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Shire of Lake Grace

Report for Lake Grace Floodplain Management Study

Flood Mitigation Preliminary Design - Concept Development

December 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report Assumptions – Section 8, including (but not limited to):

- *Modelling was undertaken using data available at the time: survey of ground surface and infrastructure, CBH drawings, aerial imagery, regional topography, previous report results, observations made during previous site visits and previous study outcomes which are assumed to be correct and relevant.*
- *Hydrological and hydraulic modelling from the previous report was used as a base for the current study.*
- *The previous study's results were used to generate boundary condition water levels for the current study.*
- *Methods given in AR&R (Pilgrim 2001) were used to calculate design rainfall.*
- *The 100 year ARI 6 hour storm was adopted as the design storm.*
- *Hydrological and hydraulic parameters were adopted as discussed in Section 2.2.*
- *Antecedent conditions were assumed for the design as discussed in Section 2.2.*

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1. Introduction

1.1 Background

The flooding event of the 12th and 13th of January 2006 was the worst the Lake Grace town has experienced in recorded history. Over the two day period approximately 215 mm of rain fell in the Lake Grace town and its catchments. Figure 1 below shows the aftermath of the flooding event with the downstream lakes system at capacity and significant areas of and around the town flooded. The catchments to the north and east of town discharged through the town to Cemetery Lake. Some of the key impacts and outcomes included:

- Major transport links were cut and severely damaged for a prolonged period including the railway and major and minor highways out of the townsite in all directions.
- Access to the town airstrip was not possible creating a potential emergency situation for residents.
- The area downstream of the Stubbs Street/South Road intersection (Figure 2) was inundated, and a number of homes had to be evacuated.
- Floodwater caused damage to houses and commercial and industrial properties within the central parts of the townsite.
- Backwater (inundation) from Cemetery Lake after it filled was a significant issue which took some time to resolve.

A floodplain study was commissioned to assist the Shire in implementing measures to help protect the town from flooding in the future.

Figure 1 Aerial image of 2006 flooding impact, Lake Grace

1.2 Previous work

The Lake Grace Township Flood Study was completed by GHD for the Shire of Lake Grace in 2008. Hydrologic and hydraulic modelling software was used to simulate actual and design flood events in the town of Lake Grace based upon the ground conditions at the time. A range of options to improve floodplain management were modelled following consideration of information gathered from a range of sources including survey, site inspections and discussions with local residents. The Flood Study recommended a number of non-structural and structural controls that could be implemented to protect the town from future flood events. Table 1 summaries the structural measures recommended in Option 3 of the Flood Study, which were the basis for the flood mitigation concept development reported here.

Table 1 Option 3 – Assumed structural modifications [1]

Measure	Description
Upgrade CBH North Levee	There is currently a short levee around a small compensating area in the north west of the CBH site. Simulations of the existing condition indicate that this levee is overtopped in a 100-year ARI event at a low point toward the northern end. Raising the levee to stop overtopping, though with minimal freeboard.
Drain CBH West	The aerial survey indicates several low or poorly drained areas along the eastern side of the Kulin-Lake Grace Road. To prevent stormwater from the CBH site overtopping the road and flowing toward Carruthers Lake, the roadside drain was deepened to maintain 0.3 m minimum depth and 0.1% slope.
Levee CBH West	A levee east of the Kulin-Lake Grace Road and north of Stubbs Street to close a flow path to the west.
Levee CBH South	Levee on the southern end of the CBH site to contain stormwater for compensation on site. Located conceptually north of the railway line.
Levee North	Levee on the northern side of the compensation basin. Ties into Levee East, South and the railway crossing.
Compensation Basin	Basin to compensate flow from a 10-year ARI event and release via the existing culverts under Stubbs Street. Concept was developed in a separate GHD project. Overflow via spillway for events greater than 10-year ARI.
Floodway	Overflow from the compensating basin with this option is via a floodway across Stubbs Street some 150 m east of the South Road intersection, along the road reserve then through Lot 1, discharging across Griffin St toward the South Road drain. Allows passage of events between 10 and 100-year ARI.
Levee East	Levee on the northern side of the compensation basins. Ties into Levee South and North.
Levee South	Levee along the eastern side of South Road to prevent stormwater from the east entering the town.
Levee Wattle Drive	Levee from the edge of the raised area behind the service station to Wattle Drive, diverting a stormwater flow path in the area toward the south, to join the South Road drain south of Wattle Drive.
Floodway Wattle Drive	Road lowering to create a floodway near the South Road drain crossing. Currently the South Road drain overflows in large events and crosses South Road to the north, flooding private lots. This floodway combined with the South Road levee would control flow across South Road and reduce flooding in lots along Mason St.
Modify Dunham Street	Dunham Street has a low area adjacent to the existing vacant and waterlogged block. The street level could be raised in the middle and lowered near Absolon St to allow free drainage. Tie into Absolon St.
Modify Absolon Street	In the 2006 event, ponded water from Cemetery Lake also inundated Absolon Street and the industrial area in several places. Lowering the street and allowing free drainage to Cemetery Lake near Lawson Street could help improve stormwater drainage in the area.
Modify Mason Street	As with Absolon Street, lowering Mason Street and improving drainage could help with local stormwater management. Parts of Mason Street were also flooded in the 2006 event.

1.3 Scope

This report details the work recently completed to date by GHD on the concept development of selected structural flood mitigation controls for Lake Grace following the 2008 flood study. The objective of the current study is to provide a practical, cost effective preliminary engineering concept that protects the Lake Grace town from flooding in the design 100 year Average Recurrence Interval (ARI) flood event, particularly that which is a result of the known drainage 'bottleneck' at the corner of Stubbs Street and South Road, shown below in Figure 2.

The initial scope of works and the basis for this report is as follows:

[1] (Based on GHD 2008 report)

1. Review the recommended Option 3 Flood Mitigation Concept,
2. Undertake a desktop study to ascertain site restriction and constraints,
3. Build a one-dimensional surface water model to determine the storm water flows in the area for a 100 year ARI event and to develop and validate concepts for flood mitigation infrastructure,
4. Confirm the likely position, size and hydraulic profile of proposed infrastructure,
5. Develop a preliminary cost estimate (+/- 30%) and preliminary construction schedule, and
6. Present recommended flood mitigation concepts to stakeholders for comment in the form of a preliminary design (concept development) report.

The flood mitigation concept design presented in this report has been developed to ameliorate known problem areas adjacent to the Stubbs Street/South Road intersection and downstream areas. This study has not considered the back inundation as the result of the downstream lake becoming full. The design has focused on the need to provide preferable flow paths for floodwaters from the north-eastern catchments to reach Cemetery Lake; it has not considered the drainage of Cemetery Lake.

The flood mitigation concept has been broken into stages to allow the Shire to consider construction over a number of years. These stages are ordered in such a way as to prioritise the most critical items. The staged concepts are discussed in detail below, and an overview figure is provided in Figure 3.

Figure 2 South Road/Stubbs Street during 2006 event

1.4 Report format

This report details the work completed to date to develop the Option 3 structural controls suggested in the Flood Study to preliminary concept designs of flood mitigation infrastructure. Section 2 details the hydrologic and hydraulic modelling study. Sections 3, 4, 5, and 6 give detailed information about the proposed Stages 1 to 4 of the Lake Grace flood mitigation concept design. Section 7 summarises the recommendations of this study and the “order of magnitude” cost indications of the proposed works. Assumptions and limitations of this study are discussed throughout the report and are summarised in Section 8.

LEGEND

- Contours
- Flow Paths

Flood Mitigation Concept

- Drain
- Extent
- Levee
- Culvert
- Basin
- Road
- Cadastre

Flood Mitigation Staging

- 1
- 2
- 3
- 4

1: 5,000 (at A3)

0 25 50 100 150 200 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Shire of Lake Grace
Lake Grace Flood Mitigation Preliminary Design

Job Number	61-26284
Revision	F
Date	19 Dec 2011

Lake Grace Flood Mitigation Concept

Figure 3

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Data source: Landgate: Kukerin 2011 Mosaic - 20111206, Cadastre - 20111206, Roads - 20111206; GHD: Flood Mitigation Concept - 20111206, Contours - 20111209, Basin - 20111206, Culvert - 20111206, Road - 20111206, Flood Mitigation Staging - 20111206 Created by: cagilbert

2. Flood modelling methodology

2.1 Scope of modelling study

The previous hydrological and hydraulic models developed for the Flood Study (GHD 2008) have been reviewed as part of this study. The current concept is similar to Option 3 of the Flood Study with some slight modifications. Due to scope and cost constraints a one-dimensional hydraulic model has been used for this study. The scale of the original (2008) two-dimensional modelling was too broad for the current study, where significant interaction with structures (culverts, basins etc.) was required to develop designs. The original catchment delineation has been used where possible (although there have been some changes in the catchments since the 2006 event) and the hydrology of the current study has been compared with the Flood Study to ensure that current modelling gives similar results for areas which have remained unchanged.

Hydrologic and hydraulic modelling of stormwater entering Lake Grace town from catchments to the north and east was completed using DHI MIKE11 (Release 2011) software. Modelling results were used to develop and assess concept designs of structural controls (such as detention basins, culverts, drains and levees) for mitigating flooding around the Stubbs Street/South Road intersection. It is envisaged that future revisions of the model will be made as concepts for flood mitigation infrastructure are refined following stakeholder engagement.

2.2 Methodology

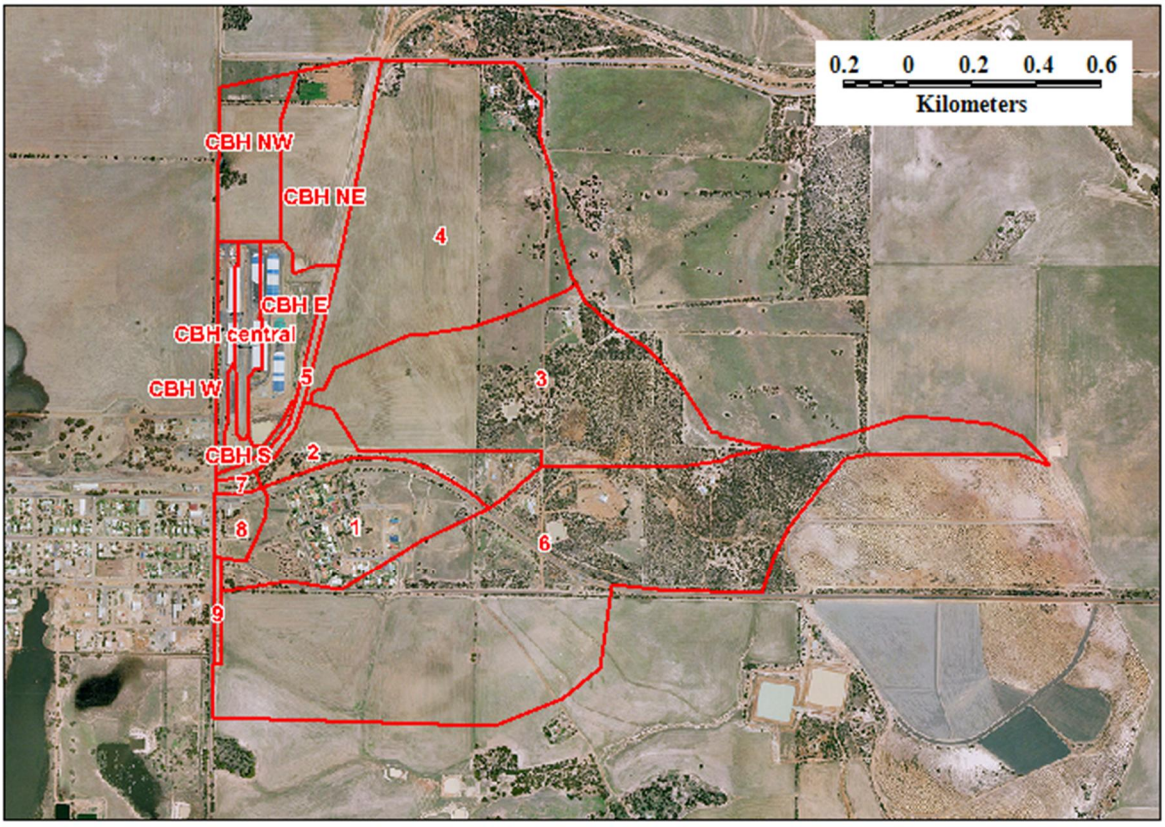
The MIKE11 modelling software was used to model catchment runoff and hydraulics of waterways and structures in the east of Lake Grace town that contribute flow to the drain adjacent to South Road and ultimately to Cemetery Lake. The catchments contributing flow to South Road drain are presented in Table 2 and Figure 4 below.

Table 2 Modelled catchments and assumed hydrologic parameters

Name	Description	Area (ha)	Stream length (m)	Average stream slope (m/km)	Fraction flat impervious	Fraction pervious
1	Development east of town: developed lots and cleared farmland and reserve	20.6	765	24.8	10	90
2	Cleared farmland between railway and Stubbs Street	8.6	240	8.3		100
3	Farm dam catchment	44.8	1219	19.7		100
4	Farm catchment: water drains to/along railway	52.9	950	12.6		100

5	Railway and reserve, fully cleared	1.8	582	12.0		100
6	Farmland southeast of town	96.9	1924	20.8	5	95
7	Catchment between railway and Stubbs Street	0.7	132	15.1	10	90
8	Small catchment between Stubbs Street and Griffen Street	2.9	200	10.0	15	85
9	Catchment to South Road drain	0.8	400	5.0		100
CBH W	CBH west: 50% hardstand	3.1	790	6.3	50	50
CBH S	CBH south: area near rail, 50% hardstand	1.9	145	13.8	50	50
CBH E	CBH east: 30% hardstand, one existing basin	9.3	595	8.4	50	50
CBH central	CBH central: almost entirely hardstand, one existing basin	4	547	7.3	100	0
CBH NE	CBH northeast: cleared farmland, one existing basin	14.4	666	13.5		100
CBH NW	CBH northwest: cleared farmland and CBH hardstand, two existing basins	10.2	419	4.8	40	60

Figure 4 Modelled catchments



Key catchment characteristics (e.g. catchment area, slope, roughness) were based on observations of catchments from survey data, topography and aerial imagery. Runoff coefficients were estimated based on observed streamflow at a nearby gauging station (DoW station 602003 Jackitup Creek – Wellards) as discussed in the previous study. Adopted parameters are displayed in Table 3.

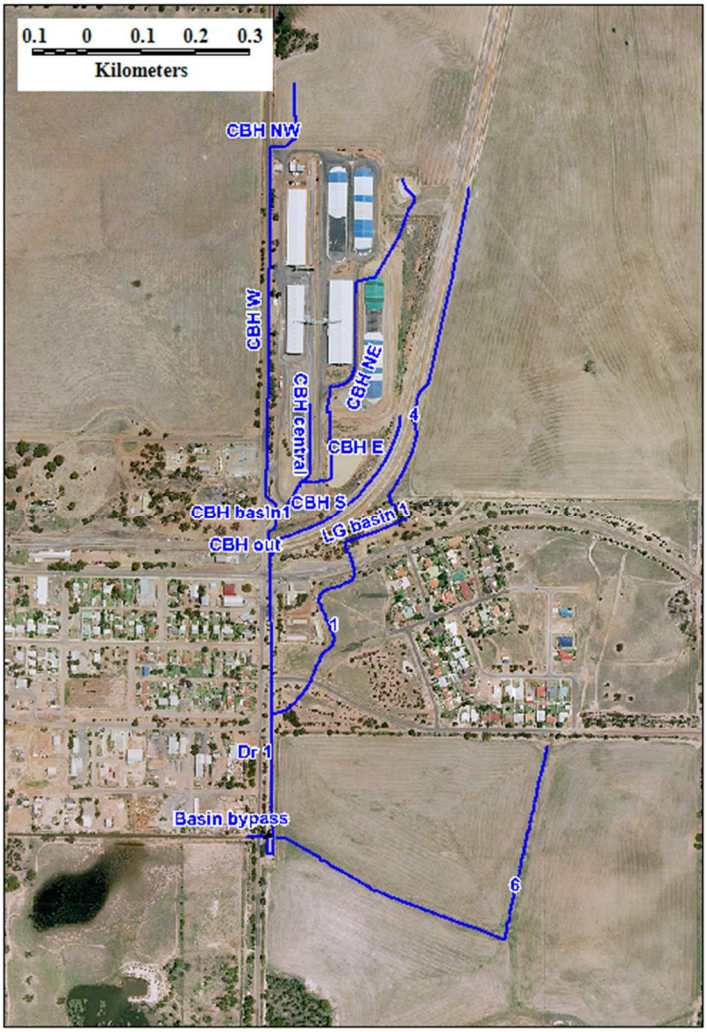
Table 3 Key hydrology parameters used in modelling

	Flat impervious	Pervious
Initial loss	1	5
Continuing loss	-	2.5
Manning number	70	14

Preliminary designs of flood mitigation concepts were modelled in 12d Model (version 9.0 c2b), a terrain modelling, surveying and civil engineering software package. The project models included ground surface information, survey of existing drainage infrastructure, geographical data including roads and cadastre and the preliminary concept designs, which were built into the existing landscape within the software.

Models of reaches (flow paths) and cross sections were output from 12d for use in the hydraulic model (MIKE11). Only major flow paths and those which were altered as part of the flood mitigation concept were modelled in MIKE, and a plan of these are displayed in Figure 5.

Figure 5 Modelled reaches



The reaches and cross sections output to MIKE11 were used to produce a one dimensional hydraulic model (layout shown in Figure 6) which included a network, cross sections, structures, boundary conditions and hydrology links from the catchments described above. Mannings roughness coefficients used for the model are as shown in Table 4.

