GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

Goulburn River Environmental Flow Hydraulics Study

Asset Mapping – Data Collation and Review

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PROJECT DETAILS

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1. INTRODUCTION

Goulburn Broken CMA has commissioned the Goulburn River Environmental Flow Hydraulics Study. This project is required to undertake hydraulic and hydrologic modelling of the Goulburn River from Lake Eildon to the River Murray.

The study brief outlines the following project tasks:

1. Data collation and review – Collation and review of the available topographic and streamflow data information.
2. Topographic data gap identification – Identify the gaps in the available topographic data, and suggest potential mediation options.
3. Asset mapping – Locate and map known public and private assets along the Goulburn River and adjacent surrounds.
4. Hydrologic analysis – Investigate relative contribution from downstream tributaries, and assess design flood hydrographs for the Goulburn River catchment.
5. Hydraulic analysis and flow behaviour – Assess flow behaviour of the Goulburn River over a range of potential environmental flows.
6. Socioeconomic assessment – Evaluate the social and economic costs of potential Goulburn River environmental flows.
7. Real time flow management – Review and scope real time flow management framework.
8. Management option assessment – Scope feasibility of management options for environmental flow releases.

This report addresses the third project task, and documents the collation and review of asset mapping databases.

Public and private assets along the Goulburn River and its floodplain may be affected during periods of high flows. Assets can be classified as economic, social or environmental. The costs and benefits due to inundation are being evaluated by URS, as part of the socio-economic assessment.

The key objective of this task is to spatially locate a range of assets on the floodplain to match to the areas computed to be inundated by the hydraulic models. Accuracy of asset location is important as it needs to align with the floodplain elevation data to allow reasonable asset inundation prediction. The nature of the asset is important to determine benefit or damage incurred for different flooding regimes.

The sources of the asset databases have principally been through the Goulburn Broken Catchment Management Authority (Goulburn Broken CMA). It is understood Goulburn Broken CMA principally sourced the asset database through Department of Sustainability and Environment (DSE).

Reliable and suitable asset data is integral to the asset mapping component of this project, and the subsequent socioeconomic assessment. The accuracy of the asset mapping is inherited from the asset data.

The structure of this report is as follows:

- Section 2: Outlines available asset mapping data collated
- Section 3: Comments on the spatial accuracy of selected key assets
- Section 4: Discusses alternative approaches to delineating wetlands and building features

2. ASSET DATA COLLATION

2.1 Overview

This section identifies relevant asset layers and their available metadata. Sources of this data are:

- Goulburn Broken CMA
- Department of Sustainability and Environment
- Department of Primary Industries
- Country Fire Authority

2.2 Database source

The Victorian Spatial Data Directory (VSDD) was used to source appropriate asset and environmental layers. This provides a good starting point as all government maintained spatial information is catalogued here.

Most of the relevant layers to this study are maintained by the DSE, although other state government departments, such as the Department of Primary Industries, make their data available.

A list of the most suitable layers was created. Important considerations included:

- The layer's relevance to this study
- How recently the layer was updated
- If it continues to be updated and maintained
- Spatial accuracy

These layers were requested from the DSE, and provided to Water Technology by the Goulburn Broken CMA, as ESRI feature classes.

2.3 Relevant database and layers

Table 2-1 outlines the relevant databases/layers. Relevance was determined by the study outcomes, and any limitations of the data provided.

Most layers obtained were quite accurate and subject to ongoing maintenance, particularly cadastral and planning layers (including roads, rail lines, and utilities).

Environmental layers are inherently more difficult to accurately define, as there is usually not a clear and measured boundary which defines the feature's extent. For instance the native vegetation layer and its constituents will be more difficult to quantify accurately than cadastral data. Environmental extents are also usually more 'fuzzy' and dynamic than most cadastral and planning boundaries. Many of these environmental layers have been digitised from aerial photos or satellite imagery, and so the accuracy of the sensor, as well as the digitising process, needs to be taken into account.

The metadata shown in Table 2-1 was summarised from the VSDD website, and provides good insight into the reliability of these datasets. It should be noted that where some layers have only been 'irregularly' updated since 1995, it is because they are considered complete data sets, and are only updated as changes are made.

Table 2-1 Relevant spatial databases and layers

Layer Name	Brief Description	Positional Accuracy	Last Modified	Maintenance
ACHP_SURVEYS	Archeological survey sites	To be determined	Current	Monthly
CFA Buildings	CFA derived building locations	Unknown	Unknown	Unknown
CL_TENURE	Crown Land	Not Documented	Current	As Required
CULTURE_SEN	Aboriginal Heritage Sites	±30m	2007	Quarterly
FAUNA100	Threatened Fauna	100 - 200m	Current	Updated Annually
FLORA100	Threatened Flora	varies, generally 100m	Current	Updated Annually
HIST100	Non-Aboriginal Sites	Not Documented	Current	As Required
HY_WATER_STRUCT _AREA _POLYGON	Dam Batters, Spillways	±30m	1995	Irregular
IN_BUILDING_AREA _ POLYGON	Building Area's	±30m	1995	Irregular
IN_LANDMARK_AREA _POLYGON	Cemeteries, Parks etc	±30m	1995	Irregular
IN_UTILITY_AREA_ POLYGON	Mines, Quarries etc	±30m	1995	Irregular
IN_UTILITY_LINE	Cableway, Utility	±30m	1995	Irregular
IN_UTILITY_POINT	Tanks, Windmills, etc	±30m	1995	Irregular
lum_gbc_lower	Land use classes for the lower Goulburn	25-100m	2005	Unknown
Lum_gbc_upper	Land use classes for the upper Goulburn	25-100m	2001	Unknown
NV2005_EXTENT	Native Vegetation (modelled)	"Highly accurate"	2007	Not Known
PLAN_OVERLAY	Zone Number etc	±25m (worst case)	Current	Weekly
RECSITE100	Recreational Sites	0.5 - 300m	Unknown	Not Planned
TR_AIR_INFRA_AREA _POLYGON	Airports	±30m	1995	Irregular
TR_RAIL	Railway Yards, Tunnels, etc	±30m	2000	Bi-Annual
TR_ROAD	Bridges, Roads, Tunnels, etc	15 - 60m (worst case)	Current	Continual
TREE_DENSITY	Woody Vegetation >2m tall	15m	2003	Irregular
VICMAP_ADDRESS	Geocoded point addresses	±0.5 - 25m	Current	Continual
VICMAP_FEATURES/ IN_BUILDING_POINT	Public building locations	~8m (worst case ±30m)	1995	As Required
WETLAND_1994	Wetlands > 1Ha.	10 - 100m	1994	Not Planned

3. SPATIAL ACCURACY OF KEY SELECTED ASSETS

3.1 Overview

This section reviews the selected key assets, and discusses problems with their accuracy, and possible ways to work around this so as to avoid digitising. From Table 2-1 nine datasets were seen as most useful to this study. These were:

- WETLAND_94
- NV2005_EXTENT
- CL_TENURE
- lum_gbc_lower/lum_gbc_upper (land use layers)
- CFA BUILDINGS
- VICMAP_FEATURES/IN_BUILDING_POINT
- VICMAP_ADDRESS
- TR_ROAD

3.2 Wetlands

Accurately defined wetlands information forms an important aspect of this study. The wetlands layer provided by the DSE is listed as current, but not very accurate (see Table 2-1). Detailed metadata for the wetlands layer states how this layer was initially defined:

"*Polygons showing the extent and types of wetlands in Victoria based on photography taken during the 1970's and 80's. Wetlands are classified into primary categories based on water regimes and subdivided into sub areas based on vegetation or hydrologic attributes. The polygon boundaries were derived from digitizing marked up aerial photography interpretation."*

(From the VSDD, accessed online on February 24th from: http://www.land.vic.gov.au/VSDDcategory.htm)

The age of the photography will certainly have an impact on the accuracy of the wetlands delineation. It is likely that these images were not orthorectified, resulting in increasing spatial errors radiating outwards from the centre of the photo (assuming the sensor was perpendicular to the ground when the image was taken). Added to this is the difficulty of visually defining the boundaries of wetlands. This dataset is as accurate as can be expected considering how it was created. Unfortunately there is no updated layer using more appropriate and current technologies.

Figure 3-1 shows the wetlands layer overlayed on orthoimagery of the Goulburn River, near Ghin Ghin. Assuming the trees and visible vegetation follow the wetland boundaries, there are considerable and varying discrepancies in some areas.

