Design and Cost Report

Tuckean Swamp Implementation Toolkit

OzFish Unlimited

30 March 2023

The Power of Commitment

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1. Introduction

1.1 Purpose of this report

GHD Pty Ltd (GHD) has been engaged by OzFish Unlimited on behalf of the Tuckean Steering Committee (Committee) to prepare an implementation toolkit, including design and costing of infrastructure changes and ongoing maintenance costs, a comprehensive values assessment, landholder incentives/change options, for the management options identified in the Tuckean Swamp Options Study (Water Research Laboratory, 2020). The overarching aim of the Tuckean Swamp Options Study was to provide options to assist in restoring hydrological function and water quality within the Tuckean Swamp project area at Bagotville, NSW.

The engagement includes the following key deliverables:

– A report detailing the design and costing of the preferred options from those outlined in the Options Study (Water Research Laboratory, 2020).
– A values assessment which utilises desktop information already available, along with targeted, high level community and agency engagement to determine the relative value of each option (from the Options Study and Design and Cost Report) from an environmental, economic (including agricultural) and social perspective.
– A toolkit for change that should include wide, varied and innovative options for creating land use change, wherever it may be necessary, in the Tuckean catchment.

This report addresses the first deliverable outlined above and will provide a high level cost to assist with decision making when comparing and implementing management options.

1.2 Scope and limitations

This report: has been prepared by GHD for OzFish Unlimited and may only be used and relied on by OzFish Unlimited for the purpose agreed between GHD and OzFish Unlimited as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than OzFish Unlimited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared the preliminary cost estimates set out in Section 4 of this report (“Cost Estimate”) using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD and provide in Section 2.2.

The Cost Estimate has been prepared for the purpose of comparison of options and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

GHD has prepared this report on the basis of information provided by OzFish Unlimited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.3 Assumptions

This report has been prepared on the basis of the key assumptions that are detailed within the relevant sections of this report. The report is to be read in its entirety to ensure that these assumptions are considered when making any commercial decisions.

2. Methodology

2.1 Site inspection

A site inspection was undertaken by GHD on 10 February 2022 with representatives of Rous County Council (RCC), OzFish Unlimited and National Parks and Wildlife (NPWS). The inspection allowed GHD to understand the project site and the context of each of the nominated options.

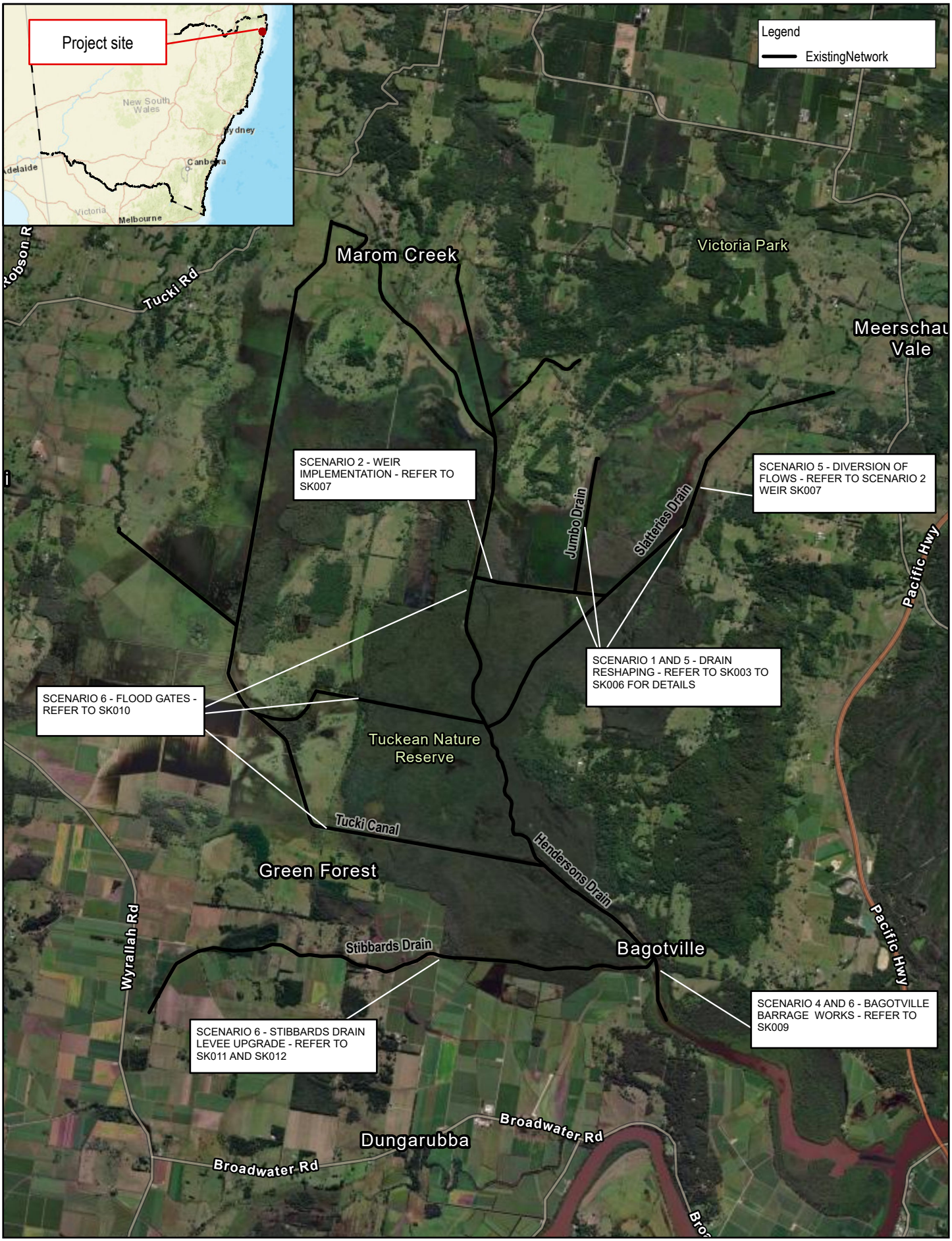
Key observations of the site inspection are documented in the following sections. A location map is provided in Figure 2.2.

2.1.1 Bagotville Barrage

The Bagotville Barrage (Figure 2.1) forms the downstream extent of the options assessed in this report and is the main tidal gate that separates the tidal influence of the Richmond River from the swamp. The barrage consists of a series of culverts and a roadway, which are the responsibility of Ballina Shire Council (BSC), the eight floodgates on the downstream side of the barrage are the responsibility of RCC.

RCC advised that maintenance works, which typically involve accessing and modifying the gates, are difficult due to the proximity to Old Bagotville Road and lack of space (Figure 2.4). Typical operational requirements for the barrage include modifying the sluice-gate aperture of the flood gates to allow some tidal flows into the swamp outside of floods (Figure 2.4). Accessing the spindles for these gates is undertaken from the bridge, which does not provide pedestrian access. It was also noted that there is little room outside of the traffic barrier on the bridge for any additional fixings that might allow works to accommodate the gates to remain open.

Figure 2.1 Bagotville barrage



Paper Size ISO A4

0 0.4 0.8 1.2 1.6

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Revision No. **0**
Date **29/06/2022**

Site location

FIGURE 2-2

\\ghdnet\ghd\AU\Newcastle\Projects\22\12553451\GIS\Maps\12553451_PROJECTDATA.aprx
Print date: 29 Jun 2022 - 10:16

Data source: Hybrid Reference Layer: Department of Resources, Dept.of Environment and Science, Esri, HERE, Garmin, METI/NASA, USGS
World Imagery: Earthstar Geographics
World Street Map: Esri, HERE, Garmin, NGA, USGS. Created by: tthompson2

Figure 2.3 Flood gate fixing at the barrage

Figure 2.4 Flood gates at the barrage with smaller control gates

2.1.2 Stibbards Drain

Stibbards Drain is located on the southern side of Tuckean Swamp (see Figure 2.2). The Tuckean Swamp Options Study identified that if the tidal gates remain open, this area may be subject to tidal inundation due to the existing heights of the levee.

Observations during the site inspection identified that the area next to the drain appeared significantly lower than the standing water level within the channel (Figure 2.5). The proposed works would require the existing levee to be modified such that its height would exceed the nominal limit of the high tide. It was noted by RCC during the site inspection that there were potential sand lenses within the existing levy, however there is no geotechnical information available to define the location or depth.

Figure 2.5 Stibbards Drain, note the lower area to the right

2.1.3 Tuckean drains

The Tuckean Swamp Options Study identifies a number of tidal controls to be placed on the upstream end of the waterways that pass through the Tuckean Swamp (at Tucki Drain and at Stoney Island, see Figure 2.6 and Figure 2.7). Anecdotal feedback by RCC on site was that fish (including native) are regularly observed within these channels. Discussions on site with OzFish Unlimited concurred that it would be ideal to provide fish passage at any new infrastructure on these channels to encourage and enhance fish populations.

Figure 2.6 Tucki Drain

Figure 2.7 Stoney Island

2.2 Design options

The options identified within the Tuckean Swamp Options Study (Water Research Laboratory, 2020), which are the basis of this assessment, are summarised in Table 2.1.

Table 2.1 Summary of operating scenarios for design and costing

Category	Description of Works
Current	Base Case no change to the current operation
Freshwater management options ***Focus on the north-eastern (Slatteries) corner of the floodplain***	Scenario 1 – Reshaping of major drains in the north-eastern corner of the floodplain (Slatteries, Meerschaum Vale and Jumbo Drains) Scenario 2 – Weir implementation at the downstream end of Meerschaum Vale Drain Scenario 5 – Reshaping of drains (as per Scenario 1), but encouraging small catchment flows onto the floodplain
Saltwater management options ***Focus on the Bagotville Barrage management, targeting the Tuckean Nature Reserve***	Scenario 3 – Alternative management of barrage sluice gates during dry periods Scenario 4 – Hinging open the Bagotville Barrage Scenario 6 – Hinging open the Bagotville Barrage, and installing structures upstream of the Tuckean Nature Reserve on all the major drains

For each of the options, we have interpreted the following broad level of works:

– Base case.

  The base case options for the assessment do not require any additional design as it is maintaining the status quo of the management of the site.

– Scenario 1 – Reshaping of the major drains.

  This scenario involves shallowing out the drains, while maintaining cross sectional areas so that ideally the inverts of the drains are above the acid sulfate soil (ASS) layer (see Figure 2.8). This reduces acidic groundwater discharge into the drain. To provide this design option, earthworks modelling of the site was undertaken based on a digital elevation model (DEM) provided by (Water Research Laboratory, 2020) and regraded the channels to sit notionally above the ASS layer. Additional elevation data of the drains was provided as discrete cross sections for the drains. We have assumed that the regrading required would be uniform for each of the three nominated (Slatteries, Meerschaum Vale and Jumbo) drains, as per (Water Research Laboratory, 2020).

– Scenario 2 – Weir implementation.

  This scenario involves the installation of a weir structure at the end of the Meerschaum Vale Drain to increase the surface and groundwater elevations.

– Scenario 3 – Alternative management of the sluice gates.

  This option is a management option for an existing gate and as such we have assumed that any operations or management costs for this structure will be as existing. This option is not addressed further in this report.