Figure 6 Hydraulic model layout

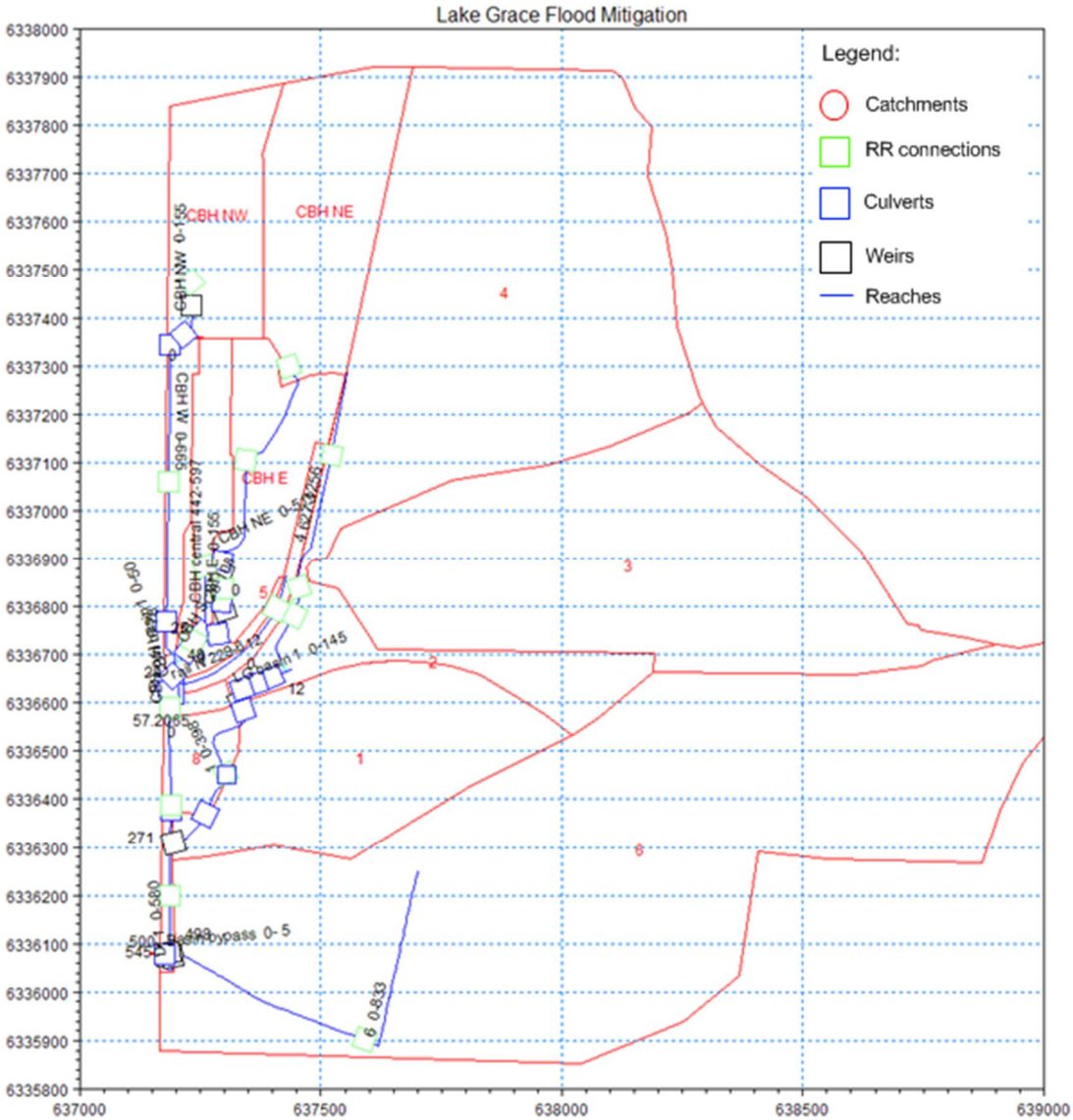


Table 4 Assumed Mannings roughness coefficients (adapted from Chow 1959)

Formation	Mannings n
Cross sections – excavated earth channel	0.03
Cross sections – rock protected channel	0.033
Concrete culverts	0.013

The downstream boundary condition for the model was a water level in the drain that connects South Road drain to Cemetery Lake, 30 metres downstream of the culvert under South Road. This dynamic water level was extracted from results of the previous Flood Study model. Extractions from the 100 and 10 year ARI event model runs were used and time series of the water levels were exported for use in the current study's models.

Information on existing structures (culverts and weirs) was taken from survey data or previous studies and input into MIKE. Proposed structures were also conceptualised, positioned and tested within the model.

A number of design storms were run through the model to determine the critical duration storm for the overall site, including flood mitigation concepts. For the 100 year ARI event, the 6 hour storm produced the largest peak flows for most of the flood mitigation design areas and so it was adopted as the design storm. The 10 year ARI storm was also modelled to determine the impact of the flood mitigation design for smaller events, and the 2 year ARI storm to assess the efficacy of small basins in frequent events.

2.3 Results

Long sections along drains and through basins within the modelled drainage network are displayed in Appendix A. The 10 year and 100 year ARI storm maximum water levels, discharges and velocities are shown. Key modelling results for the performance of drains in the 10 and 100 year ARI event are provided in Table 5.

Table 5 Summary modelling results for major drains

Drain location	10 year ARI Q	10 year ARI velocity	10 year ARI water depth	100 year ARI Q	100 year ARI velocity	100 year ARI water depth
Units	m^3/s	m/s	m	m^3/s	m/s	m
Kulin Road west of CBH	0.28	1.44	0.83	0.58	1.81	1.01
East of rail	1.38	2.43	0.63	3.29	2.76	0.72
Stubbs Street to South Road drain	1.64	1.65	0.51	4.04	2.48	1.04
South Road drain/sump	1.85	2.18	1.82	4.78	2.43	2.09

Proposed drains generally contained the 100 year ARI discharge:

- The proposed drain along Kulin Road west of CBH contained the 100 year ARI discharge except at the start and the end:
  - The existing drain and culvert downstream of the northern basins may be under capacity and protection around the CBH access road may be required to prevent overtopping.
  - The proposed southwest basin levee will need to tie-in to the natural surface upstream and adjacent to the incoming drain.

  - For the remainder of the drain the minimum freeboard was 1.5 cm.
  - The freeboard for the 10 year event was at least 14 cm.
- The proposed drain and levee within the rail reserve contained the 100 year ARI discharge with a minimum freeboard of 25 cm. The minimum 10 year ARI freeboard was 35 cm. It is considered that the design of the drain and levee could be optimised in the detailed design phase to meet the required standard while not overdesigning the infrastructure.
- The proposed drain between Stubbs Street and the South Road drain contained the 100 year ARI discharge with a minimum freeboard of 11 cm and the 10 year discharge with 28 cm.
- The South Road drain contained the 100 year ARI discharge within the cut drain until south of Griffin Street, where, until the sump at the end of the drain, ponding in a low-lying area on the eastern side of the drain (on the adjacent property) is expected to occur. With the proposed flood mitigation infrastructure, the South Road is not expected to be overtopped. Minimum freeboards to the South Road (centreline) level south of Griffin Street are 3 cm for the 100 year event and 39 cm for the 10 year event. For the 10 year ARI event, a minimum of 30 cm freeboard was achieved below the edge of the South Road in the section south of Griffin Street to the sump.
- Velocities in the open drainage system are generally maintained below 2 m/s except at structures and at inlets and outlets to connecting drains and basins.

Key modelling results for the performance of proposed basins in the 10 and 100 year ARI event are provided in Table 6. All proposed basins were predicted to overtop only at controlled overflow weirs.

Table 6 Summary modelling results for major basins

Basin	Capacity (over-flow)	Capacity (TOB)	10 year ARI Q_{in}	10 year ARI Q_{out}	10 year ARI water depth	100 year ARI Q_{in}	100 year ARI Q_{out}	100 year ARI peak WL
Units	m^3	m^3	m^3/s	m^3/s	m	m^3/s	m^3/s	m
LG01-LG04	1937	4555	1.38	1.32	1.01	3.29	3.27	1.10
CBH 1	962	1999	0.34	0.30	0.83	0.77	0.76	1.01
CBH 2	2265	4616	0.46	0.46	0.65	0.94	0.76	1.10

Geotechnical constraints identified through local knowledge of the town infrastructure and confirmed with limited information from a CSIRO report (2005) suggest that saprolite may be present at depths as shallow as 66 cm below the surface in the area around the Stubbs Street basins. The proposed basins were all designed to minimise deep excavation, but the resulting basin capacities are small. It is proposed that detailed geotechnical investigations in the flood mitigation areas are completed before detailed design, so that the basin capacities (and culvert heights, etc.) can be optimised.

The proposed Stubbs Street basins have little effect on compensating discharge from the north-eastern catchments in the 100 year event: the volume of the basins is small compared to the volume of runoff (collective basin volume is 7% of volume of hydrograph). As shown in Figure 7, however, the basins have an effect in the 10 year and 2 year ARI events, delaying and reducing the peak discharge. In the 10 year ARI event, the peak is reduced from 1.375 to 1.32 m^3/s and delayed by 15 minutes.

Figure 7 Model hydrographs: Stubbs Street basins

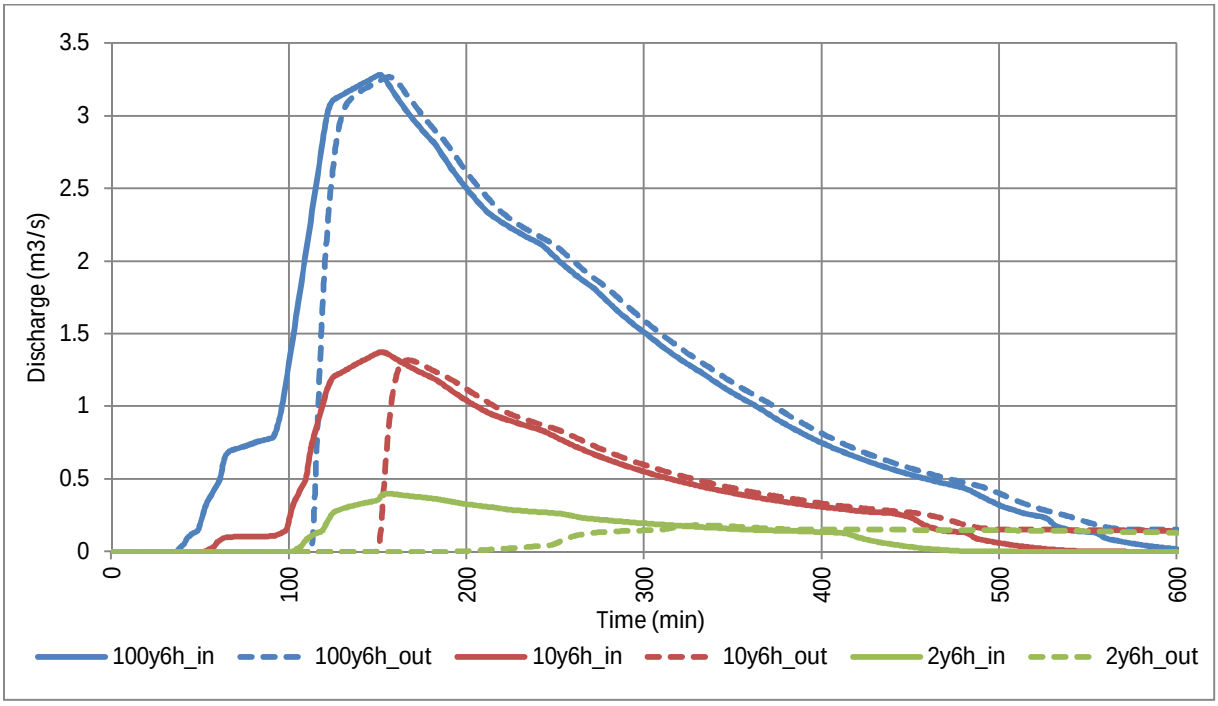
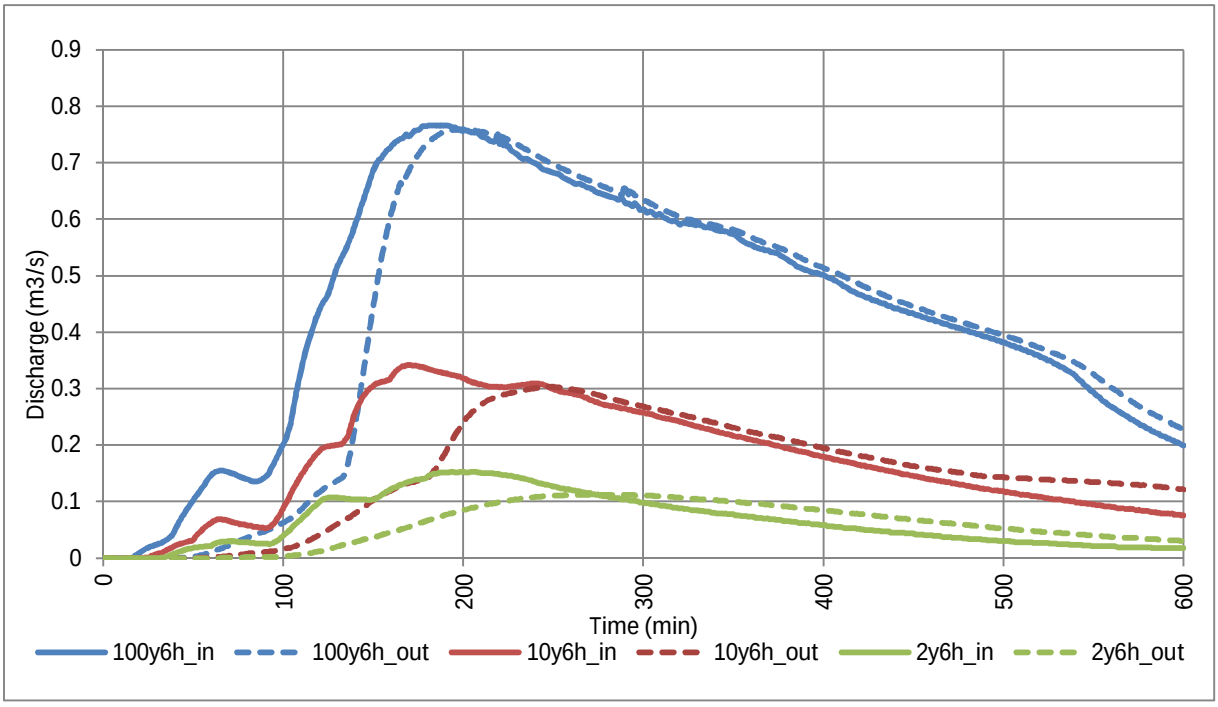


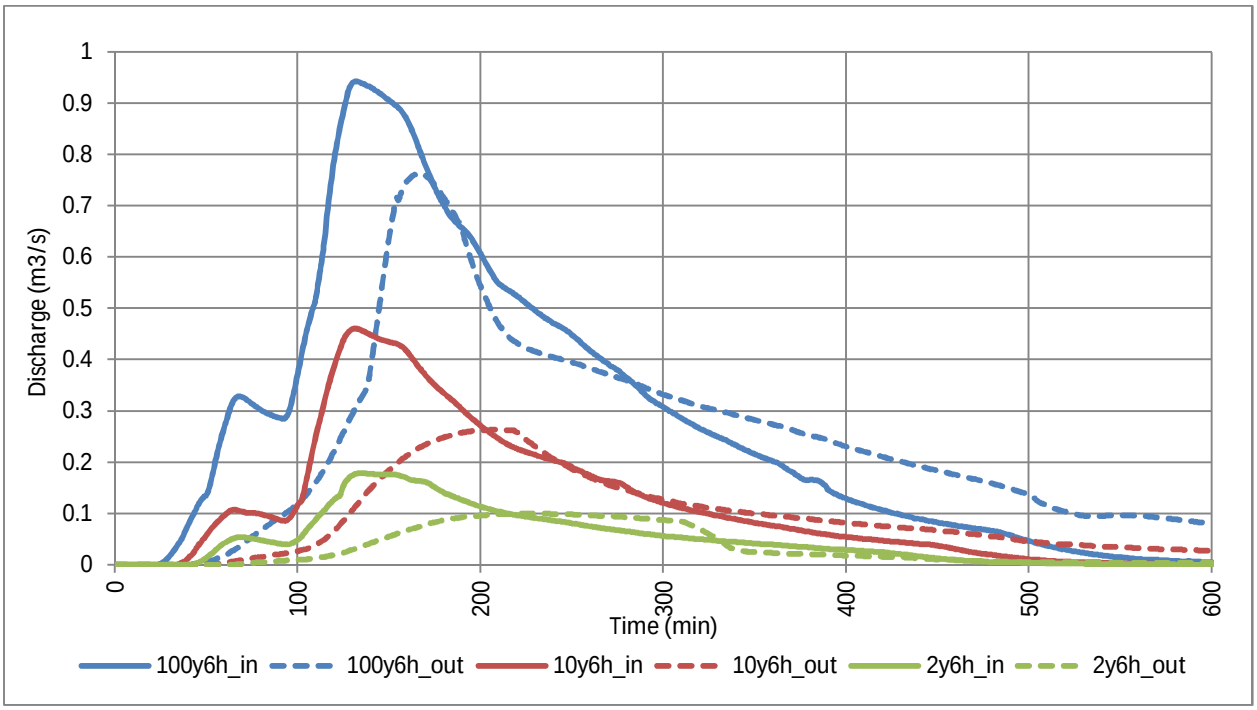
Figure 8 Modelled hydrographs: CBH southwest basin



The proposed CBH southwest basin has little effect on compensating discharge from the CBH catchments in the 100 year ARI event: the volume of the basin is small compared to the volume of discharge from the drain down Kulin Road and the internal CBH basins (basin volume to full level is 10% of the volume of the hydrograph). As shown in Figure 8, however, the basins have an effect in the 10 year and 2 year ARI events, delaying and reducing the peak discharge. In the 10 year ARI event, the peak is reduced from 3.42 to 0.304 m^3/s and delayed by 77 minutes.

The effect of the proposed and existing basins in the east of CBH can be observed in the long sections (Appendix A): there is a reduction in discharge through the basins due to water storage. Figure 9 shows the inflow and outflow hydrographs for the CBH proposed basin. The peak 100 year ARI discharge is reduced from 0.943 to 0.764 m^3/s and is delayed by 34 minutes.

Figure 9 Model hydrographs: CBH east basin



The culverts proposed at Stubbs Street, Griffin Street and South Road are adequate to prevent overtopping of the roads in the 100 year ARI storm, with maximum water levels of 291.03, 288.41, and 285.38 m AHD respectively. Key modelling results for these culverts and the existing Stubbs Street culvert are provided in Table 7.

Table 7 Summary modelling results for major culverts

Culvert Location	10 year ARI Q	100 year ARI Q	10 year ARI water depth	100 year ARI water depth	10 year ARI exit velocity	100 year ARI exit velocity
Units	m^3/s	m^3/s	m	m	m/s	m/s
Stubbs (existing)	0.32	0.82	0.18 (headwater)	0.29 (headwater)	2.09	2.21
Stubbs (new)	1.32	3.27	0.38 (headwater)	0.72 (headwater)	1.04	1.39
Griffin	1.64	4.02	0.44 (headwater)	1.04 (headwater)	1.25	1.69
South Road	2.69	6.82	1.98 (tailwater)	2.10 (tailwater)	0.44	0.82

In the previous Flood Study (GHD 2008), flood water sheeted across the road northeast to southwest at the Stubbs Street/South Road intersection, the “bottleneck” described throughout this report. In the 100 year ARI event, the depth of water as it crossed the road was more than 10 cm according to Flood Study predictions. In the current study, the flood mitigation concepts prevent this overtopping completely, with the peak 100 year ARI water level 78 cm below the edge of the road at the culvert under Stubbs Street on the northeast corner of the intersection.

3. Stage 1: Stubbs Street to South Road drain

Stage 1 of the Lake Grace flood mitigation concept is to construct a meandering earth drain south of Stubbs Street (approximately 170 metres to the east of the Stubbs Street/South Road intersection) to connect with the existing lined drain on the eastern side of South Road, and includes one major culvert structure at Griffin Street. A layout and sketch-ups of the concept for this stage are provided in Figure 10, Figure 11 and Figure 12, and details are provided below.