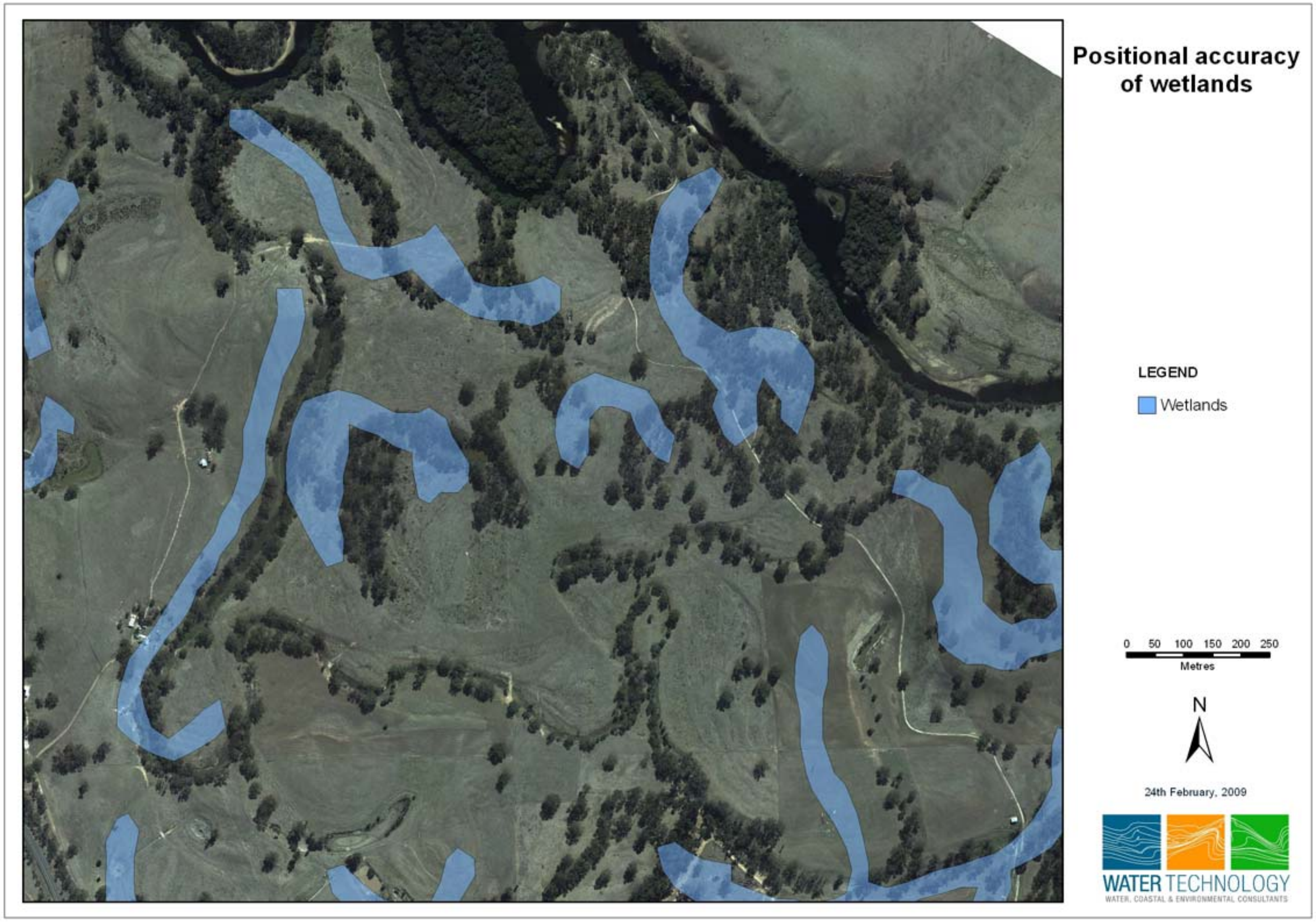

Figure 3-1 Positional Accuracy of the WETLANDS_94 featureclass – Goulburn River near Ghin Ghin

A RAMSAR wetlands layer is available however this was not considered relevant as it only includes the most ecologically significant wetlands in the study area, not all of them.

As this layer is critical to the study, a number of methods were tested to try and define the location of wetlands. Initially delineation efforts focused on the Digital Elevation Model (DEM) of the study area. This 25 m grid DEM was created from 0.25m ALS data which was flown by Fugro for the Goulburn Broken CMA in March 2007. These methods could not be refined, and so wetlands were finally defined from the hydraulic model (refer Section 4.2 for detailed methodology).

3.3 Native Vegetation

Native vegetation was hoped to be used as a means of identifying the locations of wetlands. It was thought some species of vegetation might stand out within significant wetlands. The layer, NV2005_EXTENT was provided by the Goulburn Broken CMA to test this theory. The layer was also to be used to describe the types of vegetation inundated during different flood scenarios.

The native vegetation layer was created by the Arthur Rylah Institute, and is maintained by the DSE. This is a modelled dataset that has been, "*created from time-series(between 1989-2005) Landsat Imagery, many thousands of ground-truthing points, other relevant spatial data and expert validation. The dataset is a good interpretation of native vegetation extent (including aquatic habitat)*" (VSDD website). The layer's positional accuracy is stated to be "highly accurate" (no numerical value available). It appears that the layer was created from a 25m grid, as all boundaries appear blocky. Eight categories of native vegetation are described:

- Possibly native vegetation
- Highly likely native vegetation – grassy
- Highly likely native vegetation – woody
- Highly likely native vegetation – structurally mod
- Wetland Habitat
- Artificial Impoundment
- Exotic woody vegetation

Given the spatial quality of this layer, it was hoped this may provide a reasonable indication of the locations of wetlands, particularly given one of its categories is wetland habitat. It was also hoped this layer could provide an indication of wetland health by describing the types of vegetation present within them.

It was found that on its own, this layer is not useful in locating wetlands. Figure 3-2 shows the wetlands_94 layer overlayed on top of the native vegetation classes. While in some places they appear to coincide well, identifying wetlands is generally only possible if it is already known where they are. This method was not considered comprehensive enough to identify wetland locations. As mentioned, another method was devised, and is discussed in detail in Section 4.2.1.

However, the "highly likely native vegetation – woody" layer provides a reasonable description of the treed areas on the floodplain, one of the key environmental assets being targeted with environmental flooding. Its spatial accuracy is good, and tends to be inclusive of most trees. It does include some small areas that are not treed.

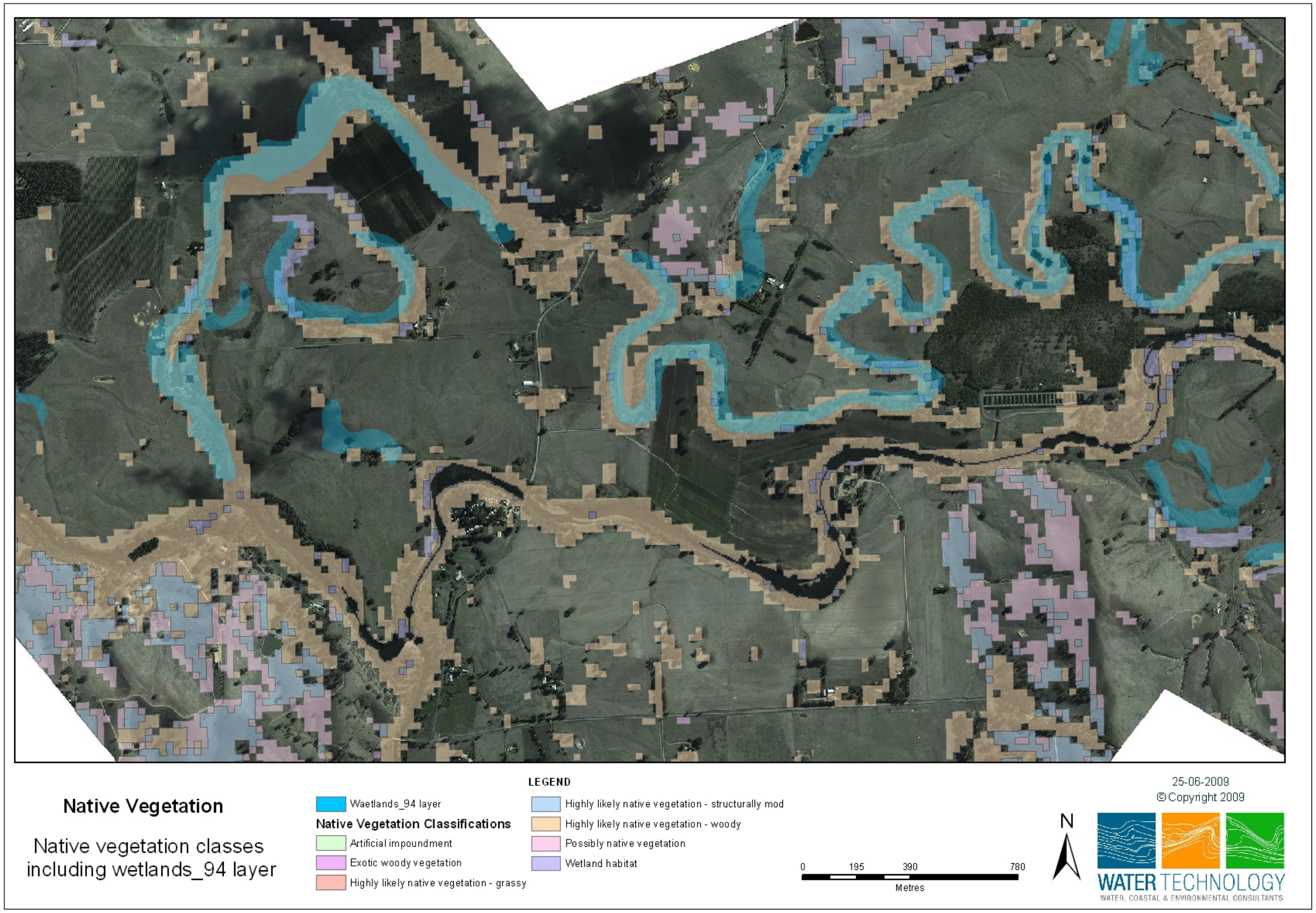

Figure 3-2 Native vegetation classes overlayed with the wetlands_94 layer

3.4 Tenures

Another key aspect of this study is to assess potential damage to economic assets. Originally, the only available information regarding land use was a 'tenure' layer which provides information regarding private use tenures over Crown land. Table 3-1 below lists the key licenses which affect the study area. Two datasets were provided via the Goulburn Broken CMA which negated the need to use this data, however a discussion of the CL_TENURE layer's accuracy is included for completeness.