– Scenario 4 - Hinging open the barrage gates.

  This option would consist of permanently opening the tidal gates on the Bagotville Barrage. We have assumed that this option is nominated over full removal of the gates to allow for future management changes if required.

– Scenario 5 - Reshaping of drains.

  This option is as per Scenario 1, but encouraging small catchment flows onto the floodplain.

– Scenario 6 – Hinging open Bagotville Barrage and installing structures upstream of the Tuckean Nature Reserve.

  This option would consist of permanently opening the tidal gates on the Bagotville Barrage and installing upstream tidal gates and levees.

The various design options developed for each scenario are described further in Section 3.

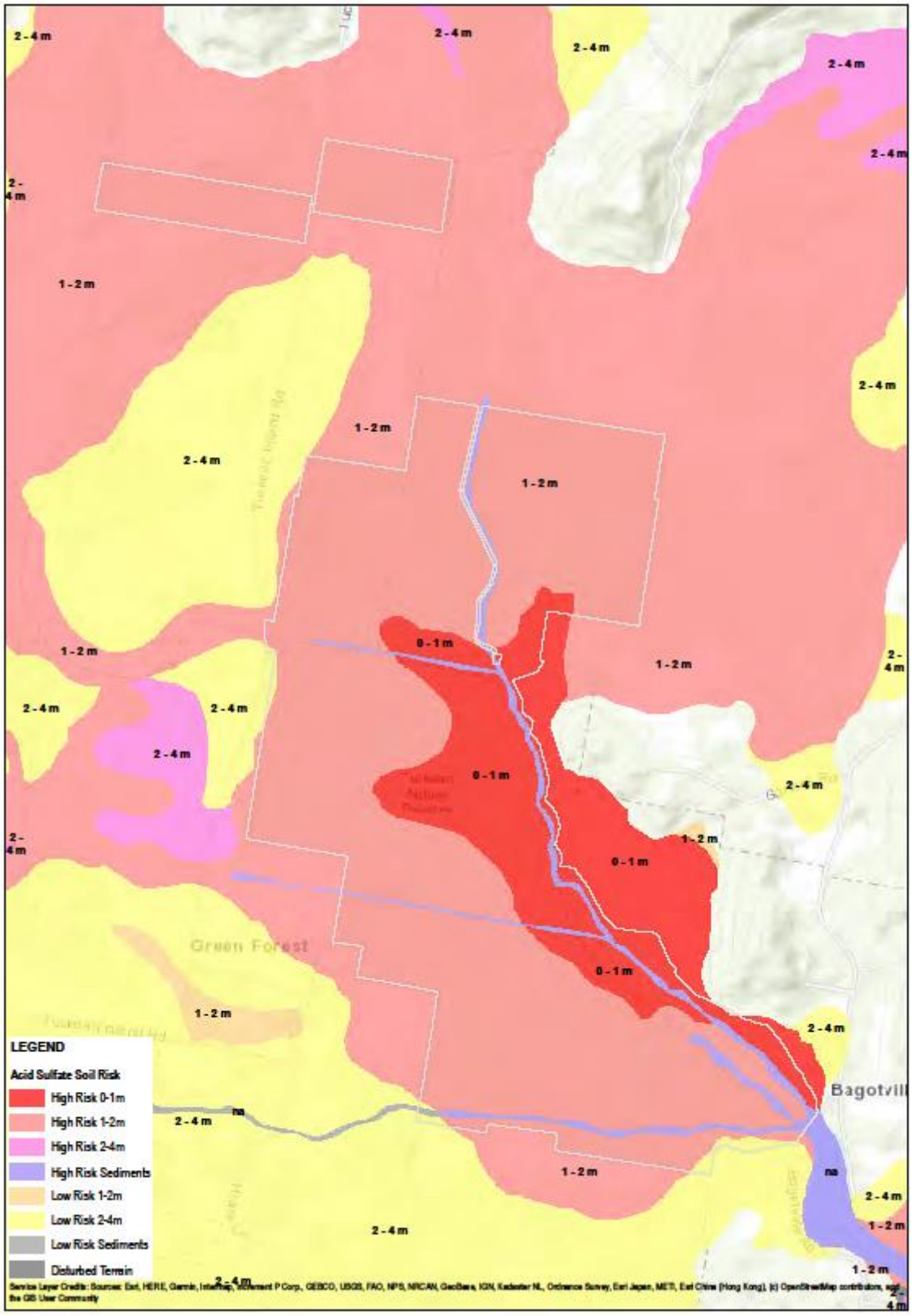


Figure 2.8 ASS risk mapping of Tuckean Swamp

Following the major floods of February and March 2022, the option to remove the barrage and construct a bridge could be considered as an additional option building on the intent of Scenario 6 to return tidal conditions back to the swamp. The existing structure, road and bridge were extensively damaged (see Figure 2.9) in the flood and may need extensive repairs to restore. As extensive reconstruction will be required at this location, the opportunity to complete major works to restore connectivity could complement the Tuckean Swamp restoration.

A design or cost estimate for the bridge has not been prepared as there is insufficient information available at this time.

Figure 2.9 Post flood damage to Old Bagotville Road at the barrage

2.3 Cost estimates

2.3.1 Assumptions and limitations

Cost estimates are provided based on the following assumptions and exclusions:

- Values are based on published information (Rawlinsons , 2022) and supplier quotes.
- The estimates provided are pre concept design and are considered to be no better than a Class 5 estimate as defined by (AACE International, 2020) used for concept screening of the options. These should be used for comparison purposes only and not to set project budgets for the works.
- There is no allowance for the following:
  - Detailed design.
  - Project management by the Principal.
  - Approvals.
  - Contractor preliminaries including site set up, laydown areas, contract documentation and profit.
  - Specific design and constructability input for the sites that would require additional investigations. These issues could have a significant impact on cost and include but are not limited to:
    - Detailed site survey
    - Geotechnical conditions
    - Contaminated land and acid sulfate soil investigations
    - Financial incentives
    - Land access, lease agreements and operational requirements

  As an example, undertaking works for Scenario 1 would be highly dependent on the surface/groundwater conditions on commencement of works, which would impact on access and constructability within the drains. If the conditions are saturated, construction costs could be significantly greater than what is estimated.

Scenarios 1, 2, 5 and 6 rely extensively on access to private properties for the works. The costs of this are not included and would need to be based on engagement with each affected property.

– At the time of preparing the report, the general construction market has been experiencing supply and procurement constraints that may not be fully reflected in the estimates. It is also noted that this report has been prepared in 2022 following significant flood events in the Northern Rivers. The regional impact of this is not known at this time and is unlikely to be known on completion of this report. The Rawlinsons quarterly assessment (Rawlinsons, April 2022) noted that the recent floods in southeast Queensland are likely to result in price rises for the Brisbane market into the second half of 2022.
– Costs provided herein do not include a range of additional items required for the implementation of the design options considered. This includes, but is not limited to:
    - Land acquisition costs
    - Detailed design fees
    - Planning professional and application fees
    - Legal costs etc.

2.3.2 Design quantities

Where quantities have been nominated for the cost estimates, these have been derived from the information summarised in Table 2.2.

Table 2.2 Source and reliance of data

Information	Source	Description	Reliance
Lidar	WRL	The lidar provided by WRL was used to generate a regional tin. No validation of the supplied digital elevation model (DEM) was undertaken.	The cross sections were included in the DEM with key waterway features such as top of bank, toe of bank, centreline of channel, which were identified and linked to the previous sections such that areas in between cross sections were a direct interpolation of the surrounding cross sections. This information was then supplemented with the lidar data to form the DEM. This model is the source of the earthworks volumes.
Creek cross sections	WRL	Selected cross sections were provided to GHD in excel format with an easting and northing and level coordinate. This data was imported into the DEM.	
ASS mapping	NSW Government	This information (Figure 2.8) provided a depth to acid sulfate soils in the region.	This information was converted to AHD by lowering the project tin by the minimum depth noted on the figure.
Flood gates	AWMA	Tidal gate details	We have relied on the information provided by AWMA.

3. Design options

The design options to facilitate each scenario identified in the Options Study (Water Research Laboratory, 2020) are described in the following sections. Drawings are provided in Appendix A.

3.1 Drain reshaping (scenario 1 and 5)

3.1.1 Recommended option

Drain reshaping works would involve filling in areas of the drains that are located below the ASS layer and reprofiling the drains to retain capacity (see SK002 – SK006 in Appendix A). Reshaping the drains will not raise them above the ASS layer, but will reduce acidic groundwater discharge into the drain. Treatment of ASS would be required as part of these works; however the extent of this is unknown until further testing has been undertaken. Lime-based rock material could also be provided to the invert of the channels to provide additional buffering of any residual ASS material that may leach in the short term.

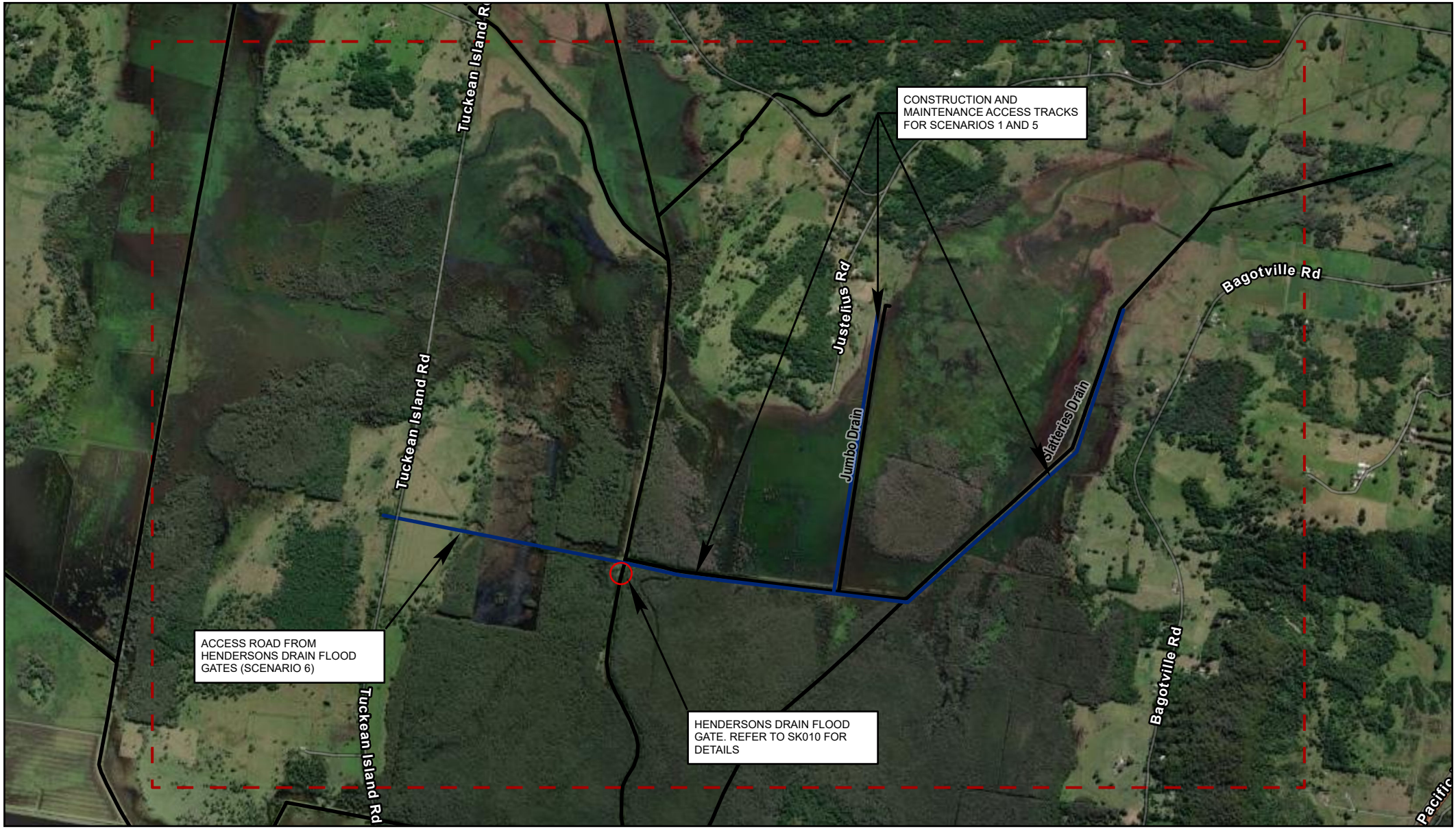
Formal permanent access to the drains will be required to float in earthmoving equipment and for future maintenance (see Figure 3.1). We have assumed that these access tracks would be 2.5 metre wide with a 200 millimetre thick gravel overlying a nominal geomembrane layer. Again, further investigations on the geotechnical conditions of the site would be required to provide a detailed access design. It is anticipated that these tracks would be retained post works to provide permanent access for maintenance.

