



Data Review and Modelling Methodology Report

Great Western Flood Investigation

Northern Grampians Shire Council

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Client	Northern Grampians Shire Council
Client Project Manager	Trent Homden
Water Technology Project Manager	Ben Hughes
Water Technology Project Director	Ben Tate
Authors	Jean Yong
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15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365
ACN 093 377 283
ABN 60 093 377 283





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GLOSSARY

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded; it would be fairly rare but it would be of extreme magnitude.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datums.
Average Recurrence Interval (ARI)	Refers to the average time interval between a given flood magnitude occurring or being exceeded. A 10 year ARI flood is expected to be exceeded on average once every 10 years. A 100 year ARI flood is expected to be exceeded on average once every 100 years. The AEP is the ARI expressed as a percentage.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A design flood is a probabilistic or statistical estimate, being generally based on some form of probability analysis of flood or rainfall data. An average recurrence interval or exceedance probability is attributed to the estimate.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from elevated sea levels and/or waves overtopping coastline defences.
Flood frequency analysis	A statistical analysis of observed flood magnitudes to determine the probability of a given flood magnitude.
Flood hazard	Potential risk to life and limb caused by flooding. Flood hazard combines the flood depth and velocity.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.



Flood storages	Those parts of the floodplain that are important for the temporary storage, of floodwaters during the passage of a flood.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Intensity frequency duration (IFD) analysis	Statistical analysis of rainfall, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.
LiDAR	Spot land surface heights collected via aerial light detection and ranging (LiDAR) survey. The spot heights are converted to a gridded digital elevation model dataset for use in modelling and mapping.
Peak flow	The maximum discharge occurring during a flood event.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Average Recurrence Interval.
Probable Maximum Flood	The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.
RORB	A hydrological modelling tool used in this study to calculate the runoff generated from historic and design rainfall events.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Topography	A surface which defines the ground level of a chosen area.



1 INTRODUCTION

1.1 Overview

Water Technology was commissioned by North Grampians Shire Council (NGSC) to undertake the Great Western Flood Investigation. The investigation area covers the Great Western township, situated on the Western Highway in the upper reaches of Concongella Creek, a tributary of the Wimmera River. The surrounding local catchments include Concongella Creek, Allanvale Creek, and Hyde Park Creek. The study area is shown in Figure 1-1.



Figure 1-1 Study area



The study has produced reliable flood intelligence for use in emergency management situations, assessed the current flood impact/exposure in terms of annual average damages caused by flooding in Great Western, investigated structural and non-structural mitigation options, investigate and make recommendations for establishing a flood warning system for the town.

This report is one of the series documenting the outcomes of the Great Western Flood Investigation. Each reporting stage is shown below:

- **R01 – Data Review Report – This Report**
- R02 – Model Development and Calibration Report
- R03 – Design Model Report
- R04 – Flood Intelligence Report
- R05 – Floodplain Management Plan
- R06 – Summary Report

The data required for this study has been collated and reviewed. This report documents a summary of the available streamflow, rainfall, topographic and structure data as well as the relevant previous projects and other information relevant to the study. The report also details verification of the available topographic datasets and the proposed hydrologic and hydraulic modelling approach. The draft report flagged data gaps with NGSC, while in this final report these have been resolved.



1.2 Objectives and Outputs

The Great Western Flood Investigation outputs are required to meet several floodplain management objectives as highlighted in the project brief prepared by NGSC. The objectives of the investigation are described below:

- Review the available data and identify where additional data is to be obtained to complete the study to the required degree of accuracy.
- Develop best-practice hydrological and hydraulic models for the study area, including Council's stormwater network.
- Determine flood information for a range of flood modelling scenarios.
- Develop flood intelligence and response documentation for inclusion in NGSC Municipal Flood Emergency Plan (MFEP).
- Analyse options for structural and non-structural flood mitigation to alleviate flooding.
- Analyse the deficiencies in the existing stormwater system.
- Deliver draft mapping updates (LSIO & FO) and explanatory reports to be used to amend the planning scheme.
- Provide a complete and concise document outlining the study methodology and deliverables.
- Providing flood data in an appropriate format to the Victorian Government and the Wimmera CMA and produce mapping suitable for DELWP's FloodZoom (VFD2), all to Australian Height Datum (AHD).
- Make recommendations, and where possible, develop a flood-warning system.