Figure 10 Stage 1: plan view of diversion drain

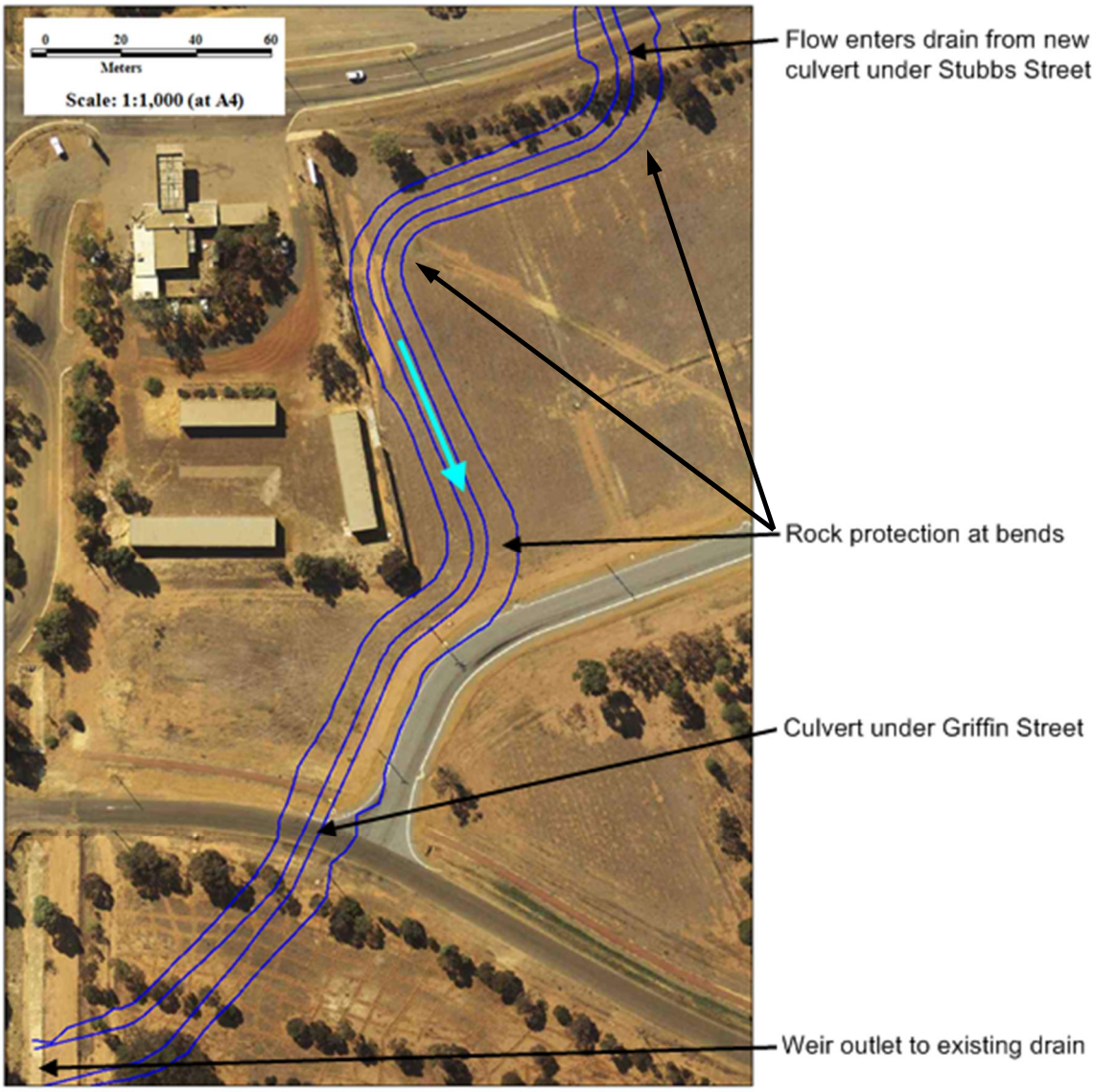


Figure 11 Stage 1: concept view of diversion drain (adjacent to Stubbs Street)

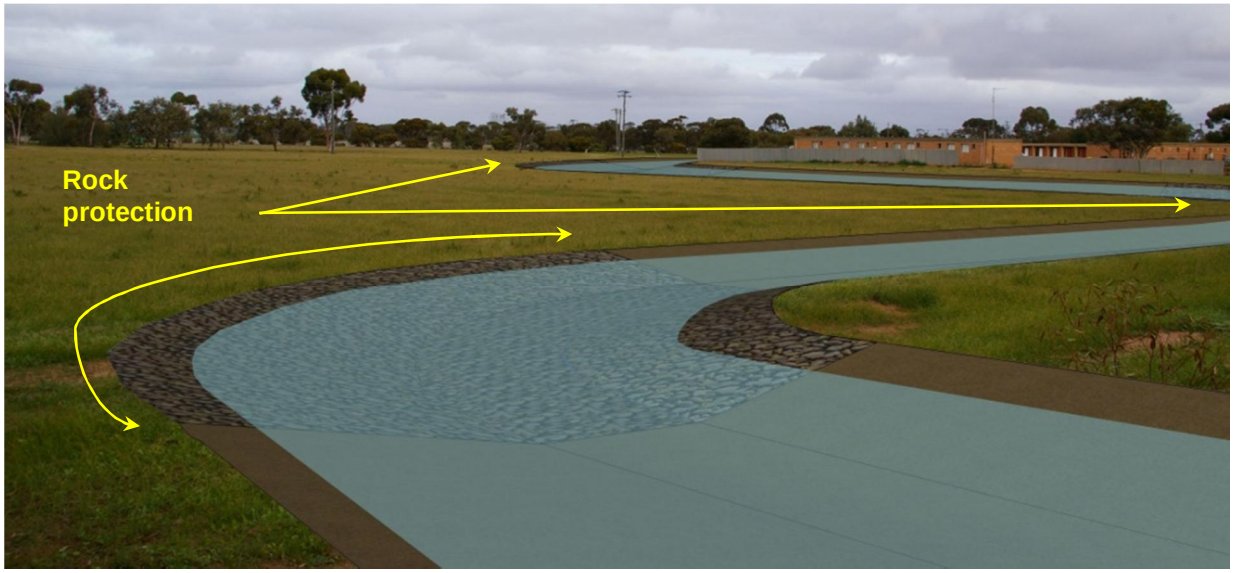
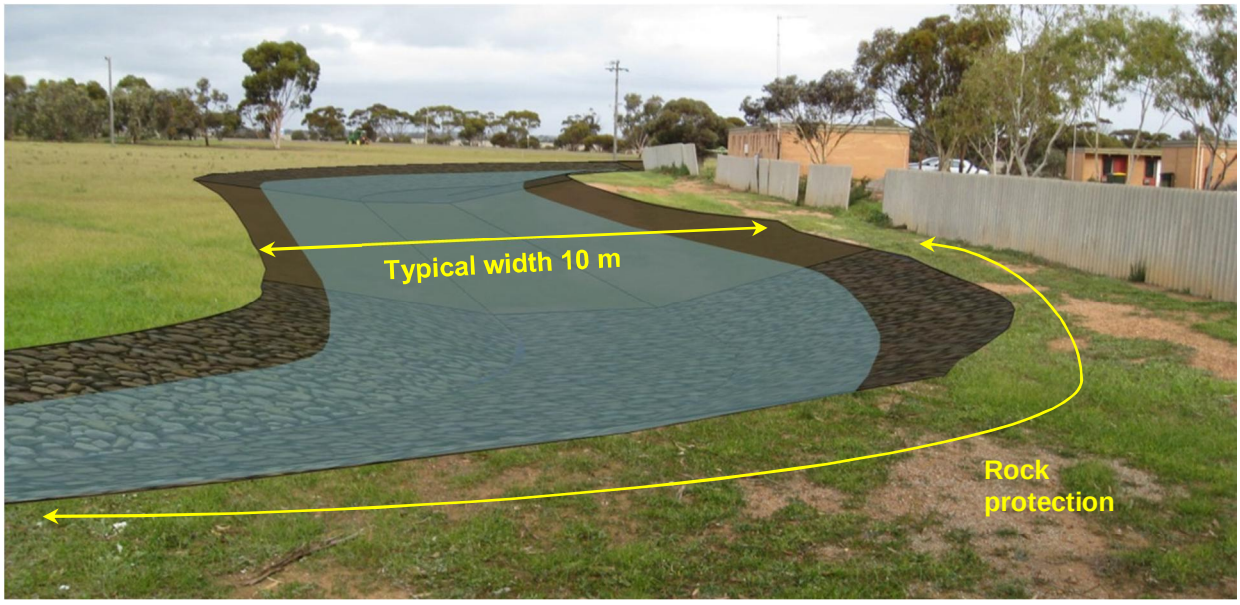


Figure 12 Stage 1: concept view of diversion drain (adjacent to the motel)



3.1 Purpose

The purpose of this drain is to divert stormwater from the rural catchments northeast of town (east of the railway) south to the South Road drain and thereby prevent stormwater from these catchments flowing to the Stubbs Street/South Road intersection. The existing culvert under Stubbs Street at this intersection and the pipeline to the open drain parallel to South Road is a known drainage “bottleneck”. The proposed drain will take pressure off the existing culvert and lessen the likelihood of flooding over Stubbs Street at

the intersection. Stormwater from the northeast catchments will be diverted under Stubbs Street before the truck bay and flow in the proposed earth drain to join the South Road drain after Griffin Street.

3.2 Infrastructure requirements

The flood mitigation infrastructure requirements expected for this stage include construction of:

- A new earth drainage path primarily in cut including:
  - Lengths of approximately 400 metres,
  - Batter slopes 1v to 6h,
  - Approximately 1 m deep,
  - 4 metres wide for 300 metres, transitioning over 50 metres after Griffin Street to 10 metres wide, and
  - Rock protection in drain around bends – estimated to be a total length of 120 metres.
- A new culvert under Griffin Street:
  - 3 x 1200 mm x 450 mm reinforced concrete box culverts with end walls, and
  - Rock protection downstream of culvert.
- Outlet to existing drain:
  - Rock protection at weir outlet to drain parallel to South Road.

3.3 Design considerations

The concept design of the drain was conceived with consideration of the following points:

- The earth channel was designed with shallow side slopes (1v to 6h) for safety as it is located within public open space. It is envisaged that the drain will be grassed to increase amenity and the shallow slopes will allow for safe maintenance of the drain.
- The drain depth was chosen to allow for the passage of the 100 year ARI storm discharge.
- The drain has no levee, although further protection may be desirable for stakeholders (e.g. motel owners) and this could be revised during the detailed design phase.
- The drain widens at the end to allow for shallow flow over a rock-protected weir into the existing drain that runs parallel to South Road.
- The Griffin Street culverts were sized to convey the entire flow (i.e. no water passes over the road) as the location was determined to be unfavourable for a floodway due to the curve in the road, the intersection with Wattle Drive and the natural ground slope down towards South Road. The culverts are wide and shallow because there is a risk of geotechnical constraints (hard rock) close to the surface. The culvert design could be reviewed following more detailed geotechnical investigations in the flood mitigation areas, as discussed in Section 2.3.
- Since the concept for this drain was conceived, a new road has been constructed (Wattle Drive) which limits the space available for the drain. The drain passes close to the west of Wattle Drive at the bend in the road and then crosses Griffin Street to the west of the intersection. No survey was

available for Wattle Drive and the current design will need to be verified following site survey. Issues regarding the safety risks of locating a drain close to the roads should also be investigated through consultation with Main Roads.

Section 2.3 details the results of hydraulic modelling of design concepts including the performance of the drain and culvert. A long section of the modelled maximum water level, discharge and velocity in this drain is provided in Appendix A, Plot 7.

The horizontal alignment of the drain includes a number of curves (Figure 11). This alignment was chosen after consultation with the Shire. The design considered the need for potential development on the eastern side of the drain. If the area is developed, minimum setbacks and floor levels for dwellings should be considered in a separate study. There will likely be a need for infill to maintain a minimum clearance level over the 100 year flood level in the drain.

An assessment was made of the potential for scour to occur at these bends during large flow events. Chow (1959) describes the presence of spiral flow in curved channels. The strength of spiral flow (for subcritical flow around a bend) decreases gradually with the increase of the radius-width ratio and the curve effect is minimised at a ratio of 3 (higher ratios have little effect). The radius of curves in this drain is 20 m, and the width is a minimum of 4 and a maximum of 10 m. All curves except the final curve (towards south road) in the wider section of drain have a radius-width ratio greater than 3. The wide section of drain will have lower velocities and scour may be less of an issue here. This assessment was done to confirm the chosen curve radii, but does not preclude scour occurring in the drain.

Currently, rock protection is recommended for all locations where a significant change in direction of the drain occurs as there is potential for scour to occur. This includes all curves in the drain, as well as culvert outlets and the outlet of the drain to the South Road drain. It is recommended that scour protection requirements are refined with further modelling and evaluation at the detailed design phase.

4. Stage 2: diversion infrastructure - Stubbs Street

This stage will involve the construction of an earth drain and levee parallel to the railway (Figure 13 and Figure 14) that discharges to a series of cascading basins north of Stubbs Street (Figure 15 and Figure 16). Outflow from these basins will be passed under Stubbs Street in a new major culvert structure which will connect to the drain from Stage 1.