3.1.2 Maintenance requirements

Maintenance for this option is likely to be similar to the current requirements for the existing earthen drains and would consist of:

– Periodic slashing of vegetation along the batters
– Management of aquatic weeds within the drainage channel to maximise flow capacity
– Removal of sediment after significant flow events to retain flow capacity
– Scour repair after significant flow events
– Annual and post flooding inspections and top up of gravel on the access road

It should be noted that it is unknown how the maintenance of the reshaped drains would change from the current requirements. Access is likely to be impacted, as the shaped drains will elevate surface and groundwater levels for longer. Vegetation growing in the drain will be different and may require different control methods.



Legend

- Construction and maintenance access road
- Existing network
- Proposal site

Paper Size ISO A4

0 210 420 630 840

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Revision No. **0**
Date **29/06/2022**

Project access roads

FIGURE 3-1

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Print date: 29 Jun 2022 - 10:03

Data source: Hybrid Reference Layer: Department of Resources, Dept.of Environment and Science, Esri, HERE, Garmin, METI/NASA, USGS
World Imagery: Maxar. Created by: tthompson2

3.2 Weir works (scenario 2)

3.2.1 Options considered

The following options were considered for this scenario:

– Concrete v-notch weir. The Options Study (Water Research Laboratory, 2020) identified that a weir across the Meerschaum Vale Drain would control water in the upstream areas of the Tuckean Swamp. A concrete weir would retain the water level in the drains at approximately sea level and provide a robust structure that would span the channel and provide a defined control point. On the downstream side of the weir, some rock protection would be required to prevent scour and undermining of the structure. Within the weir structure, baffle boards could be used to provide fine manipulation of the water levels upstream.
– Rock/earth weir. Permeability of the rock/ earth weir would be managed with a clay core. The rock/earth weir would be a low height structure embedded into the banks. It is assumed that material for the weir could be obtained from within the site with some modifications to surrounding levels subject to geotechnical and ASS investigations. A nominal 300 millimetre thick rock scour protection would be placed over the clay core to provide durability to the structure when it is overtopped. The level of this weir could be raised with additional material placed on the crest or lowered with material removed to allow for fluctuating seasonal water levels.

As noted in Section 2.1.3, there is anecdotal evidence of fish in the drains. Either weir option could form a permanent barrier to fish passage limiting repopulation of the swamp and surrounding areas. Consequently, fish passage requirements are considered as part of the weir design.

3.2.2 Recommended option

The concrete v-notch weir control structure (see SK007 in Appendix A) is recommended due to its durability. To improve functionality of the concrete weir, the following features are also proposed:

– Drop boards to allow fine tuning of water levels for acid water control
– Rock ramp style fishway to enable fish passage

Access to the weir for construction and ongoing maintenance would be formalised with an access track as described in Section 3.1 and shown in Figure 3.1.

3.2.3 Maintenance requirements

Maintenance for this option would include:

– Routine and post flooding inspections of the structure and surrounds to assess for scour of the abutments as well as downstream channel bed conditions and potential seepage paths around or under the weir.
– Desilting of the weir pool and management of vegetation within the permanent water body as required.
– Annual and post flooding inspections and top up of gravel on the access road.

3.3 Bagotville Barrage (scenario 4 and 6)

3.3.1 Options considered

The Options Study (Water Research Laboratory, 2020) identified that the existing gates at the barrage should be retained and permanently opened. Hinge gates with a pully system that could be manually or mechanically operated are the option recommended. As noted in Section 2.1.1, the existing gates are attached to the culverts on Baggotville Road and there is limited opportunity to attach any opening system other than the following:

– Cantilever a structure from the culverts over the gates (three metres in distance), which would be problematic and need significant structural assessment, or
– Install a gantry that is partially supported from the bridge and spanning the length of the culverts with supports on the downstream side of the gates (this would be required as there is little to no space between the flood gates to provide the supports). This option would result in an approximately three metre wide structure.

At the site inspection, RCC commented that removing the gates and replacing them with more functional types of gates was not supported due to cost and operational issues. However, options to provide more adaptive control would involve the replacement of the flood gates with a regulation gate such as a:

– Multi-leaf gate fixed to the existing culverts. Access to the gates would require a gantry/walkway to be built immediately adjacent to the culvert structure. These gates could be operated via motors controlled via programmable logic controllers (PLC) and level sensors. Fine tuning with the multi-leaf gate can be problematic due to the mechanics involved and the fixed width panels. They are also not considered fish friendly when operating in undershot mode. Another potential concern is that the spindles for the gates would protrude above the road line and could be damaged by debris in floods. An example of multi-leaf gate systems is shown in Figure 3.2 and Figure 3.3.
– Lay flat gate to replace the existing flood gates, which would require a new structure to be fixed immediately downstream of the culverts. These gates can provide fine control of water levels via an adjustable gate that is lowered and raised. These gates could also be operated via motors controlled via programmable logic controllers (PLC) and level sensors. Figure 3.4 and Figure 3.5 show examples of lay flat gates.

Further control can be implemented for both the options above with telemetry (see Figure 3.5) that would allow safe remote operation in response to changing conditions such as managing flood peaks from the river, adapting to breeding conditions for key species or minimising the shock transition of change from the current freshwater system to a more tidal brackish situation. This technology is not included in the option as this stage.

Figure 3.2 Multi-leaf gates fully open (AWMA, 2022a)

Figure 3.3 Multi-leaf gates operating (AWMA, 2022a)

Figure 3.4 Lay flat gate (AWMA, 2022c)

Figure 3.5 Lay flat gate (left) and Penstock attached to culverts (AWMA, 2022b)

3.3.2 Recommended option

To provide a system for the existing gates to be permanently opened or be able to be partially controlled, typical hinge gates using a pulley system, which could be manually or mechanically activated, are recommended. This is the safest and potentially most cost-effective solution to control the flood gates at the barrage. It would include provision of a separate gantry, independent of the existing barrage, that includes a system to lift and hold the gates open and closed when required (see SK009 in Appendix A). The gantry arrangement would be located outside of the swing zone of the tidal gates with supports aligned with the culvert legs so that there is minimal impact on flows.

The flood gates could be manually controlled (this is the option costed) or include an automated system that could release the gates such that they revert back to a traditional flood gate to restrict inflows on spring tides or floods. Automation could include level sensors and a PLC unit that close the gates when the water level exceeds the limits of the upstream works (levees and weirs). Concerns about vandalism of these structures could be mitigated by having fenced access.

3.3.3 Maintenance requirements

Maintenance of the proposed gantry and pulley system would include:

– Annual inspection of the components for damage, corrosion and vandalism. It is expected that this would be done in conjunction with the standard maintenance inspections of the flood gates and hence incur minimal additional costs.
– General mechanical maintenance of the winch system, which would include inspection of the cables, greasing of the winch etc. and certification in accordance with Australian standards.
– Detailed inspections after flooding to inspect for damage.

3.4 Upstream tidal gates (scenario 6)

3.4.1 Options considered

Flood gates

The upstream tidal gates nominated in the Options Study (Water Research Laboratory, 2020) are similar to that of the barrage, consisting of a box culvert with a flap gate on the downstream side. This is a robust solution to exclude tidal flows.

Buoyancy activated gates

As noted in Section 2.1.3, there is anecdotal evidence of fish in the drains. As such, new structures on any drains throughout the Tuckean Swamp should consider fish passage. The suggested option for flap gates on culverts as nominated in the Options Study (Water Research Laboratory, 2020) is not considered fish friendly as it creates undershot flow, which can damage small fish and larvae. Additionally, culverts without mitigation can be detrimental to fish passage due to dark and constrained conditions.

An alternative option for the upstream tidal gates is a proprietary item from AWMA Water Control Solutions (https://www.awmawatercontrol.com.au/) that provides an overshot gate, which opens and closes with the tide (see SK0010 in Appendix A). This arrangement would eliminate potential impacts on small fish and larvae and would operate with a 100 millimetre head loss. It would allow connectivity between fresh and tidal areas at low tide and freshwater flows to enable fish passage.

Figure 3.6 AWMA tidal gate (looking from upstream) (AWMA, 2022d)

Figure 3.7 AWMA tidal gate (looking from downstream) (AWMA, 2022d)

3.4.2 Recommended option

As the buoyant gates are a relatively new technology and their maintenance and operation are unfamiliar to RCC, a flap gate arrangement is recommended so that in house maintenance and operation can be retained. Buoyant gates could be adopted with agreement by RCC regarding maintenance and operation requirements.

For all of the sites except Stony Island, installation of tidal gates would require a new set of box culverts. The gates at Stibbards Drain would be positioned adjacent to an existing crossing. As there are no existing crossings at the location of the Tucki and Hendersons gates, single 2.44 metre long box culverts are proposed that would allow pedestrian and small farm vehicles (i.e. quad bike) access across the drain. A wider crossing could be accommodated if vehicle (car or tractor) access is required. Culvert details are summarised in Table 3.1.

Table 3.1 Upstream tidal gates

Gate location	No. box culverts	Width (m)	Height (m)	Invert (m AHD)
Stibbards Drain	4	3	2	-0.8
Tucki Canal	5	3	2.5	-1.2
Stony Island	1	3.4	1.9	-0.76
Hendersons Drain	6	3.0	2.5	-1.1

For Tucki and Henderson Gates, access for construction and maintenance would need to be provided. Nominally, the following access requirements for the four sites would be required:

– Stibbards Drain – There is an existing access point off Hoare Lane onto the Stibbards Canal track with an existing crossing of the channel. This could be augmented with a small set of culverts immediately downstream of the existing crossing.
– Tucki Canal - Access would be from Tuckean Island Road and east along the channel to the edge of the park boundary.
– Stony Island – Access would be directly from Tuckean Island Road with no additional access works required.
– Henderson Drain – Access could be from Tuckean Island Road and then east to the drain. An additional 1.3 kilometre access track is required across private property. Access from the north via Marom Creek Road is also possible using existing private access where possible. An additional 1.3 kilometre track would also be required for this option but the route is via more low-lying areas. For both options some assessment of routes would be required based on land ownership, terrain constraints (areas subject to inundation) and vegetation management.

