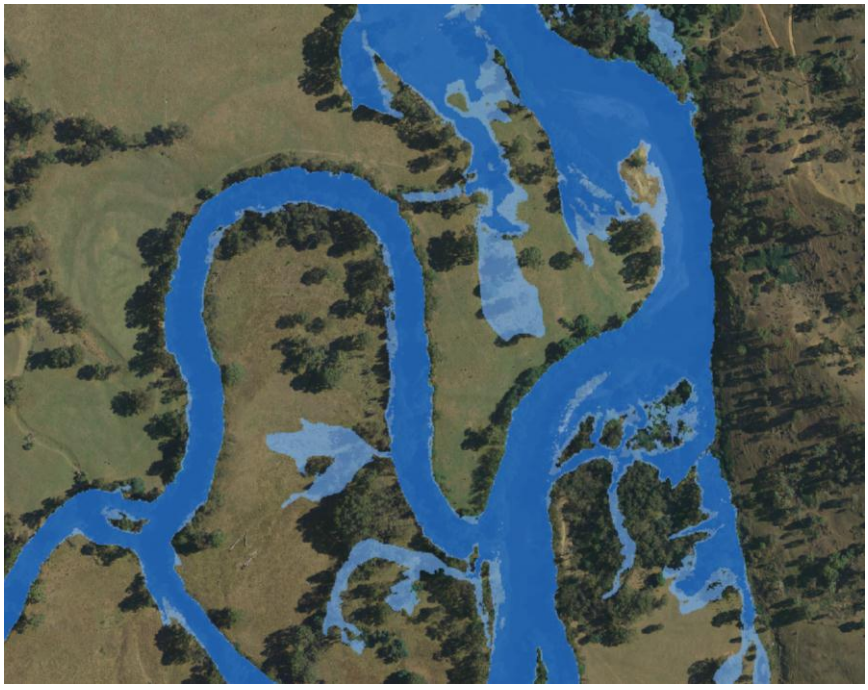
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Mid Goulburn River Elevation Analysis Final Report



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PROJECT DETAILS

Project Name	Mid Goulburn River Elevation Analysis
Client	Goulburn Broken Catchment Management Authority
Client Project Manager	Simon Casanelia
Water Technology Project Manager	Georgina Race
Report Authors	Georgina Race, Richard Connell
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Cover Photo: Interpolated inundation extent from modelled flows, Mid Goulburn River.

15 Business Park Drive
Notting Hill VIC 3168

Telephone (03) 9558 9366
Fax (03) 9558 9365

ACN No. 093 377 283
ABN No. 60 093 377 283

EXECUTIVE SUMMARY

The flows in the mid Goulburn River are regulated through releases from Eildon Reservoir. The Goulburn Broken CMA (GB CMA) is investigating how environmental water can be delivered to inundate wetlands along the mid Goulburn River floodplain without impacting on private and public assets. A trial release of 7,000 ML/d and 9,000 ML/d flows was undertaken between the 16th and 24th November 2011 and water levels were monitored at 13 sites. Water Technology was commissioned by Goulburn Broken CMA (GBCMA) to undertake an analysis of river water levels for these flows and out-of-bank inundation, particularly in relation to private land and wetlands within the study area defined as the Mid Goulburn River floodplain and the Rubicon River, Acheron River, Home Creek, Spring Creek and Yea River floodplains

The specific objectives of the project were to identify areas along the private land boundary that may be at risk from inundation from high river flows and the hydrological connection of wetlands to the Goulburn River. It is important to note that the project scope specifically did not include hydrological modelling and inundation was inferred from a comparison of water levels and the DEM at specified locations.

The data sources include a range of GIS data sets and hydrological data provided by GBCMA and/or sourced directly by Water Technology. The primary Digital Elevation Model (DEM) used was the 1 m ISC River DEM which was supplemented in areas by the 5 m Mid Goulburn DEM.

Water level profiles for the two release flows were developed using 13 monitoring sites set up by Thiess to monitor the trial environmental flow releases from Eildon in November 2011; and the flow profiles extracted from the Mid Goulburn hydraulic model, developed by Water Technology for the GBCMA in 2010.

The water level profiles were applied to generate a water surface elevation data overlay which was used to investigate out of bank inundation along the private land boundary and wetlands along the mid Goulburn floodplain.

Public and private land was delineated using a combination of the cadastral data set and the public land data set. The ground elevation along this boundary was compared to the water levels and points of land below the water levels highlighted in both the mapping and longitudinal section outputs.

A review of the wetlands data set was undertaken with the most recent aerial imagery and DEM data sets to verify the location and extent of mapped wetlands and to undertake any required spatial adjustment of their location. Shortest flow path analysis from each wetland to the river channel was undertaken using advanced hydrological analysis tools within ArcGIS. The commence-to-flow thresholds were derived for the directly connected wetlands. The outputs from this analysis included a GIS data set of the wetland flow paths to the river and the commence-to-flow thresholds.

All source data and results from the analysis have been collated into a Project GIS. This has been provided separately to the GBCMA as an ArcReader application, along with the project maps and longitudinal sections.