1.3 Study Area

Great Western is situated in the Wimmera region of western Victoria, located 16.1 km northwest to Ararat and 12.7 km southeast to Stawell. It is situated on the banks of Concongella Creek and Hyde Park Creek, which both merge downstream of the township. The first European settlers of Great Western consisted of sheep graziers in mid 1800s, before the discovery of gold and then the later development of viticulture, which remains as one of Great Western's primary economic drivers in the region to the present day.

The catchment of Concongella Creek and the main tributary of Hyde Park is located approximately 490 metres north and 1.2 km south of Western Highway (centre of township) respectively, before merging into Concongella Creek 1.7 km downstream, northwest of the township. Another tributary, Allanvale Creek located east of town, joins into Concongella Creek 680 metres upstream.

The catchment within and upstream of the study area is predominately agricultural land, including extensive viticulture and farming activities. There are also bushland reserves and a quarry.

The study area is focused on the township of Great Western and included the following key structures which required consideration as part of the study:

- Main waterway road crossings, formal or informal, at the following roads:
 - Western Highway
 - Sandy Creek Road
 - Moyston-Great Western Road
 - Bests Road
 - Hurleys Lane.
- Road crossings at other locations than main waterways
- Underground pits and pipe drainage network within the township
- Railway located track southwest of the township and associated hydraulic structures
- Great Western Racecourse Dam.



2 DATA SUMMARY

2.1 Previous Studies

The following previous studies were identified producing flooding information for Concongella Creek at Great Western as part of the data collation and review:

- Regional Flood Mapping: Concongella Creek (2014)
- Western Highway Duplication Project (2017)

The modelling used in these studies has formed a framework for the modelling undertaken as part of the Great Western Flood Investigation, this is discussed in full detail in the Model Development Report.

2.2 Flood Information

2.2.1 Historical Flood Records

There are limited historical flood observations within the study area. The 2011 flood event has been the largest in living memory and was used to the both the *Regional Concongella Creek Flood Study* and *Western Highway Duplication Project*.

The sources listed below were used to form a basis of the known historic flooding in Great Western.

- Historic data related to Great Western and Concongella Creek flooding collated via Trove (a free online database of historical newspapers etc.).
- Anecdotal evidence gathered from an initial community consultation meeting.
- Agency staff survey amongst CFA, local SES, and Council staff.

Further historic flood information and anecdotal evidence was gathered during community consultation including feedback on the mapping. This is documented in R02, the Model Development and Calibration Report.

2.2.2 Recent Flood Records

2.2.2.1 October 2022

Western Highway at Great Western was closed in both directions due to inundation on October 13, 2022, see Figure 2-1. While it was inundated it was considered trafficable shortly after closure and supervised passage on the inundated road was managed.



Roads and river warnings

Some regional townships are starting to be cut off as floodwaters close roads and access points.

[Multiple roads have been closed](#), including the Melbourne-bound lanes of the Hume Freeway between Benalla and Avenel, the Western Highway in both directions at Great Western and the Calder Highway at Marong between Charlton and Wedderburn.

Major flood warnings remain in place across the state, with authorities warning the [Thomson Dam in eastern Victoria could spill for the first time in 30 years](#).

Figure 2-1 Screenshot of online news about the road cutoff (Source: ABC News)

2.2.2.2 January 2011

The January 2011 flood event was the largest flood on record for most waterways in the Wimmera River catchment. The Bureau of Meteorology (BoM) recorded high rainfall totals on the 12th and 14th of January at the Mt. William daily rainfall gauge, totalling 91.0 mm and 86.0 mm respectively. The Great Western daily rainfall gauge recorded higher totals on both days with 134.6 mm and 132.8 mm recorded on the 12th and 14th respectively.

The 2011 flood event resulted in a widespread inundation, overtopping of roads and flooding of buildings.