3.4.3 Maintenance requirements

Maintenance of the tidal gates would be similar to options 4 and 6 consisting of:

– Routine inspections of the gates and repair of any damage.
– Routine inspections of the culvert structure and access.

3.5 Levee works (scenario 6)

3.5.1 Options considered

The Options Study (Water Research Laboratory, 2020) assumes that the existing levees are suitable to provide sufficient hydraulic disconnectivity between the drain and the adjacent farmland and that these only require topping up and not a full reconstruction. The recommendation therefore is to provide an additional 400 millimetres (max) over and above the existing levee at specific low points (see SK0011 and SK0012 in Appendix A).

RCC identified at the site inspection that the current levee is built from spoil material won from the existing drain and may not meet current standards or requirements. With the proposal to open up the barrage, allowing the swamp, and in turn the drain, to be tidal, the levee would be subject to more frequent inundation to a higher depth than what is experienced currently. This could be managed by either:

– Construction of an engineered impermeable barrier along the length of the levee along Stibbards Drain. This could be a nominal 600 millimetre wide trench dug into the levee that is backfilled with impermeable material, or
– Provision of a collection system on the farm side of the levee to collect seepage that is discharged back to the drain by pump or when the channels levels are low enough (i.e.at low tide) via the existing flood valve.

3.5.2 Recommended option

For the purpose of estimation, we have allowed a nominal topping of the levee with select, impermeable material to achieve the required containment height with seepage collected and discharged via the existing farm drains.

As the existing levee does not provide formal vehicle access, the recommended option also does not include vehicle access.

3.5.3 Maintenance

Maintenance of the levee would be similar to that undertaken at the moment and include:

– Routine vegetation management including mowing/ slashing and weed control.
– Routine inspections of the levee for seepage and scour. Repair as required with particular attention to penetrations (culverts, pipelines) through the levee that can facilitate seepage paths.

4. Cost estimates

4.1 Capital costs

The estimated costs of material procurement for each of the scenarios is summarised in Table 4.1. A detailed breakdown of the costed components is included in Appendix B. These should be read and utilised in conjunction with the assumptions noted in Section 2.3.

Table 4.1 Estimated material costs

Scenario	Capital cost estimate
Scenario 1	$2,260,000
Scenario 2	$369,000
Scenario 4	$396,000
Scenario 5	$2,629,000
Scenario 6	$1,933,000

4.2 Maintenance costs

Maintenance costs (see Table 4.2) assumes the following:

– Hourly rate for inspections would be $80/hour/person and would be undertaken by a two person team.
– Vegetation management would consist of either a boom slasher or a boom sprayer with an allowance of $250/hour for an operator and machinery.
– Operational tasks (i.e. manipulation of the Bagotville Barrage) are not included in the cost as this is an existing task.

Maintenance costs are indicative and do not include associated on-costs such as the use of cars, tractors or boats, herbicide, and so not include periodic heavy maintenance, which could be required every 5-10 years and may include heavy machinery and environmental permits and approvals.

Table 4.2 Estimated maintenance costs

Scenario	Inspections	Vegetation management	Total annual maintenance cost estimate
Scenario 1	Quarterly inspections of the drains and roads. Allowance of 8 hours per inspection = 4 x 8 x 160 = $5,120	Maintenance 4 times each year (summer months) for 2 days each time = 8 x 2 x 250 x 4 = $16,000	$21,120
Scenario 2	Quarterly inspections of the weir and road. Allowance of 4 hours per inspection = 4 x 4 x 160 = $2,560	Maintenance 4 times each year (summer months) for 1 day each time = 8 x 250 x 4 = $8,000	$10,560
Scenario 4	Monthly inspections of the gantry and winch system. Allowance of 4 hours per inspection = 4 x 12 x 160 = $7,680	N/A	$7,680
Scenario 5	Quarterly inspections of the drains and roads. Allowance of 8 hours per inspection = 4 x 8 x 160 = $5,120	Maintenance 4 times each year (summer months) for 2 days each time = 8 x 2 x 250 x 4 = $16,000	$21,120
Scenario 6	Quarterly inspections of the levee, gates and roads. Allowance of 16 hours per inspection = 4 x 16 x 160 = $10,240 Monthly inspections of the gantry and winch system. Allowance of 4 hours per inspection = 4 x 12 x 160 = $7680	Maintenance 4 times each year (summer months) and 1 day levee slashing = 8 x 250 x 4 = $8,000	$25,920

4.3 Total costs

To enable comparison of scenarios, capital and maintenance costs have been combined in Table 4.3 to calculate a total cost. Table 4.3 includes an estimate of asset life based on the conditions at the site and materials used to construct the asset. These are estimates only for comparison purposes.

Table 4.3 Estimated total cost for each scenario

Scenario	Assumed design life (years)	Capital cost estimate	Maintenance cost estimate (total)	Total
Scenario 1	50	$2,260,000	$1,056,000	**$3,316,000**
Scenario 2	30	$369,000	$316,800	**$685,800**
Scenario 4	30	$396,000	$230,400	**$626,400**
Scenario 5	30	$2,629,000	$633,600	**$3,262,600**
Scenario 6	30	$1,933,000	$777,600	**$2,710,600**

4.4 Impact of construction and access

Agreement with affected landowners for both temporary and permanent access to the sites is required for all scenarios. The costs for this cannot be determined without that engagement (not part of the scope of this report) and would be subject to commercial agreements with each landowner.

To assist with these discussions, an approximate area of impact for construction and access for each scenario is provided in Table 4.4. The asset area denotes the area required for the actual works. Access road areas comprise the area to gain access to the asset from a main road.

Table 4.4 Estimated area of impact

Scenario	Asset area (m^2)	Access road area (m^2)
Scenario 1 – Reshaping drains[1]		27,640
Scenario 2 - Meerschaum Weir[2]	600	3750
Scenario 4 – Bagotville Barrage gantry	0	0
Scenario 5[3] – Reshaping drains plus diversion weir	600	27,640
Scenario 6[4] - Bagotville Barrage plus upstream tidal gates and levee works	37,500	6,250

[1] It is assumed that the existing drain reshaping will occur under existing agreements or easements.
[2] It is assumed that access to the weir is from the north.
[3] Allows for specific easement over diversion weir.
[4] The asset area is for the levee and the new culverts. It is assumed the access track is on the levee at Tucki Canal and Hendersons Drain only.

5. Conclusion

GHD was engaged by OzFish Unlimited to prepare concept design options for the scenarios recommended in the Tuckean Swamp Options Study (Water Research Laboratory, 2020) to restore environmental flows to the swamp. The concept designs were prepared to enable cost estimates to be prepared for comparison purposes.

Of the five scenarios assessed in this report:

– Scenarios 2 and 4 have the least capital and maintenance costs. The key differentiator between the two scenarios is that Scenario 4 would not require any additional land acquisition or agreement to construct the additional infrastructure, which could have a significant cost impact if land must be acquired for Scenario 2.
– Scenarios 1, 5 and 6 are an order of magnitude more costly than Scenario 2 and 4. Scenarios 1 and 5 require significant works on the upper flood plain. This would involve construction of temporary/permanent access roads to enable works to proceed. Option 6 requires long levee works, several flood gates and culverts, which will also require some form of additional land access/ acquisition agreement.

Further work that could be undertaken to improve the level of accuracy of the cost estimates provide herein includes:

– Engage with the respective landowners and seek agreement for the works and costs of land acquisition or lease. These costs could be added to the estimates contained in this report to enable better cost comparison of the scenarios as not all options have comparable impacts to landowners.
– More detailed field investigations for the preferred option/s could be undertaken. This would include geotechnical, ASS, ecological and topographical surveys, which would allow further engineering design and refinement of the options.

This Design and Cost Report has been prepared to provide high level costings for comparison purposes during ongoing decision making by stakeholders regarding Tuckean Swamp; assessment of other impacts and benefits for recommended options will be prepared by others in future stages of the project.

6. References

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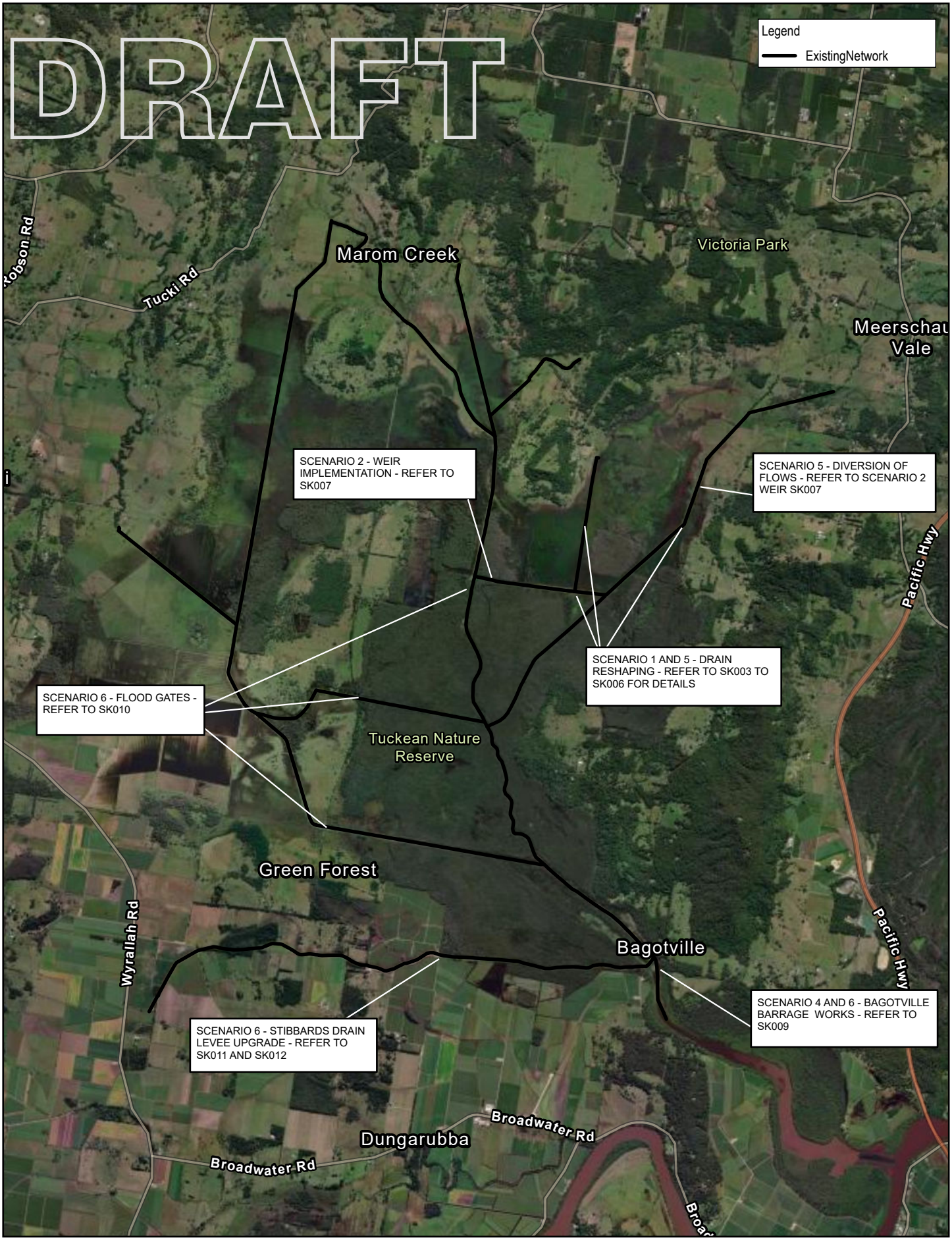
Appendix A