The analysis of commence-to-flow and out-of-bank inundation indicates that 43 wetlands are likely to be inundated with a 7,000 ML/d flow and a further 8 wetlands (55 in total) are likely to be inundated with 9,000 ML/d flows. A total of 146 ha of private land may be inundated with 7,000 ML/d flows compared to 498 ha of public land. With 9,000 ML/d flows, a total of 240 ha of private land and 558 ha of public land may be inundated.

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1. INTRODUCTION

1.1 Project background

The flows in the mid Goulburn River are regulated through releases from Eildon Reservoir. The Goulburn Broken CMA (GB CMA) is investigating how environmental water can be delivered to inundate wetlands along the mid Goulburn River floodplain without impacting on private and public assets. A trial release of 7,000 ML/d and 9,000 ML/d flows was undertaken between the 16th and 24th November 2011 and water levels were monitored at 13 sites. Water Technology was commissioned by Goulburn Broken CMA (GBCMA) to undertake an analysis of river water levels for these flows and out of bank inundation, particularly in relation to private land and wetlands.

The study area is defined as the Mid Goulburn River floodplain and the Rubicon River, Acheron River, Home Creek, Spring Creek and Yea River floodplains as shown in Figure 1-1 below.

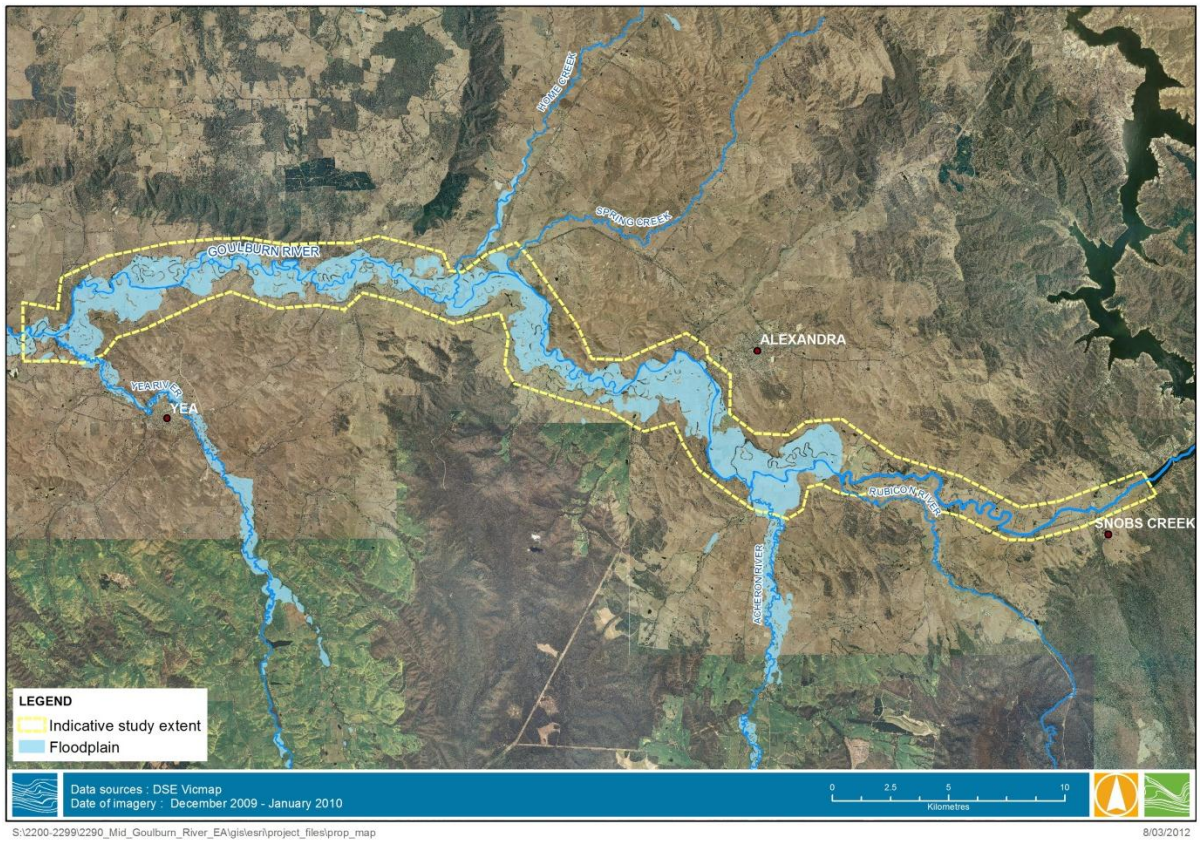


Figure 1-1-1 Project study extent

The specific objectives of the project were to identify areas along the private land boundary that may be at risk from inundation from high river flows and the hydrological connection of wetlands to the Goulburn River. In addition to this report, the project deliverables include GIS based information, maps and longitudinal section plans. It is important to note that the project scope specifically did not include hydrological modelling and inundation was inferred from a comparison of water levels and the DEM at specified locations.

