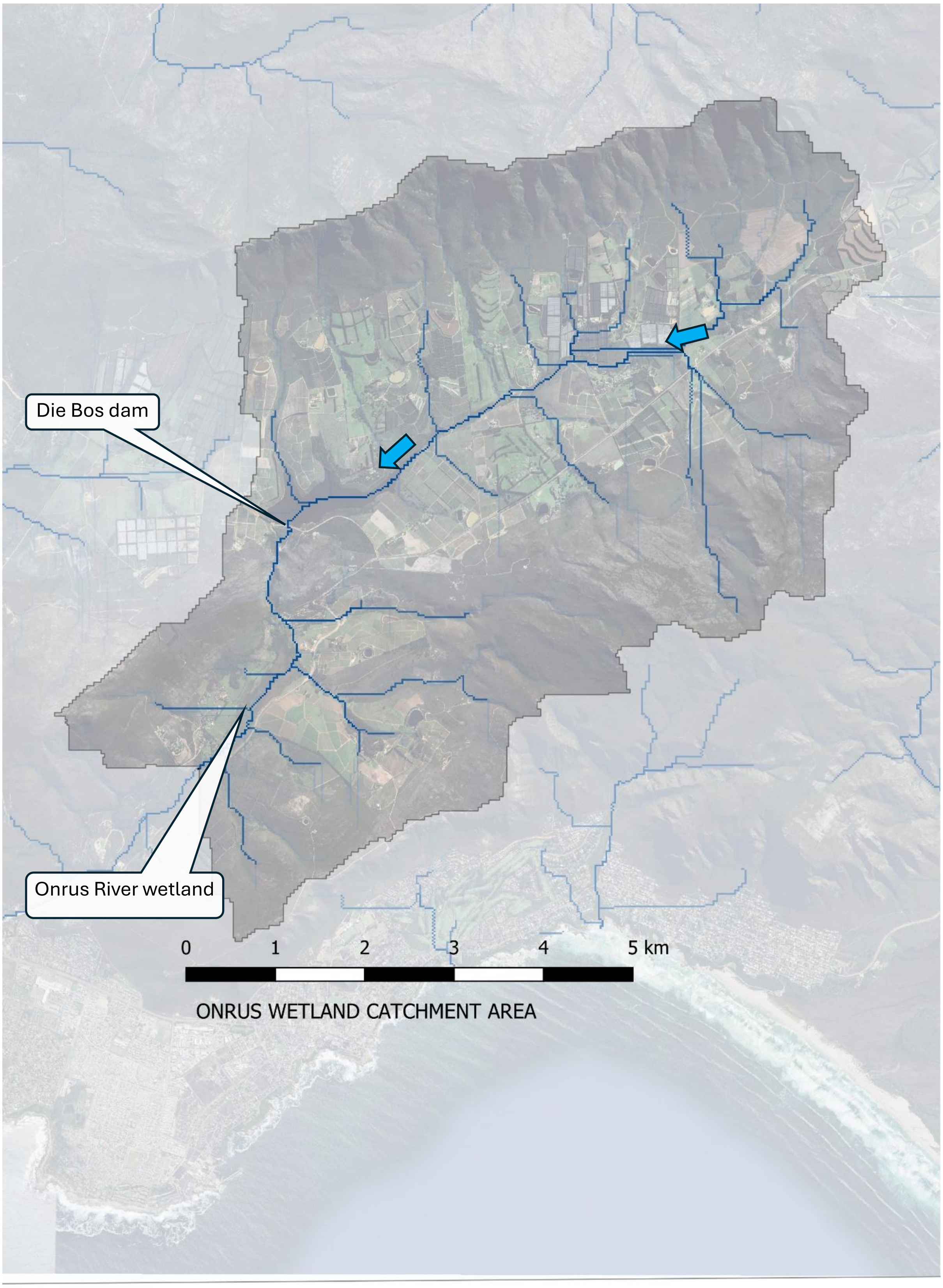

Figure 15 The catchment area upstream of the wetland

STORM PEAK RUN-OFF USING MIDGLEY'S RATIONAL METHOD

Run date: July 8, 2025

Farm :	Onrus - whole catchment	District:	Hermanus
File number:			

Catchment area (km^2)	47.129	(must be between 0 and 30 000 km^2)
Average annual rainfall (mm)	753	(must be between 100 and 200 mm/a)
Enter code for rainfall type	1	1 = Winter; 2=Summer; 3=Both

SLOPE FACTOR

Slope class	Percentage of area (1)	Cs factor (2)	(1)x(2)
< 3	10	0.03	0.00
3 - 10	25	0.08	0.02
10 - 30	40	0.16	0.06
> 30	25	0.26	0.07
		Cs =	0.152

SOIL FACTOR

Soil class	Percentage of area (1)	Cp factor (2)	(1)x(2)
A	0	0.04	0.00
B	10	0.10	0.01
C	50	0.20	0.10
D	40	0.26	0.10
		Cp =	0.214

VEG. FACTOR

Soil use	Percentage of area (1)	Cv factor (2)	(1)x(2)
Thick bush	30	0.05	0.02
Unspecified	0	0	0.00
Grassveld	40	0.21	0.08
Bare ground	30	0.28	0.08
		Cv =	0.183

Flood frequency	10	20	50	100
Flood frequency reduction factor	0.6	0.67	0.83	1
Runoff factor C	**0.329**	**0.368**	**0.456**	**0.549**

Overland flow:

Roughness factor r	0.15
Average slope (%)	15
Flow distance (m)	100
t_c overland (hr)	**0.13**

The time of concentration has been determined by considering individual slope stretches along the longest flow path.

t_c channel (hr)	**3.05**
t_c total (hr)	**3.18**

(minimum 0,25 maximum 48 hours)

Rainfall intensity:

Flood frequency (years)	**10**	**20**	**50**	**100**
Point rainfall (mm)	41.26	52.49	66.99	77.32
Point intensity (mm/hr)	12.98	16.52	21.08	24.33
Aerial reduction factor	0.981	0.976	0.969	0.963
Rainfall intensity (mm/hr)	12.74	16.13	20.43	23.44
Runoff (m^3/sec)	**55.0**	**77.7**	**122.0**	**168.6**

Comments
1) Section 1 is the section upstream of the weir
2) Rainfall ex HRC shapefile, area 3 recommended
3)
4)

Version 2 : April 2010 H King (Tc computed by stretches of similar slope)

Figure 16 Design flood peak flows for the entire catchment (impact of the De Bos Dam ignored)

STORM PEAK RUN-OFF USING MIDGLEY'S RATIONAL METHOD

Run date: July 8, 2025

Farm :	Onrus - upper catchment	District:	Hermanus
File number:			

Catchment area (km^2)	31.899	(must be between 0 and 30 000 km^2)
Average annual rainfall (mm)	753	(must be between 100 and 200 mm/a)
Enter code for rainfall type	1	1 = Winter; 2=Summer; 3=Both

SLOPE FACTOR

Slope class	Percentage of area (1)	Cs factor (2)	(1)x(2)
< 3	10	0.03	0.00
3 - 10	25	0.08	0.02
10 - 30	40	0.16	0.06
> 30	25	0.26	0.07
		Cs =	0.152

SOIL FACTOR

Soil class	Percentage of area (1)	Cp factor (2)	(1)x(2)
A	0	0.04	0.00
B	10	0.10	0.01
C	50	0.20	0.10
D	40	0.26	0.10
		Cp =	0.214

VEG. FACTOR

Soil use	Percentage of area (1)	Cv factor (2)	(1)x(2)
Thick bush	30	0.05	0.02
Unspecified	0	0	0.00
Grassveld	40	0.21	0.08
Bare ground	30	0.28	0.08
		Cv =	0.183

Flood frequency	10	20	50	100
Flood frequency reduction factor	0.6	0.67	0.83	1
Runoff factor C	**0.329**	**0.368**	**0.456**	**0.549**

Overland flow:

Roughness factor r	0.15
Average slope (%)	15
Flow distance (m)	100
t_c overland (hr)	**0.13**

The time of concentration has been determined by considering individual slope stretches along the longest flow path.

t_c channel (hr)	**1.88**
t_c total (hr)	**2.01**

(minimum 0,25 maximum 48 hours)

Rainfall intensity:

Flood frequency (years)	**10**	**20**	**50**	**100**
Point rainfall (mm)	38.08	45.78	61.01	70.81
Point intensity (mm/hr)	18.97	22.81	30.40	35.28
Aerial reduction factor	0.980	0.976	0.966	0.960
Rainfall intensity (mm/hr)	18.60	22.25	29.37	33.87
Runoff (m^3/sec)	**54.3**	**72.6**	**118.7**	**164.9**

Comments

1) Section 1 is the section upstream of the weir
2) Rainfall ex HRC shapefile, area 3 recommended
3)
4)

Version 2 : April 2010 H King (Tc computed by stretches of similar slope)

Figure 17 Design runoff from catchment upstream of the De Bos Dam

STORM PEAK RUN-OFF USING MIDGLEY'S RATIONAL METHOD

Run date: July 8, 2025

Farm : Onrus - lower catchment ignoring dam District: Worcester File number:

Catchment area (km^2)	15.23	(must be between 0 and 30 000 km^2)
Average annual rainfall (mm)	753	(must be between 100 and 200 mm/a)
Enter code for rainfall type	1	1 = Winter; 2=Summer; 3=Both

SLOPE FACTOR

Slope class	Percentage of area (1)	Cs factor (2)	(1)x(2)
< 3	10	0.03	0.00
3 - 10	25	0.08	0.02
10 - 30	40	0.16	0.06
> 30	25	0.26	0.07
		Cs =	**0.152**

SOIL FACTOR

Soil class	Percentage of area (1)	Cp factor (2)	(1)x(2)
A	0	0.04	0.00
B	10	0.10	0.01
C	50	0.20	0.10
D	40	0.26	0.10
		Cp =	**0.214**

VEG. FACTOR

Soil use	Percentage of area (1)	Cv factor (2)	(1)x(2)
Thick bush	30	0.05	0.02
Unspecified	0	0	0.00
Grassveld	40	0.21	0.08
Bare ground	30	0.28	0.08
		Cv =	**0.183**

Flood frequency	10	20	50	100
Flood frequency reduction factor	0.6	0.67	0.83	1
Runoff factor C	**0.329**	**0.368**	**0.456**	**0.549**

Overland flow:

Roughness factor r	0.15
Average slope (%)	15
Flow distance (m)	100
t_c overland (hr)	**0.13**

The time of concentration has been determined by considering individual slope stretches along the longest flow path.

t_c channel (hr)	**1.17**	
t_c total (hr)	**1.30**	(minimum 0,25 maximum 48 hours)

Rainfall intensity:

Flood frequency (years)	**10**	**20**	**50**	**100**
Point rainfall (mm)	34.38	40.70	52.05	64.86
Point intensity (mm/hr)	26.39	31.24	39.95	49.78
Aerial reduction factor	0.987	0.984	0.980	0.975
Rainfall intensity (mm/hr)	26.03	30.74	39.14	48.52
Runoff (m^3/sec)	**36.3**	**47.9**	**75.5**	**112.8**

Comments
1) Section 1 is the section upstream of the weir
2) Rainfall ex HRC shapefile, area 3 recommended
3)
4)

Version 2 : April 2010 H King (Tc computed by stretches of similar slope)

Figure 18 Design runoff from the catchment below the De Bos Dam

APPENDIX 2 : TERRAIN SURVEY

Figure 19 The orthophoto produced with drone-based photogrammetry on a Google Earth background. This shows the extent of the area surveyed for the construction of the hydraulic simulation models.

After the hydraulic modelling of the 5 weir concept had been completed, a Lidar survey became available. The Lidar survey was used to model the 6 weir option because at the time when the Lidar was flown, a lot of the alien trees in the wetland had been removed. The Lidar also has superior penetration through the remaining alien trees. This dataset was kindly made available by Mr Nardus Bosman[i].

[1] Bosman, B.L.B, 2025. LIDAR dataset for the Onrus and Bot River wetlands, Western Cape, South Africa. Collected as part of PHD research. University of the Free State, Bloemfontein, South Africa. Unpublished and in progress.