Design drawings



Paper Size ISO A4

0 0.4 0.8 1.2 1.6

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

OZ FISH
Tuckean Swamp Project:
Implementation Toolkit

Project No. **12553451**
Revision No. **B**
Date **4/8/2022**

Overview map

FIGURE 1

\\ghdnet\ghd\AU\Newcastle\Projects\22\12553451\GIS\Maps\12553451_PROJECTDATA.aprx
Print date: 08 Apr 2022 - 12:07

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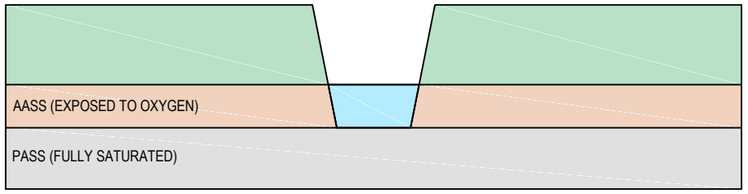
World Imagery: Earthstar Geographics. Created by: tthompson2



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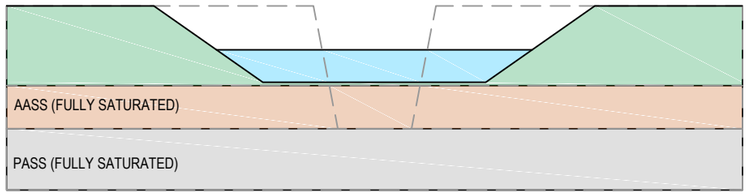
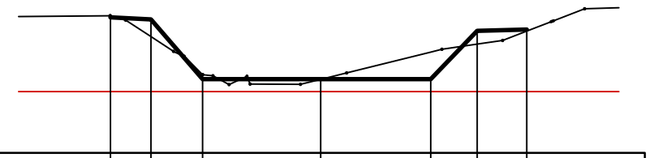


AFTER RE-SHAPING

DRAIN RE-SHAPING CONCEPT



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EXISTING SURFACE LEVEL	1.47	0.79	-0.45	-0.6	0.29	0.54	0.97	
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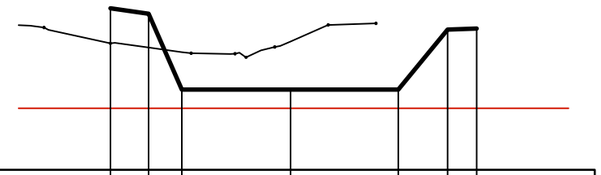
CH 2615



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EXISTING SURFACE LEVEL	1.12	0.99	0.84	1.18			
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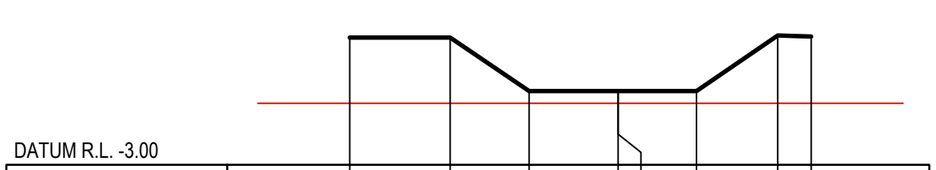
CH 3000



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EXISTING SURFACE LEVEL									
OFFSET FROM CENTRELINE	-8.75	-5.47	-2.91	0	0	2.56	5.2	6.3	

CH 1983

DRAIN RE-SHAPING TYPICAL DETAIL

Rev	Description	Checked	Approved	Date
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Designer		Design Check		

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Project No.

Client OZ FISH

Project TUCKEAN SWAMP

Status

Status Code

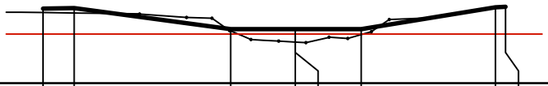
Drawing Title SCENARIO 1 & SCENARIO 5: DRAIN RE-SHAPING TYPICAL DETAILS

Size A3

Drawing No. 12553451-SK002

Rev

Plot Date: 8 April 2022 - 6:35 PM Plotted by: Eden Balas File Name: C:\01ebalas\12553451 - Tuckean Swamp\Drawings\12553451-SK002.dwg



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EXISTING SURFACE LEVEL	0.75	0.71	-0.76	-1.65	-1.65	-1.04							
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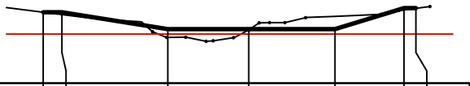
CH 239



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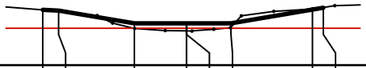
EXISTING SURFACE LEVEL	0.78	0.59	-1.28	-0.67	0.44	0.98	1.1						
OFFSET FROM CENTRELINE	-16.76	-15.23	-6.6	0	7.04	12.66	13.64						

CH 800



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ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1					
EXISTING SURFACE LEVEL	0.51	0.36	-1.02	-1.21	-1.21	-0.91	0.57	0.71					
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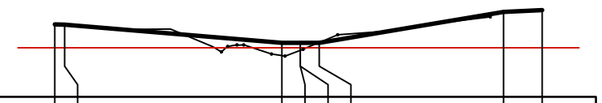
CH 1163



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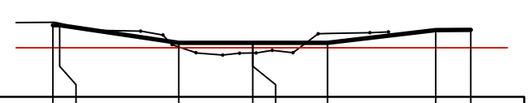
EXISTING SURFACE LEVEL			-1.65	-1.21	-1.21	-0.59							
OFFSET FROM CENTRELINE	-20.02	-19.21	-1.49	0	0	1.55	16.58	19.72					

CH 2



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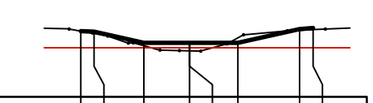
ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1					
EXISTING SURFACE LEVEL	1.06	0.98	-0.93	-1.43	-1.43	0.15							
OFFSET FROM CENTRELINE	-16.29	-15.73	-6.03	0	0	6.11	14.92	17.78					

CH 504



DATUM R.L. -5.00

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ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1					
EXISTING SURFACE LEVEL	0.35	0.16	-0.84	-1.25	-1.25	-0.2	0.42	0.47					
OFFSET FROM CENTRELINE	-8.86	-7.78	-3.72	0	0	3.94	8.97	10.08					

CH 1486

12d Model
Horizontal Scale 1:500
Vertical Scale 1:500

Rev	Description	Checked	Approved	Date

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Designer Design Check

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Project No.

Client OZ FISH
Project TUCKEAN SWAMP
Status
Status Code

Drawing Title SCENARIO 1 & SCENARIO 5: DRAIN RE-SHAPING - DETAIL SECTIONS (MEERSCHAUM VALE)

Size A3
Drawing No. 12553451-SK003-SK006
Rev

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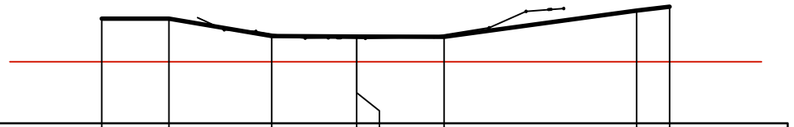

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EXISTING SURFACE LEVEL			-0.1	-0.23	-0.23	-0.13			
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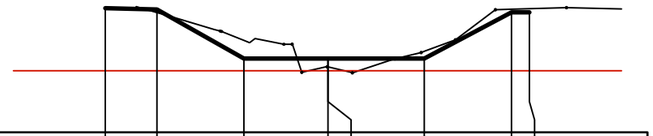
CH 45



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EXISTING SURFACE LEVEL		0.9	-0.01	-0.87	-0.87	-0.36	1.01	1.03	
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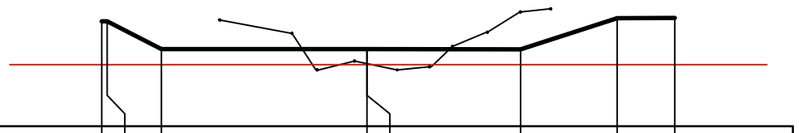
CH 885



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ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1	
EXISTING SURFACE LEVEL				-0.96	-0.96	0.72			
OFFSET FROM CENTRELINE	-8.65	-8.47	-6.7	0	0	5.02	8.16	10.04	

CH 1

DATUM R.L. -3.00

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ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1	
EXISTING SURFACE LEVEL			0.33	-0.9	-0.9	-0.78	0.62	0.81	
OFFSET FROM CENTRELINE	-9.44	-6.04	-2.41	0	0	2.44	5.65	6.15	

CH 606

12d Model
Horizontal Scale 1:200
Vertical Scale 1:200

Rev	Description	Checked	Approved	Date

Author E. BALAS Drafting Check
Designer Design Check

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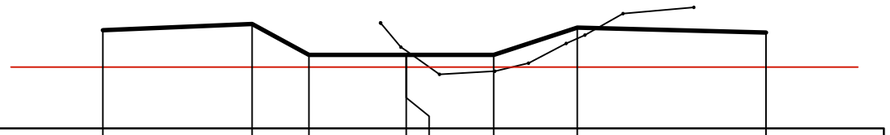
Project No.