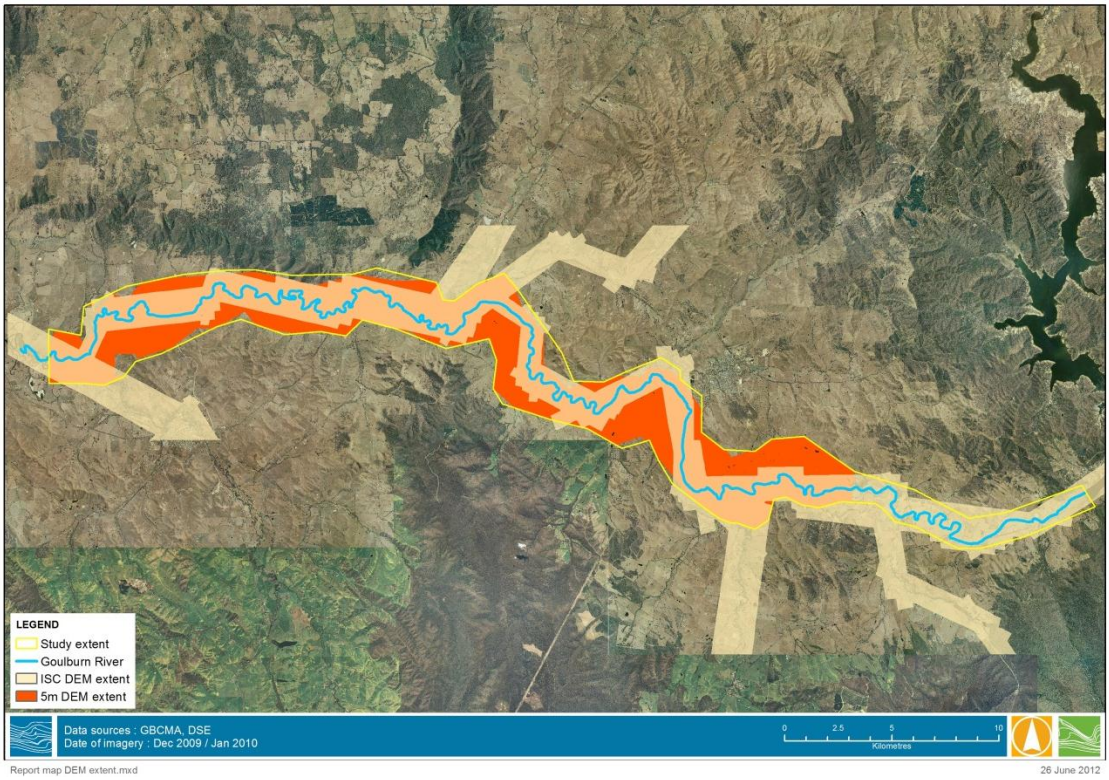
1.2 Data sources

Key data inputs are listed in Table 1-1 below. The data sources include a range of GIS data sets and hydrological data provided by GBCMA and/or sourced directly by Water Technology. The primary Digital Elevation Model (DEM) used was the 1 m ISC River DEM which was supplemented in areas by the 5 m Mid Goulburn DEM. The project analysis area has been limited to the extent of the DEM data within the indicative project extent (shown in Figure 1-2).

Table 1-1 Data sources

Data	Data set name	Source
1 m digital elevation model	ISC River DEM (2010)	DSE / GBCMA
5 m digital elevation model	Mid Goulburn Study DEM (2007)	GBCMA
Wetlands	Wetlands 1994	DSE
Public land	PLM25	DSE
Cadastre	Vicmap Parcel View	DSE
Running distances	VFD Running distances	Victorian Flood Database, DSE
15 cm Imagery	ISC Imagery (Feb 2010)	DSE
50 cm Imagery	CIP Landcover Imagery (2010)	DSE
Goulburn River water level monitoring data	Goulburn River Benchmarks, Environmental Flow Monitoring (November 2011)	GBCMA / Thiess
Mid Goulburn Hydraulic Model	Mike21 Hydraulic Model	GBCMA / Water Technology

Figure 1-1-2 DEM extents



2. METHODOLOGY

2.1 Hydrology

A water surface elevation (WSE) GIS overlay was developed for the 7,000 ML/day and the 9,000 ML/day flows. The key data inputs for developing the WSE overlay were:

- The 13 monitoring sites set up by Thiess to monitor the trial environmental flow releases from Eildon in November 2011; and
- The flow profiles extracted from the Mid Goulburn hydraulic model, developed by Water Technology for the GBCMA in 2010.

This analysis required the fitting of the 13 monitoring sites to the modelled water level profiles for the Mid Goulburn. The main challenge encountered was that the trial flows were below the minimum environmental flows modelled (20,000 ML/day). The approach adopted the water level profile from the 20,000 ML/Day scenario and adjusted it to fit the 13 monitoring sites. The difference in water level between the 20,000 ML/day modelled scenario and the 7,000 and 9,000 ML/Day trial flows were calculated at each monitoring site. The difference in water level was linearly interpolated between each monitoring site and then subtracted from the modelled water level profile for each trial flow scenario.

Using the fitted model profile, water levels were extracted for 1 m postings along the Goulburn River. These levels were extrapolated across the study area and a WSE Grid data set was developed for the two flow scenarios. An indicative inundation layer was derived for the analysis extent by subtracting the DEM from the WSE. This layer was refined by removing the unconnected low lying areas. The inundation layer derived from this analysis has been included in the project maps.