APPENDIX 3: IMAGES FROM THE HYDRAULIC MODELLING OF THE SITE

PLOTS OF FLOW THROUGH WETLAND IN AS SURVEYED (NO INTERVENTION)

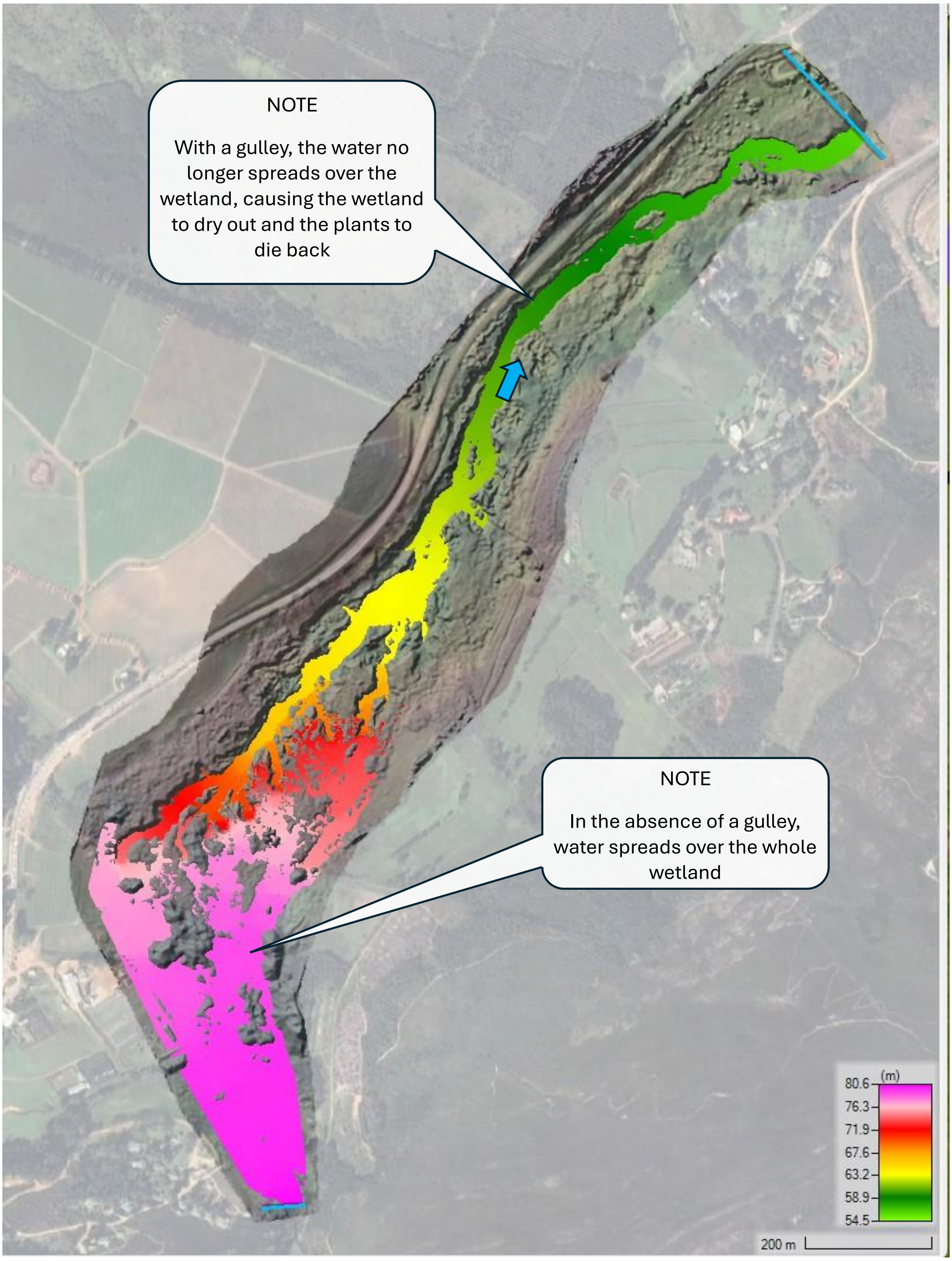

Figure 20 Inundation plot t=3hours 1:10 year flood (terrain as surveyed)

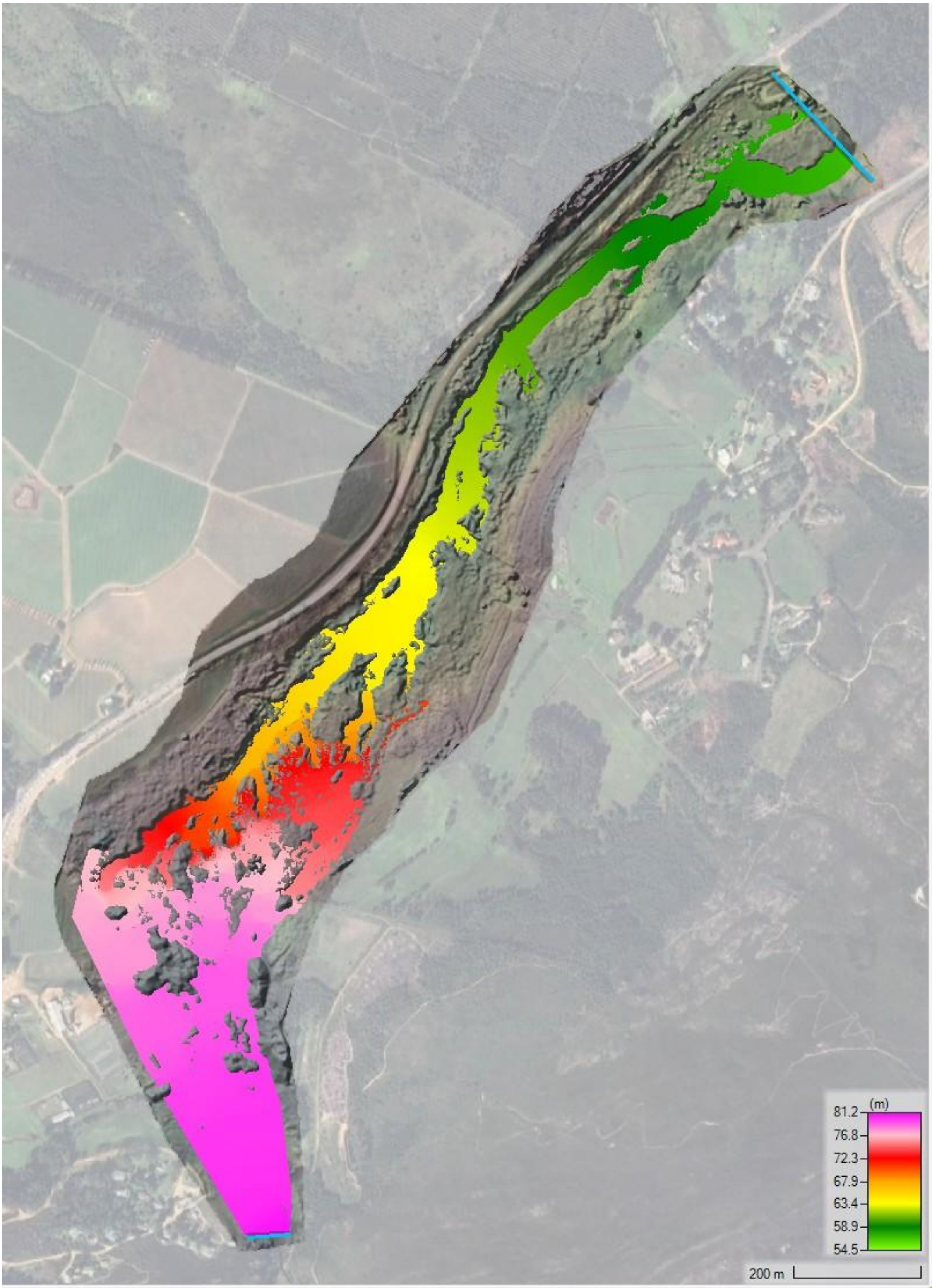

Figure 21Inundation plot t=3hours 1:100 year flood (terrain as surveyed)

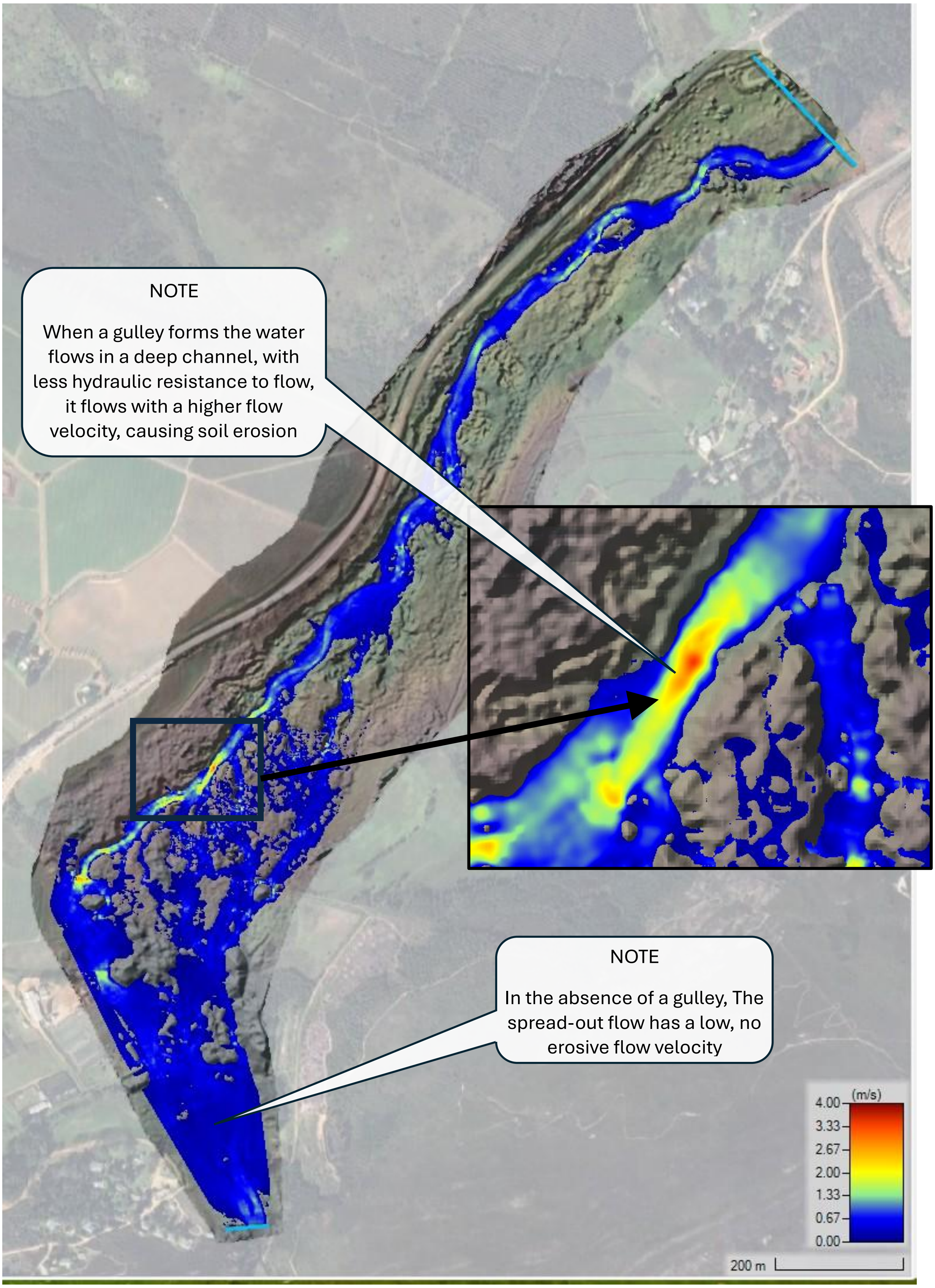

Figure 22 Flow velocity 1:10 year flood (terrain as surveyed)

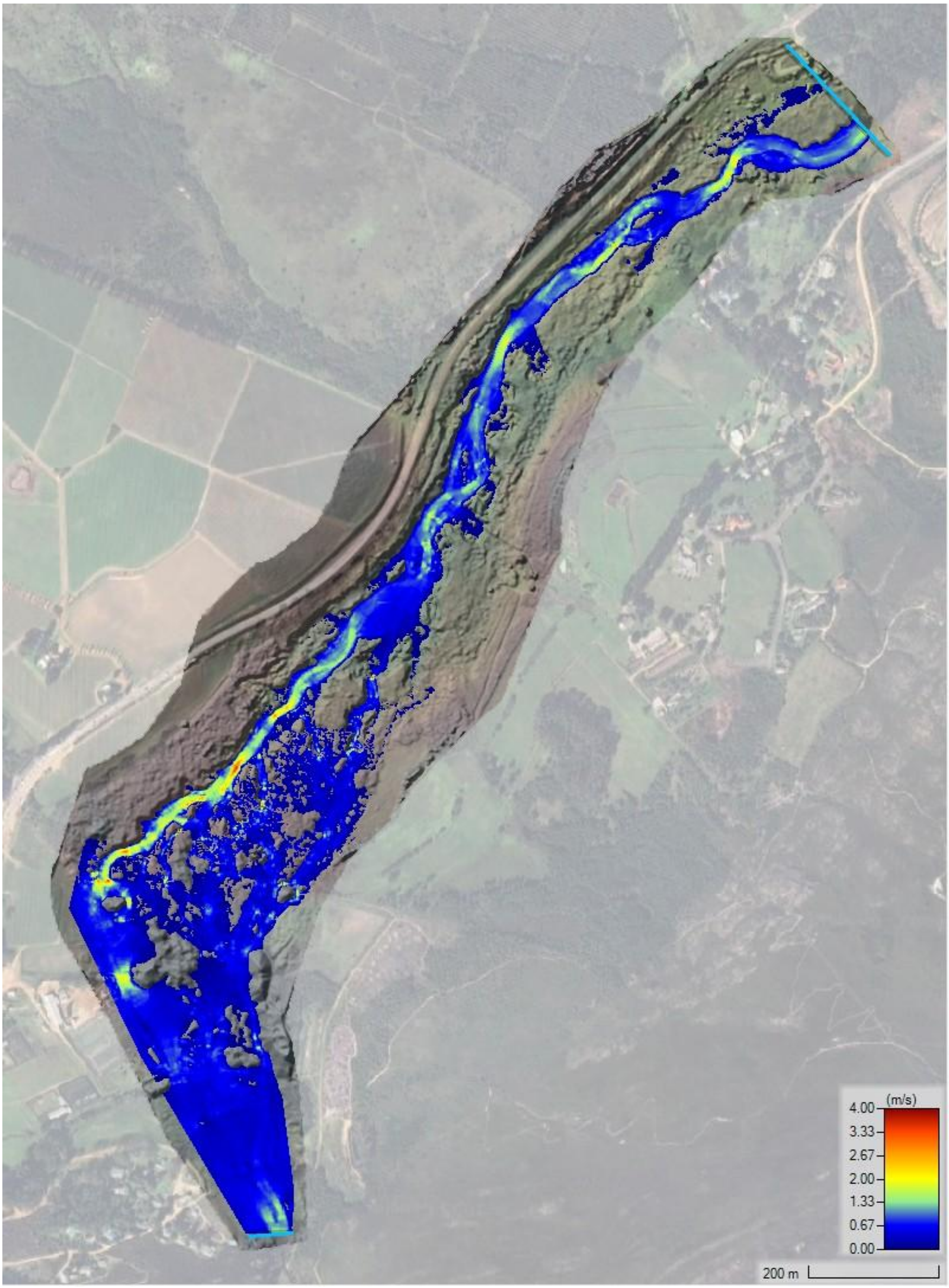

Figure 23 Flow velocity 1:100 year flood (terrain as surveyed)