Table 3-1 Land use – Tenure classes

Tenure Type
CONSERVATION LICENCE - WF
CULTIVATION/GARDEN LICENCE
DIV./REG. MANAGER CONSENT
EMERGENCY SERVICES USE LICENCE
GRAZING LICENCE
INDUSTRIAL/COMMERCIAL LICENCE
MISCELLANEOUS (GENERAL) LICENCE
RADIO/TV/TELECOM LEASE
RECREATION/AMUSEMENT LICENCE
UNUSED ROAD LICENSE
WATER FRONTAGE LICENCE - NON PROD
WATER FRONTAGE LICENCE - PRIM PROD
WATER SUPPLY LICENCE

The tenure layer provides reasonably detailed information regarding Crown land in the study area. To supplement this, planning layers may be used to get a sense of the land use on privately owned land. Unfortunately, no datasets exist which detail how private land is used. Regardless, this would be a difficult layer to keep updated, as changes to land use may occur quickly at the owner's discretion, without having to notify any relevant authorities. Figure 3-3 below provides an example of the land tenure layer near Ghin Ghin, overlayed on the orthoimagery. This area is indicative of the entire study area, where the primary tenures are water frontage licenses, unused roads, and grazing licenses.

As mentioned, this layer was omitted from the study as better data regarding land uses became available through the Goulburn Broken CMA. The accuracy of these layers is discussed below.

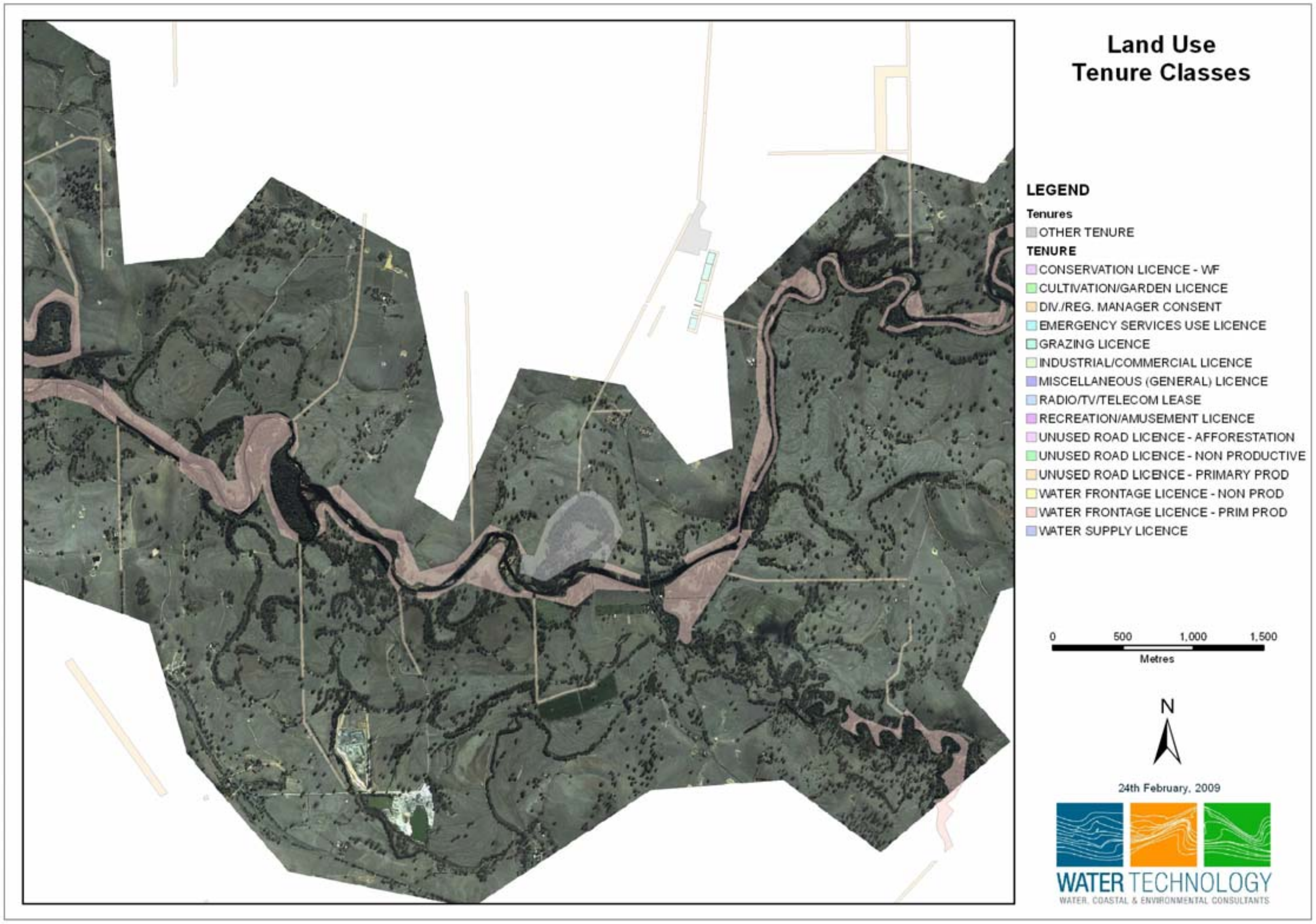

Figure 3-3 Land tenure layer showing relevant tenure classes

3.5 Land Use Layers

The Goulburn Broken CMA provided Water Technology with land use layers for the lower and upper sections of the Goulburn catchment. These were considered a much better solution to using the tenure layer.

The lower Goulburn layer is maintained by the DPI, called, "lum_gbc_lower". The classification scheme used was the Australia Land Use Mapping (ALUM) classification version 5 (BRS, 2001). This layer was derived from a number of sources; "*Corporate Geospatial Data Library (CGDL), DPI regional data sets, VGV Shire Valuation Datasets, SPC-Ardmona surveyed datasets, SPOT imagery, satellite imagery, aerial photography, tree cover and field survey information*" (taken from the layer's metadata). The layer's overall accuracy is still being validated however its positional accuracy is between 25 and 100m.

The upper Goulburn layer is maintained by the Department of Natural Resources and Environment (DNRE). In this layer, land was classified using the Australia Land Use Mapping (ALUM) classification version 4 (BRS, 2001). It was derived from the following sources, "*Corporate Geospatial Data Library (CGDL), DNRE regional data sets, satellite imagery from ACRES, the planning maps from Infrastructure Department, and the newly acquired field survey information*" (from the layer's metadata). The overall accuracy of the layer is stated to be 89.27% and its positional accuracy is 25-100m.

These layers are important particularly for identifying areas of economically productive land uses, which will be most adversely affected in a large flood event.

The different classifications are shown in Table 3-2. There are some inconsistencies where the same classification number is used to define more than one land use, for example 4.4.1 is listed as irrigated cereals and as irrigated tree fruits. This is most likely due to the lower Goulburn being classified using a newer version of the ALUM classification scheme. While it is useful to have so much detail regarding specific land uses, this list will need to be condensed for the economic assessment URS will carry out

When visually verified against the aerial photos, the spatial accuracy of both land use layers appears to be quite good. A number of distinctive, linear features were identified on the aerial photo, and cross check against the land use layers to confirm their accuracy. Figure 3-4 shows the land use classes near over Thornton. As in other data layers, the coverage of assets is not perfect. In particular, dryland and irrigated pastures seem interchangeable. This may reflect the difficulty in identification, or in changing land use patterns in response to recent drought conditions.

For the purpose of this study, it was decided that these two land use layers would be detailed and accurate enough to provide overall statistics on areas of different land use inundation, but would not be accurate enough at a local scale .