Client OZ FISH
Project TUCKEAN SWAMP
Status
Status Code

Drawing Title SCENARIO 1 & SCENARIO 5: DRAIN RE-SHAPING - DETAIL SECTIONS (SLATTERIES)

Size A3
Drawing No. 12553451-SK003-SK006
Rev

Plot Date: 8 April 2022 - 6:35 PM Plotted by: Eden Balas File Name: C:\01ebalas\12553451 - Tuckean Swamp\Drawings\12553451-SK003-SK006.dwg



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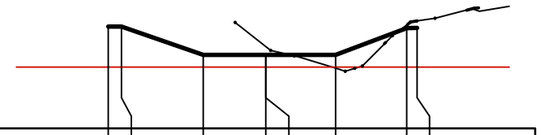
ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1	
EXISTING SURFACE LEVEL				-0.47	-0.47	-1.14	-0.07		
OFFSET FROM CENTRELINE	-9.89	-5.03	-3.17	0	0	2.86	5.58	11.73	

CH 217



DATUM R.L. -3.00

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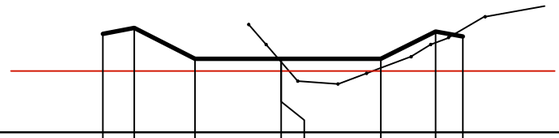
EXISTING SURFACE LEVEL				-0.33	-0.33	-1.04	0.37	0.5	
OFFSET FROM CENTRELINE	-5.14	-4.71	-2.04	0	0	2.27	4.59	4.94	

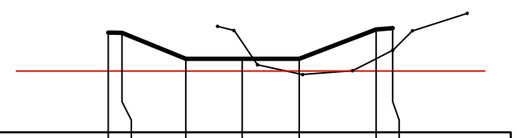
CH 750



DATUM R.L. -3.00

DESIGN SURFACE LEVEL	0.205	0.402	-0.6	-0.6	-0.6	-0.6	0.289	0.124	
ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1	
EXISTING SURFACE LEVEL				-0.71	-0.71	-0.9	-0.08	0.36	
OFFSET FROM CENTRELINE	-5.81	-4.79	-2.81	0	0	3.25	5.04	5.93	

CH 1



DATUM R.L. -3.00

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ESTIMATED ACID SULPHATE LEVEL	-1	-1	-1	-1	-1	-1	-1	-1	
EXISTING SURFACE LEVEL				-0.06	-1.1	-0.6	-0.32		
OFFSET FROM CENTRELINE	-4.37	-3.92	-1.83	0	1.86	4.37	4.91		

CH 545

Rev	Description	Checked	Approved	Date

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Client OZ FISH

Project TUCKEAN SWAMP

Status Status Code

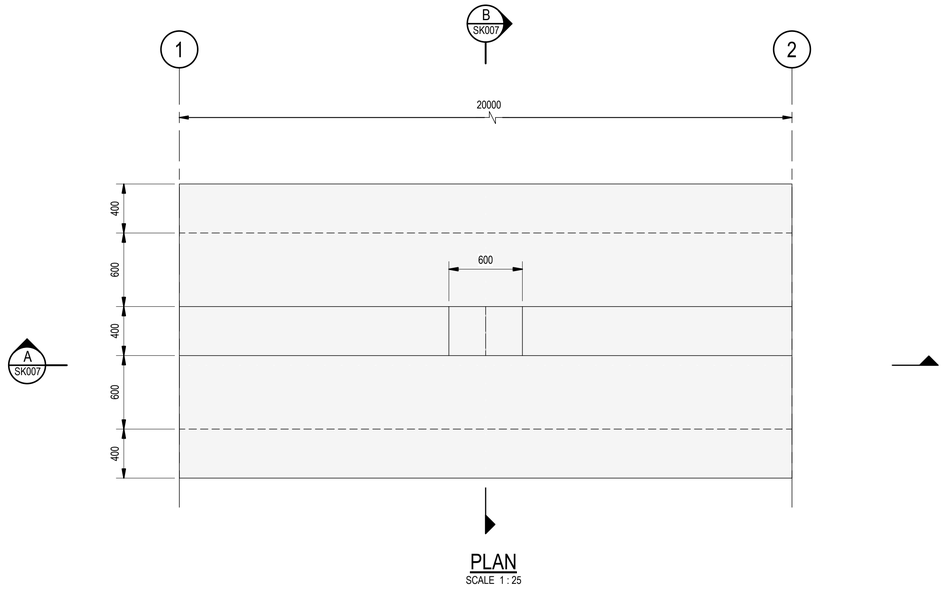
Drawing Title SCENARIO 1 & SCENARIO 5: DRAIN RE-SHAPING - DEATIL SECTIONS (JUMBO)

Size A3

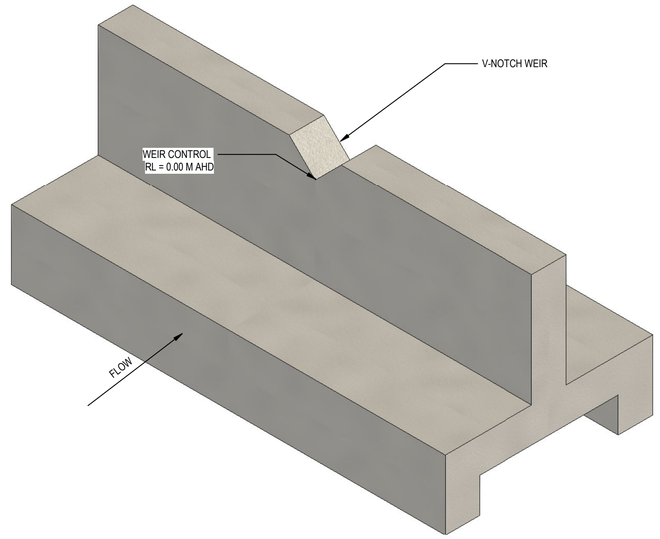
Drawing No. 12553451-SK003-SK006

Rev

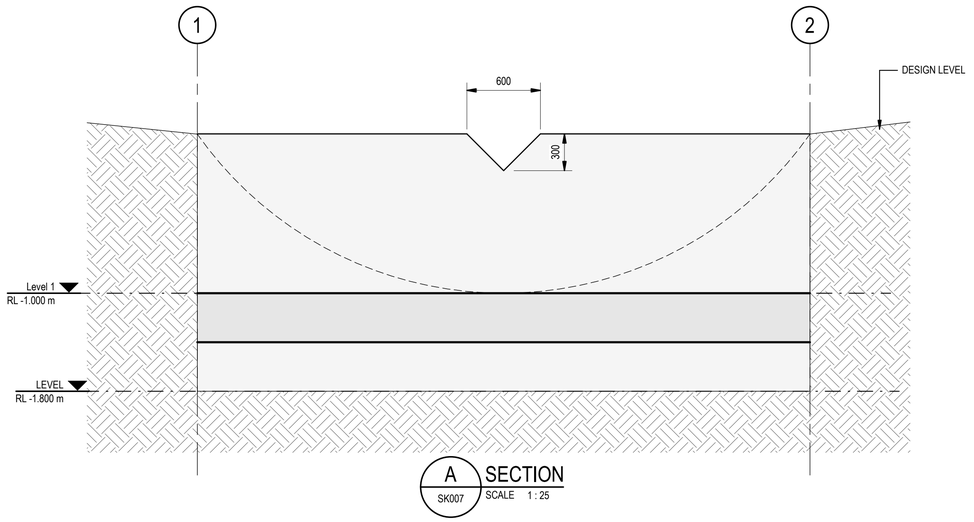
Plot Date: 8 April 2022 - 6:35 PM Plotted by: Eden Balas File Name: C:\01ebalas\12553451 - Tuckean Swamp\Drawings\12553451-SK003-SK006.dwg



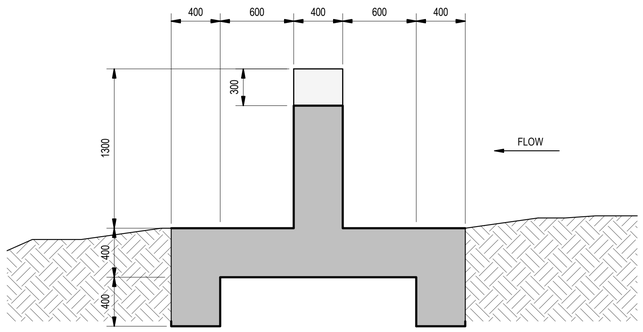
PLAN
SCALE 1 : 25



3D VIEW



A SECTION
SK007 SCALE 1 : 25



B SECTION
SK007 SCALE 1 : 25

SCENARIO 2 & 5

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Author	Author	Drafting Check		Reg No.	
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Project No. 12553451

Client: OZFISH UNLIMITED

Project: TACKEAN SWAMP PROJECT IMPELMENTATION TOOLKIT

Status: Status Code

Drawing Title: WEIR FRAMING PLAN, ELEVATION AND SECTION

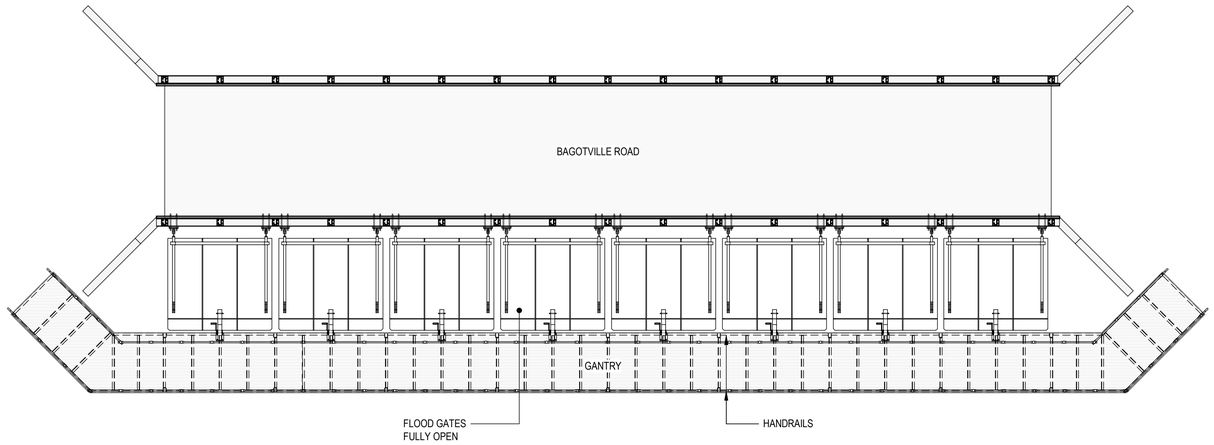
Size: A1

Drawing No. 12553451-SK007

Rev

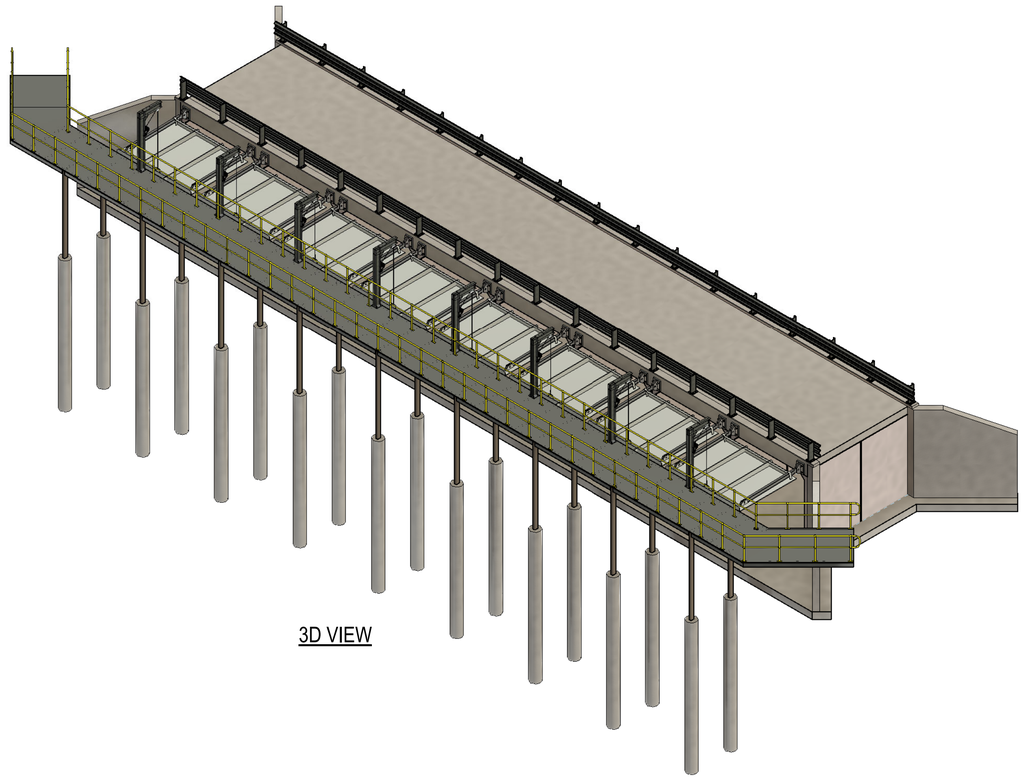
Plot Date: 20/06/2022 12:08:15 PM

File Name: C:\Users\jffaigao\Documents\Revit 2022 Local Files\1253451-MEERSCHAUM VALE FISHWAY-V_WEIR-STR_R22.rvt