THE MODELLING OF THE PROJECT WITH THE FINAL (HIGHER) SPILWLAY LEVELS

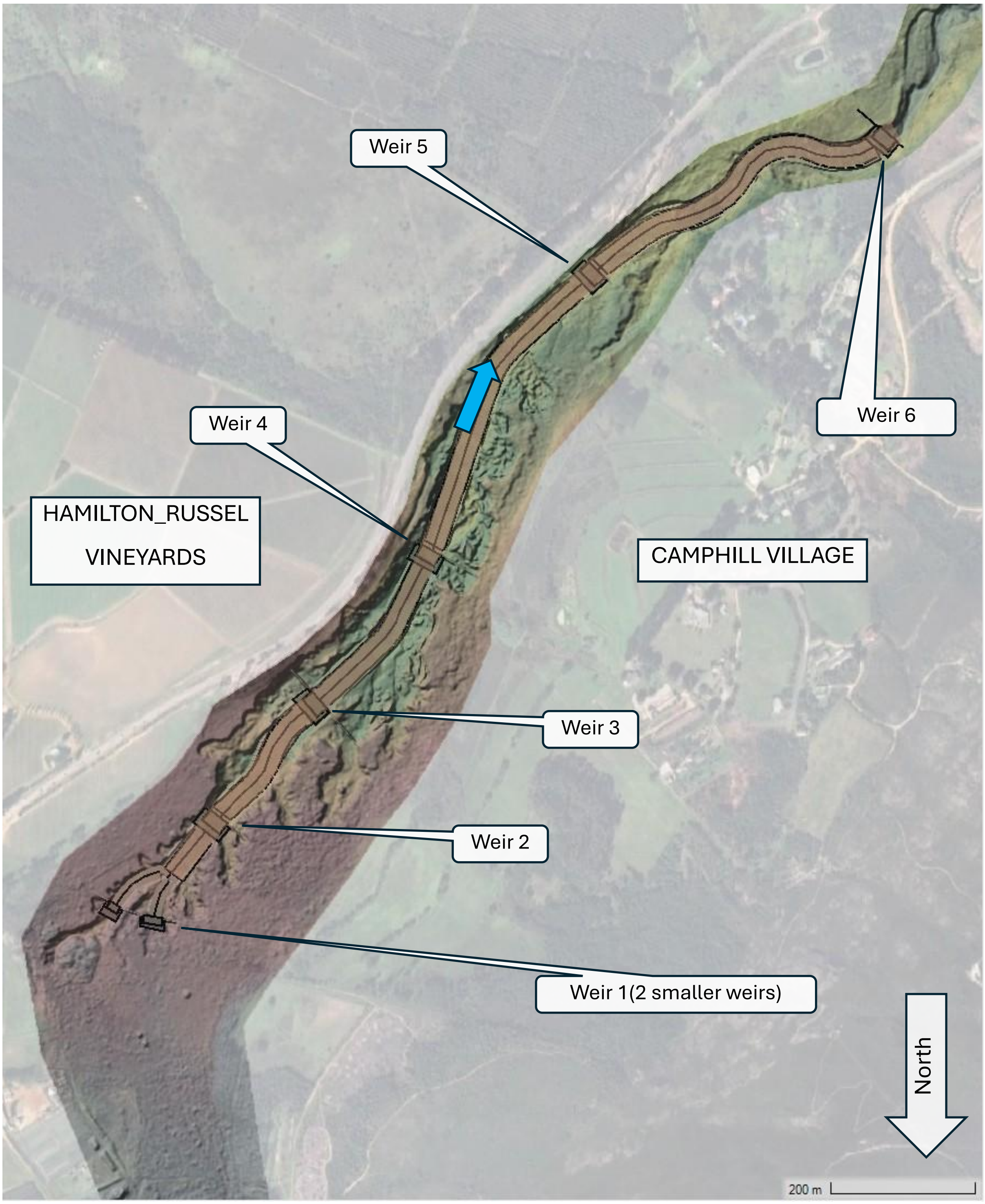

Figure 24 Layout of the Model 4 weirs (the final version with 6 weirs)

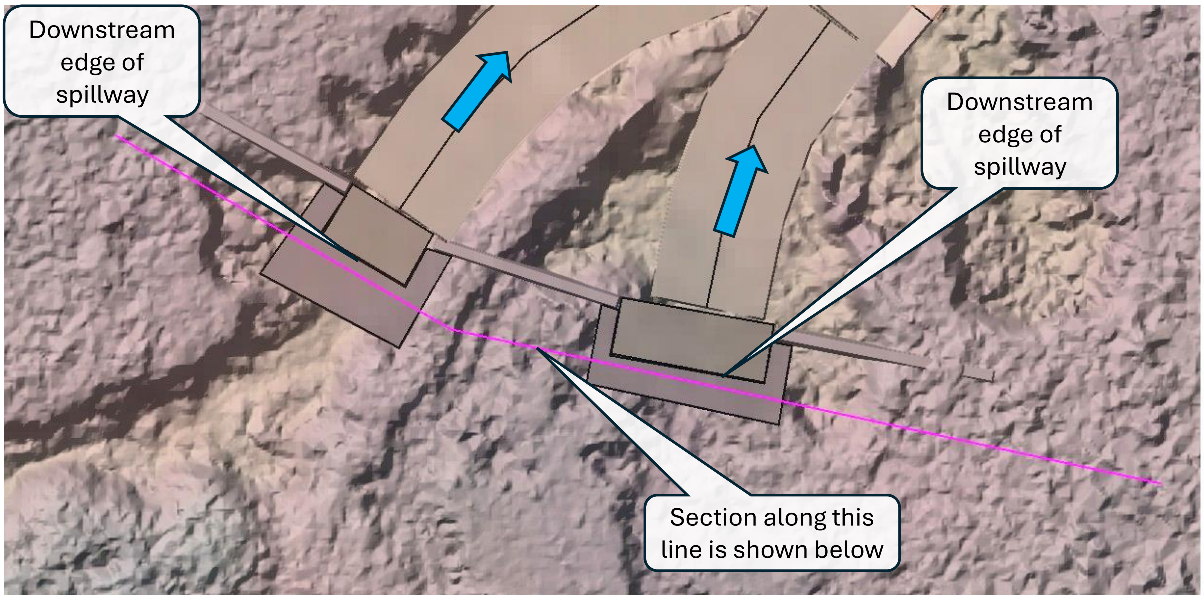

Figure 25 Weir 1 (left and right – both channels 20 m wide)

Figure 26 Section though weir 1 (looking downstream)

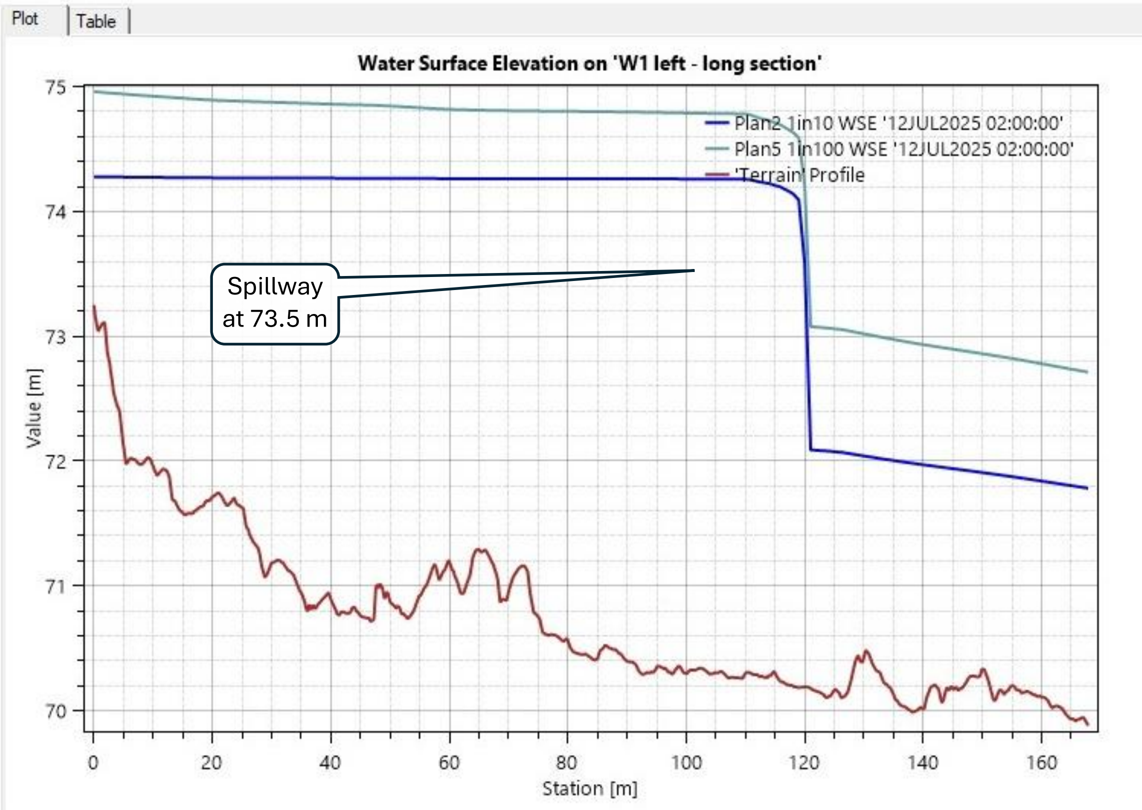

Figure 27 Long section through Weir1 showing 1:10 as well as 1:100 year peak flow levels

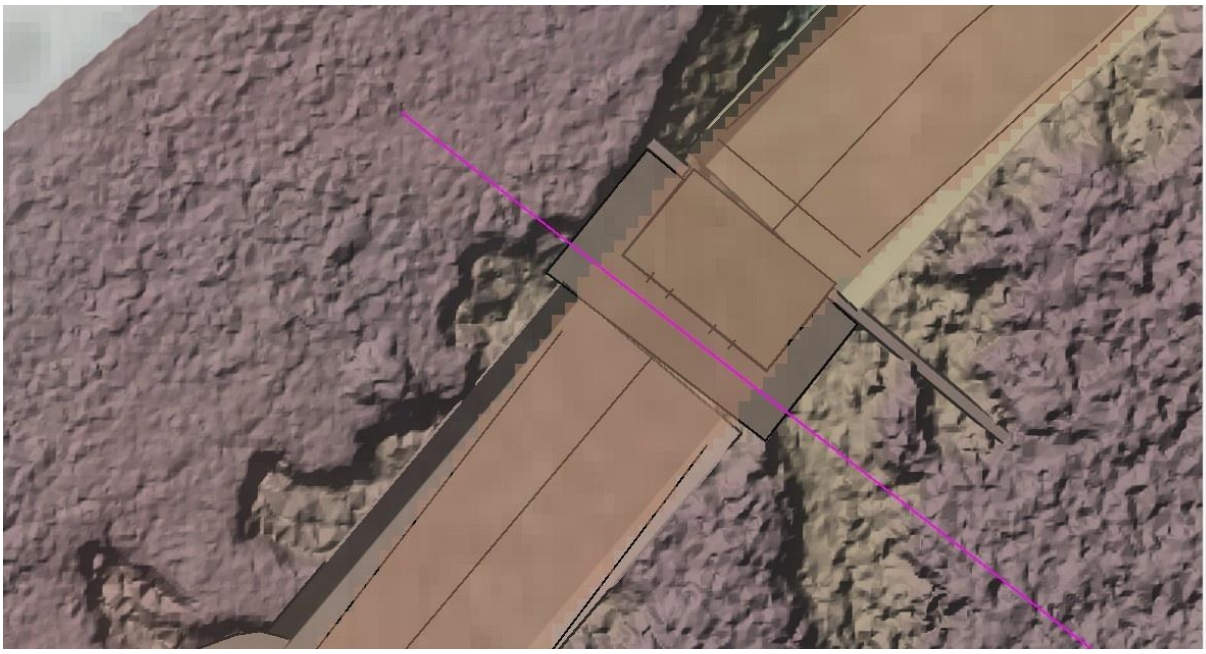

Figure 28 Weir 2

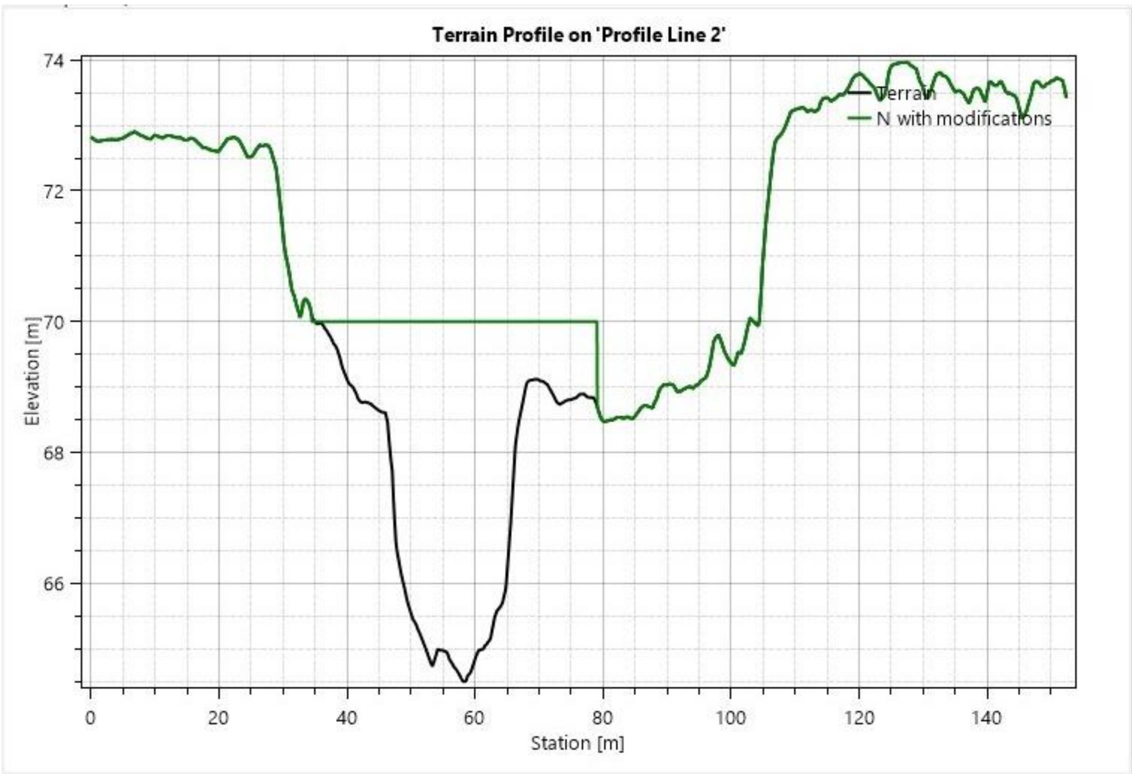

Figure 29 Section though weir 2 (looking downstream)