Table 3-2 Land use classifications for the upper and lower Goulburn

1.1.1 Strict nature reserves	3.5.3 Tree nuts	5.2.6 Aqaculture
1.1.3 National park	3.5.4 Vine fruits	5.3.0 Manufacturing and industrial
1.1.4 Natural feature protection	3.5.5 Shrub nuts fruits & berries	5.4.0 Residential
1.1.5 Habitat/species management area	3.5.6 Flowers & bulbs	5.4.1 Urban residential
1.1.6 Protected landscape	3.5.7 Vegetables & herbs	5.4.2 Rural residential
1.1.7 Other conserved area	3.6.0 Land in transition	5.4.3 Rural living
1.2.0 Managed resource protection	3.6.1 Fruits	5.5.1 Commercial services
1.2.1 Biodiversity	3.6.2 Nuts	5.5.2 Public services
1.2.2 Surface water supply	4.1.0 Irrigated plantation forestry	5.5.3 Recreation and culture
1.2.4 Landscape	4.1.3 Irrigated plantation nurseries	5.5.4 Defence facilities
1.2.5 Traditional indigenous uses	4.2.0 Irrigated modified pastures	5.5.5 Research facilities
1.3.0 Other minimal use	4.3.0 Irrigated cropping	5.6.0 Utilities
1.3.1 Defence	4.3.0 Irrigated modified pastures	5.6.1 Electricity generation/transmission
1.3.3 Remnant native cover	4.3.2 Irrigated pasture legumes	5.6.2 Gas treatment, storage and transmission
1.3.3 Residual native cover	4.3.3 Irrigated hay & silage	5.7.0 Transport and communication
2.1.0 Grazing natural vegetation	4.3.4 Irrigated sown grasses	5.7.1 Airports/aerodromes
2.1.0 Livestock grazing	4.4.0 Irrigated cropping	5.7.2 Roads
2.2.0 Production forestry	4.4.0 Irrigated perennial horticulture	5.7.3 Railways
2.2.1 Hardwood Production	4.4.1 Irrigated cereals	5.7.5 Navigation and communication
3.1.0 Plantation forestry	4.4.1 Irrigated tree fruits	5.8.0 Mining
3.1.1 Hardwood plantation	4.4.2 Irrigated beverage & spice crops	5.8.1 Mines
3.1.2 Softwood plantation	4.4.2 Irrigated oleaginous fruits	5.8.2 Quarries
3.2.0 Grazing modified pastures	4.4.3 Irrigated hay & silage	5.9.0 Waste treatment and disposal
3.2.1 Woodlots	4.4.3 Irrigated tree nuts	5.9.3 Solid garbage
3.3.0 Cropping	4.4.4 Irrigated vine fruits	5.9.5 Sewage
3.3.0 Grazing modified pasture	4.4.7 Irrigated vegetables & herbs	6.0.0 Water
3.3.0 Grazing modified pastures	4.4.8 Irrigated Legumes	6.1.0 Lake
3.3.1 Cereals	4.5.0 Irrigated perennial horticulture	6.2.0 Reservoir
3.3.1 Native/exotic pasture mosaic	4.5.1 Irrigated tree fruits	6.2.0 Reservoir/dam
3.3.4 Oil seeds	4.5.2 Irrigated oleaginous fruits	6.2.1 Reservoir
3.3.5 Sown grasses	4.5.4 Irrigated vegetables & herbs	6.2.1 Water storage and treatment
3.4.0 Cropping	4.5.4 Irrigated vine fruits	6.2.2 Water storage - intensive use/farm dams
3.4.1 Cereals	5.1.0 Intensive horticulture	6.3.0 River
3.4.3 Hay & silage	5.1.1 Shadehouses	6.4.0 Channel/aqueduct
3.4.4 Oil seeds & oleaginous fruit	5.1.2 Glasshouses	6.4.1 Supply channel/aqueduct
3.4.7 Tobacco	5.2.0 Intensive animal production	6.5.0 Marsh/wetland
3.5.0 Perennial horticulture	5.2.1 Dairy	6.5.1 Marsh/wetland - conservation
3.5.1 Tree fruits	5.2.4 Poultry	6.5.2 Marsh/wetland - production
3.5.2 Oleaginous fruits	5.2.5 Pigs	

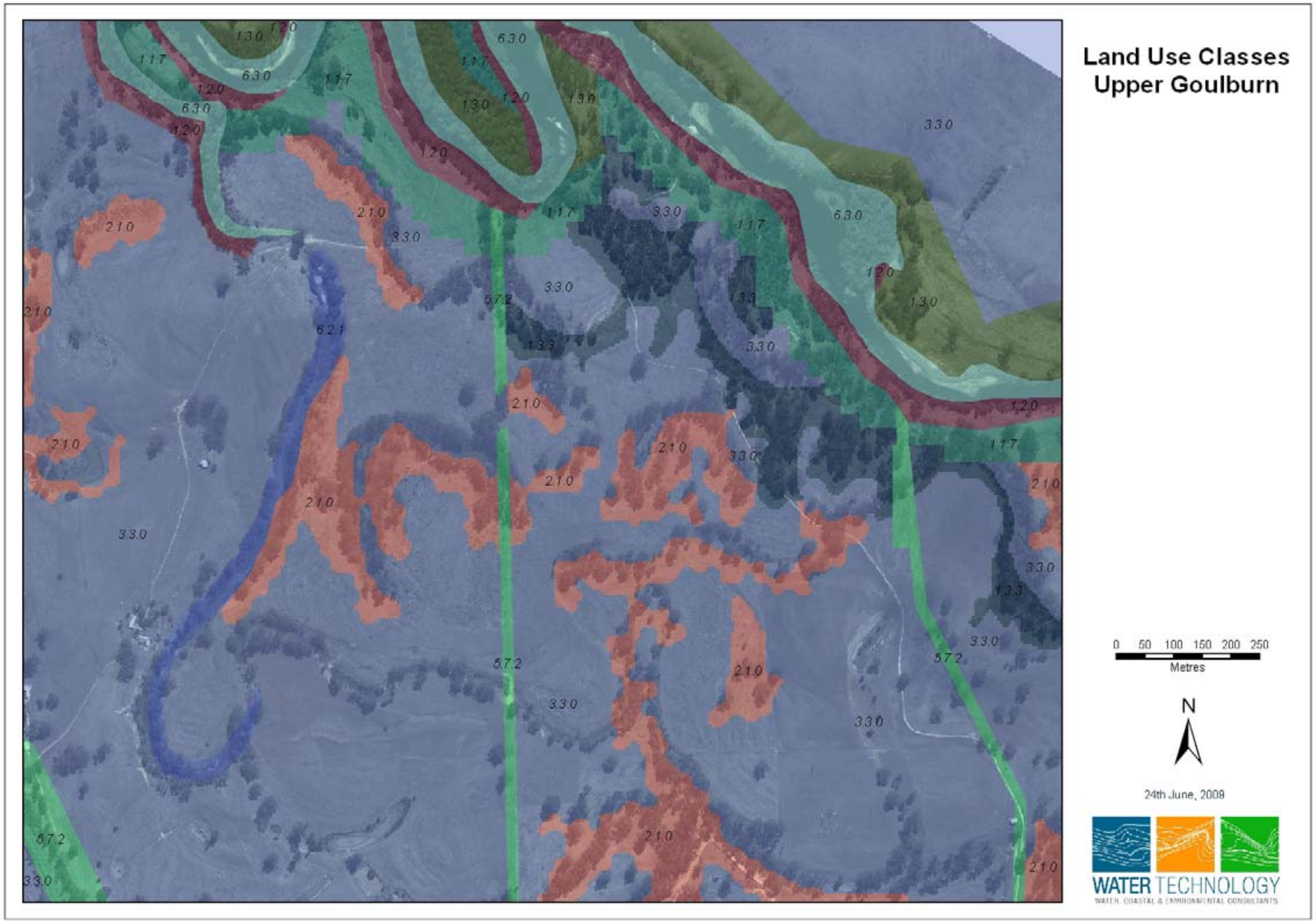

Figure 3-4 Upper Goulburn land use classes near Thornton

3.6 CFA Buildings layer

An important outcome for this project is to assess potential damage to public and private assets during simulated floods. The CFA's building layer was hoped to provide a good indication of the locations of dwellings, sheds, silos and other significant public and private buildings along the floodplain.

Unfortunately the dataset is less complete, and less accurate than anticipated, and there was no metadata available to confirm it's spatial and attribute accuracy. Regardless, the layer was overlayed on an aerial photo for a visual verification. From this, it becomes clear that the spatial accuracy is poor in areas, and the dataset appears to be incomplete, with many dwellings missing. A figure showing the CFA layer over Thornton is shown in Figure 3-5.

The CFA buildings layer was not considered appropriate to use in this study, due to its incompleteness and unknown spatial accuracy.

3.7 VICMAP Buildings layers

Two VICMAP point datasets, "IN_BUILDING_POINT" and "VICMAP_ADDRESS", were compared against the aerial photo to see if these would be more appropriate choices for locating buildings. It was found that they will be more useful than the CFA building layer, particularly by reducing the amount of digitising required. Metadata for both VICMAP layers is discussed in detail below.