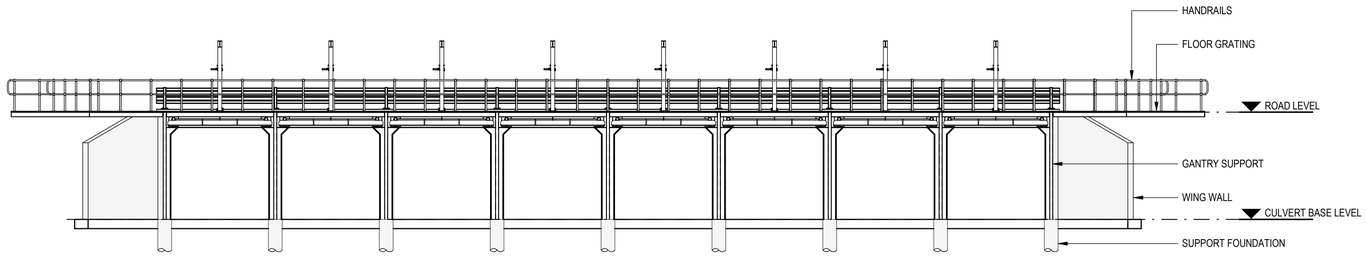


GANTRY FRAMING PLAN

SCALE 1 : 100

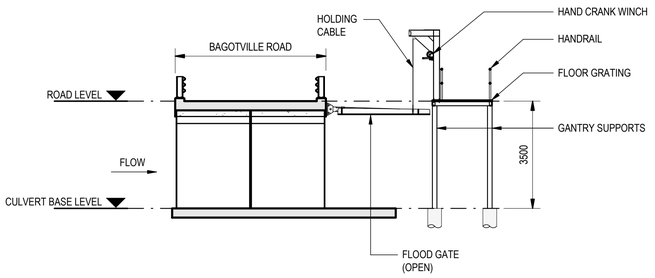


3D VIEW



ELEVATION

SCALE 1 : 100



TYPICAL SECTION

SCALE 1 : 100

SCENARIO 4 & 6

Rev	Description	Checked	Approved	Date

Author Author **Drafting Check** **Reg No.**

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Project No. 12553451

Client OZFISH UNLIMITED

Project TACKEAN SWAMP PROJECT IMPELMENTATION TOOLKIT

Status **Status Code**

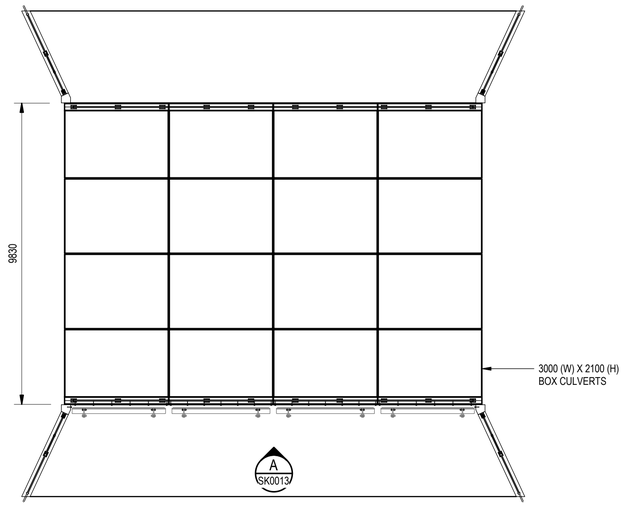
Drawing Title GANTRY FRAMING PLAN, ELEVATION AND SECTION

Size A1

Drawing No. 12553451-SK009

Rev

Plot Date: 11/04/2022 12:18:08 PM File Name: C:\Users\jffaigao\Documents\Revit 2022 Local Files\1255351-TUCKEAN SWAMP PROJECT-STR_R22.rvt



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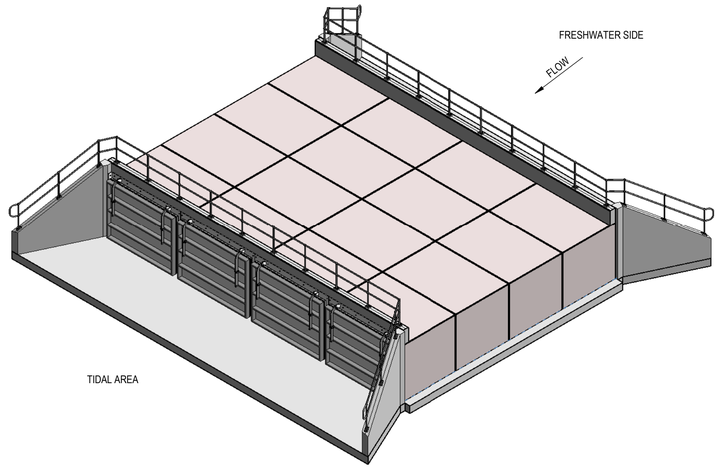
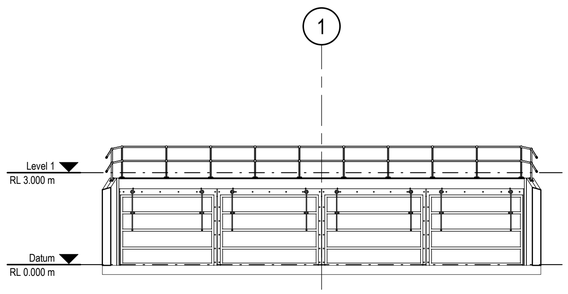
SCALE 1 : 100



PERSPECTIVE



A
SK0013
ELEVATION
SCALE 1 : 100

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Project TUCKEAN SWAMP

Drawing Title TYPICAL DETAIL - FLOOD GATE

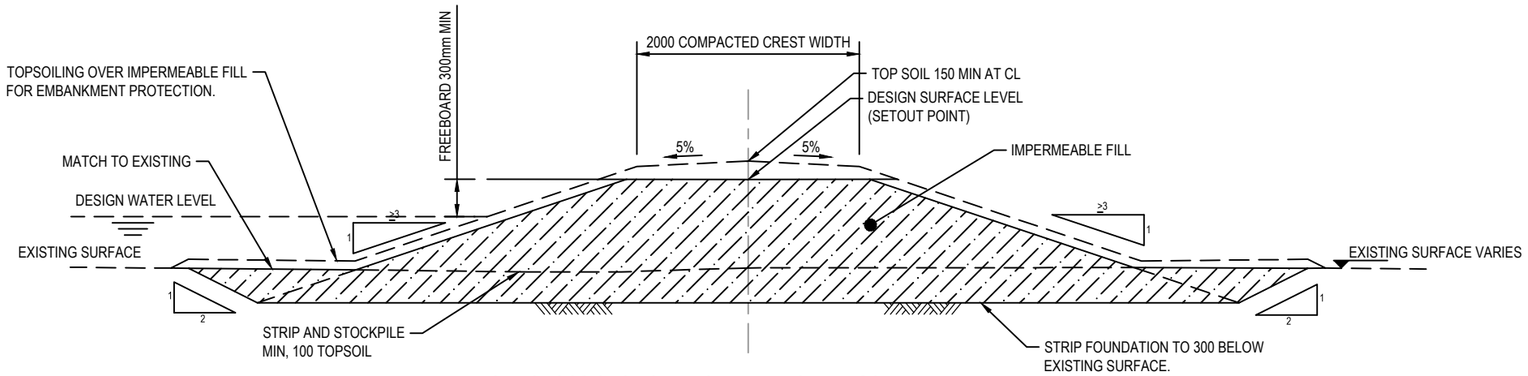
Size A1

Status **Status Code**

Drawing No. 12553451-SK0013

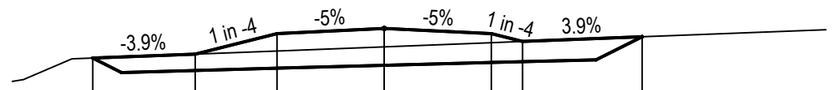
Rev

Plot Date: 15/06/2022 9:57:56 AM File Name: C:\Users\jffaigao\Documents\Revit 2022 Local Files\1255351-TUCKEAN SWAMP PROJECT_PENSTOCK-STR_R22.rvt



TYPICAL CROSS SECTION - NON TRAFFICABLE CONATINMENT BANK
TYPE B4 - BANK HEIGHT <1m

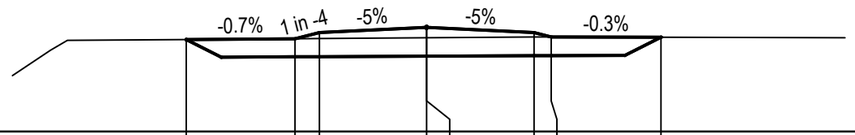
NOT TO SCALE



DATUM R.L. -1.00

DESIGN SURFACE LEVEL	0.215	0.28	0.612	0.7	0.7	0.612	0.486	0.562	
BASE DESN SURFACE LEVEL	0.21	0.01	0.05	0.1	0.1	0.14	0.16	0.56	
EXISTING SURFACE LEVEL	0.21	0.28	0.33	0.4	0.4	0.47	0.49	0.56	
OFFSET FROM CENTRELINE	-4.75	-3.08	-1.75	0	0	1.75	2.25	4.21	

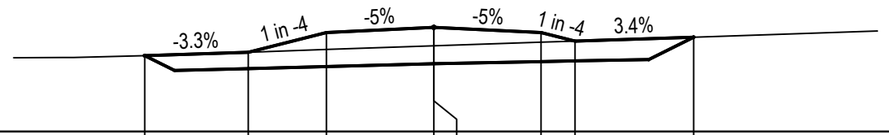
CH 1530



DATUM R.L. -1.00

DESIGN SURFACE LEVEL	0.501	0.513	0.612	0.7	0.7	0.612	0.542	0.537	
BASE DESN SURFACE LEVEL	0.5	0.22	0.22	0.23	0.23	0.24	0.24	0.54	
EXISTING SURFACE LEVEL	0.5	0.51	0.52	0.53	0.53	0.54	0.54	0.54	
OFFSET FROM CENTRELINE	-3.92	-2.15	-1.75	0	0	1.75	2.03	3.82	