2.2 Private land analysis

Public and private land was delineated using a combination of the cadastral data set and the public land data set (refer to Table 1-1). A private land boundary GIS data set was then derived by tracing the boundary of public land along the right and left bank of the Goulburn River. The boundary was extrapolated across small widths of public land where roads and waterways intersected the boundary. In addition, the boundary was shifted away from the river where the boundary of the private land fell within the banks of the river.

One metre points along the boundary were developed and the DEM elevation and the Water level from each flow were extracted for 1 m postings (points) along the left and right bank boundaries. The ground elevation was compared to the water levels and points of land below the water levels highlighted in both the mapping and longitudinal section outputs.

2.3 Wetlands analysis

A review of the wetlands data set was undertaken with the most recent aerial imagery and DEM data sets to verify the wetlands and to undertake any required spatial adjustment of their location. The majority of wetlands were moved to better match their location as represented in the DEM and/or imagery.

Shortest flow path analysis from each wetland to the river channel was undertaken using advanced hydrological analysis tools within ArcGIS. The flow paths indicated the chain of low points with the DEM between the wetland and the river and effectively defined the channel between the river and wetland. The wetlands were either directly connected to the river or were connected to the river via one or more other wetlands. The flow paths were then analysed to identify the elevation of the commence-to-flow threshold, being defined as the **maximum** height along the path. The

commence-to-flow thresholds were only derived for the directly connected wetlands, as inundation and flows between wetlands are dependent on complex hydraulic interactions between the river and floodplain. This floodplain/wetland behaviour can only be effectively mapped using detailed hydraulic modelling and is beyond the scope of this project.

The outputs from this analysis were a GIS data set of the wetland flow paths to the river and the commence-to-flow thresholds. These are included in the project map outputs.

3. RESULTS

3.1 Hydrology

The indicative inundation extents for 7,000 ML/d and 9,000 ML/d release flows are included in the project maps and an example of the data is shown below in Figure 3-1, along with unconnected low lying areas.

The resulting water level profiles for the environmental flows are shown in Figure 3-2 and Figure 3-3. These show a comparison of the adjusted modelled water level profile to the basic linear interpolated water level profile. The modelled profile provides a better estimate of the water level profile and illustrates the change in grade of the water profile between the monitoring sites.