3.7.1 IN_BUILDING_POINT

The IN_BUILDING_POINT is a featureclass within the "VICMAP_FEATURES" featuredataset. Building locations were picked up at a scale of 1:25,000. The VSDD states the positional accuracy as "*not more than 10% of well-defined points will be in error by more than 16 m. The worst case error for the data is +/- 30 m*". The spatial accuracy of this layer was verified against aerial photos. It appears to be accurate to within its specifications.

This layer seems to pick up most of the buildings along the floodplain very accurately. It is not so detailed in built up areas such as Thornton and Seymour, but does include important assets such as hospitals, police stations and schools. In this regard, it will be a more useful starting point than the CFA's data. A comparison between the IN_BUILDING_POINT layer and the CFA layer near Scabby Creek is shown in Figure 3-5.

This layer will be used in preference to the CFA buildings layer, as it captures most of the buildings along the floodplain, without requiring too many manual edits. Its coverage is poorer over populated areas, however this could be supplemented by the VICMAP_ADDRESS layer, discussed below.

3.7.2 VICMAP_ADDRESS

The VICMAP_ADDRESS dataset is a point layer, representing geocoded addresses for all of Victoria. The purpose of this layer is to attach an address to every cadastral parcel in Victoria, *not* to accurately locate dwellings. This means its attribute accuracy is the main focus of this layer, not its positional accuracy (as the point's position is almost irrelevant provided the point falls within the correct cadastral boundary). That said, the positional accuracy of the points is published at ±25m.

It was thought that this layer may be used to supplement the CFA building layer over populated areas within the floodplain, for example over Thornton and Seymour. This layer's metadata on the VSDD website states that for "*Urban addresses in rural Victoria - Limited number 8 metres back from centre of the property road frontage, with the remainder at the property centroid*". In a built up area where cadastral parcels are smaller, this range may be good enough to locate most buildings without too many manual edits.

Figure 3-6 below shows the location of the three buildings layers discussed. The CFA buildings layer is obviously the most sparse, with almost no points over Thornton, and appearing to miss its targets. The IN_BUILDING_POINT layer appears to pick up more detail and appears to pick up buildings relatively accurately in most cases.

The final adopted methodology used to define building locations is described below in Section 4.3.

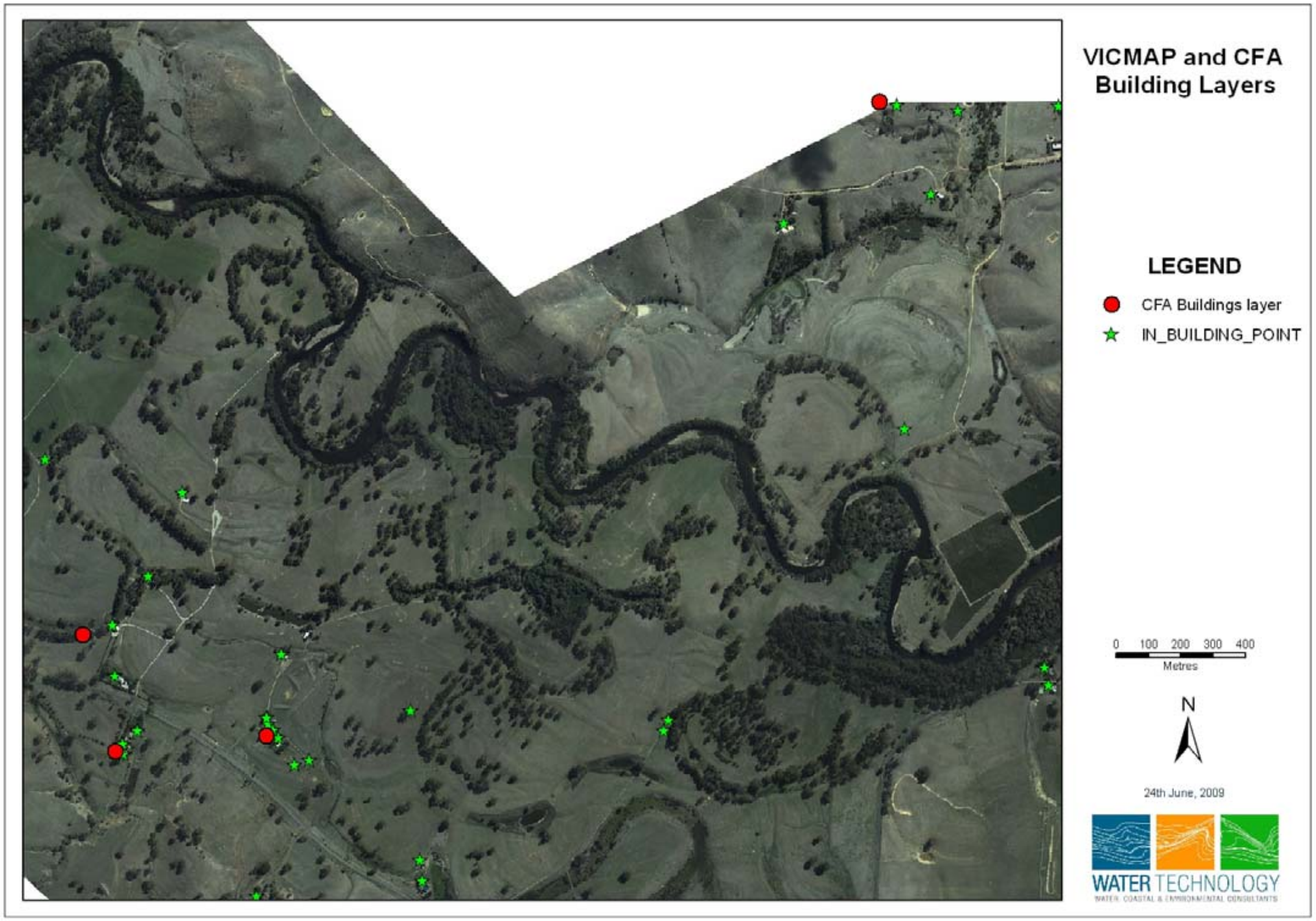

Figure 3-5 Comparison of spatial accuracy and completeness between the IN_BUILDING_POINT and CFA building layers