- 11 surveyed flood marks were gathered in Great Western following the January 2011 event. The dataset has a reported survey accuracy of less than 50mm, however, it should be noted that peak water levels can be difficult to accurately define and therefore flood survey has inherent uncertainty. Surveyed levels also need to be used with judgement and caution.
- Residents of Great Western have commented there was a steep rise in Concongella Creek water levels from around 4:30 am on Friday 14th January. It is estimated the inundation peak in Great Western occurred at approximately 8 am on Friday morning, with significant decreases in water levels between 10am and 11am. 12 km north (downstream) of Great Western the Concongella Creek stream gauge recorded a peak level of 5.05 m (greater than 7,000 ML/d) at 6.30 am on Friday. Six buildings within Great Western were inundated, with the Wimmera Highway closed and a large number of homes isolated. This compares to an estimated 12 properties inundated in a 100 year ARI event (Economic Evaluation of Flood Damages for the WCMA, 2001). Figure 2-2 shows the impacted dwellings in Great Western during January 2011 and Figure 2-3 shows an aerial image captured of Great Western on Friday 14th January 2011 at 10am.



Figure 2-2 Great Western township showing flood affected property (Source: January 2011, Wimmera Flood Review Report (Water Technology, 2011))



Figure 2-3 Great Western on Friday 14th January 2011 at 10am

2.2.2.3 Pre-2000

Investigation of historical news articles identified flood events in Great Western in September 1910 and August 1936, as shown in Figure 2-4.

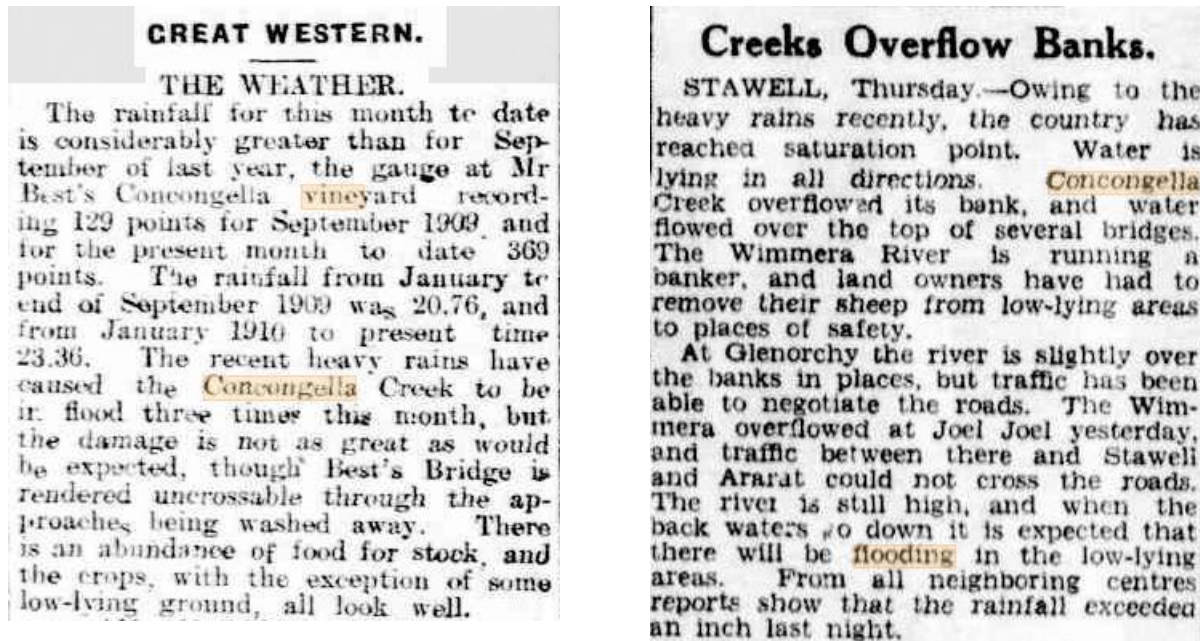


Figure 2-4 News articles featuring flooding in Great Western in 1910 and 1936.

2.3 Storages

2.3.1 Overview

There are no major storages within the Concongella Creek and Hyde Park Creek catchments. There is a storage dam flowing from an unnamed tributary transversing through the Great Western Racecourse, which also has several dams within the property area.

There are several small farm dams, mostly located at south of the town, within the study area.