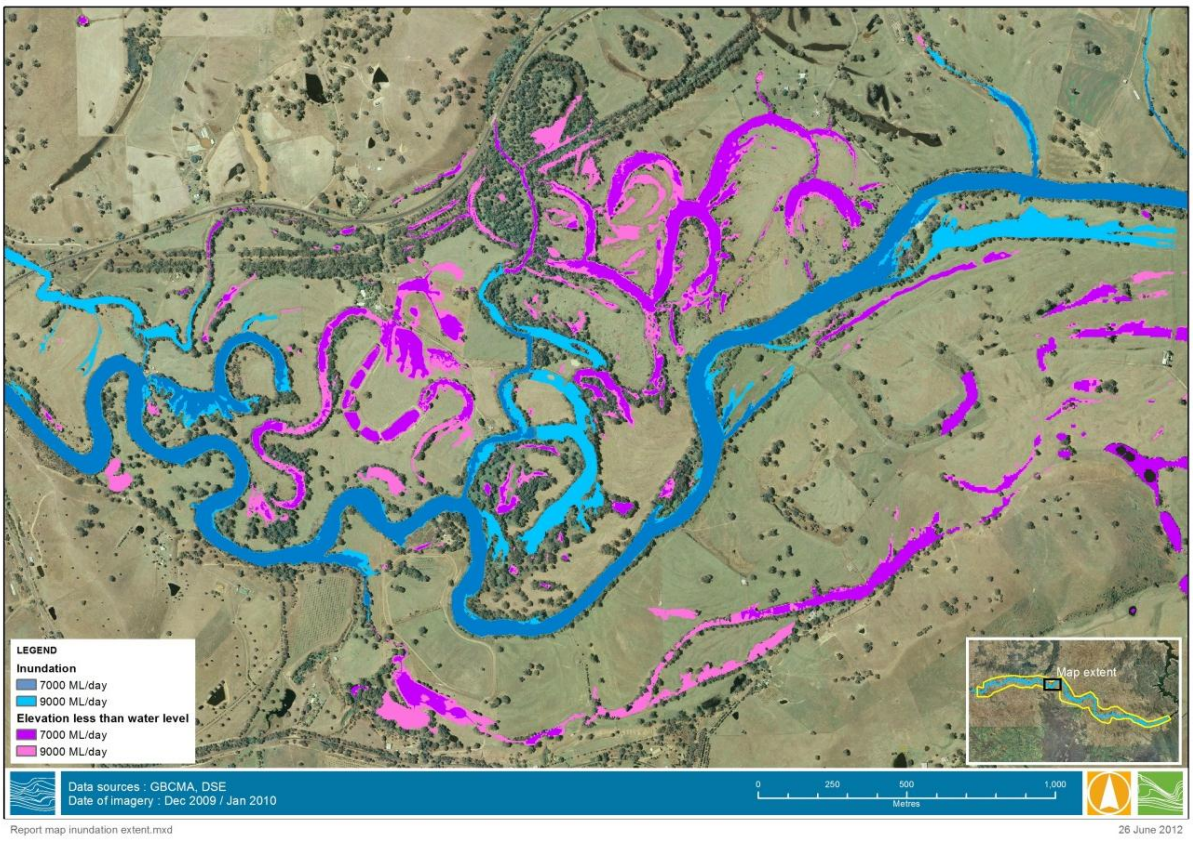


Figure 3-1 Example of inundation & unconnected low lying land

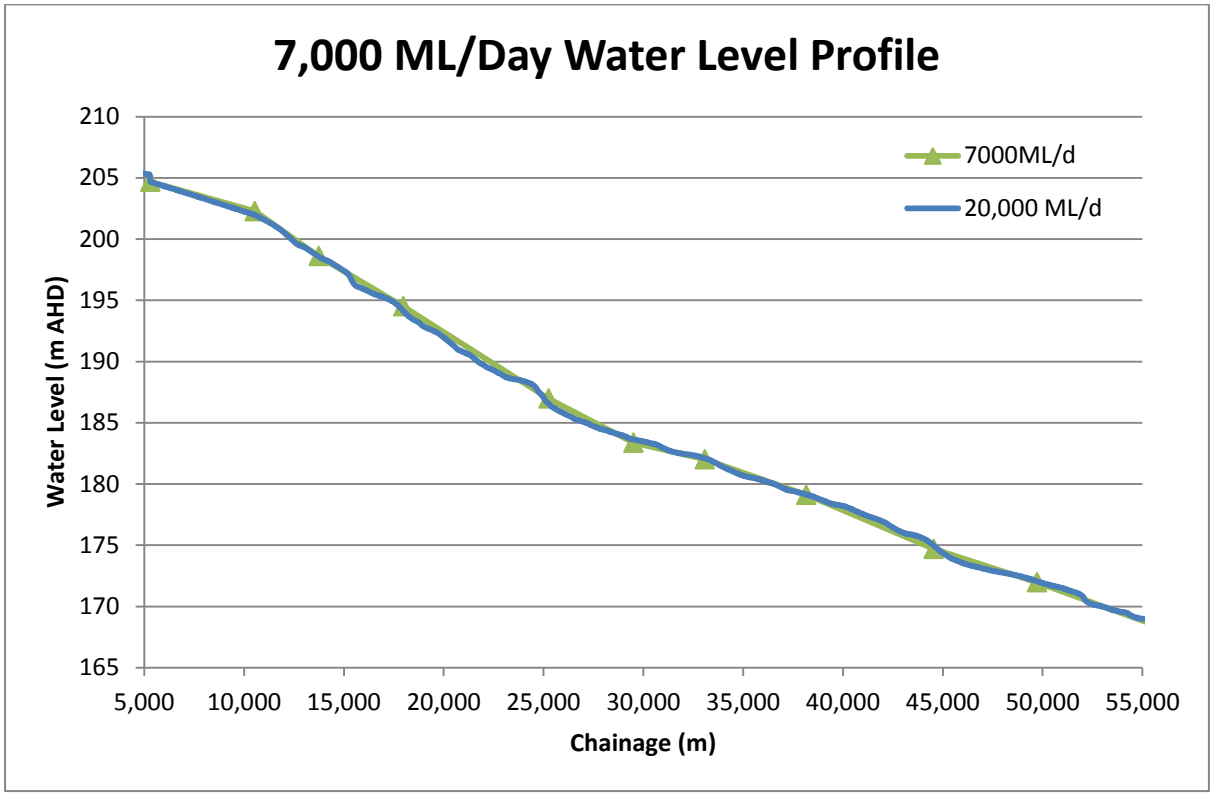


Figure 3-2 Water Level Profile for 7,000 ML/Day

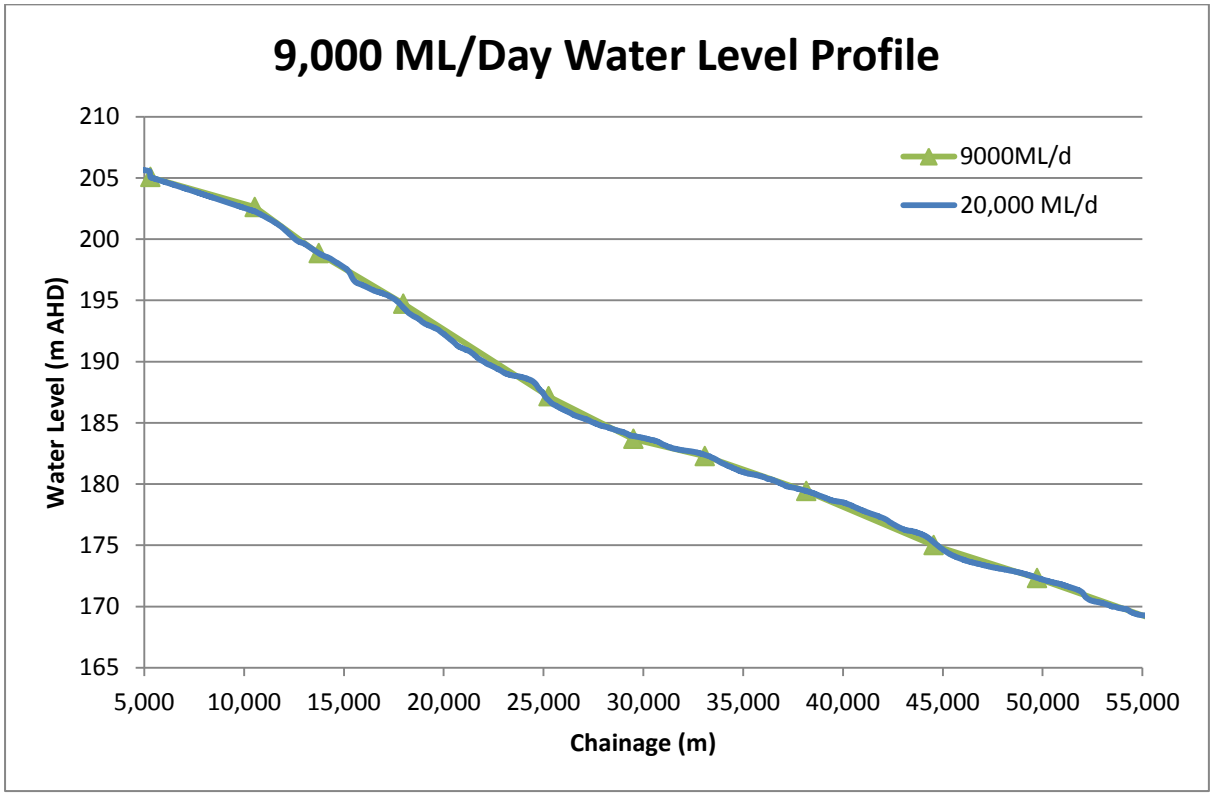


Figure 3-3 Water Level Profile for 9,000 ML/Day

3.2 Private land analysis

The private land boundary extends 85.96 km along the right bank and 84.46 km along the left bank of the Goulburn River. Points lying below the modelled water levels are highlighted in the project maps and the longitudinal sections. The extents of public and private land in the study area are shown in Figure 3-4. It should be noted that when interpreting the longitudinal sections, low lying property boundaries should be cross-referenced to the maps to understand the proximity and flow path between the land boundary and the river. In some cases low lying property boundaries may be protected by high banks and therefore not necessarily at risk of a breakout.

3.3 Wetlands analysis

A total of 210 wetlands have been mapped on the Goulburn River floodplain within the project analysis extent in the Wetlands 1994 data set. Of these, the locations of 191 wetlands were adjusted to better match the imagery and DEM. An example of the wetland adjustment is provided in Figure 3-5.

Forty percent (83) of the floodplain wetlands have been identified as being directly connected to the Goulburn River and commence-to-flow elevations have been recorded on the project maps. An example of the results of the flow path and commence to flow analysis is provided in Figure 3-6.

3.4 Project outputs

All source data (listed in Table 2-1) and results from the analysis have been collated into a Project GIS. This has been provided separately to the GBCMA as an ArcReader application, along with the project maps and longitudinal sections.