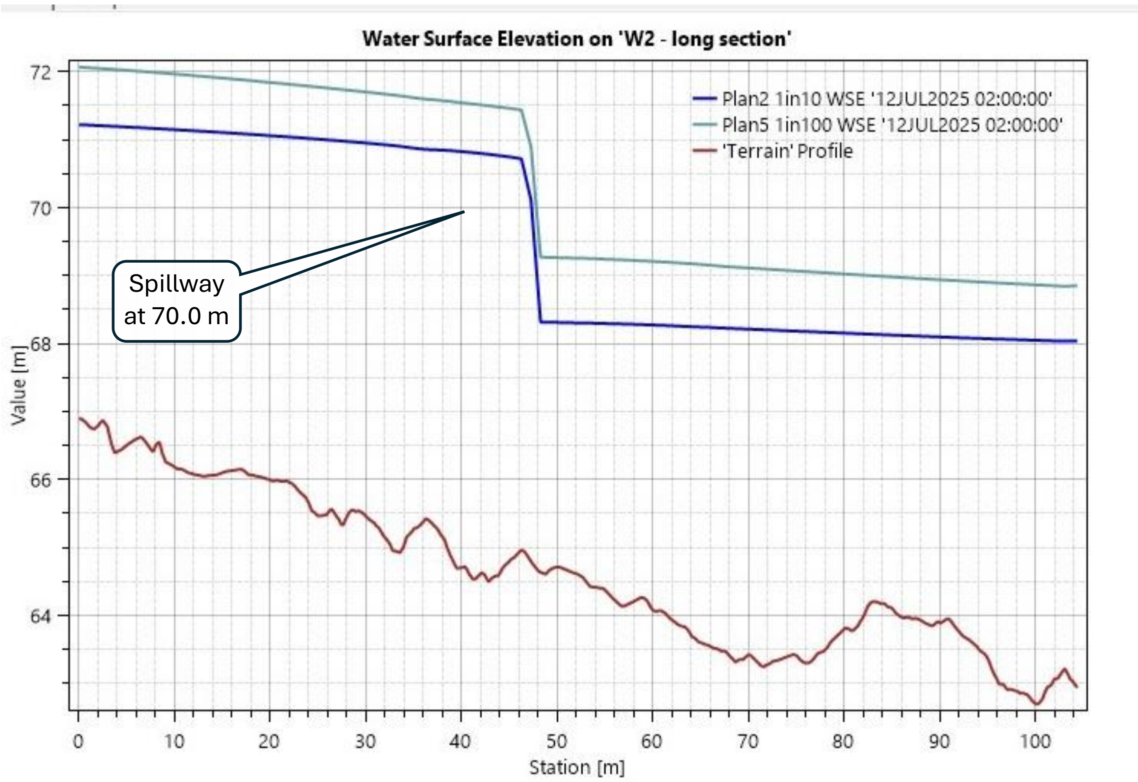

Figure 30 Figure 31 Long section through Weir2 showing 1:10 as well as 1:100 year peak flow levels

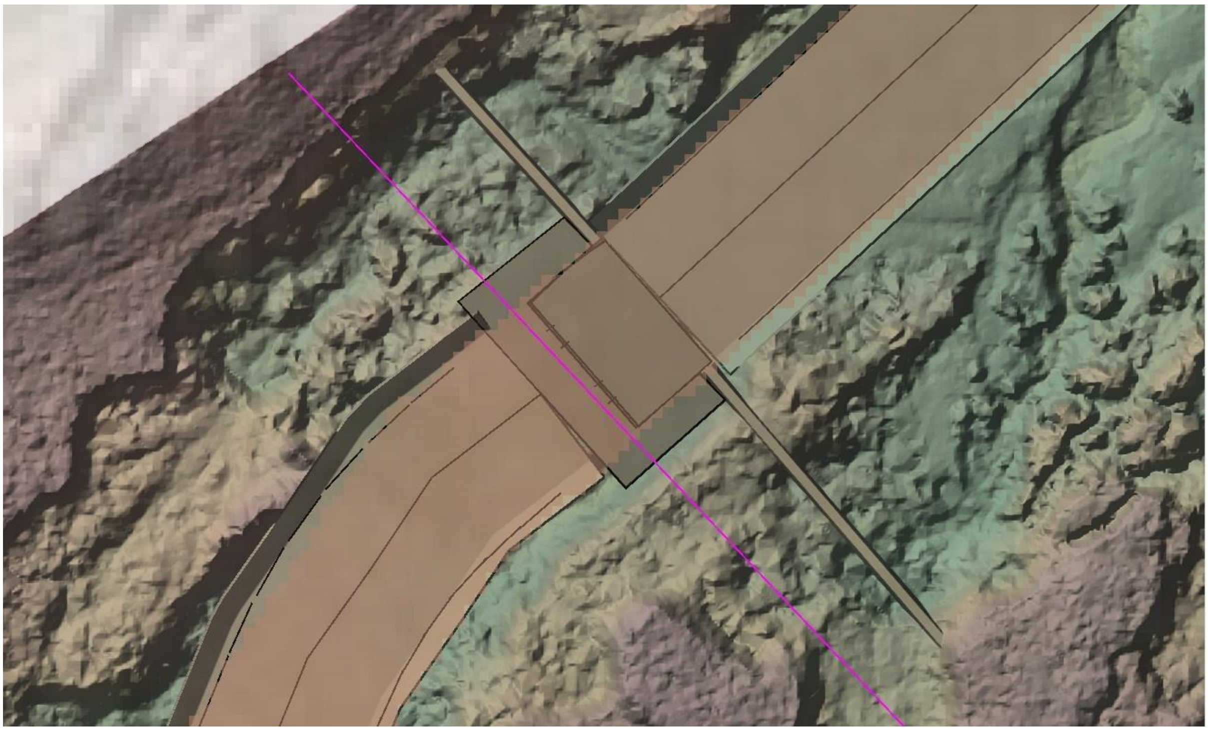

Figure 32 Weir 3

Figure 33 Section though weir 3 (looking downstream)

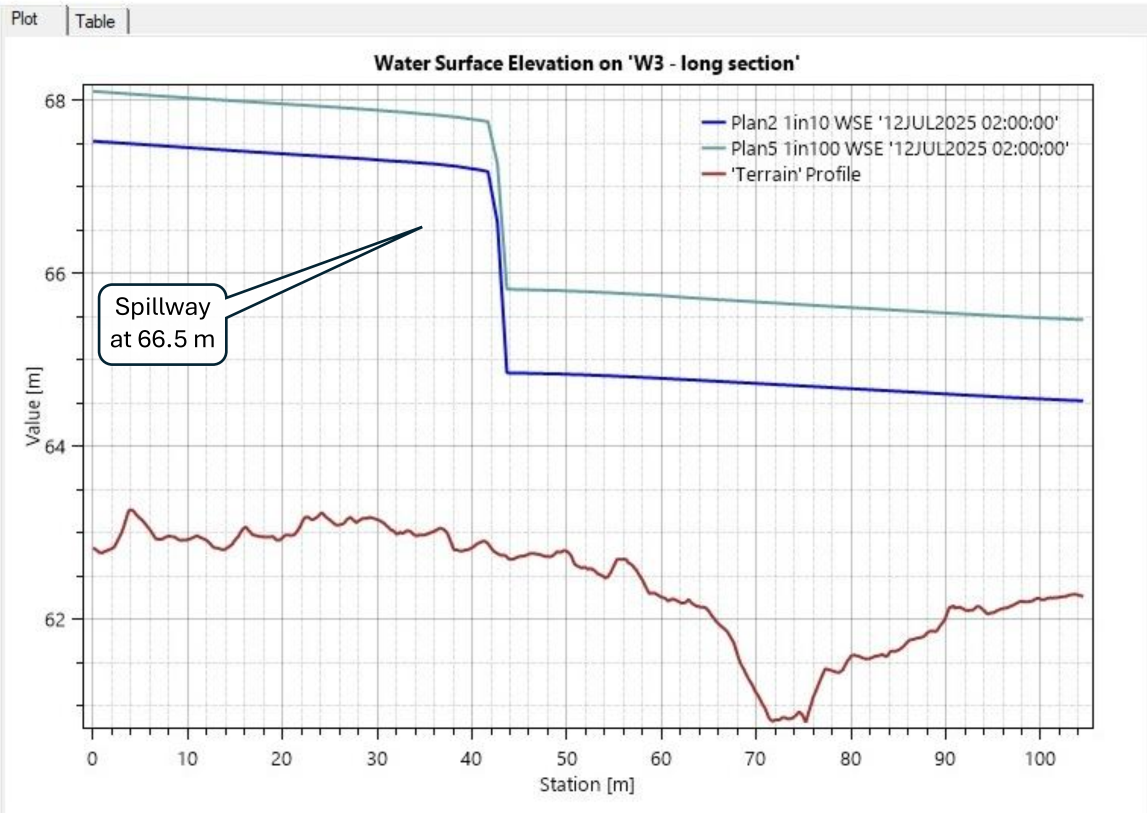

Figure 34 Figure 35 Long section through Weir3 showing 1:10 as well as 1:100 year peak flow levels

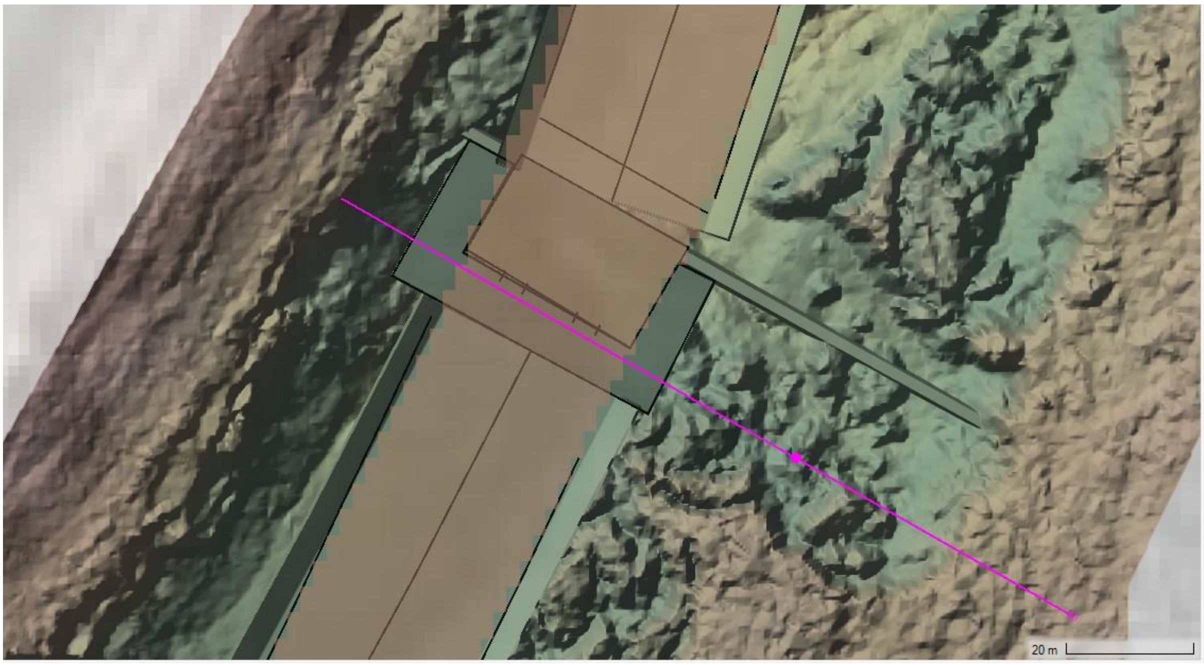

Figure 36 Weir 4

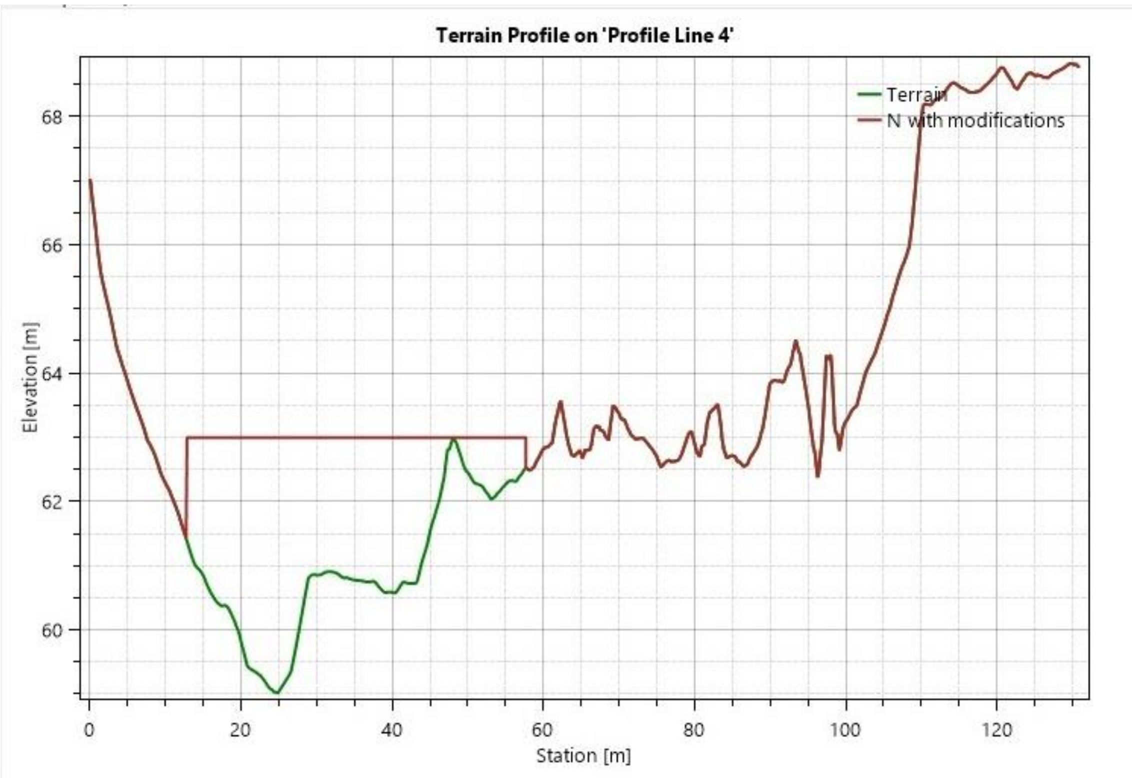

Figure 37 Section though weir 4 (looking downstream)