2.4 Streamflow Data

The Concongella Creek at Stawell (Gauge ID: 415237) stream height and flow gauge is located approximately 12km downstream of Great Western and 5 km east of Stawell. The gauge records water level, rainfall and stream flow date, available from 1976 to the present day. This data will be used in the hydrologic model calibration. The following flood events were identified in the available data:

- January 14, 2011 (~12,605.6 ML/day)
- September 14, 2016 (~4,129.4 ML/day)
- October 14, 2022 (~2,439.2 ML/day)

The Concongella Creek at Stawell gauge catchment and subarea delineation determined during the Western Highway Duplication Project is shown in Figure 2-5.

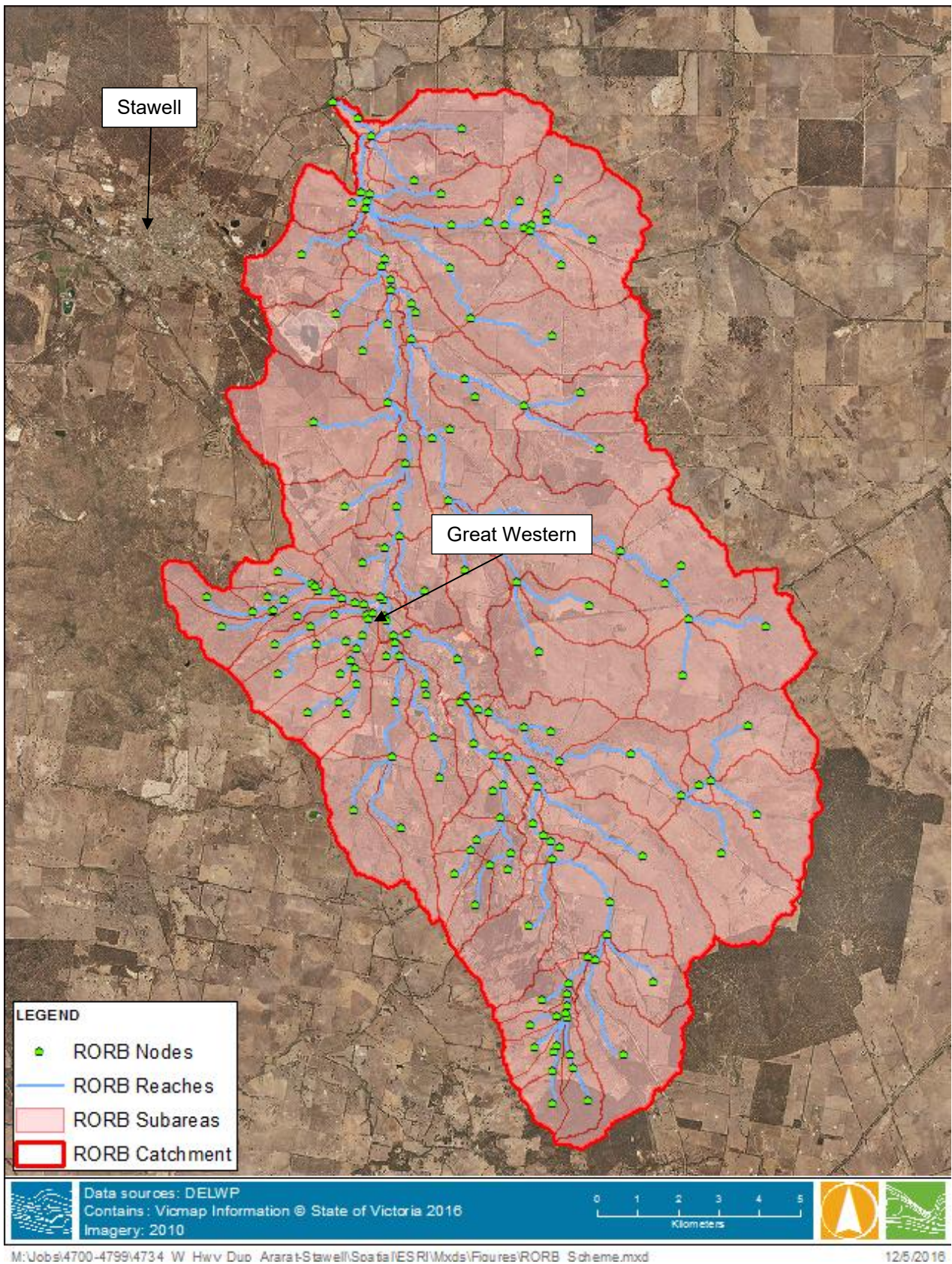


Figure 2-5 Concongella Creek at Stawell gauge catchment.