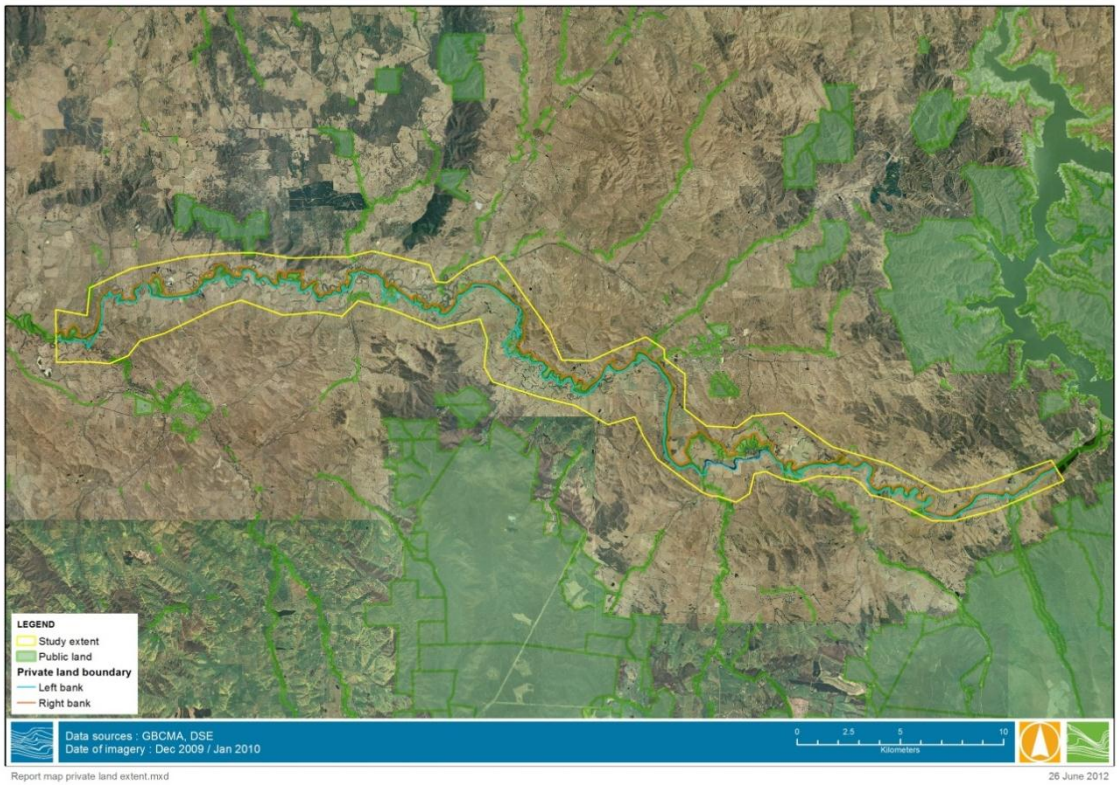


Figure 3-4 Private land boundary

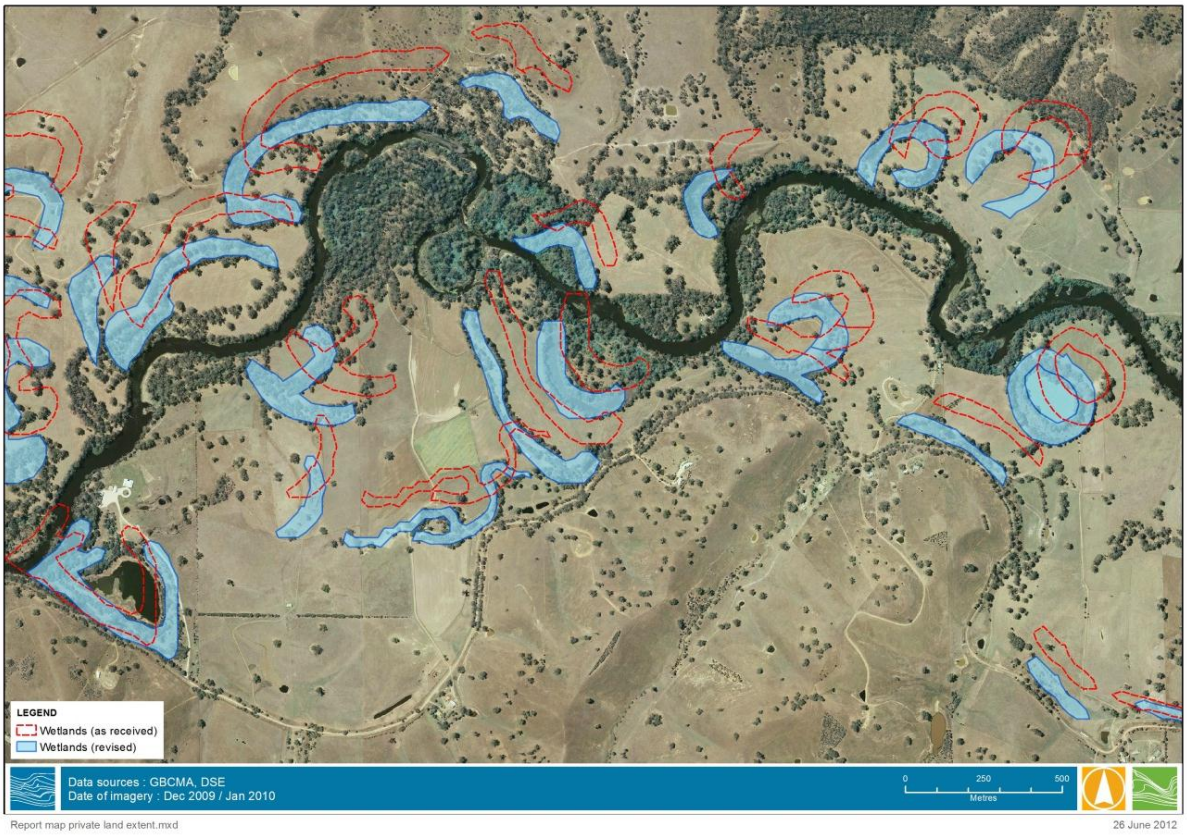


Figure 3-5 Example of the adjustment of the source Wetlands 1994 data layer.