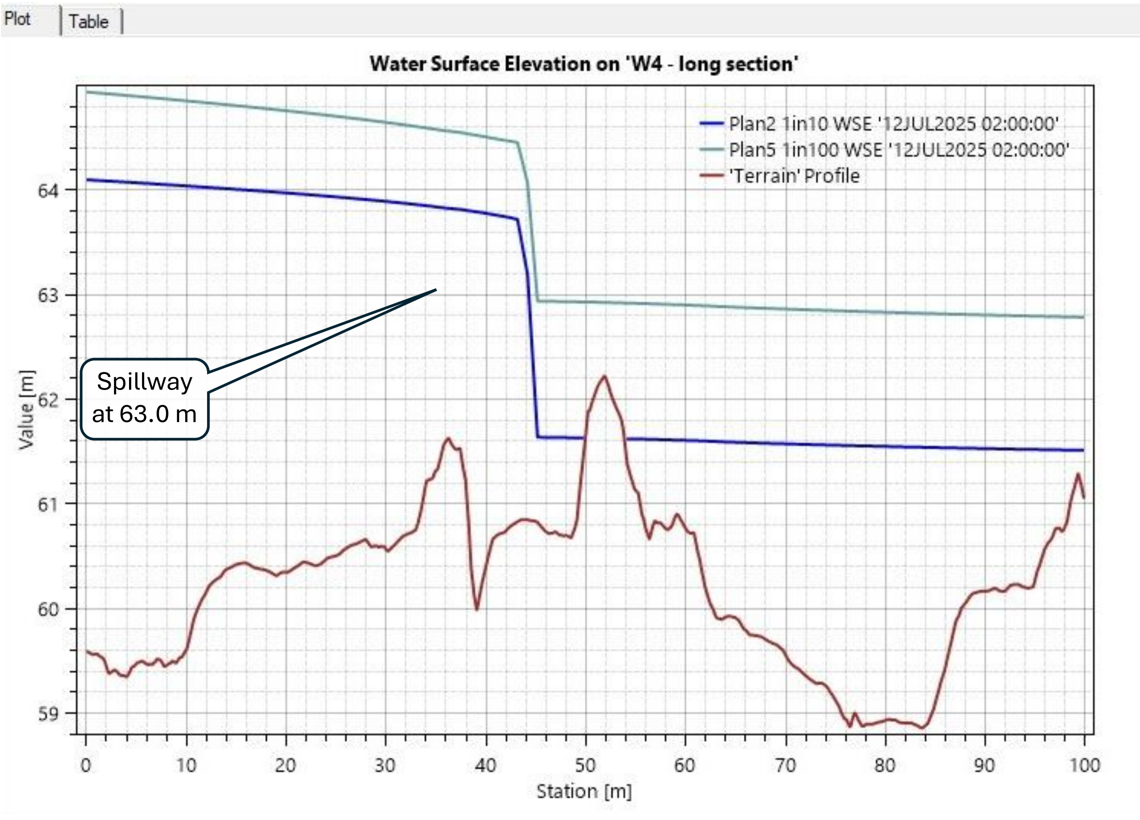

Figure 38 Figure 39 Long section through Weir4 showing 1:10 as well as 1:100 year peak flow levels

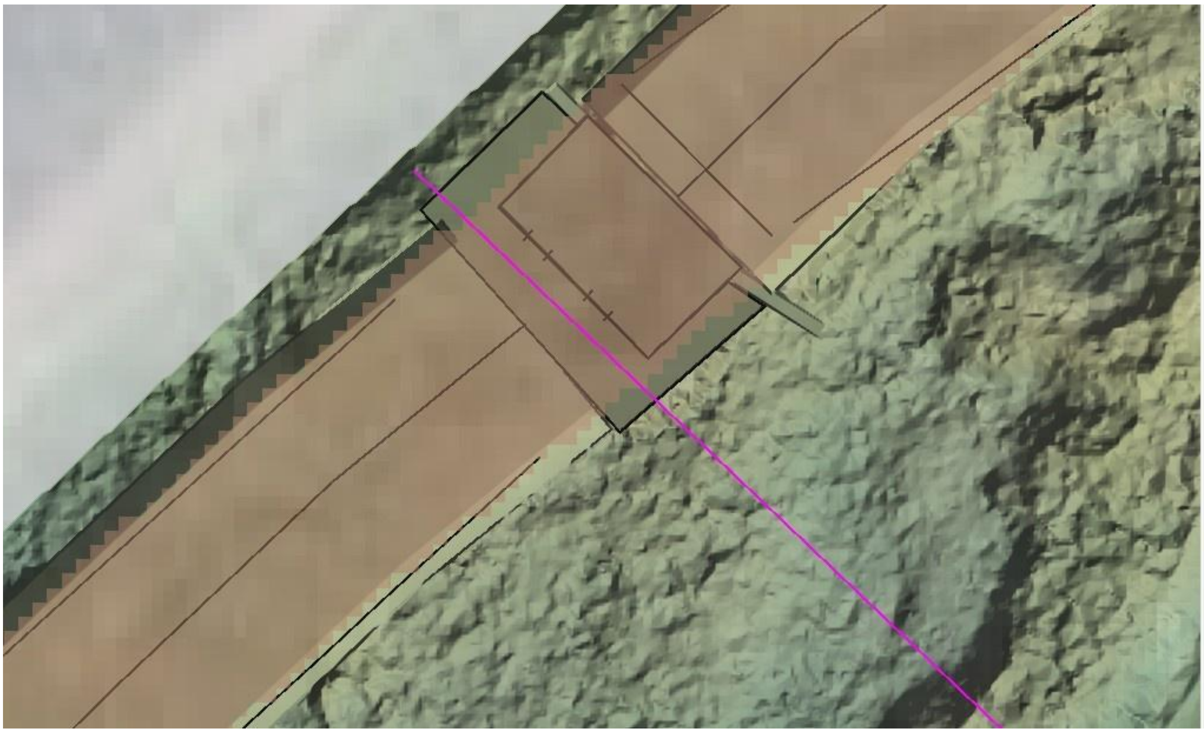

Figure 40 Weir 5

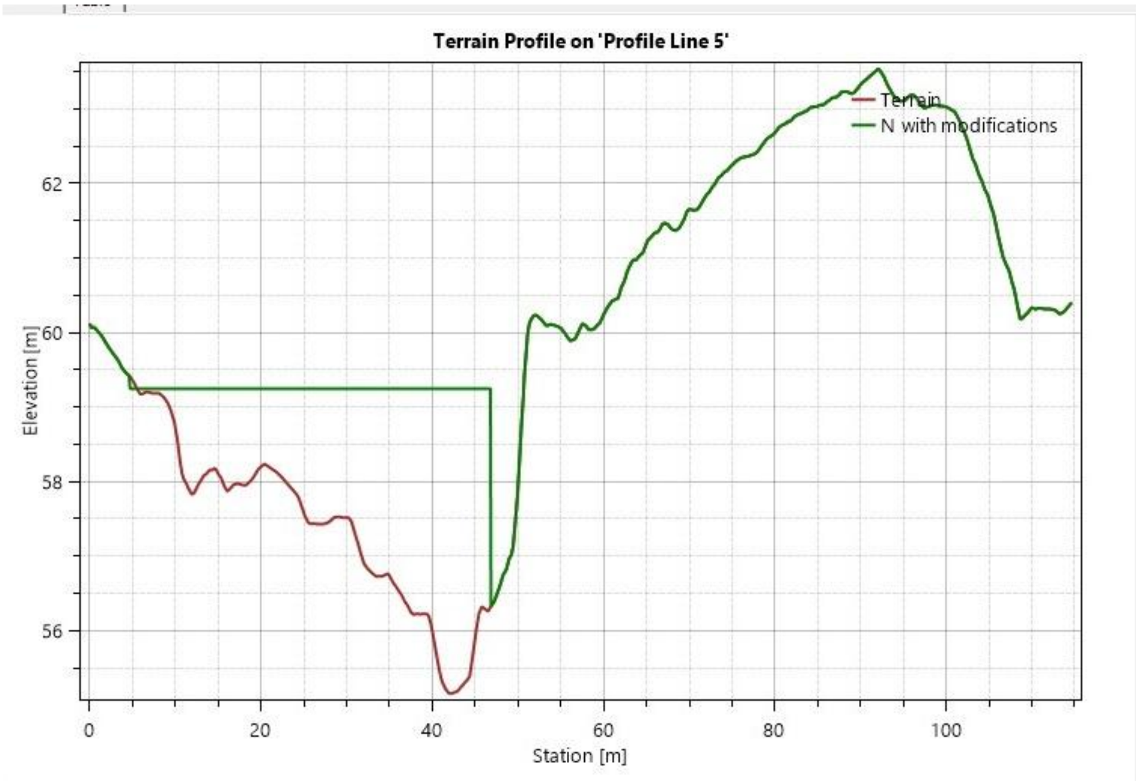

Figure 41 Section though weir 5 (looking downstream)

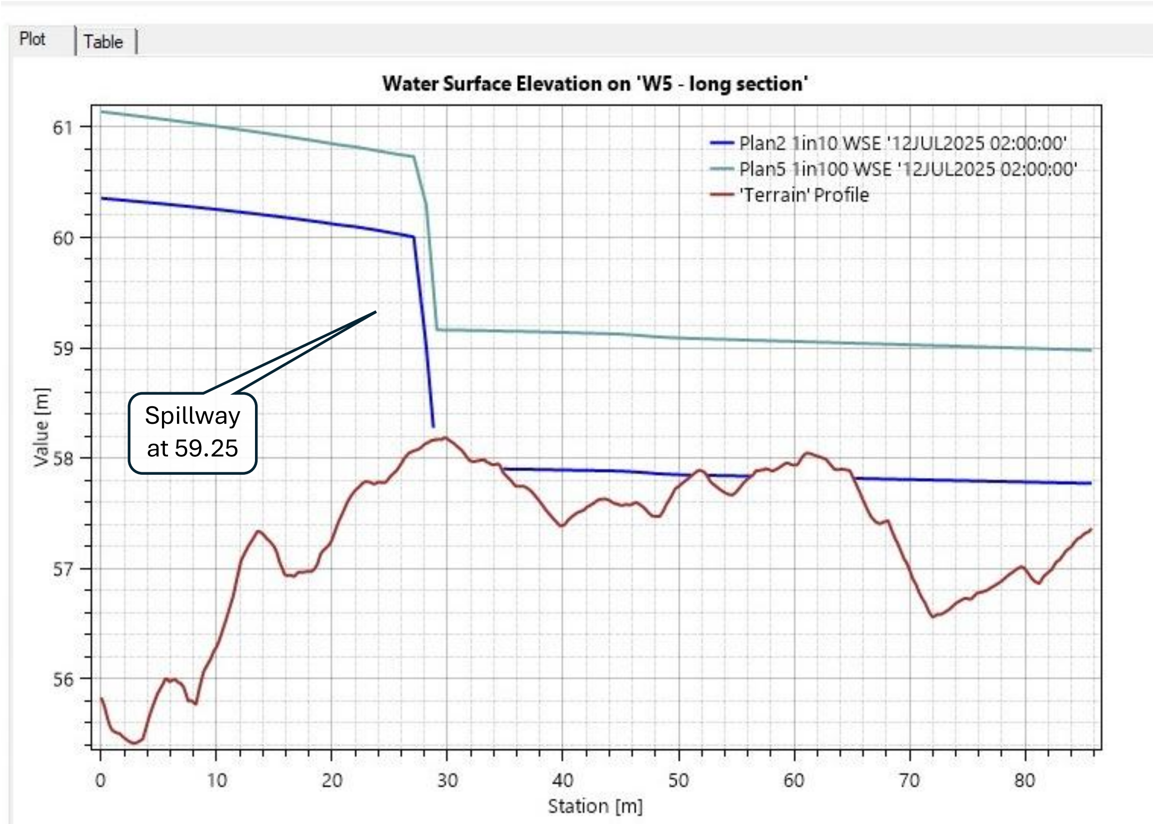

Figure 42 Long section through Weir5 showing 1:10 as well as 1:100 year peak flow levels