2.5 Rainfall Data

2.5.1 Overview

Historic daily and sub daily rainfall data is required for the hydrologic and hydraulic model calibration. Daily rainfall gauges are used to provide a representation of spatial rainfall variation while sub daily gauges provide a representation of temporal rainfall distribution.

2.5.2 Daily Rainfall

Table 2-1 summarises the daily rainfall information available within or near Concongella Creek catchment, using 30 km radius from Great Western. The closest active rainfall gauge is being Great Western (Seppelt) gauge located approximately 3.5 km southwest of Great Western.

Table 2-1 Daily rainfall station information

Station Name	Dist. from Great Western	Station ID	Start	End
Great Western (Seppelt)	3.5 km SE	079019	1892	Current
Stawell Aerodrome	15.8 km NW	079105	1996	
Ararat Prison	16.3 km SE	089085	1969	
Grampians (Mount William)	21.7 km W	079103	2005	
Halls Gap	27.4 km	079074	1954	
Buangor (Biranga)	30.8 km	089045	1958	
Moyston (Barton Estate)	16.8 km W	079050	1906	2023

2.5.3 Pluviograph Rainfall

Sub daily rainfall data is available at the Ararat Prison (BoM) and the Concongella Creek at Stawell gauges (DEECA). This data will be used to determine historic rainfall temporal patterns for model calibration events.

The 30min and cumulative rainfall totals for these gauges recorded during the January is shown in Figure 2-6 and Figure 2-7 respectively.