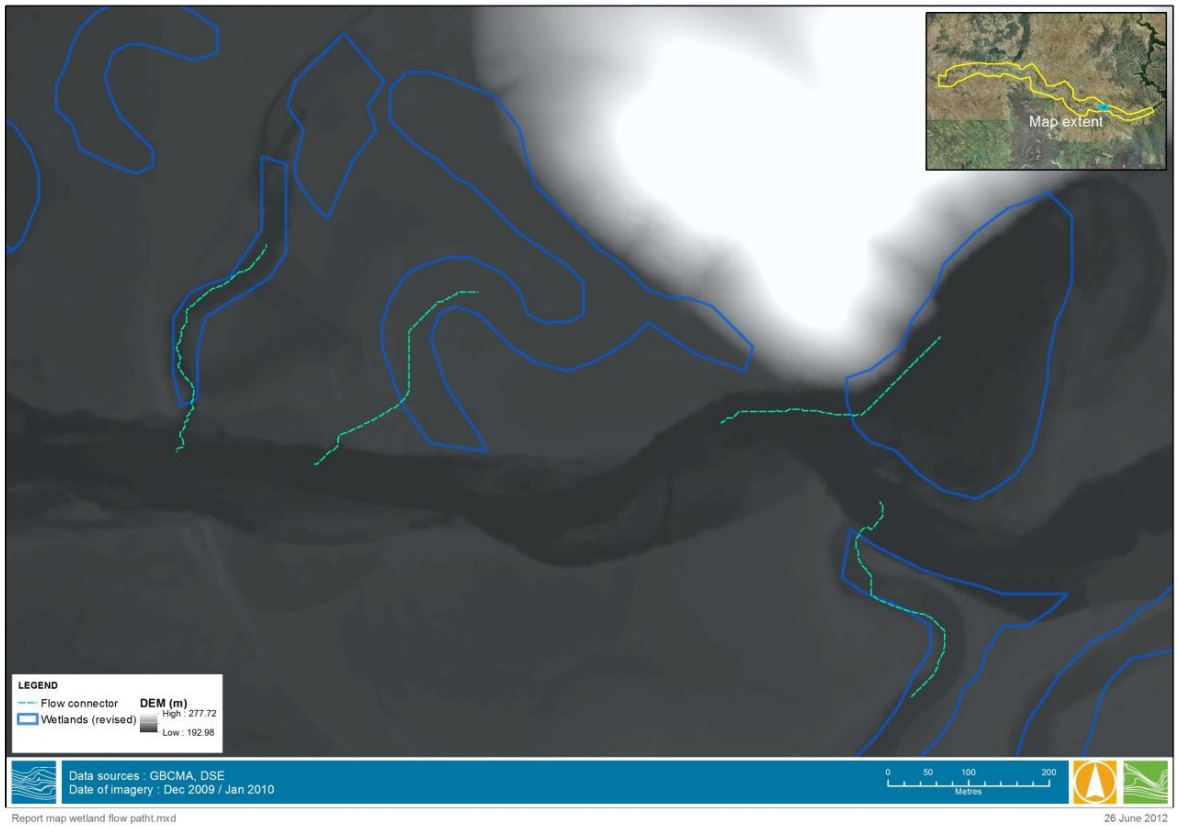


Figure 3-6 Example map of wetland flow paths and the DEM

4. CONCLUSIONS

4.1 Accuracy and limitations of the analysis

The project has been limited to identifying areas of potential inundation by applying GIS analysis methodologies. The data has been matched to the 1 m ISC DEM which has a vertical accuracy of +/- 10 to 20 cm and orthorectified aerial imagery with a nominal horizontal accuracy of 1 m.

The wetlands analysis has been based on the Wetlands 1994 GIS data set. No ground-truthing of the wetland mapping has been undertaken and while this project has improved the location accuracy of the mapped wetlands, it did not set out to map and/or validate the wetlands. Furthermore there may be additional wetlands in addition to those identified in the Wetlands 1994 data set. A desktop and field ground-truthing exercise is required to more accurately map and characterise the wetlands of the floodplain.

The spatial accuracy of the cadastral GIS data set may be +/- 20 m or more. In addition it appears that sections of the river may have changed course significantly since the original land titles were set-out, as the present river channel in some locations runs entirely within private land. Some land titles are defined by an offset from the river channel and therefore, due to channel migration over time, may require an adjustment of the river frontage title boundary. An example of this issue is shown below in Figure 4-1. A detailed review of the titles and land boundaries is required to confirm the status of the river frontage land.

A key limitation of the study is that no new hydrological and/or hydraulic modelling has been undertaken. Such modelling could enhance the detailed understanding of wetland inundation patterns and processes at a local scale. For this project, the applied method is considered to provide a robust and reliable outcome at the reach scale which is appropriate for the study outcomes.

Figure 4-1 Land boundary issues

4.2 Key findings

The analysis of commence-to-flow thresholds and out-of-bank inundation indicates that 43 wetlands are likely to be inundated with a 7,000 ML/d flow and a further 8 wetlands (55 in total) are likely to be inundated with a 9,000 ML/d flow in the Goulburn River through the study area. These represent 20 – 26 % of the wetlands mapped on the mid Goulburn River floodplain.

A total of 146 ha of private land may be inundated with a 7,000 ML/d flow along with 498 ha of public land. With a 9,000 ML/d flow, a total of 240 ha of private land and 558 ha of public land may be inundated. However, noting the land title and boundary issues raised in Section 4.1, any quantification of the land areas based on the currently available GIS data sets should be considered indicative only and subject to clarification of land title boundaries.

Commence-to-flow analysis for directly connected wetlands could be applied in other areas where high resolution DEMs exist and may be useful at a regional scale to better understand wetland hydrologic regimes. However, detailed modelling is required to investigate the complex hydrology of floodplain wetlands which represent 60% of the wetlands in the study extent. Much of this information is already available for the Goulburn River downstream of Eildon. There are many benefits in applying a detailed hydraulic modelling approach for environmental flow purposes, including:

- ability to understand the dynamic nature of river/wetland hydrologic regimes (i.e. commence-to-flow thresholds, flow capacity constraints, volume-to-fill, impact of different river hydrographs on ability to inundate wetlands, duration of inundation, etc.).
- ability to understand variability over an entire reach rather than a discrete number of indicator sites.
- ability to understand a wide range of flood related impacts associated with water delivery.
- ability to link some of these hydrologic/hydraulic parameters to ecological response (i.e. how does duration of inundation impact recruitment of vegetation or bird breeding, etc.).

Remote sensing techniques may be able to be applied to track and verify the performance of environmental flow delivery over time through inundation patterns and/or vegetation response.