Figure 13 Stage 2: plan view of realigned railway drain and levee

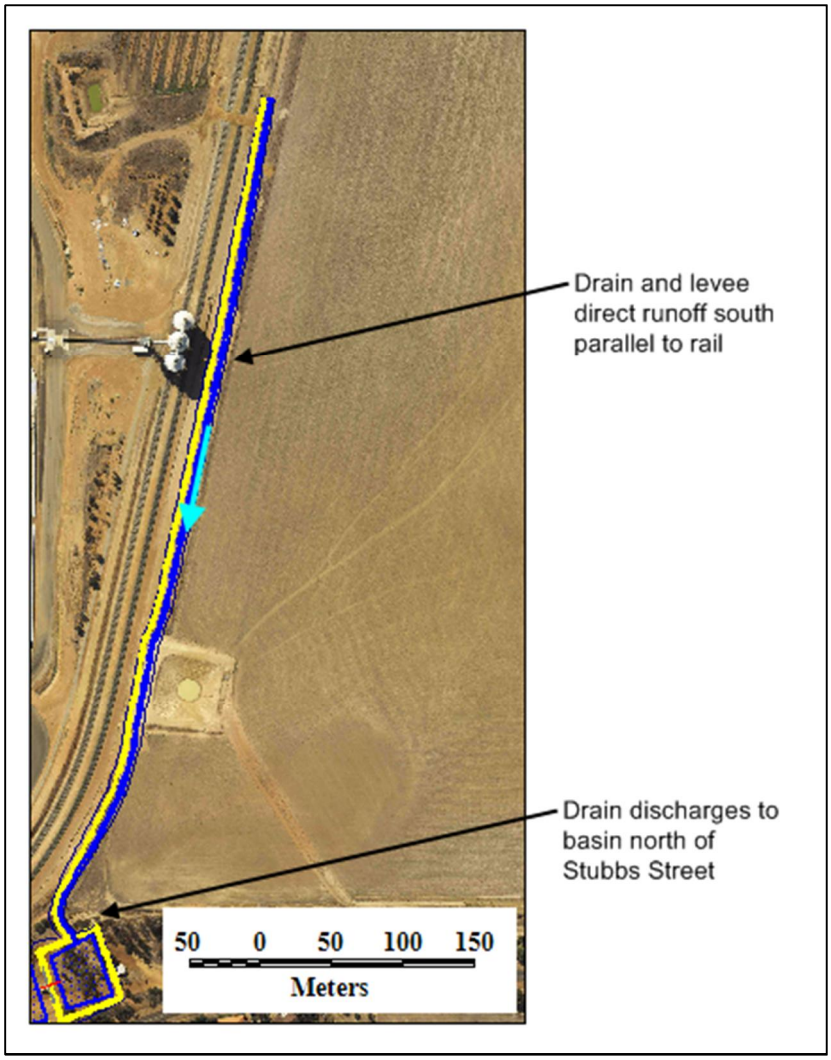


Figure 14 Stage 2: concept view of drain and levee in rail reserve

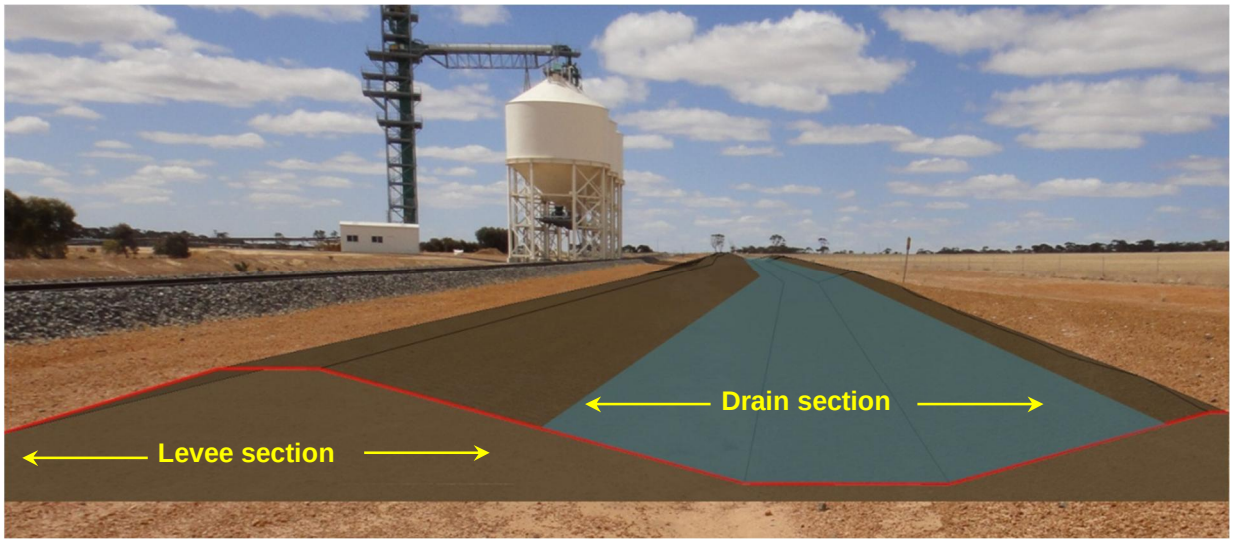


Figure 15 Stage 2: plan view of cascading basins between rail and Stubbs Street

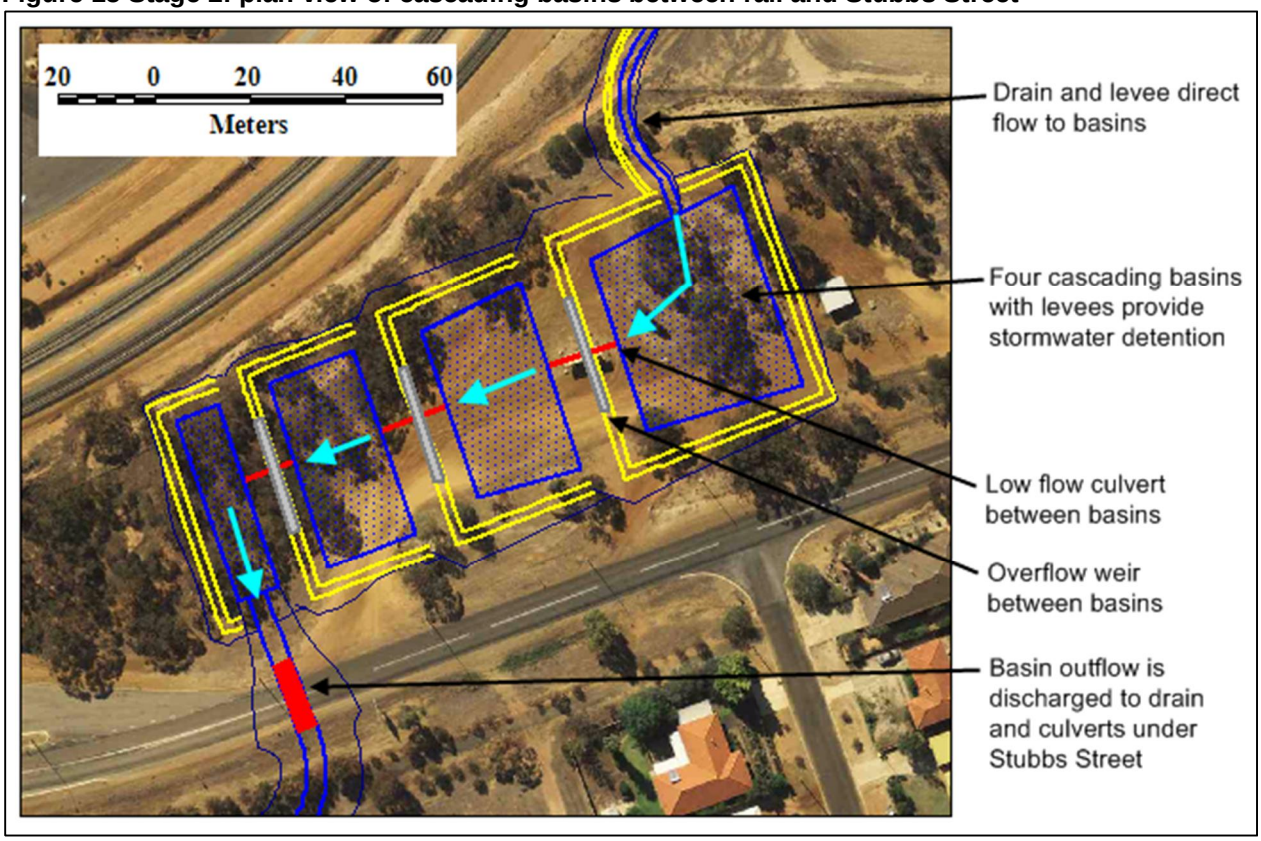
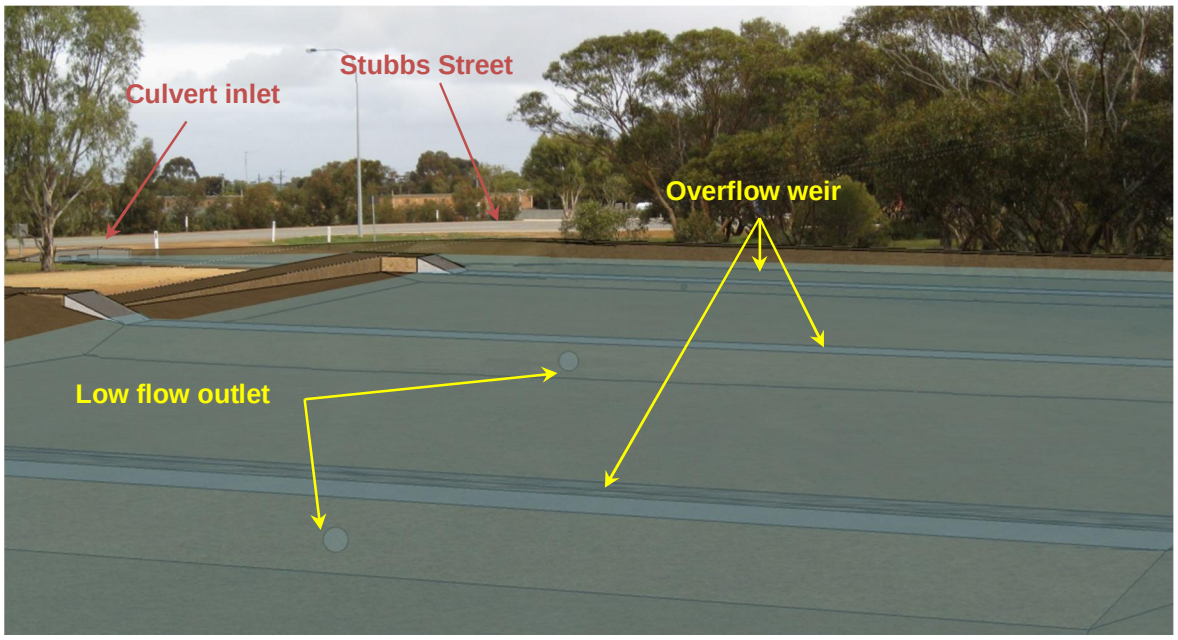


Figure 16 Stage 2: concept view of cascading basins (looking towards Stubbs Street)



4.1 Purpose

The Stage 2 drain, levee and basins are designed to prevent runoff from the north-eastern farm catchments from crossing the rail or reaching the Stubbs Street/South Road intersection. The drain and levee will divert water south to a series of cascading basins (contained within the generally cleared areas of the Lions Park) adjacent to Stubbs Street. The basins have been designed to compensate and control flows prior to crossing Stubbs Street via a large culvert under this main road. The basins also create an opportunity for the Shire to consider harvesting stormwater.

4.2 Infrastructure requirements

The flood mitigation infrastructure needed for this stage of the design includes construction of:

- An earth drain and levee adjacent to the rail with the following configuration:
  - 620 m long,
  - Approximately 1 m deep drain, levee 0.6-1 m high,
  - Drain 2 m wide at base,
  - Levee 1 m wide at top, and
  - Batter slopes 1v to 3h.
- A series of compensation basins with the following configuration:
  - 4 cascading basins with total footprint approximately 140 m x 60 m (8,400 m^2),
  - Cut (basins) and fill (levees) to a maximum depth of approximately 0.6 m below ground, 1.2 m above ground,
  - Levees 2 m wide at top,

- All batter slopes 1v to 4h,
- Low flow pipes between basins (300 mm RCP),
- High flow broad crested weirs between basins (25 m long and 2m wide); and
- Rock protection at basin inlets, outlets and on the downstream face of each high flow weir.

- A new major culvert under Stubbs Street with:
  - 3 x 1200 mm x 450 mm reinforced concrete box culverts, and
  - Rock protection at outlet provided for in Stage 1 (curve in drain).

4.3 Design considerations

The concept design was conceived with consideration of the following points:

- The drain and levee parallel to the railway are designed to prevent floodwaters flowing through the railway ballast and into the Stubbs Street/South road intersection. Instead, flow is diverted south to a series of detention basins. The drain and levee have been located to minimise impact on the railway, and a corridor for vehicle access to the rail has been reserved on the west of the levee (minimum ~5 m). The drain and levee pass close to the farm dam which encroaches on the rail reserve, and the potential impacts of this may need to be revisited at the detailed design phase.
- The basins were designed as four small, connected storages due to the steep slope of the land in this location and the risk of geotechnical constraints discussed in Section 2.3. The design should be revised following detailed geotechnical investigations in the area, as there is a potential to increase the storage volume if the basins can be cut deeper. The high flow weir outlets were designed to prevent overtopping of the basins in a 100 year storm with approximately 300 mm of freeboard above the top water level over the weir. The small pipe low flow outlets ensure that the basins fully drain and also provide an opportunity for stormwater harvesting to be considered outside times of high flood-risk. Any stormwater harvesting scheme would need careful management, and has not been considered as part of this study.
- The objective of the basins is to decrease the peak discharge of floodwater under Stubbs Street and through the drain downstream by providing a storage volume and a controlled release with the high and low flow outlets. Unfortunately due to possible geotechnical constraints the basins could not be designed too deep and the volume (combined) is small compared to the volume of discharge. The combined basins volume (to full water level) is approximately 3000 m^3 compared to a volume of discharge of approximately 40,000 m^3 in the 100 year ARI event. The impact of the basins on flow is discussed (with inflow and outflow hydrographs) in the modelling results section (Section 2.3).
- The culverts under Stubbs Street were sized to convey the entire flow 100 year flow (i.e. no water passes over the road) as the location was determined to be unfavourable for a floodway: Stubbs Street is an important access route from the east to the Lake Grace town. The culverts are wide and shallow because there is a risk of geotechnical constraints (hard rock) close to the surface. The culvert design could be reviewed following more detailed geotechnical investigations in the flood mitigation areas. During detailed design, consideration should also be given to “tying in” the levee of the last basin with the road such that water is forced under the road as Stubbs Street and cannot flow west to the bottleneck intersection with South Road.

Clearing will be required as part of this stage of the project (at and around the basins) and a potential impact is a loss of habitat for native fauna, particularly black cockatoos. A desktop-level investigation has been completed and the following points are noted:

- It appears that no Actual or Potential Black Cockatoo breeding trees are present within the flood mitigation concept areas, however some of the species of Eucalypts could be species that are known to be utilised as feeding habitat (potential breeding requires a > 500 mm diameter at breast height under the Black Cockatoo guidelines) for the protected bird.
- Where possible, particularly within the Stage 2 basins, trees should be retained, although this may be difficult with the earthworks proposed.
- For the remainder of the native vegetation (including re-vegetated areas with native species) to be impacted a vegetation clearing permit will need to be acquired. In order to complete the vegetation clearing permit a suitability qualified consultant will need to visit site to confirm species and inspect all areas of impact for other potential flora and fauna issues. At the same time a thorough inspection for Black Cockatoo habitat, breeding and feeding within the vicinity, can be completed and reported.
- In mitigating the loss of remnant or planted vegetation, rehabilitation of the area or areas adjacent with trees and shrubs in keeping with the existing landscape is recommended. Trees suitable for Black Cockatoos should be included within any replanting. The clearing permit would require the impacts to Black Cockatoos opportunistic feeding habitat areas to be mitigated. Offset for Black Cockatoo feeding varies from 4 – 6 new trees to 1 existing. At present the desktop review suggests the habitat is unlikely to be considered core feeding habitat, and thus a 4 to 1 planting program would be expected.

5. Stage 3: Kulin Road and CBH basin alterations

This stage will involve the construction of an earth drain on the western edge of CBH, parallel to Kulin Road. This drain will discharge into a new collection basin in the southwest corner of CBH which will compensate flows coming from the entire CBH site. A second new detention basin is proposed within CBH to provide further compensation for the eastern CBH catchments. A layout and diagrams of this stage are provided in Figure 17 and Figure 18 with details of the concept provided below.

Figure 17 Stage 3: plan view of concept basins and drains

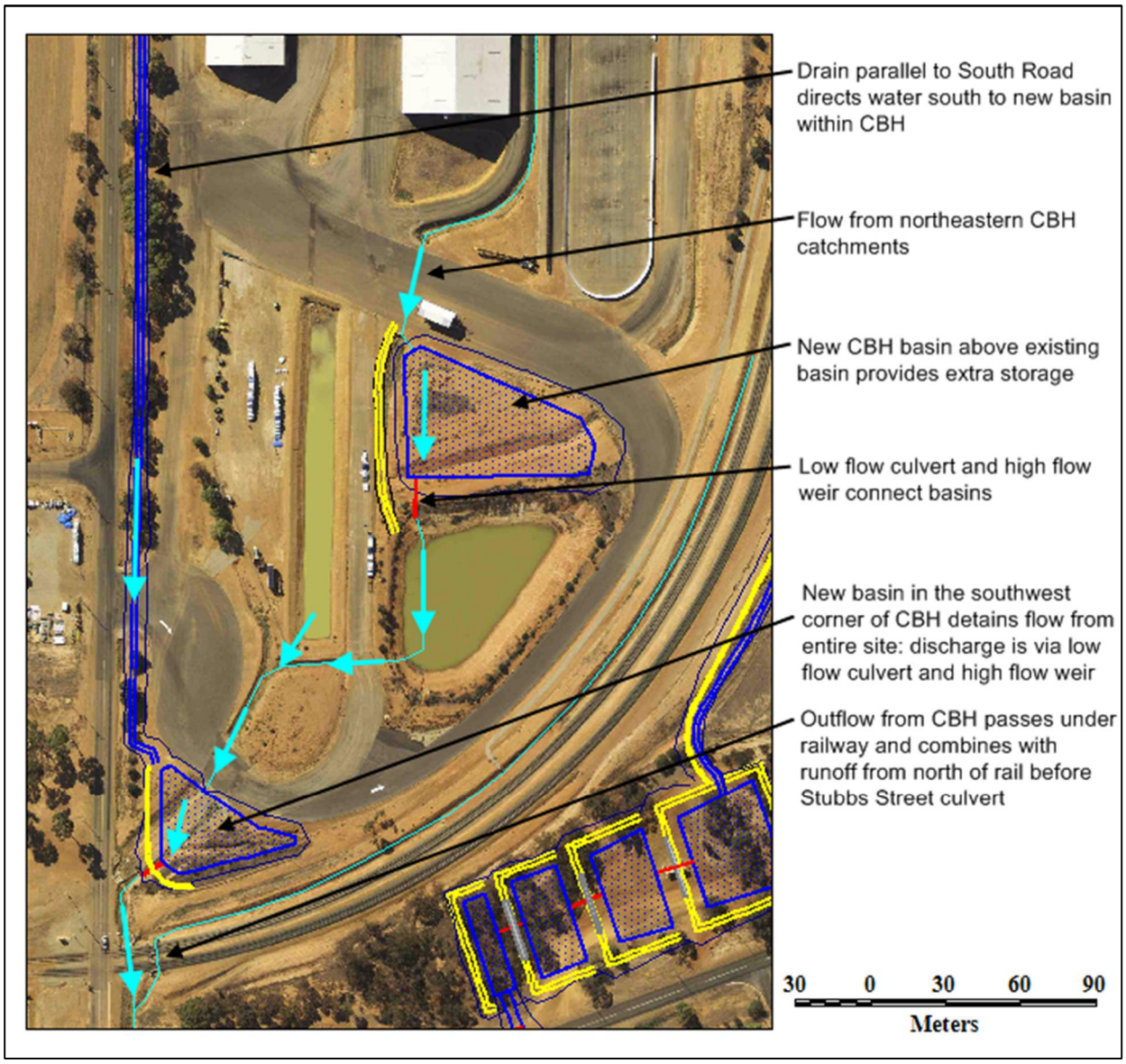
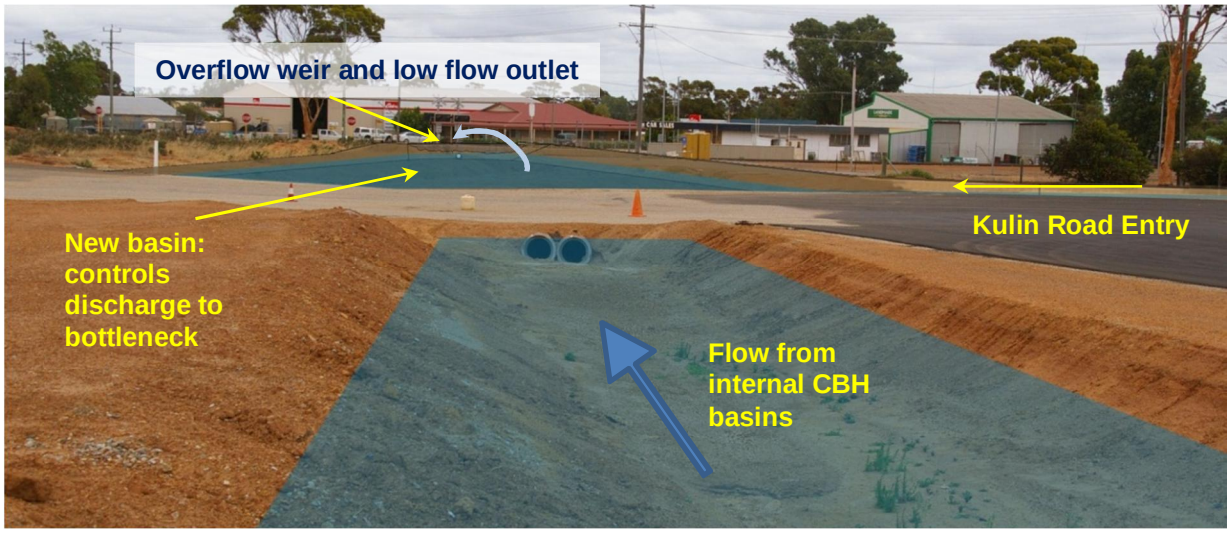


Figure 18 Stage 3: concept view of basin in southwest corner of CBH



5.1 Purpose

The purpose of Stage 3 is to control runoff from CBH within the site and on the eastern side of Kulin Road to prevent flooding at the road and rail culverts at the Stubbs Street/South Road intersection. The drain along Kulin Road will reduce the likelihood of floodwater from northern CBH crossing the road and flowing south through the town via the Carruthers Lake catchment.

5.2 Recommended infrastructure

The flood mitigation infrastructure needed for this stage of the design includes construction of:

- An earth drain adjacent to Kulin Road with the following configuration:
  - 660 m long,
  - 2 m wide at base,
  - Approximately 0.5 m deep, and
  - Batter slopes 1v to 4h.
- Two basins within CBH with the following configuration:
  - Batter slopes maximum 1v to 3h, minimum 1v to 4h,
  - Total footprint of approximately 2070 m^2 (CBH SW) and 5150 m^2 (CBH E),
  - Cut (basins) and fill (levees on downhill side only),
  - High flow/low flow outlets with small pipe (300 or 450 RCP) and rock protected overflow, and
  - Rock protection at basin inlets and outlets.

5.3 Design considerations

The concept design was conceived with consideration of the following points:

- Existing basins within CBH to the north of the proposed drain (along Kulin Road) detains runoff from new hardstand catchment and release it slowly via a low flow/high flow outlet. This type of outlet (concept) has been proposed for all new basins in the Lake Grace flood mitigation concept. The discharge from this existing basin is directed via a small drain and culvert under the CBH access road (shown in Figure 19) to an existing small drain alongside Kulin Road, which will be formalised as part of this stage of works. The connection of the existing basin to the new drain may require some localised drainage improvement to prevent overtopping of the CBH access road, such as a small bund (approximately 20 cm high). The proposed drain will convey runoff from catchments north of and within the CBH site alongside Kulin Road to the southwest corner of CBH.

Figure 19 Stage 3: concept view of outlet alteration at CBH basin adjacent to Kulin Road

- Some clearing of trees may be required, particularly to make way for the drain alongside Kulin Road, west of CBH. The potential impacts on habitat as described in Section 4.3 should be considered. The horizontal alignment of the drain will also need to be revised in consultation with CBH regarding some small buildings that exist alongside Kulin Road. The drain batter slopes may need to be revised in these areas with some localised erosion protection being needed.
- The area for the proposed basin north of the existing sump within CBH has been marked on CBH drawings as a future basin site. As this land has been reserved, the concept design has assumed that this construction could occur as part of this project. It will provide both additional storage and compensation of flows. The effect of the basin is shown with inflow and outflow hydrographs and discussed in Section 2.3. The invert level (of the low flow outlet) was chosen so that the basin will completely drain via the outlet to the existing basin below. The levee/embankment was added on the western side to ensure controlled discharge via the outlets rather than down the natural surface grade on that side of the proposed basin.
- The proposed basin in the southwest corner of CBH is designed to provide a final compensation and control of flows before stormwater is discharged off site. The area south of the CBH internal road was chosen as the best location to avoid disturbance to existing CBH infrastructure, but the design may need to be revised after engagement with CBH before final design. Due to space constraints the

basin has a small volume (approximately 1,450 m^3) compared with the volume of the discharge through the basin (approximately 14,890 m^3 in the 100 year ARI event) and so its effectiveness is limited in large flood events to controlling discharge and slightly delaying the peak discharge. In the smaller, more frequent events the basin is considered more effective. This is discussed with reference to inflow and outflow hydrographs in the modelling results section (Section 2.3).