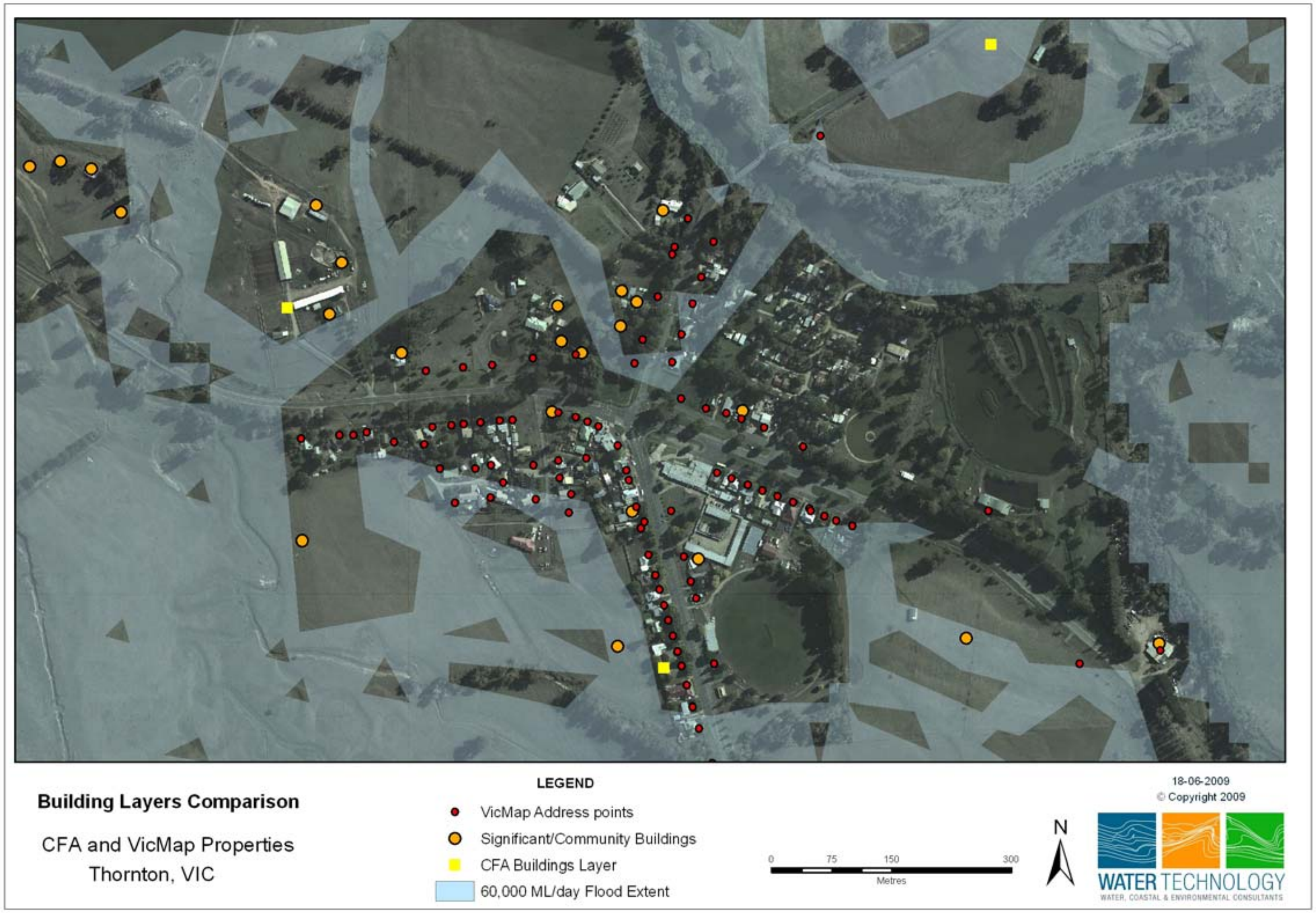

Figure 3-6 Location of three buildings layers; VICMAP_ADDRESS, IN_BUILDING_POINT and CFA Buildings

3.8 Roads and Bridges

The potential for flood damage to roads and bridges was also assessed as part of this study. The most comprehensive and accurate layer available to Water Technology was the Vicmap layer, 'TR_ROAD'. This layer contained information on the location, condition and type of roads and bridges within the study area. The road types classified in this layer are summarised below in Table 3-3. Each of these categories is also broken down into 'sealed' and 'unsealed'.

Table 3-3 TR_ROAD layer classifications

Road Type
Freeway
Highway
Arterial
Sub-Arterial
Collector
Local
2WD
4WD
Unknown
Proposed
Walking Track
Bicycle Path

This layer was derived from the Vicmap Digital topographic map base, and updated using satellite and aerial photography. The positional accuracy of this layer is stated to be, "*not more than 10% of well defined points will be in error by more than 8.2m for the Melbourne Metropolitan area and 33m. for rural areas. The worst case error for the data is 15m for the Melbourne Metropolitan area and (60m for Rural areas)*" (taken from the layer's metadata, VSDD website). When visually compared against the aerial photos, this layer appears to line up very well, with a good coverage of roads within the floodplain. This layer goes as far as to include private farm roads and long driveways. A sample of this layer is shown below in Figure 3-7.

This dataset contains useful and relevant metadata, which not only classifies the road type, but also identifies sealed and unsealed road, and includes the lengths of any bridges within each classification. This provides a good level of detail for the economic assessment to be made. The spatial accuracy is considered to be acceptable at the scale this study is being undertaken at.

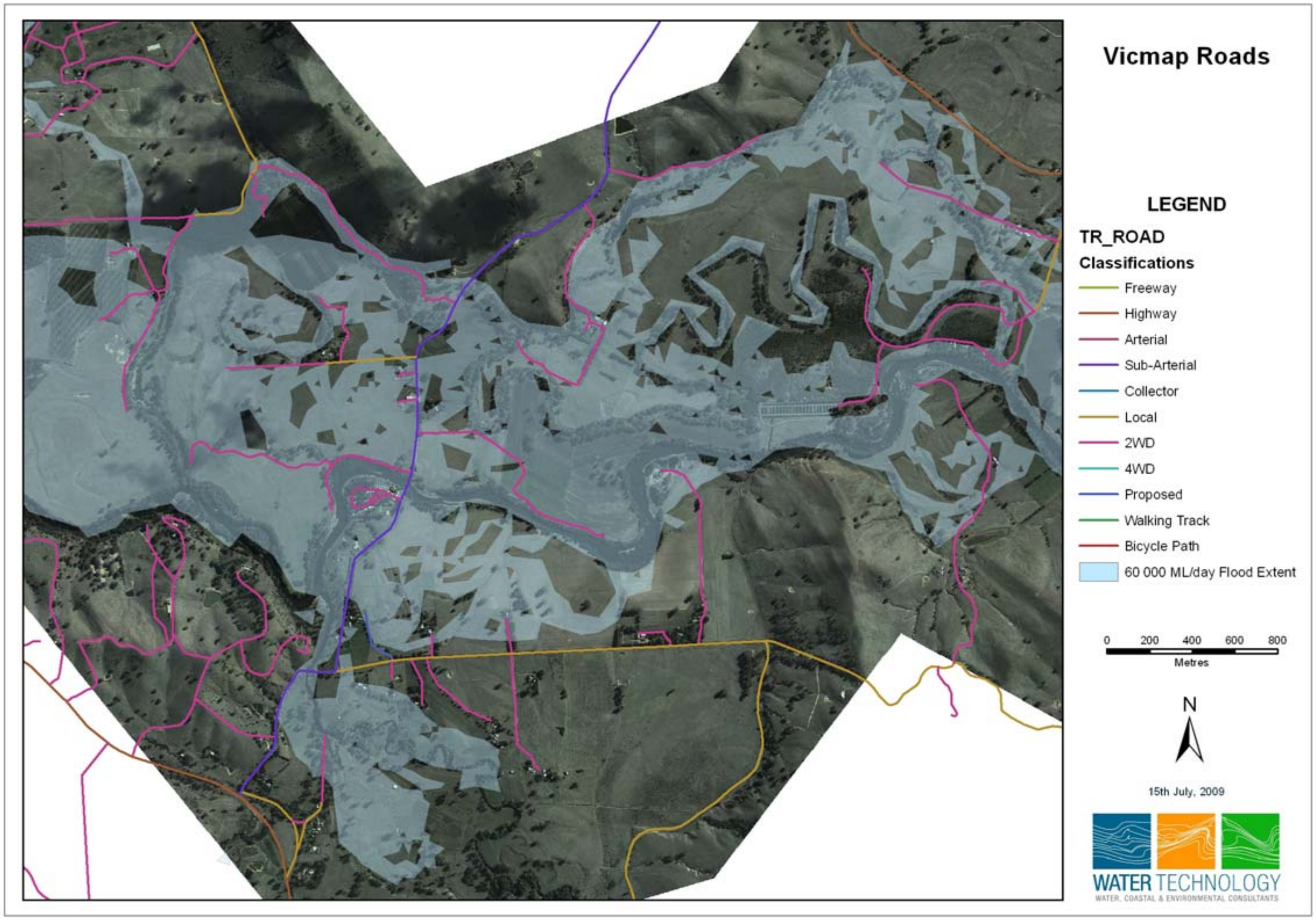

Figure 3-7 – TR_ROADS Vicmap layer compared against aerial photography

4. REVISIONS AND REFINEMENTS TO ASSET DATABASES

4.1 Overview

As discussed, a key environmental asset for this study is floodplain wetlands. In an attempt to overcome the spatial inaccuracies of the available wetlands data, efforts were made to extract wetland locations via other means. Previous attempts had been made at extracting wetlands from the DEM, however no robust solution could be found within the literature on this topic.

As a workaround, wetlands were derived from the hydraulic models run for the 60,000 ML/day scenario. These were run using the DEM so the drained floodplain conditions indicated areas of pooled water within depressions in the topography. These pools of water were used as a basis for deriving wetland locations. The methodology used is discussed in detail below in Section 4.2.

The other key dataset which required refining was locating built assets along the river. The buildings layer provided by the CFA lacked the spatial accuracy and comprehensiveness required for this study. To this end, two VICMAP layers were employed with a view to use them to supplement the CFA layer. However it was found that these may be of more use, without using the CFA layer at all. The methodology used to create a complete buildings layer is discussed below in Section 4.3.

4.2 Alternative delineation of wetlands

4.2.1 Adopted method for deriving wetland locations

The hydraulic models for the largest amount of flow, the 60,000 ML/day scenario, were run to inundate the floodplain and then to allow flood water to drain off the floodplain. The final timestep represented the drained floodplain conditions where water would be expected to pool after the flood had passed. A number of assumptions were made to filter down the pooling to wetlands.

To begin with, the location of the river was removed as this will always contain flowing water and not define a wetland. Then it was assumed that significant wetlands would contain water deeper than 0.5 m, so all cells with a water depth less than 0.5 m were removed. From what was left, it was assumed that any pools smaller than four adjacent grid cells would not be considered wetlands. The hydraulic model was run at a 25 m grid size, so all pools smaller than 2500 m² were removed.

Figure 4-1 below show a comparison between the unfiltered drained floodplain conditions and the final, derived wetlands for the 60,000 ML/day scenario. As this was the largest flow rate modelled, it was assumed that this would be the maximum wetlands inundated, and all lower flow scenarios would fill a percentage of these.