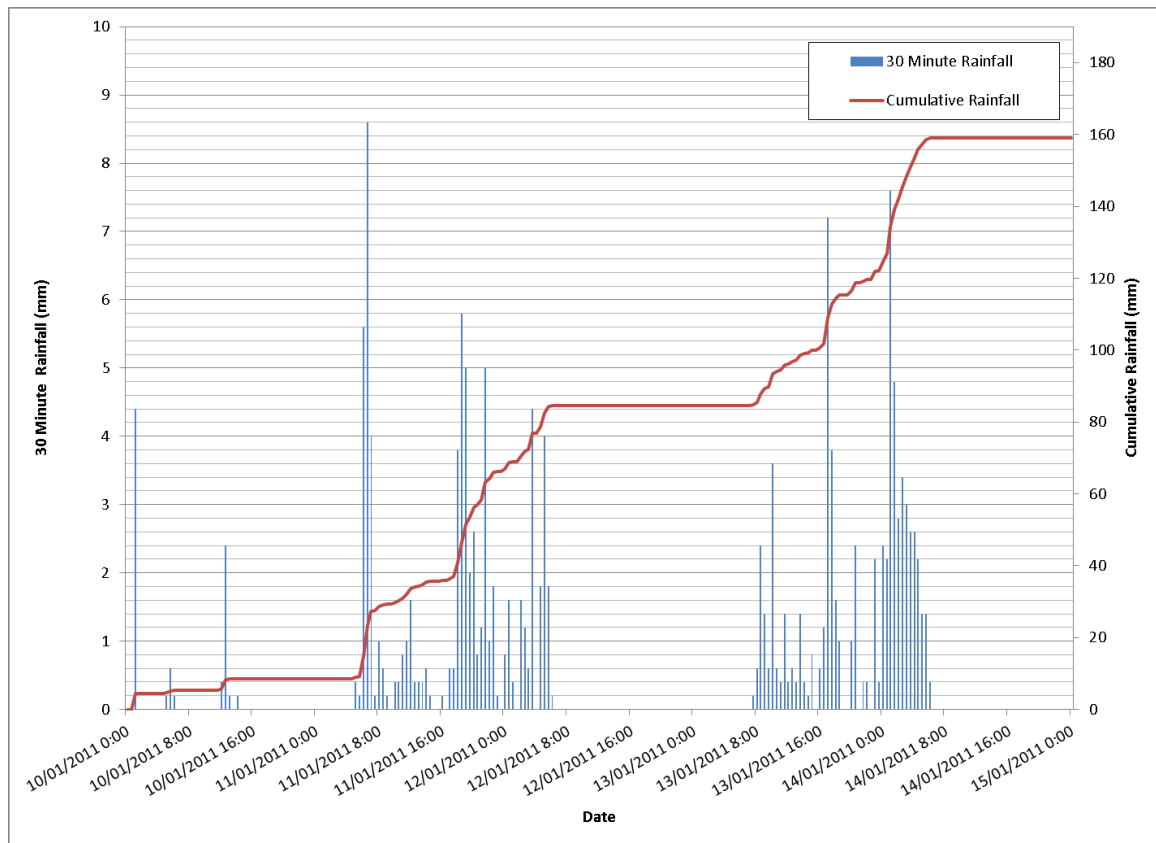


Figure 2-6 Rainfall temporal pattern: Ararat Prison

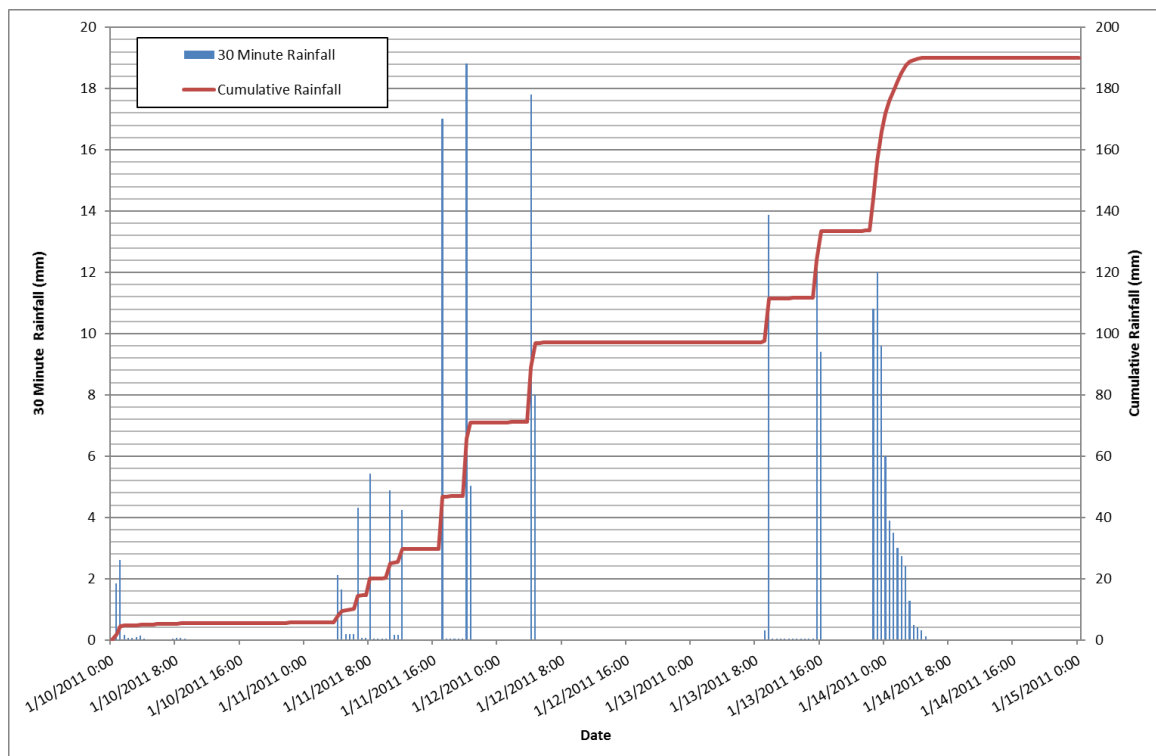


Figure 2-7 Rainfall temporal pattern: Concongella Creek @ Stawell



3 INFRASTRUCTURE

3.1 Storages

There are no major storages (e.g., lakes, lagoons, basins wetlands) located in the study area. There are several large farm dams and one waste treatment plant within the study area; however, these are not expected to impact the hydrology assessment and were modelled within the hydraulic model.