- The compensation of flows within the proposed basins has been confirmed as suitable for the current level of development within CBH. There is potential for future hardstand in the northeast area of CBH, and this would alter the flooding regime. Any future development within CBH should be compensated close to the source of runoff considering the downstream effects on both 10 and 100 year ARI events. It is likely the downstream drainage will not have capacity for a direct increase in flows without further compensation. The best location for future compensation basins if the northeast area was developed may be at the existing storage (small dam) at the southern end of the undeveloped area.

6. Stage 4: South Road levee and culvert upgrade

This stage is aimed at improving the downstream component of the drainage network adjacent to the drainage inlet to Cemetery Lake. The proposed works integrate with the existing structures (with modification or replacement) including:

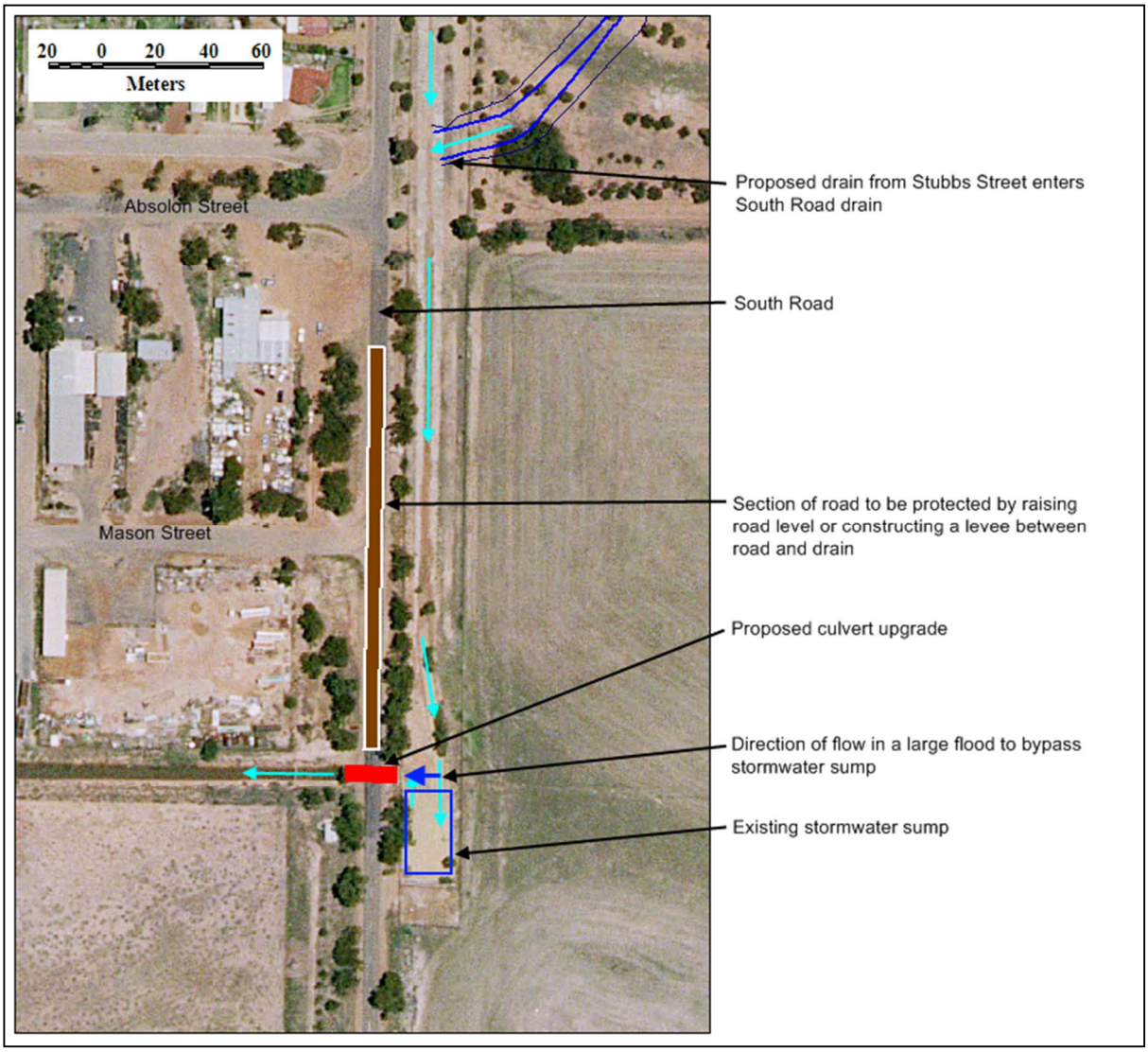
- Using the existing South Road drain (concrete lined),
- Using the existing stormwater harvesting sump (with inlet modification), and
- Replacement of the existing culverts under South Road which drain into Cemetery Lake.

A key issue in large flood events (100 year ARI or such as occurred in 2006) is that the current infrastructure is not able to accommodate the flows and water overtops South Road before the culvert and flows through town into private land around Mason Street. It is recommended that this be rectified by adopting one of two possible flood mitigation options:

1. Option 1: raise South Road, or
2. Option 2: construct a levee between South Road and the drain.

For both options it is also recommended that the culvert under South Road be upgraded and the sump modified to allow controlled bypass to occur in large flood events. A layout and diagrams of this stage are provided in Figure 20 and details of the design considerations are provided below.

Figure 20 Stage 4: plan view of road raising and other alterations



6.1 Purpose

The purpose of Stage 4 is to improve the conveyance of the flood mitigation system at the downstream end to reduce backwater and flooding impacts upstream. The road raising and levee options are both designed to lessen the likelihood of floodwater overtopping South Road.

6.2 Recommended infrastructure

6.2.1 Option 1 (shown in Figure 20 and Figure 21)

- Raise a section of South Road to remove a low point, with the following configuration:
  - Length to be raised is approximately 145 m long, and
  - The maximum level increase (at existing low point) is approximately 0.4 m.

Figure 21 Stage 4: concept view of road level increase on South Road

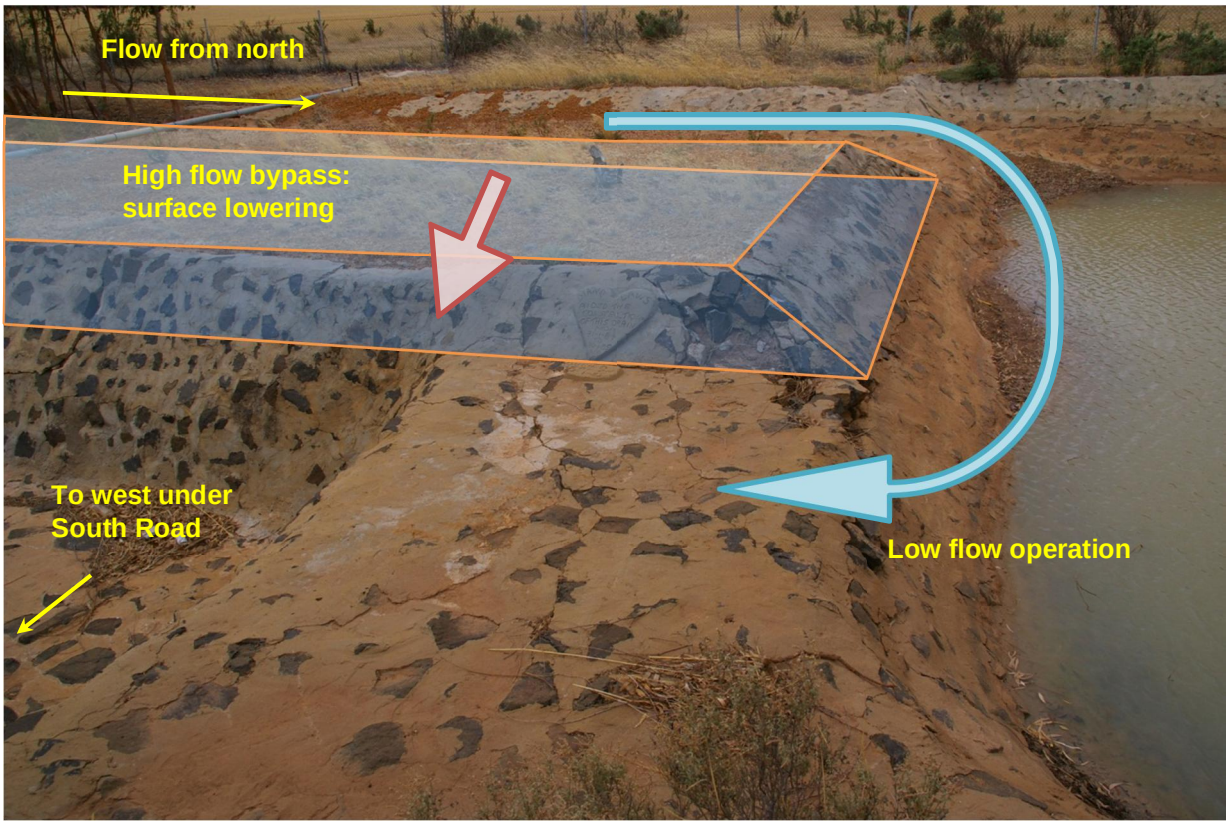
6.2.2 Option 2

- Build a levee between South Road and the drain with the following configuration:
  - 220 m long and approximately 1 m high,
  - 2 m wide at top, and
  - Batter slopes 1v to 4h.

6.2.3 Both options

- The existing culvert under South Road is to be replaced with a 2100 mm x 1200 mm reinforced concrete box or similar to increase capacity of the culvert and prevent overtopping of the road.
- Sump modifications including minor reshaping at the sump entry are required to allow water to bypass (with hydraulic efficiency) in large flood events. The concept of this modification is shown in Figure 22 below.

Figure 22 Stage 4: concept view of weir modification at South Road sump



6.3 Design considerations

Survey data was reviewed and incorporated in the initial modelled cross sections of South Road drain. A low point was identified on South Road between Absolon Street (near Mason Street intersection), and initial flood modelling results showed that the water reached a level such that the sump and drain capacities were exceeded, and the road would be overtopped. The flood mitigation concept is to increase the rate and efficiency of discharge under South Road and also prevent overtopping of South Road by building a physical barrier to floodwater (a higher road or levee). The following points provide notes on these objectives:

- There are two options for preventing the road from being overtopped: raise the road or build a levee. Raising the road level is preferable to constructing a levee because it will ensure that the transport link south out of town is maintained in large floods. The space available for constructing a levee is limited. The levee option would involve clearing a significant area of trees, with potential impacts as described in Section 4.3, and the visual amenity of the area would be impacted. The road raising option is recommended as the preferred option but both options are presented for consideration from stakeholders such as the Shire of Lake Grace and Main Roads.
- Upgrading the culvert under South Road will increase the rate at which water can leave the sump and have positive impacts upstream in the South Road drain. The water level and extent of ponding both decrease if the floodwater can reach the downstream drain and Cemetery Lake efficiently. This benefit will only be realised if the tailwater level (the water level downstream, in Cemetery

Lake) is low. If the flood is sufficiently large enough to flood the lake (such as the 2006 event), then the tailwater level will dictate the hydraulics of the system upstream.

- It is recommended that some minor works be done to improve the hydraulic efficiency of the sump during large flood events. Currently, if the sump fills and the water level rises further, the surrounding area floods. It is thought that if the culvert under South Road is upgraded it would also be beneficial to provide a flow path for flood water to bypass the sump in large events. This could be achieved by removing some of the material between the incoming drain and the outlet basin and applying rock protection (similar to what is currently lining the sump) in a weir-type arrangement.

7. Preliminary recommendations

7.1 Recommendations

Table 8 provides a list of flood mitigation concepts developed, the flood related issues around the eastern side of town that they relate to and comments relating to stakeholder engagement or future work that is required to develop these concepts further. Potential issues with services have not been included here: these are to be addressed during detailed design.

Table 8 Summary of flood mitigation recommendations

Mitigation concept	Known flood-related issue addressed	Comments
Stage 1: Stubbs Street to South Road drain		
Earth drain from south of Stubbs Street to the connection with the existing South Road drain, including one major culvert structure at Griffin Street.	Existing culvert under Stubbs Street/South Road intersection and the pipeline to the open drain parallel to South Road is a known drainage "bottleneck"	◗ Geotechnical investigation required: drain could be deeper and culverts revised ◗ Scour assessment: rock protection at bends in drain to be revised at detailed design ◗ Stakeholder engagement, motel: distance to drain and adequate protection from floodwaters ◗ Stakeholder engagement, Shire of Lake Grace: culvert under Griffin Street and distance to drain on Wattle Drive
Stage 2: diversion infrastructure - Stubbs Street		
Earth drain and levee parallel to the railway that discharges to a series of cascading basins north of Stubbs Street. Outflow from these basins will be passed under Stubbs Street in a new major culvert structure which will connect to the main drain described above.	Floodwater from eastern farm catchment may cross railway during large floods	◗ Stakeholder engagement, Brookfield Rail: corridor between levee and rail for track access ◗ Stakeholder engagement, farm owner: proximity of drain to dam ◗ Stakeholder engagement, Main Roads: culvert under Stubbs Street ◗ Stakeholder engagement, Shire of Lake Grace: basins located over existing park and information bay ◗ Geotechnical investigation: basins could be deeper and culverts revised ◗ Tree clearing: feeding habitat disturbance possible, further investigations required
Stage 3: Kulin Road and CBH basin alterations		
Earth drain on the western edge of CBH, parallel to Kulin Road, directing flow south to a new basin	In large storms, floodwater from northern CBH can cross Kulin Road and flow south through the town	◗ Stakeholder engagement, Main Roads: distance between road and drain ◗ Stakeholder engagement, CBH: buildings close to Kulin Road ◗ Tree clearing: feeding habitat disturbance possible, further investigations required

Mitigation concept	Known flood-related issue addressed	Comments
Basin in southwest corner of CBH	Flooding at the road and rail culverts at the Stubbs Street/South Road intersection is possible in large events	◗ Stakeholder engagement: CBH
Basin north of existing basin within CBH	As above: basin provides additional compensation for runoff from CBH hardstand areas	◗ Stakeholder engagement: CBH
Stage 4: South Road levee and culvert upgrade		
Raise road level or construct an earth levee adjacent to South Road between Absolon Street and the drainage sump	Floodwater from South Road drain can overtop South Road at this low point during large events	◗ Stakeholder engagement: Main Roads ◗ Tree clearing: feeding habitat disturbance possible, further investigations required
Upgrade culvert under South Road	Backwater from sump increases flooding upstream because existing culvert limits discharge	◗ Stakeholder engagement: Main Roads
Minor works at sump at end of South Road drain to provide large flood flow path	The existing arrangement is hydraulically inefficient for large floods	◗ Stakeholder engagement: Shire of Lake Grace

7.2 Cost estimate

Based upon the previously outlined design concept an “order of magnitude” cost estimate has been prepared for client and stakeholder review. This estimate is summarised below in Table 9 and full details are contained within Appendix B. The estimate was prepared in conjunction with input from Davson and Ward Quantity Surveyors based upon the current conceptual design and contractor unit costs as of Oct 2011. A number of assumptions have been made in the determination of quantities and costs; these are outlined at the end of the cost indication provided in Appendix B.

Table 9 Order of magnitude cost estimate

Stage	Description	Subtotal	Contingency	Total (exc GST)
1	Stubbs Street to South Road drain	$443,248.50	$83,109.09	$637,169.72
2	Diversion infrastructure - Stubbs Street	$639,367.50	$119,881.41	$919,090.78
3	Kulin Road and CBH basin alterations	$326,434.50	$61,189.41	$469,118.78
4	South Road culvert upgrade	$228,908.25	$42,920.30	$346,408.75

Stage	Description	Subtotal	Contingency	Total (exc GST)
	and preferred option of raising road			
Total		If all stages completed separately		$2,354,434.89
Total		If all stages completed at once		$2,319,434.89

8. Assumptions and limitations

Assumptions

- Modelling was undertaken using data available at the time: survey of ground surface and infrastructure, CBH drawings, aerial imagery, regional topography, previous report results/observations made during site visits/study outcomes which are assumed to be correct and relevant.
- Hydrological and hydraulic modelling from the previous report was used as a base for the current study, and parameters were adopted as discussed in Section 2.2.
- The results of the previous study were used to generate boundary condition water levels for the current study.
- Methods given in AR&R (Pilgrim 2001) were used to calculate design rainfall.
- The 100 year ARI 6 hour storm was adopted as the design storm event.
- Water level conditions prior to storm events were assumed for the modelling, such as the CBH southeast basin being full to the low flow outlet level. Hydrologic antecedent conditions (initial loss) were adopted as discussed in Section 2.2.

Limitations

- Geotechnical data from the CSIRO (2005) report provided limited information in the area of the proposed flood mitigation infrastructure.
- Climate change has the potential to affect the probability of rainfall events of a certain magnitude occurring, as well altering the runoff characteristics of the land form.
- The 100 year event was modelled but larger events can occur, such as those experienced in the 2006 flood.
- The model “domain” was limited to north east catchments, and the effect of other catchments on the system was not considered.
- Local conditions, blockages etc. can cause higher velocities or water levels than predicted in the modelling.
- Modelling involves simplifying complex physical systems and describing the behaviour of these systems using numerical relationships. These simplifications and descriptions could be in error and could predict flood events with different characteristics to those that may actually occur.
- The above uncertainties could lead to differences in hydrographs between predicted and observed floods. Due to the nature and complexity of the physical system modelled, it is not possible at this time to quantify the degree of difference that may be observed.

9. References

Chow, VT 1959. *Open-channel Hydraulics*, McGraw-Hill Book Company, New York.

CSIRO 2005. *Hydrogeological Modelling of Lake Grace*

GHD 2008. *Report for Lake Grace Township Flood Study*, Shire of Lake Grace.