CH 3080



DATUM R.L. -1.00

DESIGN SURFACE LEVEL	0.237	0.293	0.612	0.7	0.7	0.612	0.474	0.539	
BASE DESN SURFACE LEVEL	0.24	0.03	0.06	0.11	0.11	0.14	0.15	0.54	
EXISTING SURFACE LEVEL	0.24	0.29	0.34	0.4	0.4	0.45	0.47	0.54	
OFFSET FROM CENTRELINE	-4.71	-3.03	-1.75	0	0	1.75	2.31	4.24	

CH 6315

12d Model
Horizontal Scale 1:100
Vertical Scale 1:100

Rev	Description	Checked	Approved	Date
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Status

Status Code

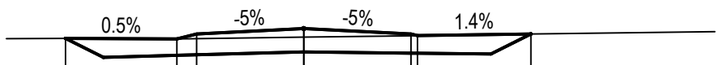
Drawing Title SCENARIO 6: LEVEE WORKS

Size A3

Drawing No. 12553451-SK0011-SK0012

Rev

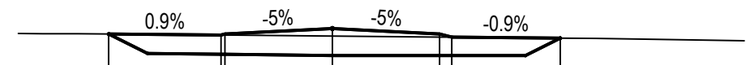
Plot Date: 8 April 2022 - 6:34 PM Plotted by: Eden Balas File Name: C:\01ebalas\12553451 - Tuckean Swamp\Drawings\12553451-SK0011-SK0012.dwg



DATUM R.L. -1.00

DESIGN SURFACE LEVEL	0.541	0.533	0.612	0.7	0.7	0.612	0.587	0.612					
BASE DESN SURFACE LEVEL	0.54	0.26	0.27	0.32	0.32	0.3	0.3	0.61					
EXISTING SURFACE LEVEL	0.54	0.53	0.54	0.56	0.56	0.59	0.59	0.61					
OFFSET FROM CENTRELINE	-3.89	-2.07	-1.75	0	0	1.75	1.85	3.7					

CH 5105



DATUM R.L. -1.00

DESIGN SURFACE LEVEL	0.613	0.596	0.612	0.7	0.7	0.612	0.563	0.547					
BASE DESN SURFACE LEVEL	0.61	0.28	0.28	0.26	0.26	0.26	0.26	0.55					
EXISTING SURFACE LEVEL	0.61	0.6	0.6	0.58	0.58	0.56	0.56	0.55					
OFFSET FROM CENTRELINE	-3.65	-1.81	-1.75	0	0	1.75	1.95	3.72					

CH 5355

DATUM R.L. -1.00

DESIGN SURFACE LEVEL	0.363	0.399	0.612	0.7	0.612	0.501	0.541						
BASE DESN SURFACE LEVEL	0.36	0.12	0.13	0.15	0.18	0.18	0.54						
EXISTING SURFACE LEVEL	0.36	0.4	0.42	0.45	0.49	0.5	0.54						
OFFSET FROM CENTRELINE	-4.33	-2.6	-1.75	0	1.75	2.2	4.08						

CH 2100

DATUM R.L. -1.00

DESIGN SURFACE LEVEL	0.495	0.493	0.612	0.7	0.7	0.612	0.487	0.486					
BASE DESN SURFACE LEVEL	0.49	0.19	0.19	0.19	0.19	0.19	0.19	0.49					
EXISTING SURFACE LEVEL	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49					
OFFSET FROM CENTRELINE	-4.03	-2.23	-1.75	0	0	1.75	2.25	4.05					

CH 2690

Rev	Description	Checked	Approved	Date

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Status Status Code

Drawing Title SCENARIO 6: LEVEE WORKS

Size A3

Drawing No. 12553451-SK0011-SK0012

Rev

Plot Date: 8 April 2022 - 6:34 PM Plotted by: Eden Balas File Name: C:\01ebalas\12553451 - Tuckean Swamp\Drawings\12553451-SK0011-SK0012.dwg

Appendix B

Cost tables

Table B.1 Scenario 1 – Slatteries Drain

Site Preparation				
Item	**Unit**	**Amount**	**Unit Rate**	**$[5]**
Scrub - Clearing and grubbing	sqm	15,735	2	$31,500
Tree removal	per tree	32	405	$13,000
Strip and heap topsoil	cum	6,294	6.44	$40,600
Earth Works				
Item	**Unit**	**Amount**	**Unit Rate**	**$**
Excavation - Cut to stockpile	cum	1,567	35.42	$55,600
Excavation - Cut and fill	cum	431	14.00	$6,700
Compaction	sqm	432	3.96	$1,800
Shape batters	sqm	2,001	4.07	$8,200
Cart excess clean fill to next site	cum	704	3.46	$2,500
Site Maintenance				
Item	**Unit**	**Amount**	**Unit Rate**	**$**
Dewatering	sqm	325		$19,400
Sediment control - silt fence	m	500		$9,500
Construction Area Rehabilitation				
Item	**Unit**	**Amount**	**Unit Rate**	**$**
Rehandle and spread topsoil	cum	6,294	6.875	$43,300
Dispose of excess clean fill	t	370	73.15	$27,100
Dispose of/Treat ASS	t	839	374	$313,900
Access road - crushed rock	sqm	15,735	21.23	$334,100
Access road - geotextile layer	sqm	15,735	22	$346,200
Total				**$1,253,400**

[5] Rounded up to nearest hundred

Table B.2 Scenario 1 - Meerschaum Drain

Site Preparation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Clearing and grubbing	sqm	14,900	2	$29,800
Tree removal	per tree	15	404.80	$6,100
Strip and heap topsoil	cum	2,235	6	$14,400
Earth Works				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Cut and fill	cum	267	15	$4,200
Fill from spoil heaps	cum	704	9	$10,900
Compaction	sqm	974	4	$3,900
Shape batters	sqm	382	4	$1,600
Site Maintenance				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Dewatering	sqm	325	59	$19,400
Sediment control - silt fence	m	500	19	$9,500
Construction Area Rehabilitation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Rehandle and spread topsoil	cum	2,235	7	$15,400
Dispose of excess clean fill	t			
Dispose of ASS	t	160	374	$60,100
Access road - crushed rock	sqm	7,450	21	$158,200
Access road - geotextile layer	sqm	7,450	22	$163,900
Total				**$497,400**

Table B.3 Scenario 1 - Jumbo Drain

Site Preparation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Clearing and grubbing	sqm	8,910	2	$17,900
Tree removal	per tree	9	405	$3,700
Strip and heap topsoil	cum	1,337	6	$8,700
Access road - basic	sqm	8,910	8	$75,300
Earth Works				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Excavation	cum	508	35	$18,000
Cut and fill	cum	217	15	$3,400
Compaction	sqm	220	4	$900
Shape batters	sqm	730	4	$3,000
Site Maintenance				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Dewatering	sqm	325	$59	$19,400
Sediment control - silt fence	m	500	$19	$9,500
Construction Area Rehabilitation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Rehandle and spread topsoil	cum	1,337	7	$9,200
Dispose of excess clean fill	t	407	73	$29,800
Dispose of ASS	t	305	374	$113,900
Access road - crushed rock	sqm	4,455	21	$94,600
Access road - geotextile layer	sqm	4,455	22	$98,100
Total				**$504,700**

Table B.4 Scenario 2 – Meerschaum Weir

Site Preparation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Clearing and grubbing	sqm	3,750	2	$7,500
Strip and heap topsoil	cum	3,750	6	$24,200
Excavation	cum	40	35	$1,500
Concrete Weir				
Foundation	cum	40	686	$27,500
Wall	cum	40	1,000	$40,000
Geofabric	sqm	200	20	$4,000
Import Rock	cum	120	250	$30,000
Shape batters	sqm	40	4	$200
Site Maintenance				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Dewatering	sqm x days	1,200	59	$71,300
Sediment control - silt fence	m	20	19	$400
Construction Area Rehabilitation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Access road - crushed rock	sqm	3,750	21	$79,700
Access road - geotextile layer	sqm	3,750	22	$82,500
Total				**$368,500**

Table B.5 Scenario 4 – Bagotville Barrage

Gantry				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Gantry inc. handrails	units	1.00	150,000	$150,000
Piles (assume 10m long)	m	200	300	$60,000
Pile Rig Establishment	m	1	10,000	$10,000
Mechanical Winch (Portable Power Pack)	unit	8	5,000	$40,000
Portable Power Pack	unit	1	10,000	$10,000
Access Gangways	item	2	60,000	$120,000
Security Fencing and Gates	m	20	300	$6,000
Total				**$396,000**

Table B.6 Scenario 6 - Levee and flood gates

Site Preparation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Clearing and grubbing	sqm	12,500	0.62	$7,700.00
Tree removal	per tree	25	404.80	$10,200.00
Strip and heap topsoil	cum	3,750	6.44	$24,200.00

Site Preparation				
Earth Works				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Fill from borrow pit	cum	6,326	15.57	$98,500.00
Compaction	sqm	2,427	3.96	$9,700.00
Shape batters	sqm	2,427	4.07	$9,900.00
Site Maintenance				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Item	Unit			
Dewatering	sqm	130	59.4	$7,800.00
Sediment control - silt fence	m	-		
Construction Area Rehabilitation				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Rehandle and spread topsoil	cum	3,750	6.88	$25,800.00
Precast Concrete Culvert				
Item	**Unit**	**Amount**	**Unit rate**	**$**
Stibbard RCBC				
Culverts 4 No. [3000 x 2100]	units	12.00	4,500	$54,000.00
Headwall	unit	2	3,000	$6,000.00
Guard Rails	m	60	150	$9,000.00
Flood Valves	unit	4	10,000	$40,000.00
Access road - crushed rock	m2			
Access road - geotextile layer	m2			
Dewatering/Coffers	sqm	1,800	59.40	$107,000
Tucki Gates				
Culverts 5 No. [3000 x 2400]	units	15	4,700	$70,500.00
Headwall	unit	2	3,500	$7,000.00
Guard Rails	m	70	150	$10,500.00
Flood Valves	unit	5	11,000	$55,000.00
Access road - crushed rock	m2	2,500	21.23	$53,100.00
Access road - geotextile layer	m2	2,500	22.00	$55,000.00
Dewatering/Coffers	sqm	1,800	59.40	$107,000
Stoney Island				
Culverts 1 No. [3600 x 2100]	units	0		
Headwall	unit			
Guard Rails	m			
Flood Valves	unit	1	12,000	$12,000.00
Access road - crushed rock	m2			
Access road - geotextile layer	m2			
Dewatering/Coffers	sqm	600	59.40	$35,700.00
Hendersons Gates				
Culverts 6 No. [3000 x 2700]	units	18	5,000	$90,000.00

Site Preparation				
Headwall	unit	2	3,700	$7,400.00
Guard Rails	m	80	150	$12,000.00
Flood Valves	unit	6	12,000	$72,000.00
Access road - crushed rock	m2	3,750	21.23	$79,700
Access road - geotextile layer	m2	3,750	22.00	$82,500.00
Dewatering/Coffers	sqm	1,800	59.40	$107,000.00
Access road - crushed rock	sqm	6,250		$132,700
Access road - geotextile layer	sqm	6,250		$137,500.00
Total				**$1,536,400.00**

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The Power of Commitment