By comparing the aerial photography with the filtered layer in Figure 4-1, the filtered layer accurately locates obvious wetlands and generally avoids depressions in the middle of cleared and farmed paddocks. However, it clearly misses picking up some wetland areas, particularly showing breaks in long, connected systems. This could be improved by reducing the 0.5 m depth filter. It could also relate to the technique only identifying standing water, as so would miss flood runners which carry water during the flood.

Given the difficulty in identifying wetlands, the filtering methodology provides a locationally accurate but incomplete data set for use in this study. However, it is possible that it will introduce bias into the inundation mapping in that the identified wetlands may be the more significant in size and therefore lower in the floodplain than those not identified by the technique.

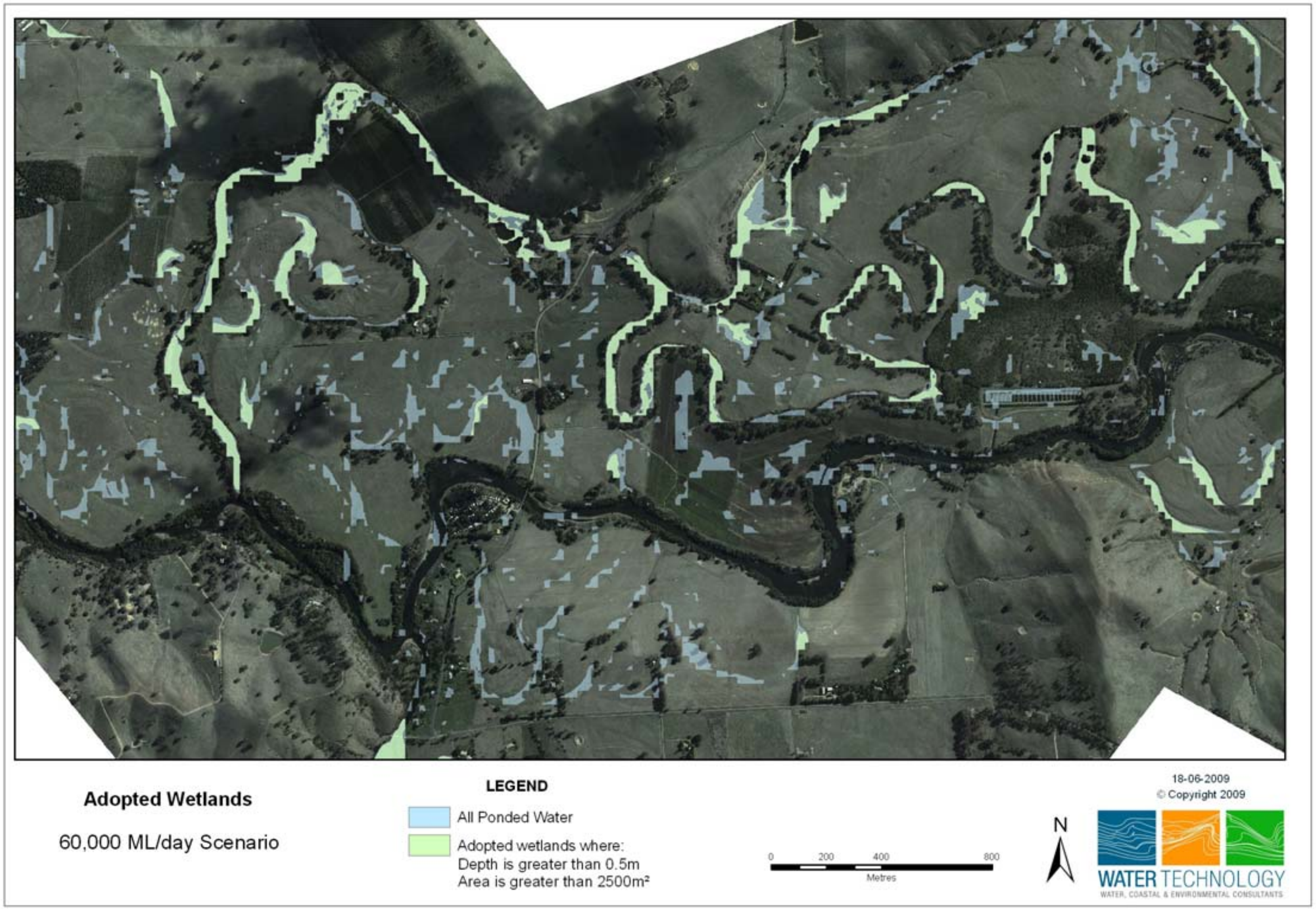

Figure 4-1 Adopted wetlands layer, derived from the drained floodplain conditions for the 60,000 ML/day scenario

4.2.2 Previous attempts made at deriving wetland locations

A wetlands layer has now been derived using the hydraulic model. However prior attempts have been made at locating wetlands using the DEM. This was initially though to be a straight forward process however it emerged that this is an area of on-going research and as such, no robust solution could be found. Below is a discussion of the techniques attempted to try an extract wetlands.

ArcHydro is a free, downloadable plug-in to ArcGIS and offers a range of tools suited to users in the water and environment fields. Before any analysis can begin, the DEM needs to be prepared for processing. This also involves the creation of a number of subsidiary grids, such as a flow direction grid. It was hoped that some of the preparation grids would provide some insight into areas where water pools.

Preparing the DEM for processing

Initially, to prepare the DEM for processing, “sinks” need to be filled. Sinks are considered small errors in the DEM, where water from all surrounding cells in the raster flow into one cell and can’t escape. To fix these small errors, and ensure the DEM is hydrologically correct, the sinks are filled by slightly changing the elevations of erroneous cells which then allows water to flow through the cell. ArcHydro has an algorithm for determining this elevation change.

Creating a flow direction grid from the DEM

Next, a flow direction grid is calculated from the modified DEM. This process determines the aspect and slope of each cell and compares this to its neighbouring cells to determine the direction water will flow between adjacent cells. By default, the output from this creates a flow direction grid of eight integer values, where each represents the flow in a different direction. This is explained diagrammatically in Figure 4-2 where red cells flow in an easterly direction, etc. The flow direction grid itself, is shown in Figure 4-3 with the wetlands layer overlayed on top.