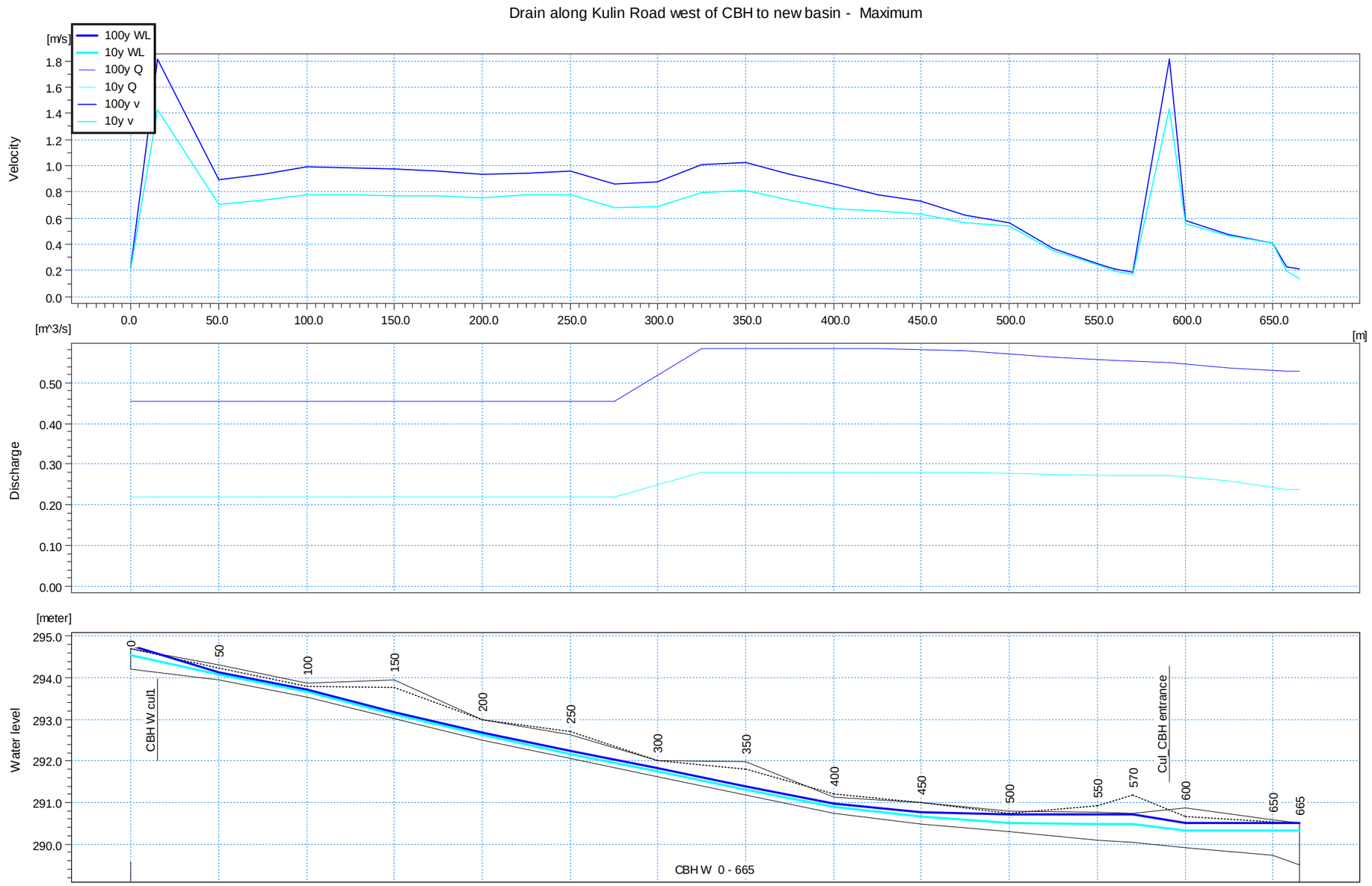
Pilgrim, D. H. (ed) (2001). *Australian Rainfall and Runoff. A Guide to Flood Estimation.* Vol. 1. The Institution of Engineers Australia: Barton, ACT.

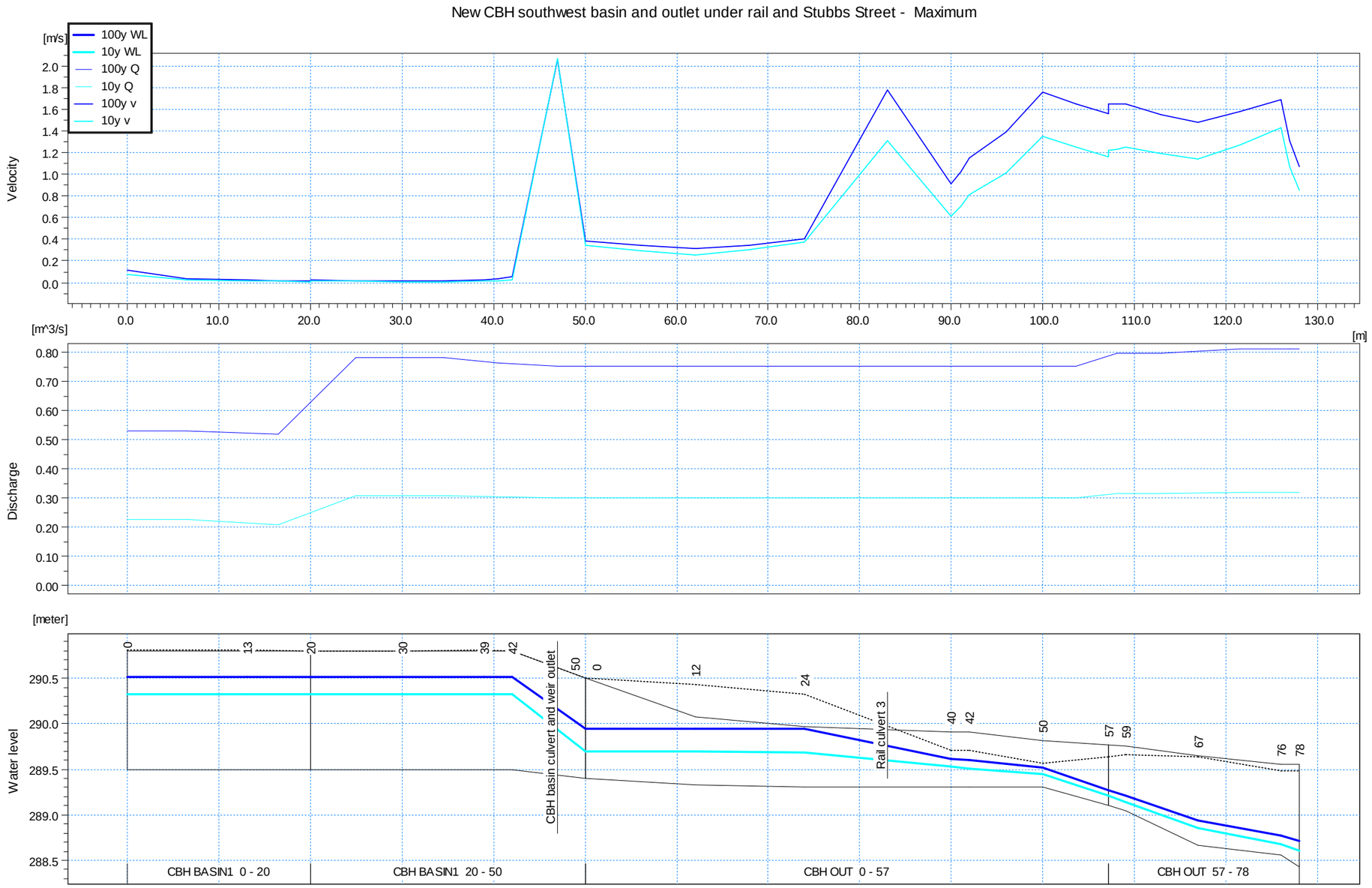
Appendix A

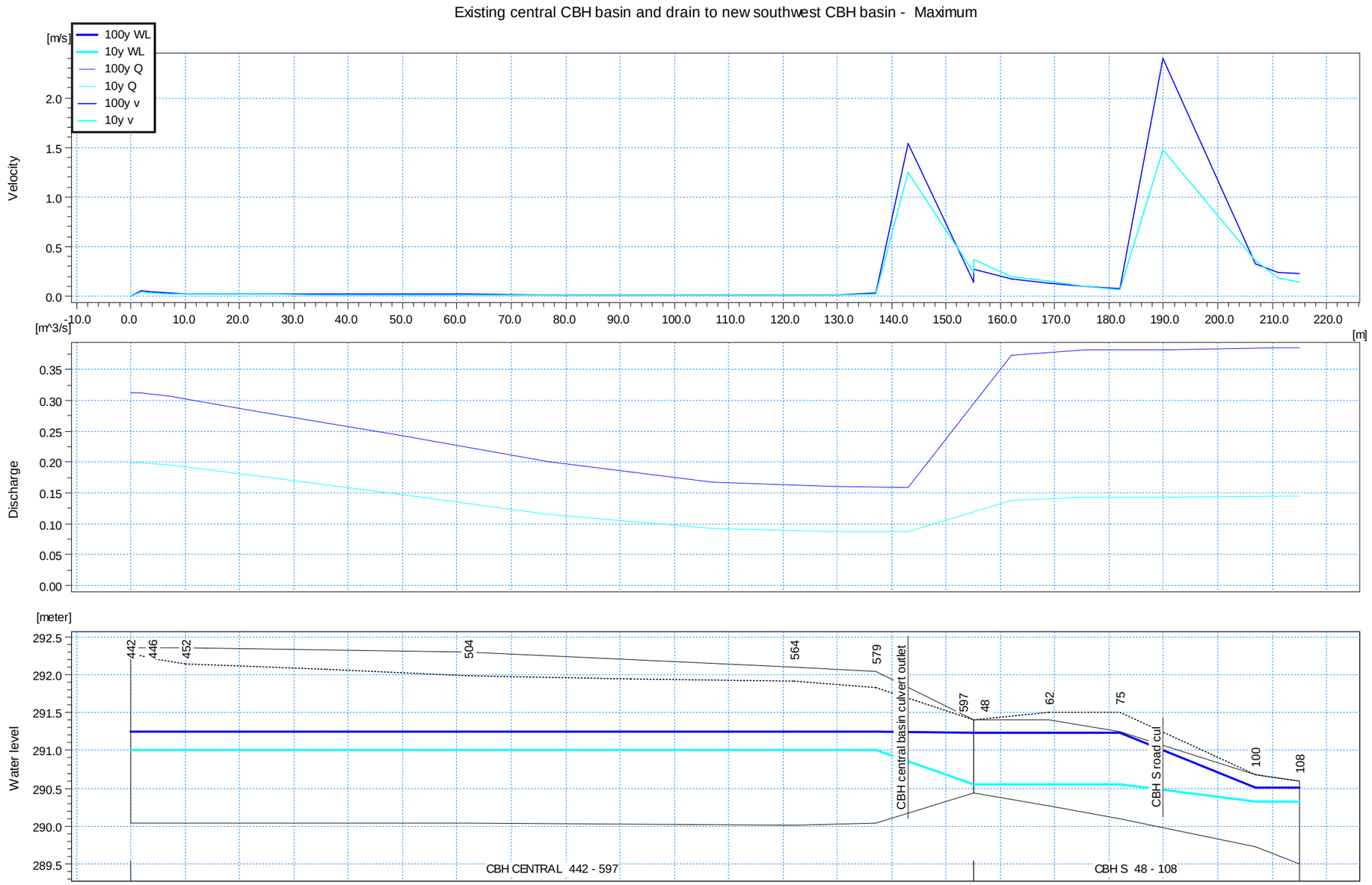
Long sections

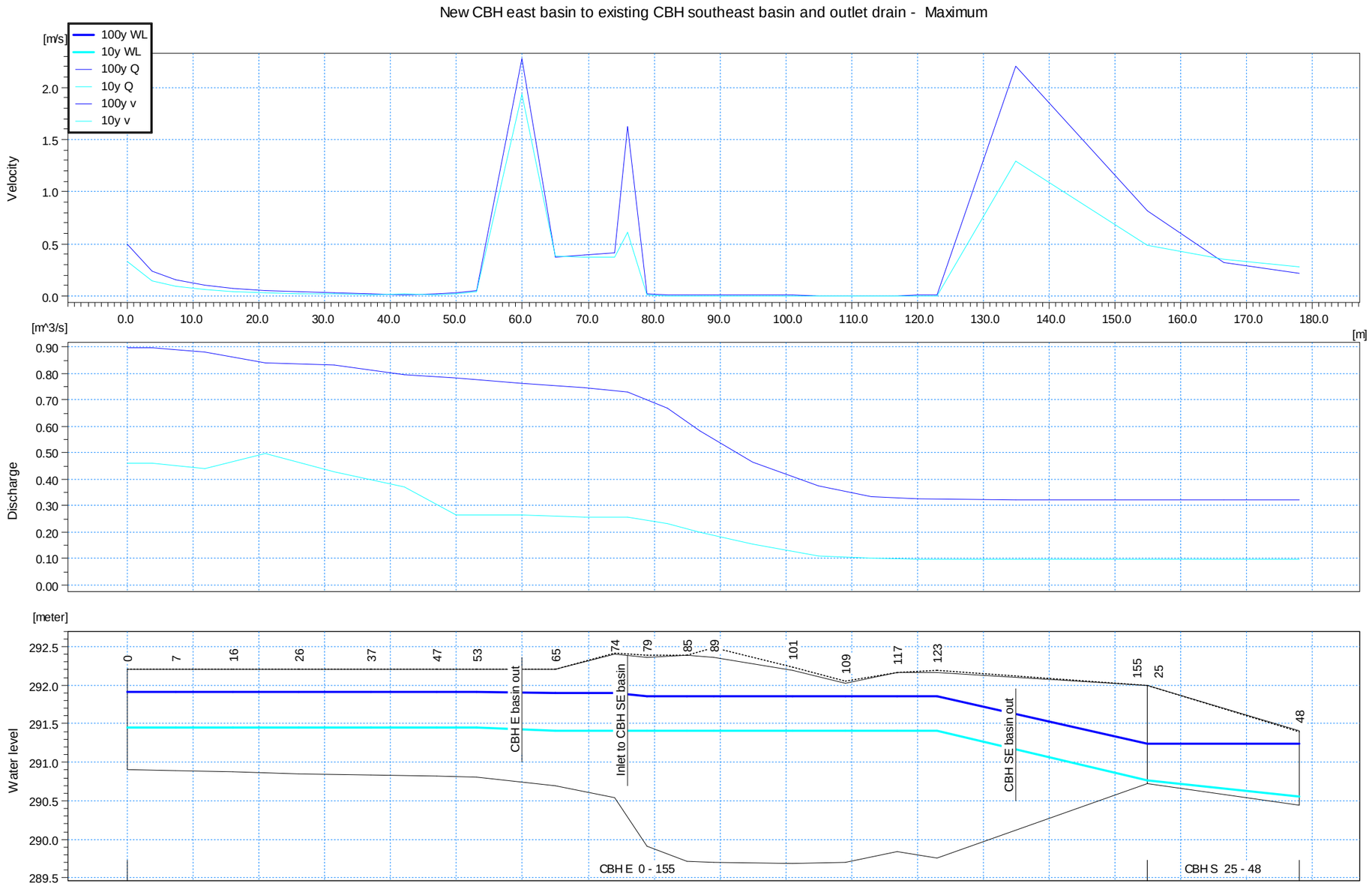
100 and 10 year ARI maximum water level, discharge and velocity profiles:

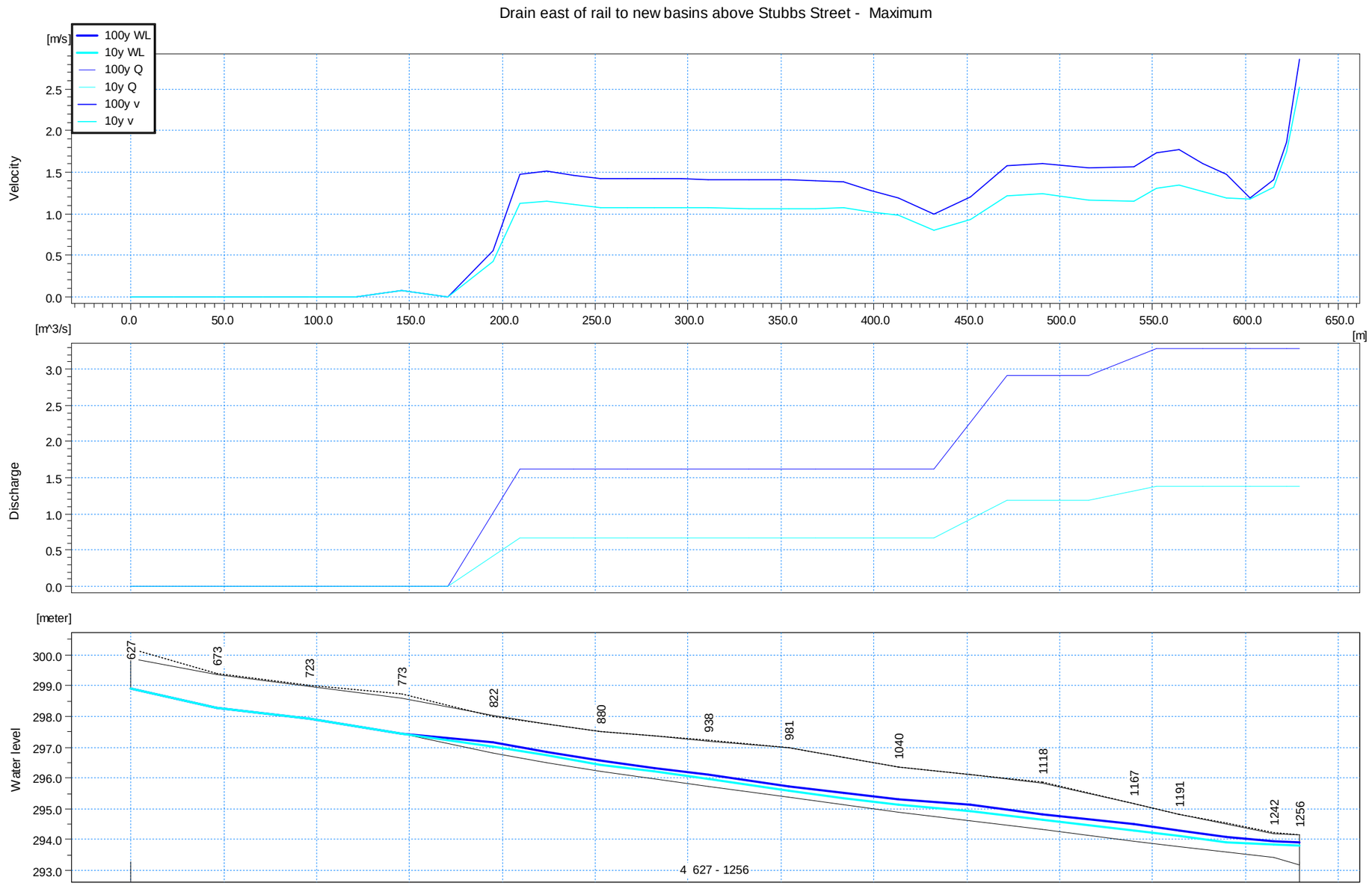
1. Drain along Kulin Road west of CBH to new basin
2. New CBH southwest basin and outlet under rail and Stubbs Street
3. Existing central CBH basin and drain to new southwest CBH basin
4. New CBH east basin to existing CBH southeast basin and outlet to drain
5. Drain east of rail to new basins above Stubbs Street
6. Cascading basins above Stubbs Street
7. Main drain from Stubbs Street to South Road drain
8. South Road drain, sump and South Road crossing