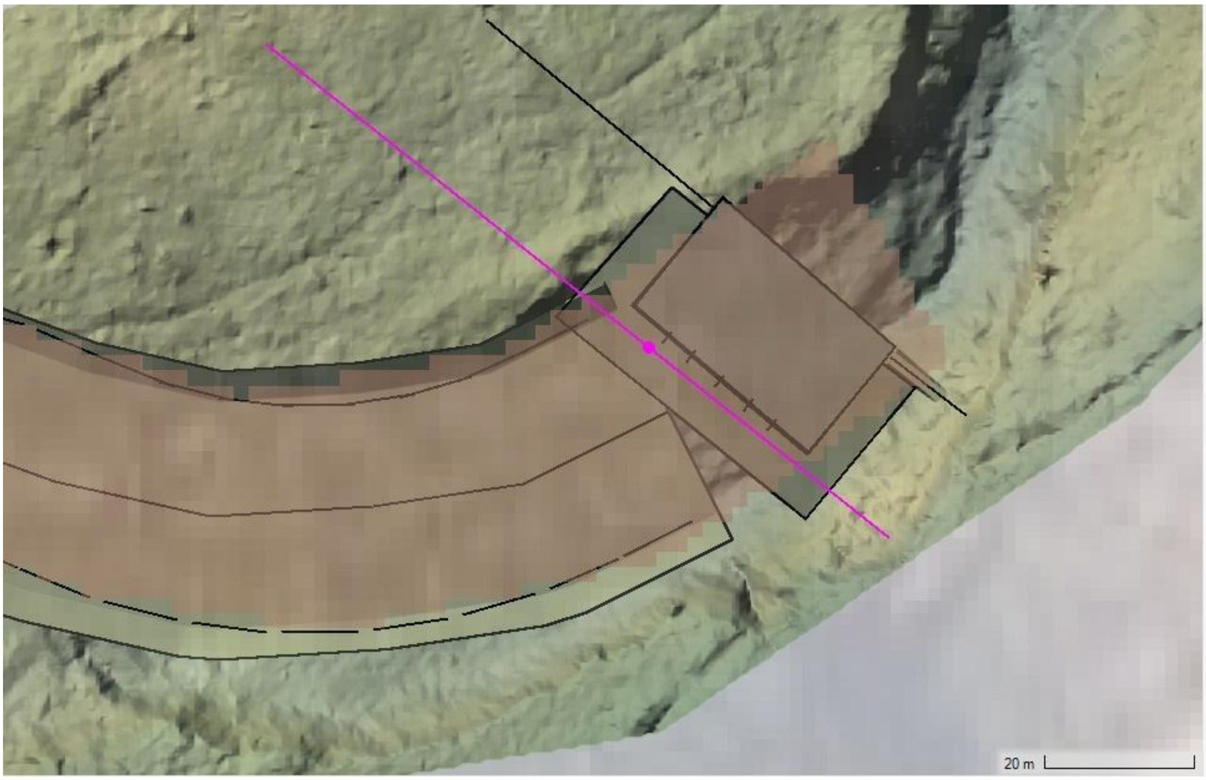

Figure 43 Weir 6

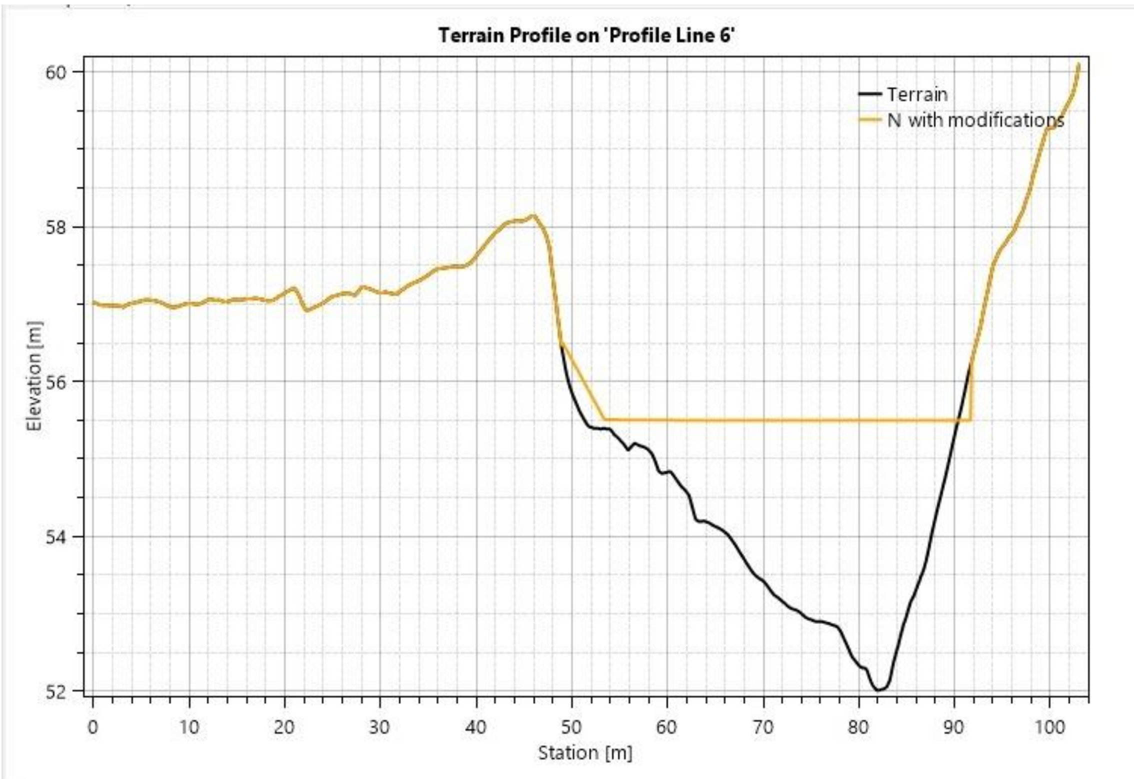

Figure 44 Section though weir 6 (looking downstream)

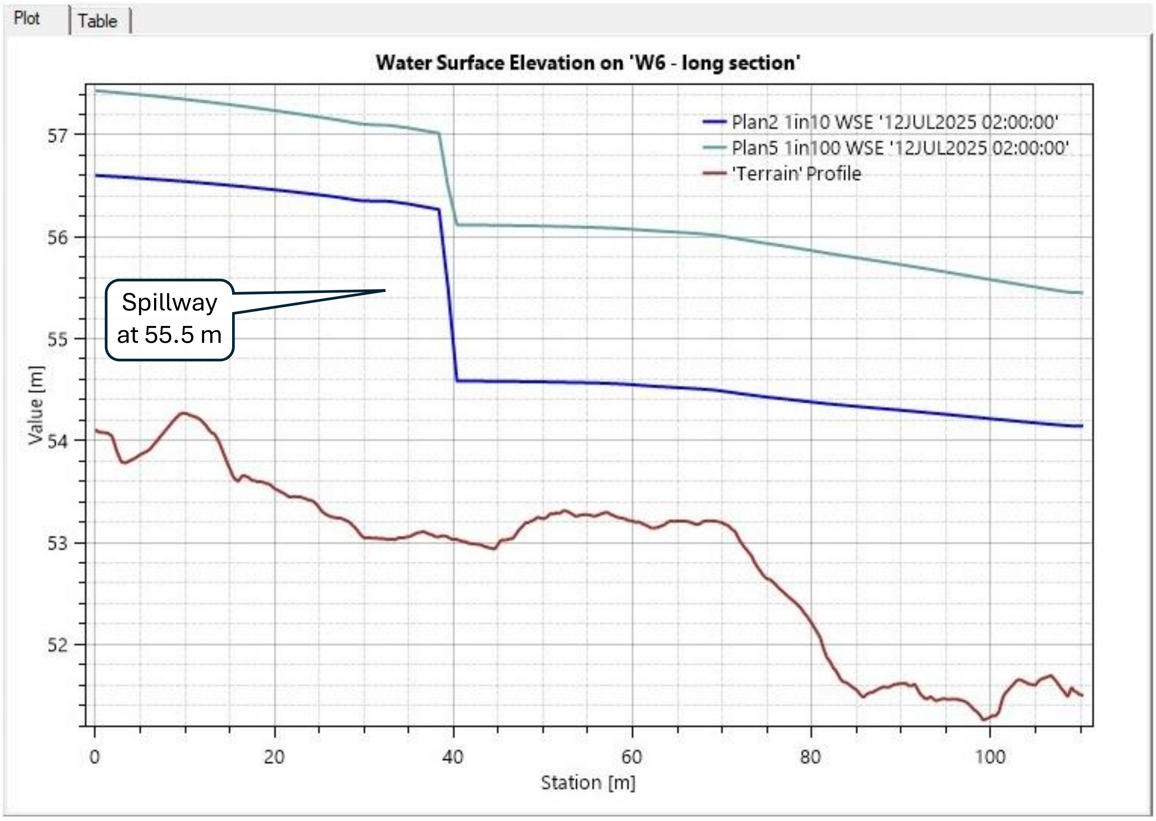

Figure 45 Long section through Weir6 showing 1:10 as well as 1:100 year peak flow levels

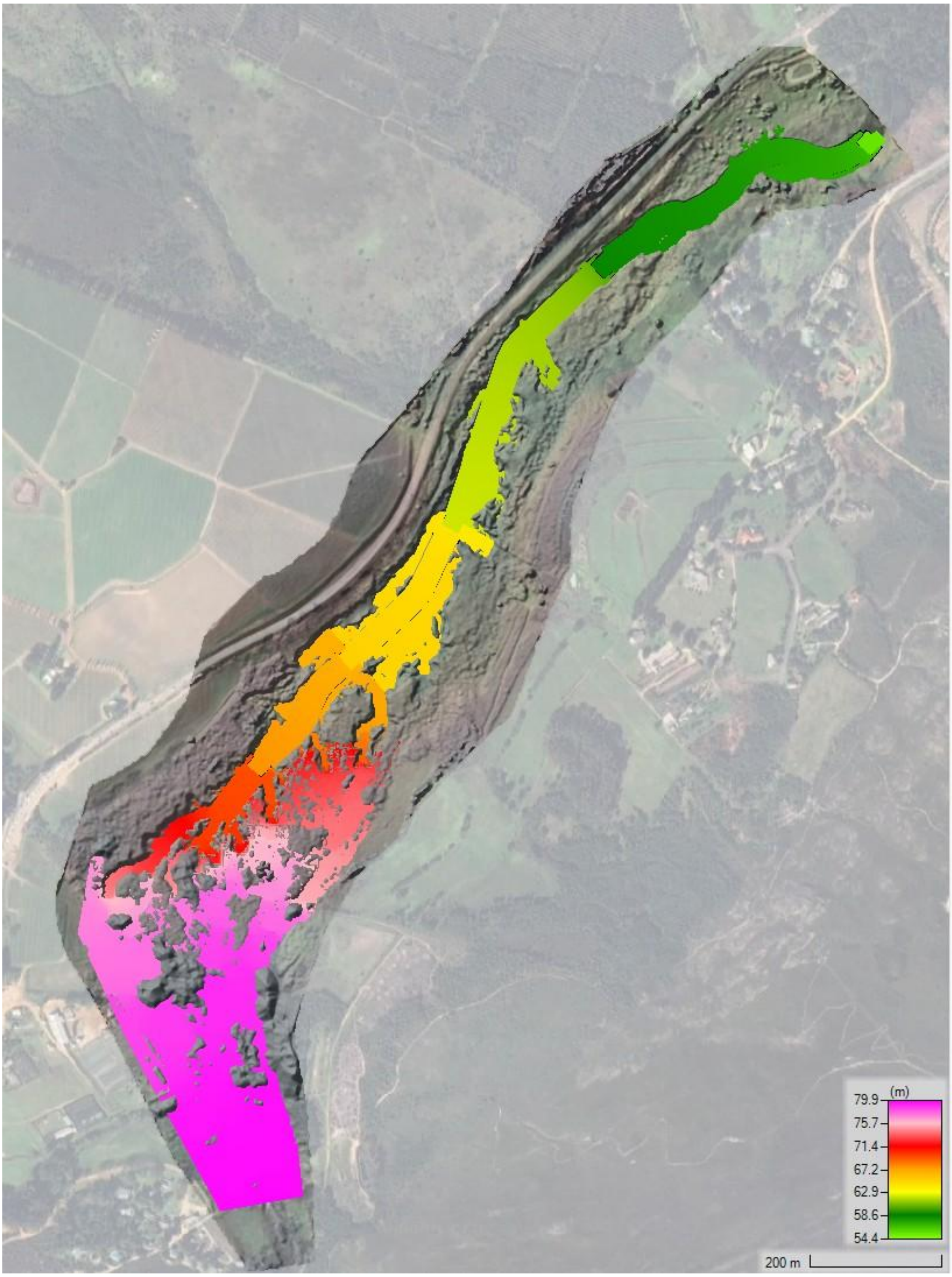

Figure 46 Inundation plot 1:10 year flood - increased level spillway (6 weirs)