3.2 Hydraulic Structures

3.2.1 Bridges

Three bridges have been also from the NGSC Assets Database in the study area of the Great Western township, these include:

Table 3-1 Great Western bridges

Crossing	Structure Type	Asset ID	Material Type
Concongella Creek			
Bests Road	Bridge	BRG124970	Triple Cell Full RC U-Slab Bridge
Sandy Creek Road	Bridge	BRG124993	Triple Cell Full RC U-Slab Bridge
Rennie Street	Bridge with culvert and endwalls	BRG124893	Small RC Bridge - Culvert with RC endwalls at both ends

3.3 Road and Drainage Infrastructure

Stormwater network data was obtained also from the NGSC Assets Database and will be used to improve modelling accuracy. The following data remains outstanding and will be sourced from NGSC or measured during the site inspection:

- Pits:
 - Main Street – Stephenson Street x 5
 - Paxton Street x3
 - Cubbit Street x9
 - Rennie Street x5
 - Locke Street x10
 - Stephenson Street x12
- Pipes
 - Main Street – Stephenson Street x4
 - Paxton Street x3
 - Cubbit Street x 9
 - Rennie x5
 - Locke Street x10



■ Stephenson Street x12

Details of any additional stormwater network data required (including culverts, pits and pipes) were to captured through photographs and measurements during the site visit. This level of accuracy is sufficient for the hydraulic modelling stage of the project.

Table 3-2 Great Western stormwater network

Crossing	Structure Type	Asset ID	Material Type	Size (mm)
Locke Street	Box Culvert	CUL126329	Single Cell Precast RC Pipe	900
Mount View Road	Box Culvert	CUL126642	-	
Moyson-Great Western Road	Pipe Culvert	CUL126344	Triple Cell Precast RC Pipes and Endwalls	1050
Delahoy Road	Pipe Culvert	CUL126281	Grouted stone & concrete floodway, drop structure with RC Pipe	300
St Ethels Road	Box Culvert	CUL126392	Twin cell Precast RC box culvert with RC floodway	1200 x 450



3.4 Topography and Survey Data

3.4.1 LiDAR Data

3.4.1.1 Overview

Four (4) LiDAR datasets were initially available for the study area including:

- 2005 WCMA LiDAR (flown Jan 2005) – 0.5m vertical accuracy
- 2010-11 Floodplains LiDAR Stage 2 - North Central CMA (flown Jun to Aug 2011) – 1m resolution with 0.1m vertical accuracy
- 2009-10 Victorian State Wide Rivers LiDAR Project - North Central CMA (flown Jan-Oct 2010)
- 2009-10 Victorian State Wide Rivers LiDAR Project – Wimmera CMA
 - This 1m LiDAR was flown for the state wide mapping project undertaken in 2009-12 to accurately map the riparian vegetation and physical form components (metrics) of the Index of Stream Condition (ISC). It has a vertical accuracy of 0.2m and a horizontal accuracy of 0.3m and covers

NGSC sourced photogrammetry data, this data was reviewed and compared and verified to the available LiDAR as detailed in R02, the Model Development and Calibration Report.

3.4.1.2 LiDAR verification

Verification of the available LiDAR and photogrammetry will be undertaken post discussion with NGSC on the available survey and supply of the photogrammetry.

3.4.2 Flood Level Survey

No existing floor level survey is available at the time of writing this report. NGSC will obtain flood level survey data through contractors after a preliminary modelling is completed.



4 HYDROLOGICAL AND HYDRAULIC MODELLING METHODOLOGY

4.1 Overview

The *Western Highway Duplication Project (2016)* produced a detailed hydrologic analysis of the Concongella Creek upstream of Navarre Road (C211) and included a construction of a RORB model. The analysis undertaken during the project was fully reviewed and additional data since 2016 will be included to update the RORB model calibration. The design modelling approach update was consistent with the recommendations of Australian Rainfall Runoff 2019 (ARR2019) to give revised design flow estimates.

The Great Western Flood Investigation hydraulic modelling will be completed in TUFLOW HPC and the TUFLOW model from the *Western Highway Duplication Project* will be used and updated as required. This section will detail the methodology for the hydrology revision and hydraulic model builds, calibration and design modelling for the Concongella Creek catchment.

4.2 Hydrological modelling

4.2.1 RORB Model Revision and Modification

The RORB model developed during Western Highway Duplication Project will be suitable for use in this project with minor updates required. A preliminary review of the RORB model method as detailed in the HARC report indicated the approach was in line with the recommendations of the latest Australian Rainfall and Runoff (ARR2019). The model will be refined with additional detail added to the local catchments contributing to Great Western.