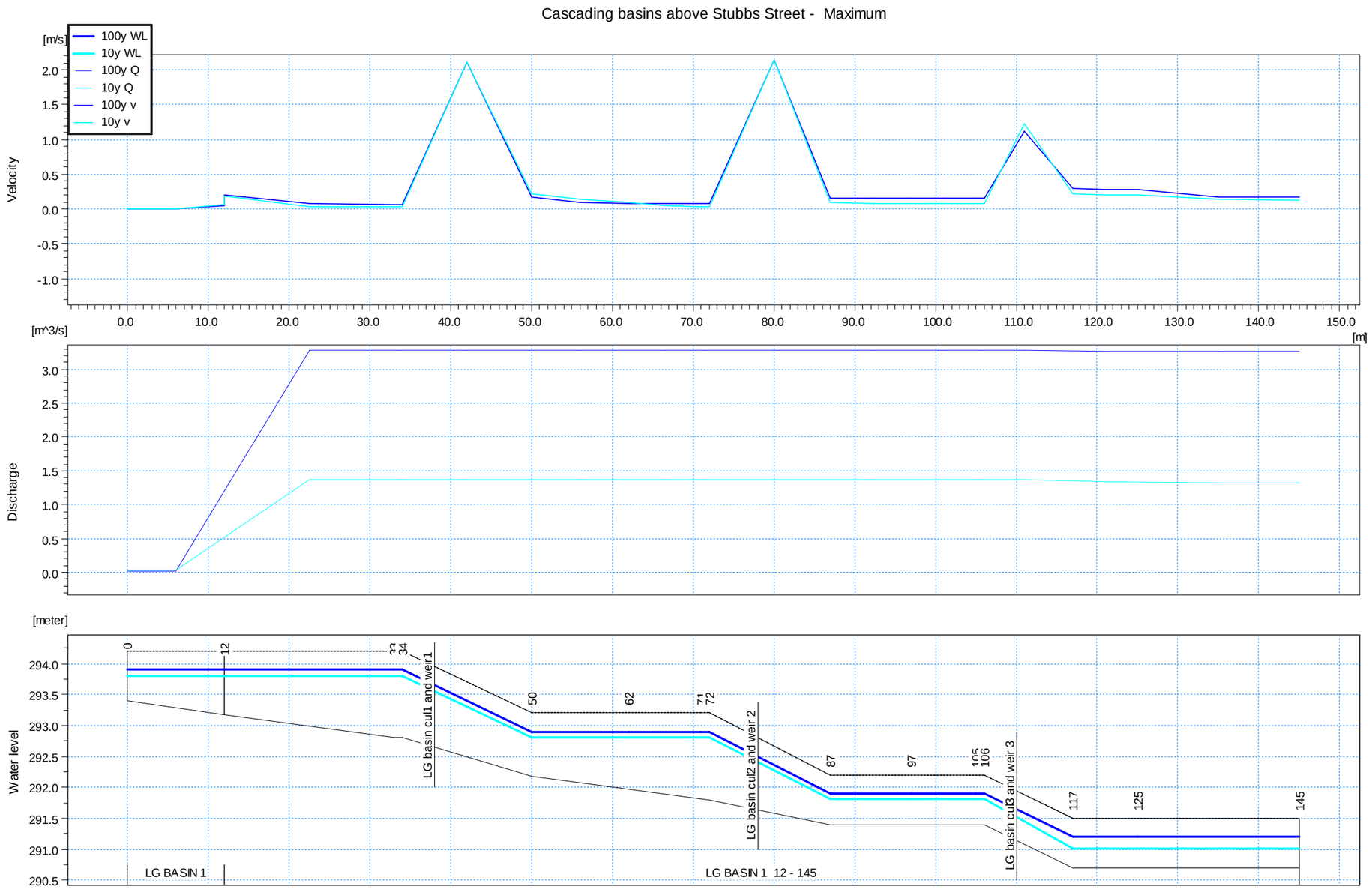

Drain along Kulin Road west of CBH to new basin - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
[m/s]
Velocity
[m]
[m^3/s]
Discharge
[meter]
Water level
CBH W cul1
Cul_CBH entrance
CBH W 0 - 665

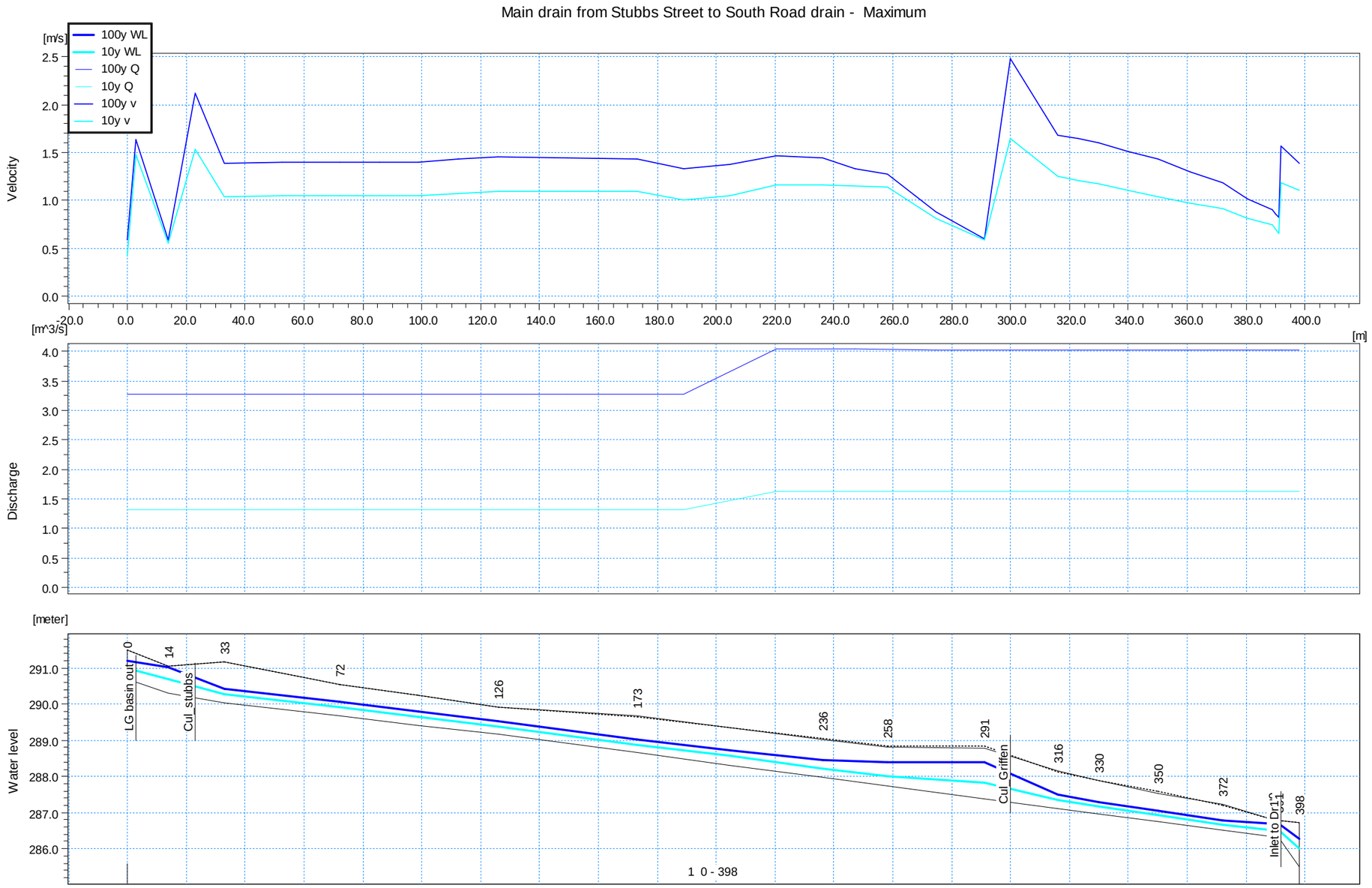

New CBH southwest basin and outlet under rail and Stubbs Street - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
Velocity
[m/s]
Discharge
[m^3/s]
[m]
Water level
[meter]
CBH basin culvert and weir outlet
Rail culvert 3
CBH BASIN1 0 - 20
CBH BASIN1 20 - 50
CBH OUT 0 - 57
CBH OUT 57 - 78

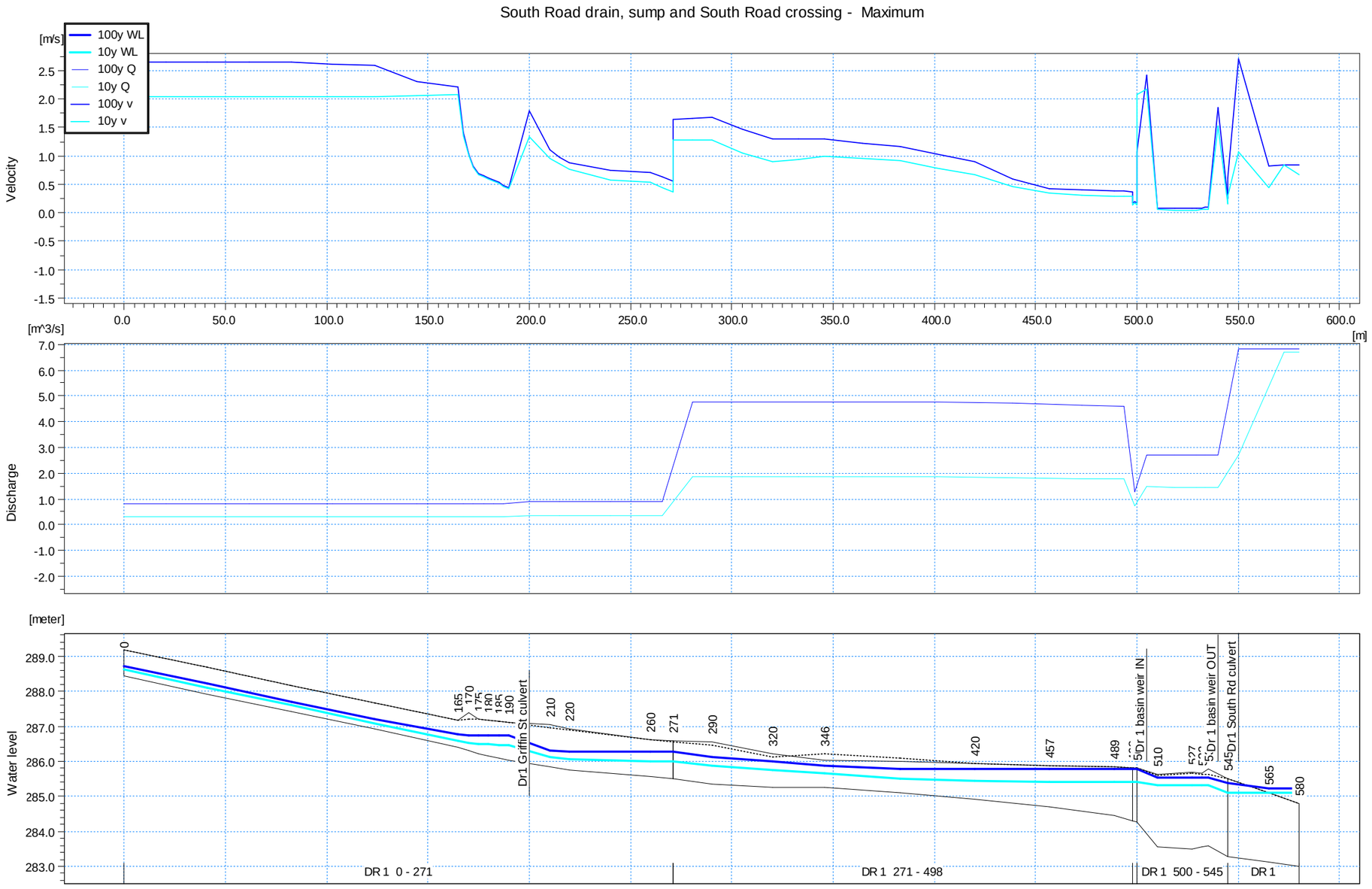

Existing central CBH basin and drain to new southwest CBH basin - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
Velocity
[m/s]
Discharge
[m^3/s]
[m]
Water level
[meter]
CBH central basin culvert outlet
CBH S road cul
CBH CENTRAL 442 - 597
CBH S 48 - 108


New CBH east basin to existing CBH southeast basin and outlet drain - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
[m/s]
Velocity
[m^3/s]
Discharge
[m]
[meter]
Water level
CBH E basin out
Inlet to CBH SE basin
CBH SE basin out
CBH E 0 - 155
CBH S 25 - 48


Drain east of rail to new basins above Stubbs Street - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
[m/s]
Velocity
[m^3/s]
Discharge
[m]
[meter]
Water level
627
673
723
773
822
880
938
981
1040
1118
1167
1191
1242
1256
4 627 - 1256


Cascading basins above Stubbs Street - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
[m/s]
Velocity
[m]
[m^3/s]
Discharge
[meter]
Water level
LG basin cul1 and weir1
LG basin cul2 and weir 2
LG basin cul3 and weir 3
LG BASIN 1
LG BASIN 1 12 - 145


Main drain from Stubbs Street to South Road drain - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
Velocity
[m/s]
Discharge
[m^3/s]
[m]
Water level
[meter]
LG basin out
Cul_stubbs
Cul_Griffen
Inlet to Dr1
1 0 - 398


South Road drain, sump and South Road crossing - Maximum
100y WL
10y WL
100y Q
10y Q
100y v
10y v
[m/s]
Velocity
[m^3/s]
Discharge
[m]
[meter]
Water level
Dr1 Griffin St culvert
Dr 1 basin weir IN
Dr 1 basin weir OUT
Dr1 South Rd culvert
DR 1 0 - 271
DR 1 271 - 498
DR 1 500 - 545
DR 1

Appendix B

Order of magnitude cost estimate

Summary

Stage 1 cost estimate

Stage 2 cost estimate

Stage 3 cost estimate

Stage 4 cost estimate

Lake Grace Flood Mitigation
Shire of Lake Grace
Job number 61/26284
Summary of cost estimation provided by Davson Ward
21/11/2011

Stage	Item	Description	Detail	Qty	Rate	Unit	Cost
Stage 1 - Construction of major diversion Drain between Stubbs St to South Rd Crossing Griffen St	301	Clearing	Site Clearing (no major trees)	0.9	$ 8,450.00	ha	$ 7,605.00
	302	Earthworks	Topsoil removal and respreading	0.9	$ 20,438.89	ha	$ 18,395.00
	402	Surface drain	Excavation	4,203	$ 24.50	m^3	$ 102,973.50
	404	Culverts	Griffen St culverts (1200x450 RCBC)and concrete work	1	$ 66,200.00	No.	$ 66,200.00
	406	Rock Protection	At inlets/outlets and gabions around bends in drain	1,997	$ 121.72	m^2	$ 243,075.00
	500	Pavement and Surfacing	Repairs to road after installation of culvert	50	$ 100.00	m^2	$ 5,000.00
	Sub Total						$ 443,248.50
	800	Mobilisation, demobilisation and preliminaries		25%			$ 110,812.13
	900	Contingencies		15%			$ 83,109.09
	Total (Exc GST)						$ 637,169.72
	GST			10%			$ 63,716.97
	Total (inc GST)						$ 700,886.69
Stage 2 - Construction of minor diversion and levee adjacent rail to series of basins within current rest area adjacent Stubb St including Major Road Culvert	301	Clearing	Site Clearing (inc 20 trees)	2.1	$ 17,973.81	ha	$ 37,745.00
	302	Earthworks	Topsoil removal and respreading	2.1	$ 20,740.48	ha	$ 43,555.00
	402.01	Surface drain, levee and basins	Excavation of drain	2,162	$ 15.00	m^3	$ 32,430.00
	402.02	Surface drain, levee and basins	Construction of levees to side of drain and basins	3,609	$ 12.50	m^3	$ 45,112.50
	402.04	Drainage Basin	Construct drainage basins	1,670	$ 15.00	No.	$ 25,050.00
	404	Culverts	Low flow pipes through basin walls (300 dia RCP)	3	$ 3,758.33	No.	$ 11,275.00
	404	Culverts	Stubbs St culvert (1200x450 RCBC) and concrete works	1	$115,300.00	No.	$ 115,300.00
	405	Drainage structures	Concrete weirs for high flow over basin walls	61	$ 2,800.00	m^3	$ 170,800.00
	406	Rock protection	At inlets/outlets and gabions around bends in drain	1,411	$ 106.73	m^2	$ 150,600.00
	500	Pavement and Surfacing	Repairs to road after installation of culvert	75	$ 100.00	m^2	$ 7,500.00
	Sub Total						$ 639,367.50
	800	Mobilisation, demobilisation and preliminaries		25%			$ 159,841.88
	900	Contingencies		15%			$ 119,881.41
	Total (Exc GST)						$ 919,090.78
	GST			10%			$ 91,909.08
	Total (inc GST)						$ 1,010,999.86
Stage 3 - Rebuild drain on Kulin Rd, construct detention basin adjacent Rail + construction major basin within CBH adjacent existing storages.	301	Clearing	Site clearing (inc 15 trees)	1.3	$ 19,988.46	ha	$ 25,985.00
	302	Earthworks	Topsoil removal and respreading	1.3	$ 19,338.46	ha	$ 25,140.00
	402.01	Surface drain, levees and basins	Excavation of drain	1,673	$ 24.50	m^3	$ 40,988.50
	402.02	Surface drain, levees and basins	Construct levees to two new drainage basins in CBH	404	$ 12.50	m^3	$ 5,050.00
	402.04	Drainage Basin	Construct drainage basins x 2	8,000	$ 24.50	No.	$ 196,000.00
	404	Culverts	Basin outlet culverts (one 300 dia RCP, one 450 dia RCP)	2	$ 8,425.00	No.	$ 16,850.00
	406	Rock protection	At inlets/outlets and gabions around bends in drain	120	$ 136.08	m^2	$ 16,330.00
	Sub Total						$ 326,343.50
	800	Mobilisation, demobilisation and preliminaries		25%			$ 81,585.88
	900	Contingencies		15%			$ 61,189.41
	Total (Exc GST)						$ 469,118.78
	GST			10%			$ 46,911.88
	Total (inc GST)						$ 516,030.66
Stage 4 - (Preferred) - Raising South Rd from Mason St to main culvert adjacent pumping station. Replacement of main Culvert and reshaping of bypass weir.	301	Clearing	Site Clearing (no trees)	2,570	$ 0.85	m^2	$ 2,184.50
	302	Earthworks	Topsoil removal, respreading, Removal pavement, Sub base etc	1,100	$ 18.37	m^2	$ 20,208.75
	402	Surface drains and levees	Allowance for provision of flow path in large events (bypass)	1	$ 20,000.00	item	$ 20,000.00
	404	Culverts	Upgrade culvert under South St (2100x1200 RCBC)	1	$119,100.00	No.	$ 119,100.00
	406	Rock protection	Culvert inlet/outlet	45	$ 225.00	m²	$ 10,125.00
	501	Pavements	Sub base & Base course	2,660	$ 16.62	m²	$ 44,216.25
	503	Bituminous surfacing	Primer seal & Seal	1,799	$ 4.49	m²	$ 8,073.75
	600	Traffic facilities	Traffic signs and road markings	1	$ 5,000.00	item	$ 5,000.00
	Sub Total						$ 228,908.25
	800	Mobilisation, demobilisation and preliminaries		25%			$ 57,227.06
	900	Contingencies		15%			$ 42,920.30
	Total (Exc GST)						$ 329,055.61
	GST			10%			$ 32,905.56
	Total (inc GST)						$ 361,961.17
Stage 4 -(Alternative) - Construction levee between South Rd & Main Drain from Mason Rd to pumping station. Replacement of Culvert & reshaping of bypass weir.	301	Clearing	Site clearing (inc 30 trees)	2,640.00	$ 8.80	m²	$ 23,244.00
	302	Earthworks	Topsoil removal and respreading	2,640	$ 1.48	m²	$ 3,916.00
	402	Surface drains and levees	Allowance for provision of flow path in large events (bypass)	1	$ 20,000.00	item	$ 20,000.00
	402	Surface drains and levees	Construct levee using imported material	1,320	$ 45.15	m^3	$ 59,595.00
	404	Culverts	Upgrade culvert under South St (2100x1200 RCBC)	1	$119,100.00	No.	$ 119,100.00
	406	Rock protection	Culvert inlet/outlet	45	$ 225.00	m²	$ 10,125.00
	500	Pavement and surfacing	Repairs to road after installation of culvert	50	$ 100.00	m²	$ 5,000.00
	Sub Total						$ 240,980.00
	800	Mobilisation, demobilisation and preliminaries		25%			$ 60,245.00
	900	Contingencies		15%			$ 45,183.75
	Total (Exc GST)						$ 346,408.75
	GST			10%			$ 34,640.88
	Total (inc GST)						$ 381,049.63