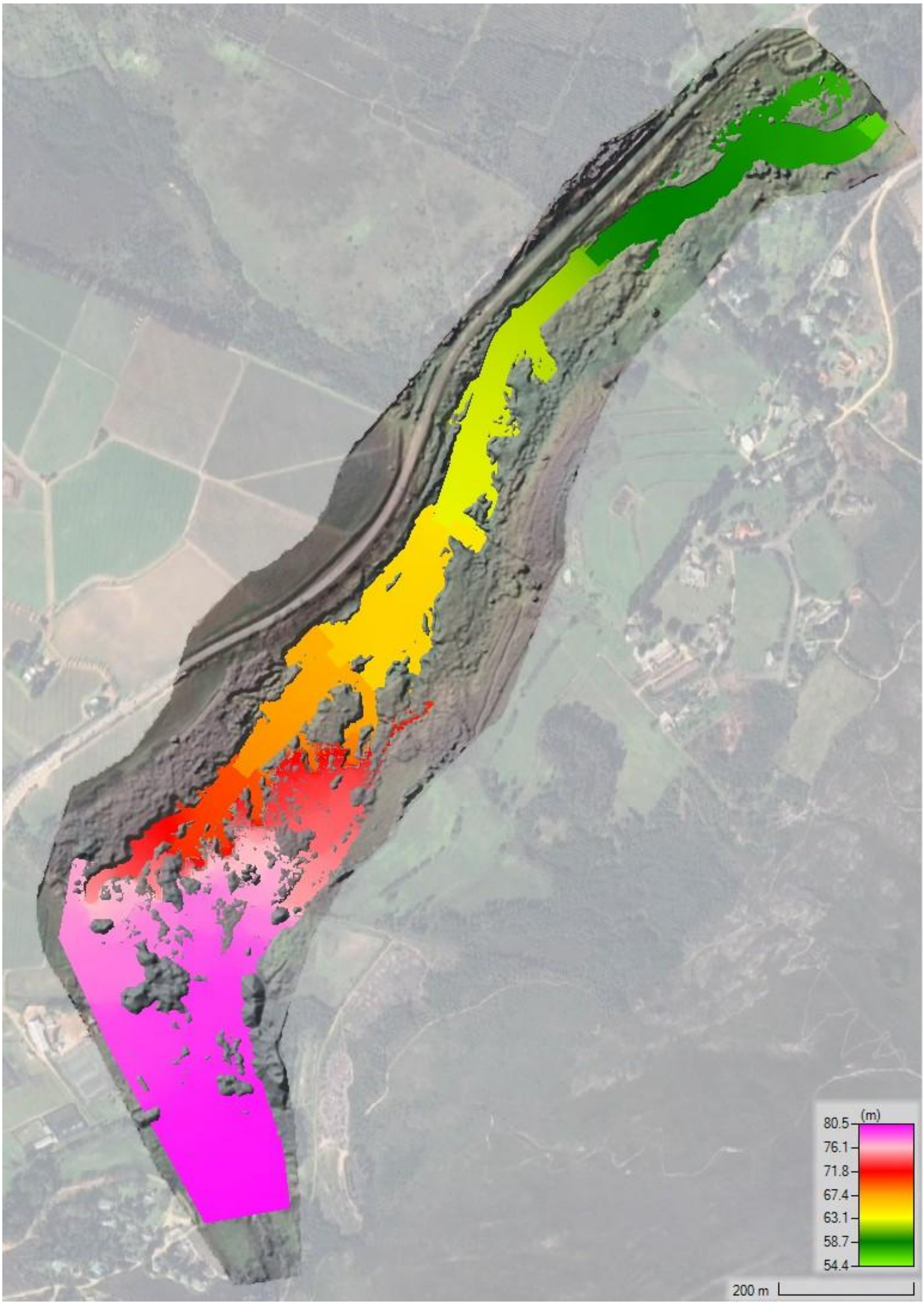

Figure 47 Inundation plot 1:100 year flood - increased level spillway (6 weirs)

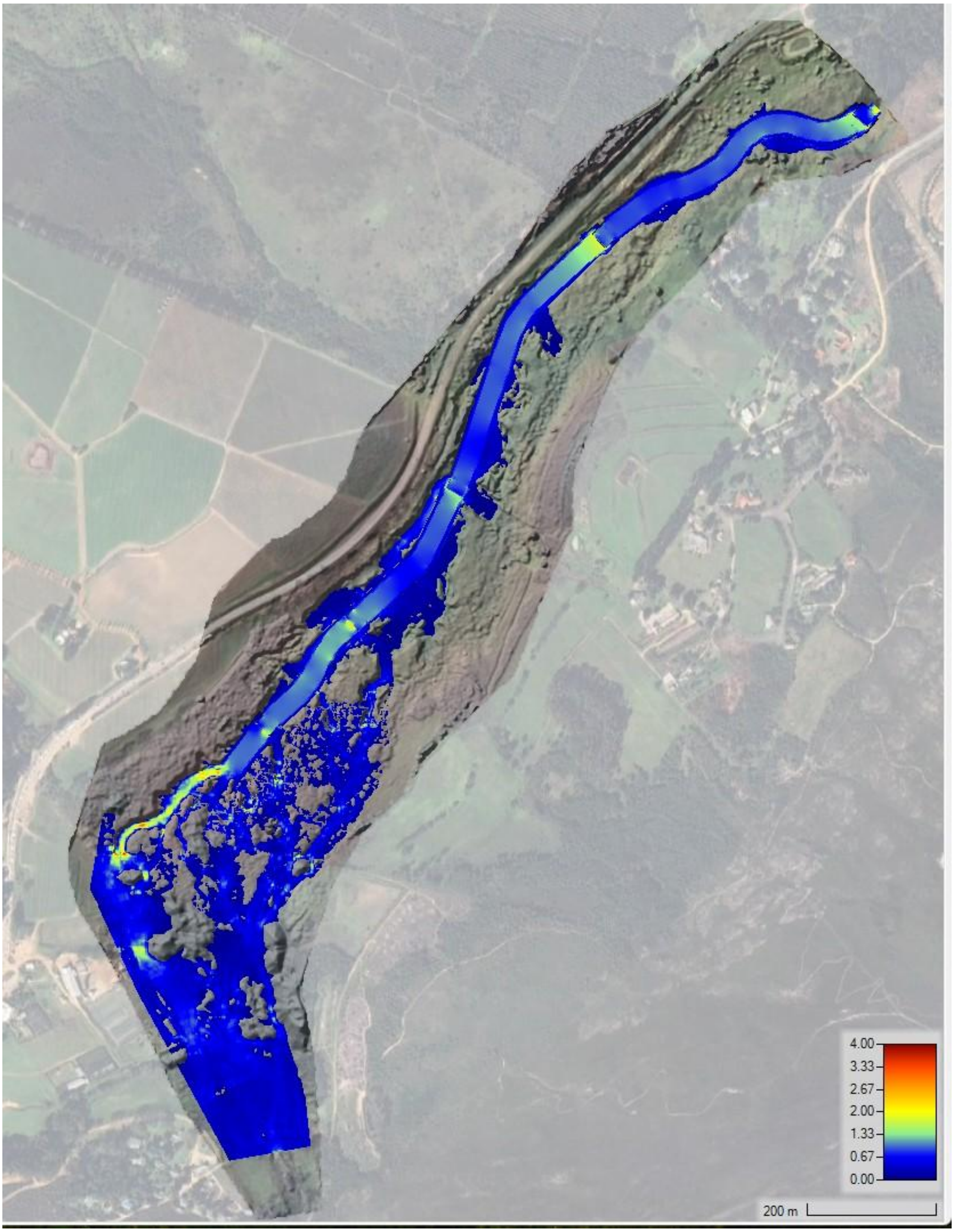

Figure 48 Flow velocity plot - 1:10 year flood - increased level spillway (6 weirs)

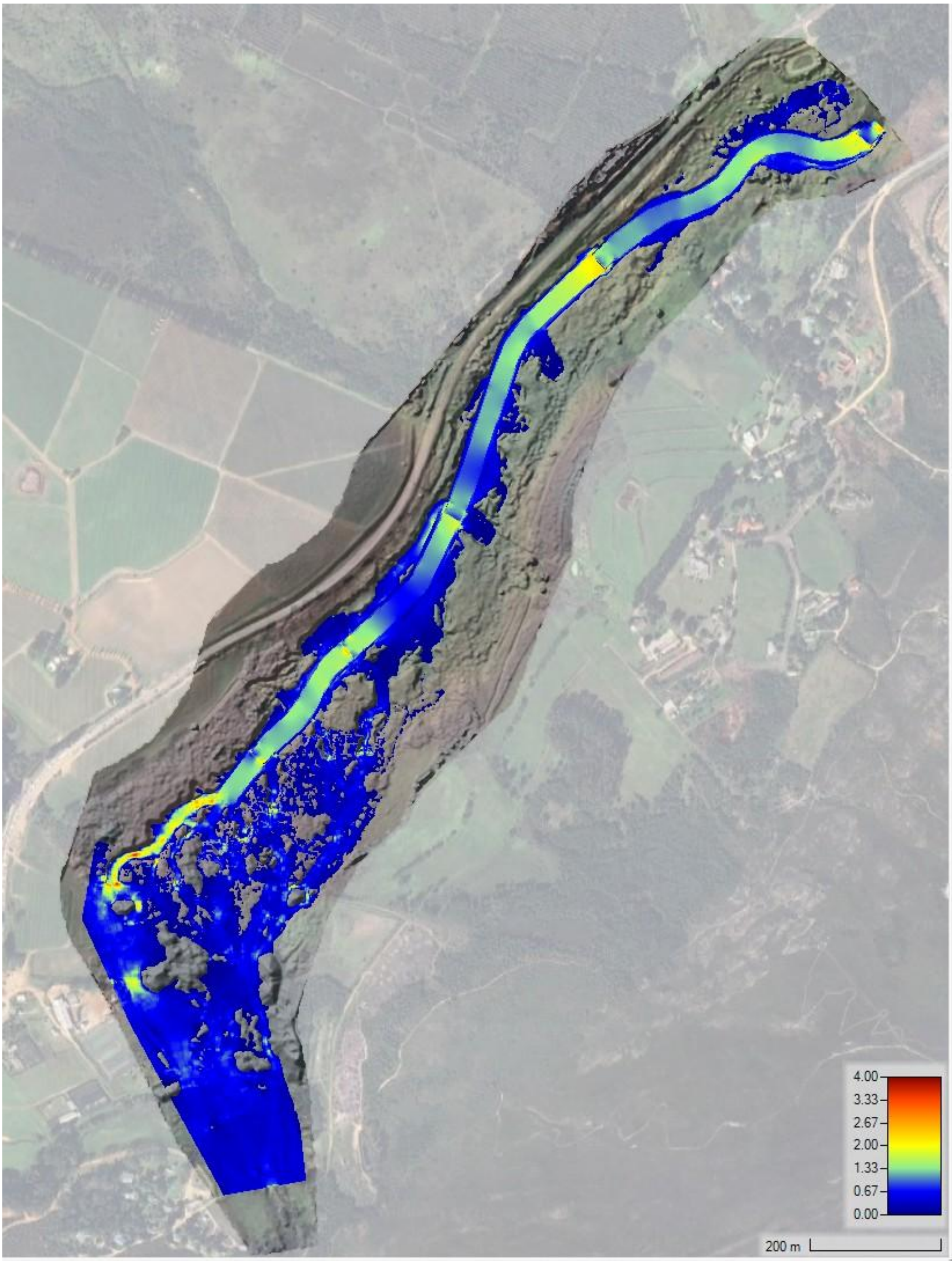

Figure 49 Flow velocity plot - 1:100 year flood - increased level spillway (6 weirs)

APPENDIX 4 : COMPUTATION OF BULK EARTHWORKS QUANTITIES

THE NEED FOR BULK EARTHWORKS

Bulk earthworks (landscaping) between the weirs is needed for :-

- Sourcing soil for partially filling the gulley left over after the 2023/24 flooding, so that the water table can be lifted to the weir spillway heights.
- Sourcing plant material (mainly palmiet reed) to assist with the revegetation of the rehabilitated gulley and other disturbed areas.
- The rescue of high-lying peat soil and vegetation which is drying out because of the permanent dropping of the water table.
- Sourcing soil for the filling in of the weir foundations and the geotextile filled envelopes within the spillway walls. The soil specifically intended for this purpose is the fine silt between the 2023/24 gulley and the tar road, as this is soil least suitable for the filling of the gulley.

THE COMPUTATION OF BULK EARTHWORKS

The bulk earthworks quantities have been computed from cut and fill areas measured on cross sections through the rehabilitated channel every 10 m down the length of the channel. The cut and fill areas have been determined by:-

1. The production of a ground surface model based on a Lidar survey. It was done initially using a photogrammetry-based surface model, but that model reflected the top of the palmiet reed beds. The Lidar has the advantage that it often penetrates the vegetation covering the soil to identify the true level of the soil, but not always. The implication of this is that, when that which is considered to be the ground level in the calculations may be incorrect, uncertainty to the earthworks quantities calculation is introduced.
2. The plotting of surface of the bed of the rehabilitated channel on the cross sections. The bed of the rehabilitated channel is 30m wide and horizontal across the river. The rehabilitated channel slopes from the top of the counter-weir of one weir structure, to the top of the spillway of the next downstream weir. The location and fall heights of the weirs had been determined so that the slope of this channel was less than 0,5 %, to ensure that flow velocities between weirs are kept low and non-eroding in most situations.
3. The plotting of the side slopes of the rehabilitated channel on the cross sections. These side slopes have been chosen considering that they to be:-

a. Flat enough to allow the re-establishment of vegetation on the side slope – this means a minimum slope of 1 vertical to 4 horizontal (ie. 1:4).
b. Flatter than the minimum so as to yield more soil for landscaping purposes when required. This is part of the reason for choosing 1:8 side slopes where possible.
c. Flat enough to enable more soil and plants to be rescued from areas adjacent to the rehabilitated gully, where the soil is currently too high to be moistened by the water table created by the rehabilitation of the channel. This is the other part of the reason for choosing a 1:8 side slope.
d. No so flat as to cause the undermining of the road prism. For this reason, the side slope on the eastern bank is less than 1:8 unless there is space. In addition, the side slope on the western bank adjacent to the Camphill Village houses also must be limited.

The shape of the rehabilitated channel was revised and recomputed several times in an attempt to balance the soil cut and fill volumes, and obviate the need to import fill material.

PROVISION FOR UNCERTAINTY REGARDING THE SUPPLY AND DEMAND FOR BULK EARTHWORKS

It is likely that the volume of fill material required may exceed the volume that is cut, but should that not be so, provision has been made to accommodate the extra fill material on site. The lower three weirs all have notches which may be partially or completely filled in should the rehabilitated river channel rise as a result of extra soil being deposited there. Should this happen, this would be of great benefit to the wetland as it will lift the water table accordingly.

Should the fill quantity required exceed that volume supplied by the cut, various options are available:-

1. Increase the volume of cut material (by widening the channel base, or, further flattening side slopes).
2. Import soil from elsewhere (such as the estuary, or the Die Bos dam).
3. Allow some areas of the rehabilitated channel to form ponds.

ESTIMATES OF BULK EARTHWORKS QUANTITIES PER WEIR PAIR

The volumes of soil cut and fill between each weir pair has been computed as follows:-

From	To	Cut	Fill	Cumulative balance
	Weir 1	500 (est)	2000 (est)	
Weir 1	Weir 2	1593.7	4126.9	-2533.2
Weir 2	Weir 3	1749.9	17435.4	-18218.7
Weir 3	Weir 4	210.6	9147.5	-27155.6
Weir 4	Weir 5	13317.0	12959.0	-26797.6
Weir 5	Weir 6	26568.9	8930.2	-9158.9

Table 1 Volume of cut and fill expected per weir pair

The right-hand column of Table 1 indicates the cumulative balance of cut and fill material. The result is that there is a shortage of roughly 10 000 m^3 of soil, should the rehabilitated channel be constructed as indicated on the drawings. As stated, this can be accommodated by generating extra cut material, importing soil from elsewhere, or allowing ponds to be left in the channel.