In general, the recommended loss values in ARR2019 have been found to be on the high side (when comparing to calibrated RORB model losses), this will be considered as will the Victorian Specification information commissioned by Melbourne Water and DEECA regarding application of pre-burst rainfall (http://data.arr-software.org/vic_specific).

4.2.2 Hydrological Modelling Calibration

The RORB model was calibrated by modification of the routing parameter k_c and varying the initial and continuing losses. The process involved comparison of modelled and observed flood hydrographs at the Concongella Creek gauge at Stawell, and adjusting the k_c and loss values to reproduce both the observed peak flow and event volume.

RORB was run for the design events using the ensemble approach for a range of durations and AEPs. The new RORB hydrograph selector tool will be used to extract the model hydrographs. The new tool has been built into RORB and completes a similar process to that which Water Technology has been applying to recent flood studies manually. This allows the user to select the most appropriate hydrograph from the ensemble series to apply for design purposes.

The above approach was undertaken for all key locations in the model, including hydraulic model inflow boundary locations, key at risk sites and streamflow gauge locations. The critical durations and temporal pattern combinations will then be selected for modelling in the hydraulic model.



4.3 Hydraulic Modelling

4.3.1 Hydraulic Model Development

An updated hydraulic model of the Great Western township was produced for this investigation. The required modelling extent covers the township and areas directly upstream and downstream, and importantly the local catchment draining towards the township.

The modelling utilised the TUFLOW (HPC) hydraulic modelling package. All key bridges, culverts, pipes and pits were included in the TUFLOW hydraulic model as detailed 1D or 2D hydraulic structures.

Major inflow boundaries were applied at the upstream extent of the model on Concongella Creek and Hyde Park Creek. The upstream boundary on Concongella Creek is located upstream of Western Highway close to Grellet Road and the Hyde Park Creek between Moyston-Great Western Road and St Georges Road.

A series of industry standard roughness values were applied to the various roughness types identified by analysis of aerial imagery and Vicmap planning layers.

The downstream boundary was located approximately 3.1 km downstream of the Great Western township and will utilise a TUFLOW 2D HQ boundary which will allow the water to leave the model without having to set a boundary level.

4.3.2 Hydraulic Model Calibration

As identified earlier, there is minimal historic survey or flood marks to calibrate to, therefore the hydraulic validation process will be undertaken based on one historic flood event (January 2011) and the draft 1% AEP flood mapping. An additional October 2022 flood event may also be used for calibration. This will be presented at a later community meeting and also discussed with the WCMA and NGSC.

4.4 Design Event Modelling

Design flood hydrographs for the 20%, 10%, 5%, 1%, 0.5% and 0.2% Annual Exceedance Probabilities (AEP) and 1 in 2000 Annual Recurrence Interval (ARI) flood events including climate change modelling for 20%, 10% and 1% AEP flood events, and the Probable Maximum Flood (PMF) at key inflow locations to the hydraulic model were derived using the calibrated TUFLOW model and appropriate design modelling parameters.



5 SUMMARY

This report has detailed the data captured as part of the initial data collation and review process, including rainfall, topographic and hydraulic structure data, to be used in the Great Western Flood Investigation. There were several datasets still required while this report was in draft: however, these were sourced prior its finalisation. This data includes:

- Photogrammetry data currently being processed by NGSC.
- Topographic verification data in the form of feature survey.
- Structure data for drainage assets.

Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800

Sydney

Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150
Telephone (02) 9354 0300

Brisbane

Level 5, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460

Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000

Perth

Level 1, 21 Adelaide Street
Fremantle WA 6160
Telephone (08) 6555 0105

New Zealand

7/3 Empire Street
Cambridge New Zealand 3434
Telephone +64 27 777 0989

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Geelong

51 Little Fyans Street
Geelong VIC 3220
Telephone (03) 8526 0800

Wimmera

597 Joel South Road
Stawell VIC 3380
Telephone 0438 510 240

Gold Coast

Suite 37, Level 4, 194 Varsity Parade
Varsity Lakes QLD 4227
Telephone (07) 5676 7602

watertech.com.au