Summary	Cost
Stage 1 - Construction of major diversion Drain between Stubbs St to South Rd Crossing Griffen St	$ 637,169.72
Stage 2 - Construction of minor diversion and levee adjacent rail to series of basins within current rest area adjacent Stubb St including Major Road Culvert	$ 919,090.78
Stage 3 - Rebuild drain on Kulin Rd, construct detention basin adjacent Rail + construction major basin within CBH adjacent existing storages.	$ 469,118.78
Stage 4 - (Preferred) - Raising South Rd from Mason St to main culvert adjacent pumping station. Replacement of main Culvert and reshaping of bypass weir.	$ 329,055.61
Grand Total -all stages (with stage 4 preferred) completed separately - Exc GST	$ 2,354,434.89
GST	$ 235,443.49
Grand Total -all stages (with stage 4 preferred) completed separately - Exc GST	$ 2,589,878.38
Estimated savings on mobilisation/demobilisation if all stages completed at once	-$ 35,000.00
Total- all stages (with stage 4 preferred) completed at once (Exc GST)	$ 2,319,434.89

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STAGE 1

Item	Description	Unit	Qty	Rate	Amount
	SERIES 300 - EARTHWORKS				
	301 - CLEARING				
301.01	Site clearing	ha	0.9	$8,450.00	$7,605.00
	302 - EARTHWORKS				
	TOPSOILING				
	Topsoil Removal				
302.01	Topsoil removal	ha	0.9	$6,550.00	$5,895.00
	Topsoil Spreading				
302.02	Respread topsoil, 100 thick	m2	5,000	$2.50	$12,500.00
	SERIES 400 - DRAINAGE				
	402 - SURFACE DRAINS AND LEVEES				
	SURFACE DRAINS AND LEVEES				
402.01	Excavation of Surface Drain	m3	4,203	$24.50	$102,973.50
	404 - CULVERTS				
	CULVERTS				
	Reinforced Concrete Box Sections				
404.01	1200 x 450 Box culvert	m	24	$675.00	$16,200.00
404.02	1200 wide link slab	m	12	$400.00	$4,800.00
	All Culverts				
404.03	Selected bedding material	m3	11	$100.00	$1,100.00
404.04	Extra over culverts for cement stabilised backfill	m3	12	$275.00	$3,300.00
404.05	Reinforced concrete base slab and shear keys	m3	12	$2,800.00	$33,600.00
404.06	Reinforced concrete insitu end treatment	m3	2	$3,600.00	$7,200.00

Item	Description	Unit	Qty	Rate	Amount
	406 - ROCK PROTECTION				
	ROCK PROTECTION				
406.01	500 thick type B or B1 rock protection to culvert inlets & outlets - length 10m, Width 16m	m2	160	$100.00	$16,000.00
	GROUT ROCK PROTECTION				
406.02	Grouted rock protection outlet to existing drain - Weir 9m wide and 10m long	m2	90	$65.00	$5,850.00
	GABIONS				
406.03	2000x500x500 rock filled gabion - anchors at US end, sides and base	No	43	$250.00	$10,750.00
406.04	170 thick rock filled gabion mattress - assuming total of 120m on major drain bends	m2	1,997	$100.00	$199,700.00
	GEOTEXTILE				
406.05	Bidin A34 geotextile beneath gabions	m2	2,155	$5.00	$10,775.00
	SERIES 500 - PAVEMENT & SURFACING				
500.00	Make good existing road on completion of culvert installation including selected fill, subbase, basecourse, primerseal and seal all to match existing	m2	50	$100.00	$5,000.00
	SUB TOTAL				$443,248.50
	ADD For General Items - Mobilisation, demobilisation, Insurances, Superintendence, Contractors facilities, and all other works associated with Sections 1 and 2 of the MRWA Model Specification and Major Works Contract conditions			25%	$110,812.13
					$554,060.63
	ADD For Contingencies			15%	$83,109.09
	GST EXCLUSIVE COST				$637,169.72
	ADD for GST	-		10%	$63,716.97
	TOTAL OF STAGE 1 COST INDICATION				$700,886.69

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STAGE 2

Item	Description	Unit	Qty	Rate	Amount
	SERIES 300 - EARTHWORKS				
	301 - CLEARING				
301.01	Site clearing	ha	2.1	$8,450.00	$17,745.00
301.02	Remove trees	No	20	$1,000.00	$20,000.00
	TOPSOILING				
	Topsoil Removal				
302.01	Topsoil removal	ha	2.1	$6,550.00	$13,755.00
	Topsoil Spreading				
302.02	Respread topsoil, 100 thick	m2	11,920	$2.50	$29,800.00
	SERIES 400 - DRAINAGE				
	402 - SURFACE DRAINS AND LEVEES				
	SURFACE DRAINS AND LEVEES				
402.01	Excavation of Surface Drain	m3	2,162	$15.00	$32,430.00
402.02	Construct Levee to side of drain	m3	2,119	$12.50	$26,487.50
402.03	Construct Levees to drainage basins	m3	1,490	$12.50	$18,625.00
	DRAINAGE BASINS				
402.04	Drainage basins (Approx. cut volume 1669 m³ in total)	No.	1,670	$15.00	$25,050.00

Item	Description	Unit	Qty	Rate	Amount
	404 - CULVERTS				
	CULVERTS Reinforced Concrete Pipes Class ?				
404.01	300 Diameter pipe culvert	m	41	$275.00	$11,275.00
	Reinforced Concrete Box Sections				
404.02	1200 x 450 Box culvert	m	24	$675.00	$16,200.00
404.03	1200 wide link slab	m	12	$400.00	$4,800.00
	All Culverts				
404.04	Selected bedding material	m3	24	$100.00	$2,400.00
404.05	Extra over culverts for cement stabilised backfill	m3	13	$275.00	$3,575.00
404.06	Reinforced concrete base slab and shear keys	m3	24	$2,800.00	$67,200.00
404.07	Reinforced concrete insitu end treatment	m3	5	$3,600.00	$18,000.00
404.08	Extra over culverts for excavation in rock	m^3	25	$125.00	$3,125.00
	405 - DRAINAGE STRUCTURES				
	WEIRS				
405.01	Reinforced concrete weirs (in 3 No.) Assumes 25m wide, 2m wide over leeve, 400mm depth of contrete. Side walls 2m x 0.2m x 0.2m	m3	61	$2,800.00	$170,800.00
	406 - ROCK PROTECTION				
	GABIONS				
406.01	2000x500x500 rock filled gabion	No	8	$250.00	$2,000.00
406.02	170 thick rock filled gabion mattress to drain 4 Assumes 30m of protection around Bend in Drain 4	m2	360	$100.00	$36,000.00
406.03	170 thick rock filled gabion mattress to drain 4 / basin LG04 inlet Assumes 8m wide, 10m long up drain	m2	80	$100.00	$8,000.00
406.04	170 thick rock filled gabion mattress to basin inlets Assumes faces where water over weir	m2	546	$100.00	$54,600.00
406.05	170 thick rock filled gabion mattress to basin LG01 base and outlet Assumes 378 m2 in base and 10 x 4.7m on outlet wall	m2	425	$100.00	$42,500.00
	GEOTEXTILE				
406.06	Bidin A34 geotextile beneath gabions	m2	1,500	$5.00	$7,500.00

Item	Description	Unit	Qty	Rate	Amount
	SERIES 500 - PAVEMENT & SURFACING				
500.00	Make good existing road on completion of culvert installation including selected fill, subbase, basecourse, primerseal and seal all to match existing	m2	75	$100.00	$7,500.00
	SUB TOTAL				$639,367.50
	ADD For General Items - Mobilisation, demobilisation, Insurances, Superintendence, Contractors facilities, and all other works associated with Sections 1 and 2 of the MRWA Model Specification and Major Works Contract conditions			25%	$159,841.88
					$799,209.38
	ADD For Contingencies			15%	$119,881.41
	GST EXCLUSIVE COST				$919,090.78
	ADD for GST	-		10%	$91,909.08
	TOTAL OF STAGE 2 COST INDICATION				$1,010,999.86

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STAGE 3

Item	Description	Unit	Qty	Rate	Amount
	SERIES 300 - EARTHWORKS				
	301 - CLEARING				
301.01	Site clearing	ha	1.3	$8,450.00	$10,985.00
301.02	Remove trees	No	15	$1,000.00	$15,000.00
	302 - EARTHWORKS				
	TOPSOILING Topsoil Removal				
302.01	Topsoil removal	ha	1.3	$6,550.00	$8,515.00
	Topsoil Spreading				
302.02	Respread topsoil, 100 thick	m2	6,650	$2.50	$16,625.00

Item	Description	Unit	Qty	Rate	Amount
	SERIES 400 - DRAINAGE				
	402 - SURFACE DRAINS AND LEVEES				
	SURFACE DRAINS AND LEVEES				
402.01	Excavation of Surface Drain (CBH W)	m3	1,673	$24.50	$40,988.50
402.02	Construct Levee to drainage basin CBH 1	m3	122	$12.50	$1,525.00
402.03	Construct Levee to drainage basin CBH E	m3	282	$12.50	$3,525.00
	DRAINAGE BASINS				
402.04	Drainage basin CBH 1 (Approx. cut volume 1514 m³ in total)	No.	1,515	$24.50	$37,117.50
402.05	Drainage basin CBH E (Approx. cut volume 6488 m³ in total)	No.	6,485	$24.50	$158,882.50
	404 - CULVERTS				
	CULVERTS				
	Reinforced Concrete Pipes Class 2				
404.01	300 Diameter pipe culvert	m	8	$275.00	$2,200.00
404.02	450 Diameter pipe culvert	m	5	$350.00	$1,750.00
	All Culverts				
404.03	Selected bedding material	m3	1	$100.00	$100.00
404.04	Reinforced concrete base slab and shear keys	m3	2	$2,800.00	$5,600.00
404.05	Reinforced concrete insitu end treatment	m3	2	$3,600.00	$7,200.00
	406 - ROCK PROTECTION				
	GROUT ROCK PROTECTION				
406.01	Grouted rock protection to basin overflow wiers	m2	42	$65.00	$2,730.00
	GABIONS				
406.02	2000x500x500 rock filled gabion	No	6	$250.00	$1,500.00
406.03	170 thick rock filled gabion mattress to basin inlets Assumes both (2) basin inlets	m2	114	$100.00	$11,400.00
	GEOTEXTILE				
406.04	Bidin A34 geotextile beneath gabions	m2	140	$5.00	$700.00
	SUB TOTAL				$326,343.50

Item	Description	Unit	Qty	Rate	Amount
	ADD For General Items - Mobilisation, demobilisation, Insurances, Superintendence, Contractors facilities, and all other works associated with Sections 1 and 2 of the MRWA Model Specification and Major Works Contract conditions			25%	$81,585.88
					$407,929.38
	ADD For Contingencies			15%	$61,189.41
	GST EXCLUSIVE COST				$469,118.78
	ADD for GST	-		10%	$46,911.88
	TOTAL OF STAGE 3 COST INDICATION				$516,030.66

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STAGE 4 - OPTION 1 RAISE ROAD

Item	Description	Unit	Qty	Rate	Amount
	SERIES 300 - EARTHWORKS				
	301 - CLEARING				
301.01	Site clearing	m2	2,570	$0.85	$2,184.50
	302 - EARTHWORKS				
	TOPSOILING Topsoil Removal				
302.01	Topsoil removal	m2	1,100	$0.65	$715.00
	Topsoil Spreading				
302.02	Respread topsoil, 100 thick	m2	900	$2.50	$2,250.00
	REMOVAL OF REDUNDANT PAVEMENTS				
302.03	Removal of redundant seal from existing pavement	m²	885	$5.00	$4,425.00
302.04	Marking out and cutting edge along junction between new pavement and existing pavement including trimming existing pavement layers as required to bond to new pavement	m	13	$12.50	$162.50
	EMBANKMENT CONSTRUCTION				
302.05	Embankment foundation compaction	m²	1,985	$2.25	$4,466.25
302.06	Embankment construction using borrow material	m³	150	$18.50	$2,775.00
	SUBGRADE				
302.07	Subgrade	m²	1,900	$2.85	$5,415.00

Item	Description	Unit	Qty	Rate	Amount
	SERIES 400 - DRAINAGE				
	402 - SURFACE DRAINS AND LEVEES				
	SURFACE DRAINS AND LEVEES				
402.01	Allowance for provision of flow path in large events (sump bypass)	item	1		$20,000.00
	404 - CULVERTS				
	CULVERTS				
	Reinforced Concrete Box Sections				
404.01	2100 x 1200 Box culvert	m	14	$1,500.00	$21,000.00
	All Culverts				
404.02	Selected bedding material	m³	17	$100.00	$1,700.00
404.03	Extra over culverts for cement stabilised backfill	m³	16	$275.00	$4,400.00
404.04	Reinforced concrete base slab and shear keys	m³	20	$2,800.00	$56,000.00
404.05	Reinforced concrete insitu end treatment	m³	10	$3,600.00	$36,000.00
	406 - ROCK PROTECTION				
	GROUT ROCK PROTECTION				
406.01	1000mm Thick Grouted 1/4 tonne rock protection to culvert inlet or outlet	m²	45	$225.00	$10,125.00
	SERIES 500 - PAVEMENT & SURFACING				
	501 - PAVEMENTS				
	SUBBASE				
501.01	200mm Thick granular subbase	m²	1,485	$18.50	$27,472.50
	BASECOURSE				
501.02	150mm Thick crushed rock roadbase basecourse	m²	1,175	$14.25	$16,743.75
	503 - BITUMINOUS SURFACING				
	ROADWORKS				
	Primerseal				
503.01	Single coat primerseal with BAR of 1.4 litres/m² and river sand aggregate	m²	914	$3.75	$3,427.50
	Seal				
503.02	Single coat seal with BAR of 1.6 litres/m² and 14mm aggregate	m²	885	$5.25	$4,646.25

Item	Description	Unit	Qty	Rate	Amount
	SERIES 600 - TRAFFIC FACILITIES				
600.01	Allowance for traffic signs & road markings	item	1		$5,000.00
	SUB TOTAL				$228,908.25
	ADD For General Items - Mobilisation, demobilisation, Insurances, Superintendence, Contractors facilities, and all other works associated with Sections 1 and 2 of the MRWA Model Specification and Major Works Contract conditions			25%	$57,227.06
					$286,135.31
	ADD For Contingencies			15%	$42,920.30
	GST EXCLUSIVE COST				$329,055.61
	ADD for GST	-		10%	$32,905.56
	TOTAL OF STAGE 4 OPTION 1 COST INDICATION				$361,961.17

Item	Description	Unit	Qty	Rate	Amount
	SERIES 300 - EARTHWORKS				
	301 - CLEARING				
301.01	Site clearing	m2	2,640	$0.85	$2,244.00
301.02	Remove trees	No	21	$1,000.00	$21,000.00
	302 - EARTHWORKS				
	TOPSOILING Topsoil Removal				
302.01	Topsoil removal	m2	2,640	$0.65	$1,716.00
	Topsoil Spreading				
302.02	Respread topsoil, 100 thick	m2	880	$2.50	$2,200.00
	SERIES 400 - DRAINAGE				
	402 - SURFACE DRAINS AND LEVEES				
	SURFACE DRAINS AND LEVEES				
402.01	Allowance for provision of flow path in large events (sump bypass)	item			$20,000.00
402.02	Construct Levee using imported material	m3	1,320	$40.00	$52,800.00
	GEOTEXTILE Geofabric attached to side of levee	m2	906	$7.50	$6,795.00
	404 - CULVERTS				
	CULVERTS Reinforced Concrete Box Sections				
404.01	2100 x 1200 Box culvert	m	14	$1,500.00	$21,000.00
	All Culverts				
404.02	Selected bedding material	m^3	17	$100.00	$1,700.00
404.03	Extra over culverts for cement stabilised backfill	m^3	16	$275.00	$4,400.00
404.04	Reinforced concrete base slab and shear keys	m^3	20	$2,800.00	$56,000.00
404.05	Reinforced concrete insitu end treatment	m^3	10	$3,600.00	$36,000.00
	406 - ROCK PROTECTION				
	GROUT ROCK PROTECTION				
406.01	1000mm Thick Grouted 1/4 tonne rock protection to culvert inlet or outlet	m^2	45	$225.00	$10,125.00

Item	Description	Unit	Qty	Rate	Amount
	SERIES 500 - PAVEMENT & SURFACING				
500.00	Make good existing road on completion of culvert installation including selected fill, subbase, basecourse, primerseal and seal all to match existing	m2	50	$100.00	$5,000.00
	SUB TOTAL				$240,980.00
	ADD For General Items - Mobilisation, demobilisation, Insurances, Superintendence, Contractors facilities, and all other works associated with Sections 1 and 2 of the MRWA Model Specification and Major Works Contract conditions			25%	$60,245.00
					$301,225.00
	ADD For Contingencies			15%	$45,183.75
	GST EXCLUSIVE COST				$346,408.75
	ADD for GST	-		10%	$34,640.88
	TOTAL OF STAGE 4 OPTION 2 COST INDICATION				$381,049.63

Davson+Ward
QUANTITY SURVEYORS & CONSTRUCTION COST CONSULTANTS

CONDITIONS & EXCLUSIONS

1.00 <u>This Cost Indication is conditioned as follows:</u>

1.01 These prices are current as at October 1, 2011 and are based on the rate currently used in similar work for MRWA

1.02 No Escalation of cost has been incorporated from the date stated in 1.01 above and the date of tender

1.03 This estimate is accurate within the following range: *** See Below**

2.00 <u>This Cost Indication excludes the cost of the following:</u>

2.01 Removal of asbestos

2.02 The value of Principal supplied items including searching for and stockpiling of embankment construction and pavement construction materials

2.03 Allowances of accelerated construction periods

2.04 Holding Costs and interest charges

2.05 Time extension costs

2.06 Legal fees

2.07 Allowances for charges and costs levied by Authorities, Councils and Service Bodies

2.08 Aboriginal heritage, cultural and native title issues

2.09 Environmental obligations and clearances

2.10 Geotechnical investigations

2.11 MRWA administrative charges including corporate overheads, etc

2.12 Redevelopment work of surplus land prior to disposal

2.13 Loss of business claims

2.14 Increased costs due to labour shortages in the Region

2.15 Increase in tender prices due to the current over supply of work for Contractors

* **<u>Please note:</u>** It is no longer Davson+Ward Company Policy to nominate limits of accuracy due to the current economic climate

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
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