APPENDIX 5 : DRONE IMAGES OF WEIR SITES

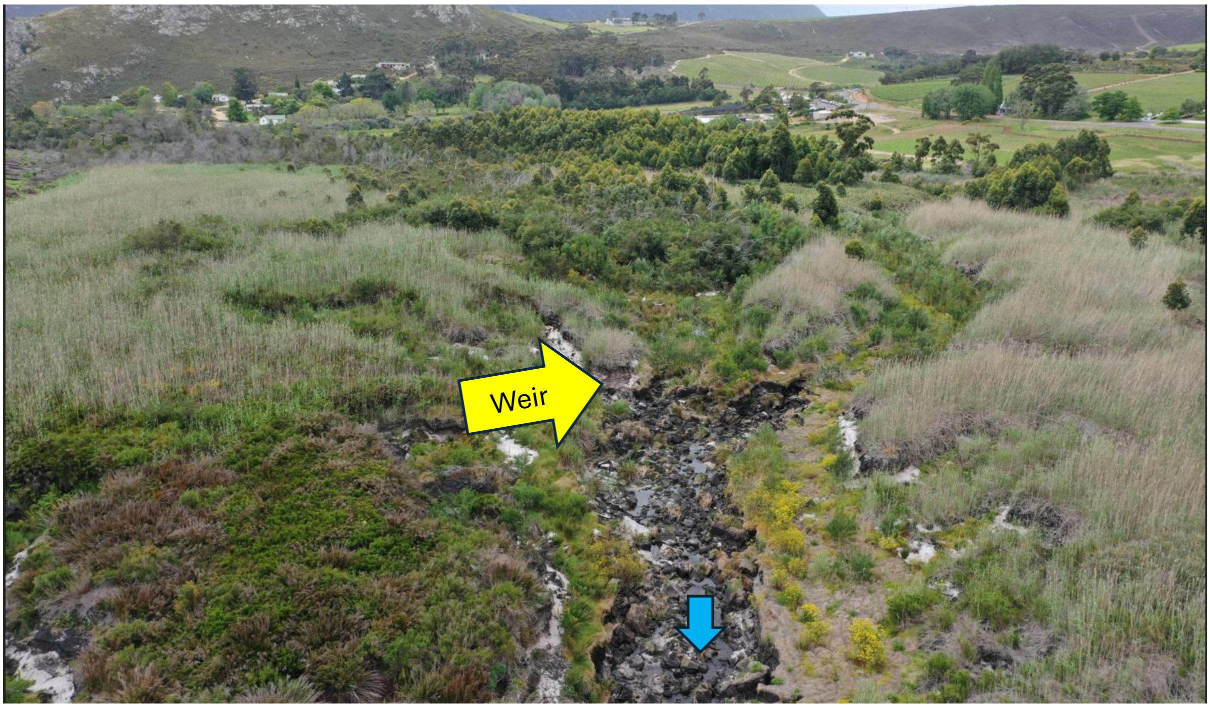

Figure 50 Weir 1

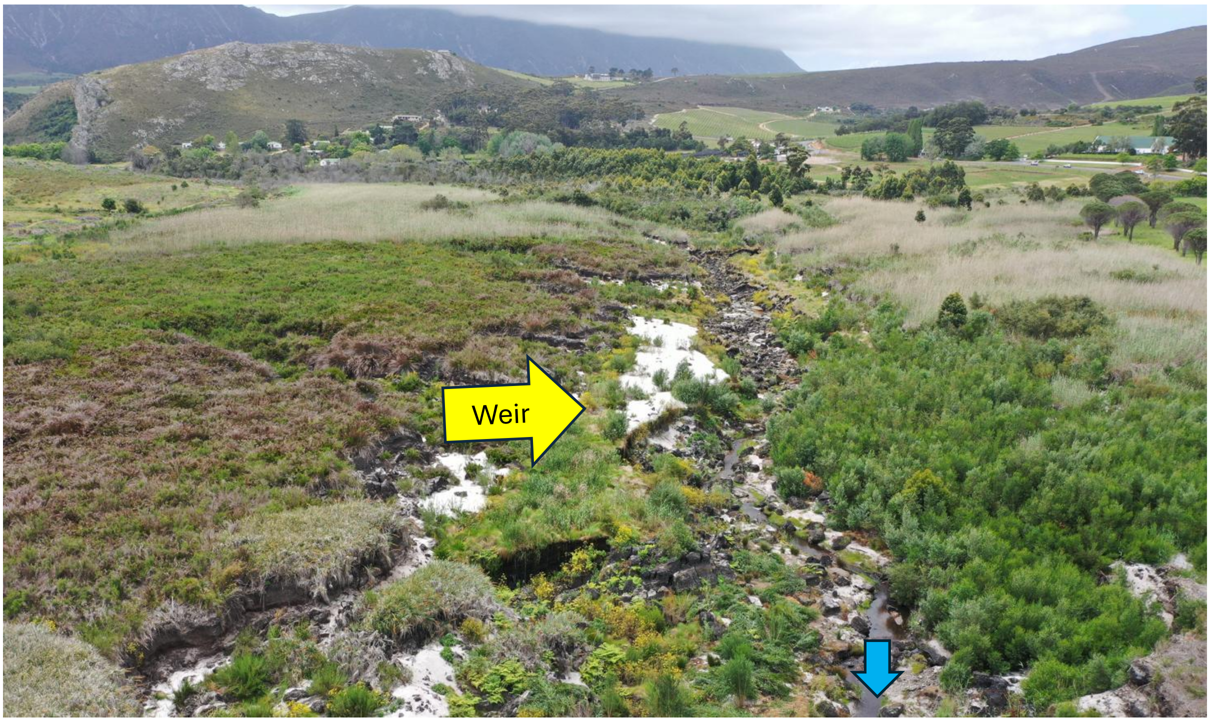

Figure 51 Weir 2

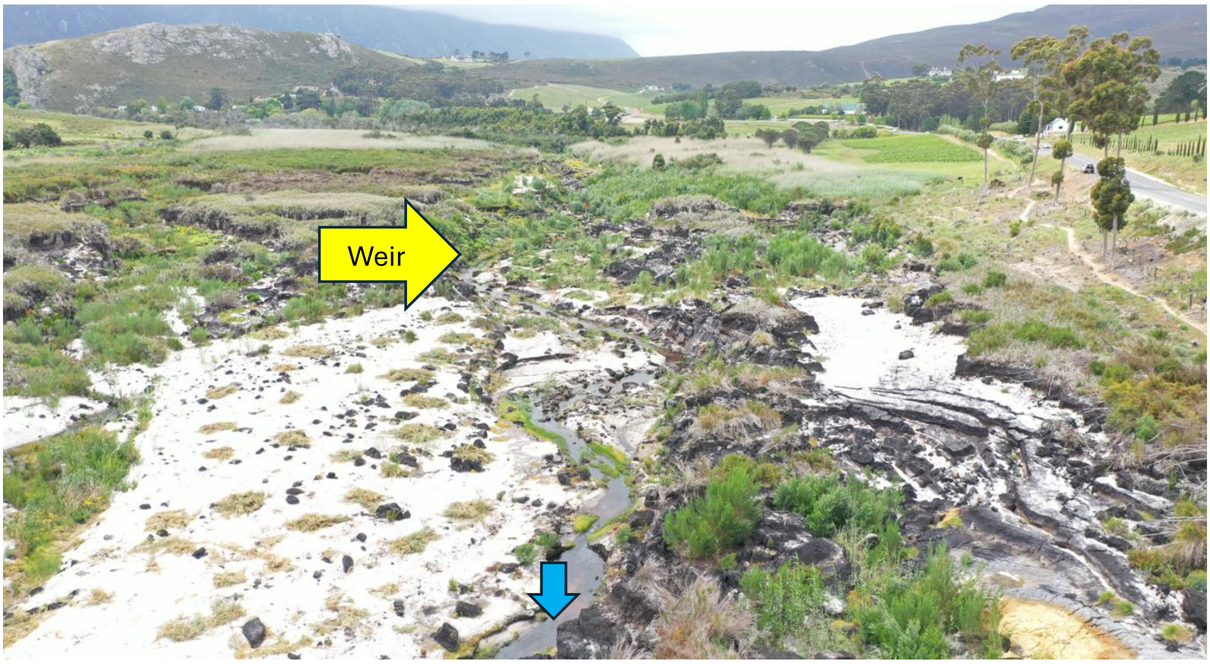

Figure 52 Weir 3

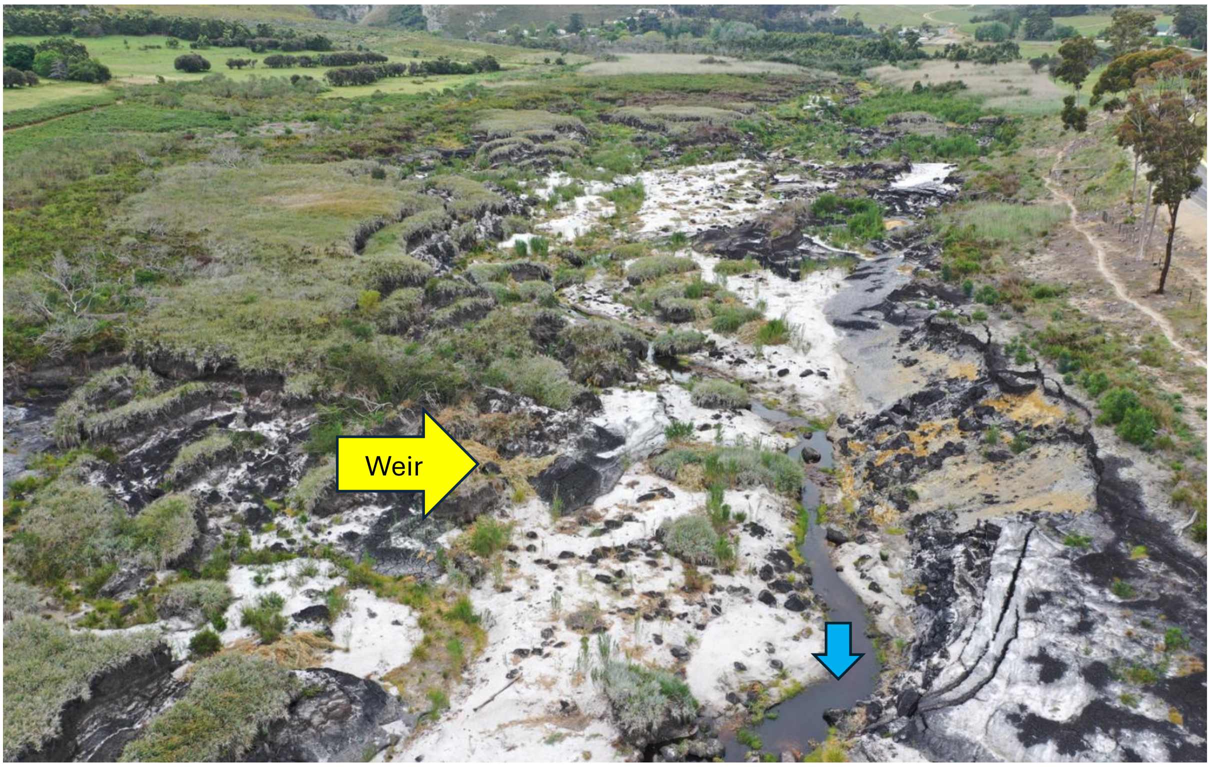

Figure 53 Weir 4

Figure 54 Weir 5

Figure 55 Weir 6

APPENDIX 6 : COST ESTIMATE

The following cost estimate has been prepared using the material quantities measured from the construction drawings and recently obtained prices for similar work.

The cost estimate includes:-

1. R 500 000 provision for the installation of irrigation to assist with the re-establishment of indigenous wetland vegetation – especially in areas where it is needed to prevent soil erosion during extreme floods.
2. R 500 000 provision for emergency environmental issues, should they occur.
3. R 3 160 195 (10%) Contingency fund

The cost estimate does not include the cost of importing soil from the Onrus estuary or the de Bos dam. It also does not include the cost of a revegetation sub-contractor for the general provision of plants.

Section A:	Preliminary & General	**R 6 800 000.00**
Section B:	Earth Works	**R 12 891 554.00**
Section C:	Concrete	**R 1 342 624.00**
Section D:	Gabions & Pitching	**R 8 461 777.50**
Section E:	Landscaping & Rehabilitation	**R 2 106 000.00**
	sub-total	**R 31 601 955.50**
Contingencies (10%)		**R 3 160 195.55**
Sub Total		**R 34 762 151.05**
ADD 15% VAT		**R 5 214 322.66**
TOTAL ESTIMATE		**R 39 976 473.71**

Table 2 Onrus project - cost estimate for civil works

APPENDIX 7 : EXAMPLE SIMILAR PROJECTS

WETLANDS STABILIZED USING THE SAME TECHNIQUE

TESSELAARSDAL

The gulley at Tesselaarsdal (between Hermanus and Caledon) washed out rapidly over 9 years. The gulley was up to 13 m deep and fell 21 m over 600 m. If not stopped it would have spread wider and higher up the valley as well. Once funding was found, it required 5 weirs to be constructed to halt the erosion.

Figure 56 The upper end of the gulley in 2015

Figure 57 The gulley with a cascade of 5 weirs today

VERGELEGEN (SITE 1)

During the heavy rain of 2018 several gulleys washed out on the farm Vergelegen. One (Site 1) was in a palmiet wetland. The slope of the land was steep and once the erosion started it was difficult to stop it. A cascade of weirs was constructed in 2021.

Figure 59 The head of the gulley in 2018

Figure 58 The weirs being constructed in 2021

Figure 60 Looking up the rehabilitated gulley in 2025 (same view as Figure 599)