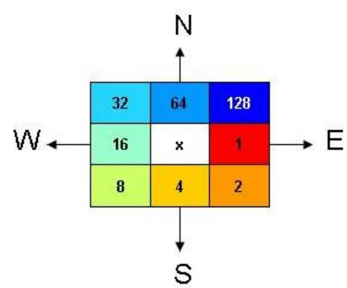

Figure 4-2 Flow direction grid value definitions

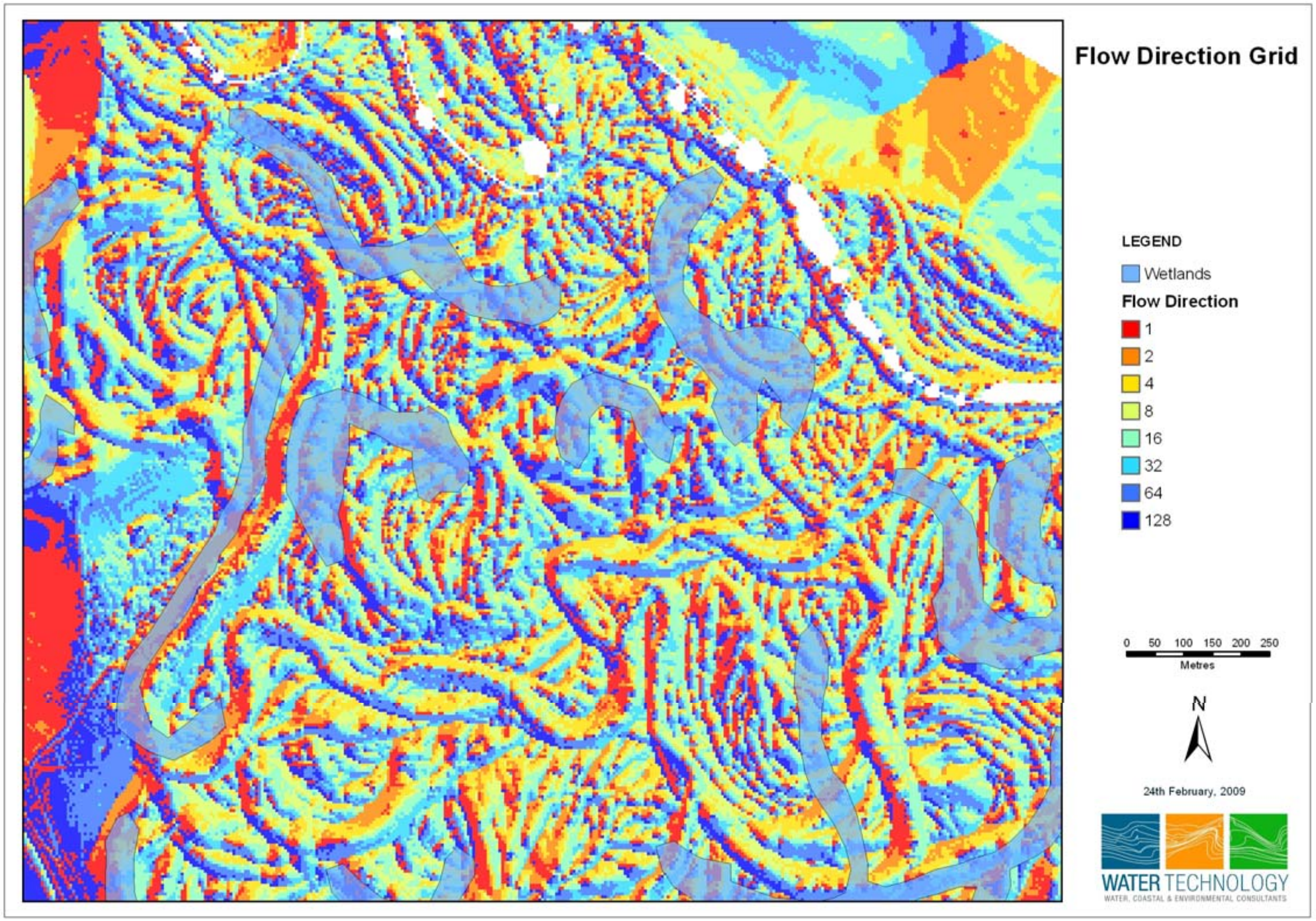

Figure 4-3 Flow direction grid with wetlands – Goulburn River near Ghin Ghin

While the flow direction grid on its own is not particularly useful, it was thought areas of pooling may be highlighted. Sections of wetland boundaries can be made out vaguely, which follow the general shape of some wetland boundaries. However, these are difficult to make out, and the fine scale DEM brings out a lot of detail making the flow direction grid difficult to interpret.

Creating a flow accumulation grid

Next, a flow accumulation grid was created. A flow accumulation grid is calculated using a flow direction grid as input, using the direction of flow to determine areas of concentrated flow. The flow accumulation function "*calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster*" (ESRI Help Menu). This means that cells with a high flow accumulation value are areas of high, concentrated flow. This analysis is generally used for delimitating stream channels. In essence, a flow accumulation grid is intended to show the amount of water which flows through any given cell, or put another way, the number of cells which flow into another.

It was thought that creating a flow accumulation grid would provide further information into locations of water pooling, as majority of water would be flowing into the wetland from a particular point, and flowing out through another downstream point. Unfortunately, it was not the case that this highlighted the wetlands clearly (refer to Figure 4-4).

In Figure 4-4, the values of the flow accumulation grid represent the number of cells which flow into an adjacent cell. This makes the values quite arbitrary, hence the grid is difficult to interpret. The maximum flow accumulation value for the grid was 3284228. In order to make the grid easier to interpret, a maximum threshold value of 1000 was adopted, so all values between 1000 and 3284228 appear bright blue. Cells with a very low accumulation will appear red, with all other values stretched in between.

Where this makes most sense, is along the banks of the Goulburn, where majority of cells appear blue, with strings of red running through the centre. This can be interpreted as the red cells are at a high elevation, so water runs off these steepest points becoming blue as they go, as so many cells are contributing to the flow towards the bottom of the incline. These values then change to red as less flow accumulates of the flatter floodplain.

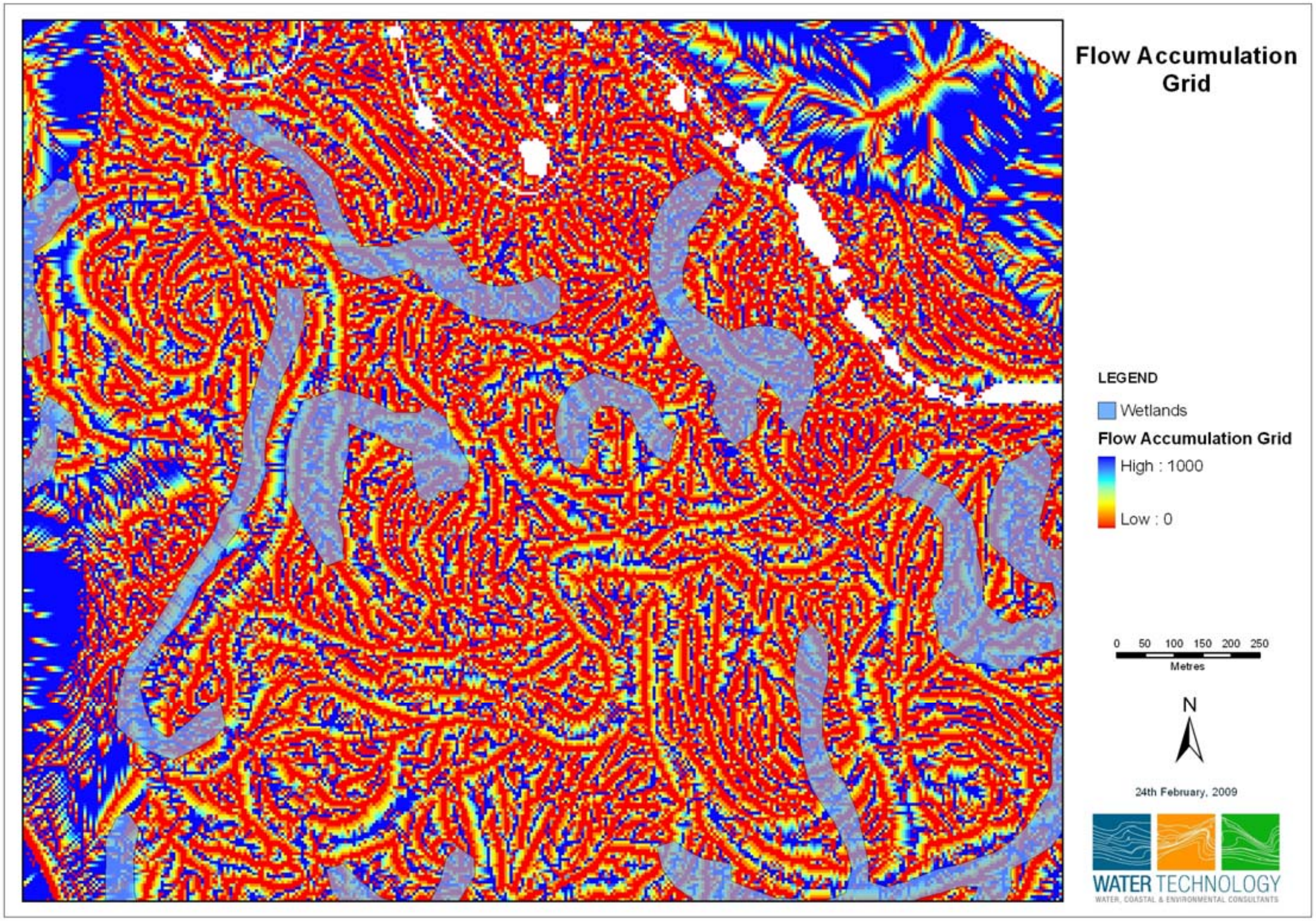

Figure 4-4 Flow accumulation grid with wetlands – Goulburn River near Ghin Ghin

Figure 4-4 is not too helpful in locating wetlands. For the long, thin, western-most wetland some definition can be seen, as the high accumulation (blue) values somewhat follow the wetland shape. This interpretation is, again, only useful if the location of wetlands is known. The upper and lower wetland boundaries are not clearly defined in this grid, and most other wetlands are not discernable at all.

As the two most promising ArcHydro outputs were found to be inappropriate, it was thought a well stretched DEM may be more useful in highlighting wetland locations, as depressions in the topography.

Stretching the DEM to highlight wetland locations

The term 'stretching' refers to the way colours representing elevation in the DEM are defined. Colours can be stretched by altering or changing the colour ramp, or by altering the maximum and minimum values to be included in the display.

In Figure 4-5 the DEM has been stretched based on its overall maximum and minimum values. That is, unlike in the flow accumulation grid, no elevation values have been omitted above a certain threshold. The colour ramp chosen brings out a lot of detail at the floodplain level. It was difficult to achieve in this instance, as the elevations along the edge of the floodplain are so steep. For example, to the north-east corner of Figure 4-5 the DEM values change to grey. This indicates these elevations are close to the maximum across the entire Goulburn River DEM of 435m AHD compared with around 150m AHD within the floodplain.

Similar problems arise from locating wetlands using a stretched DEM as with using flow direction, or flow accumulation grids. While some small depressions in the floodplain appear to align reasonably well with some wetland boundaries, this is only clear if the locations of wetlands are known. There are many depressions within the floodplain which are not wetlands, but could easily be mistaken otherwise.

Each cell represents the elevation at a particular point, and so changes in elevation vary with colour. This makes this image much easier to interpret than either Figure 4-3 or Figure 4-4. For this reason, if wetlands were to be digitised, an appropriately stretched DEM would be the most useful tool as a starting point.

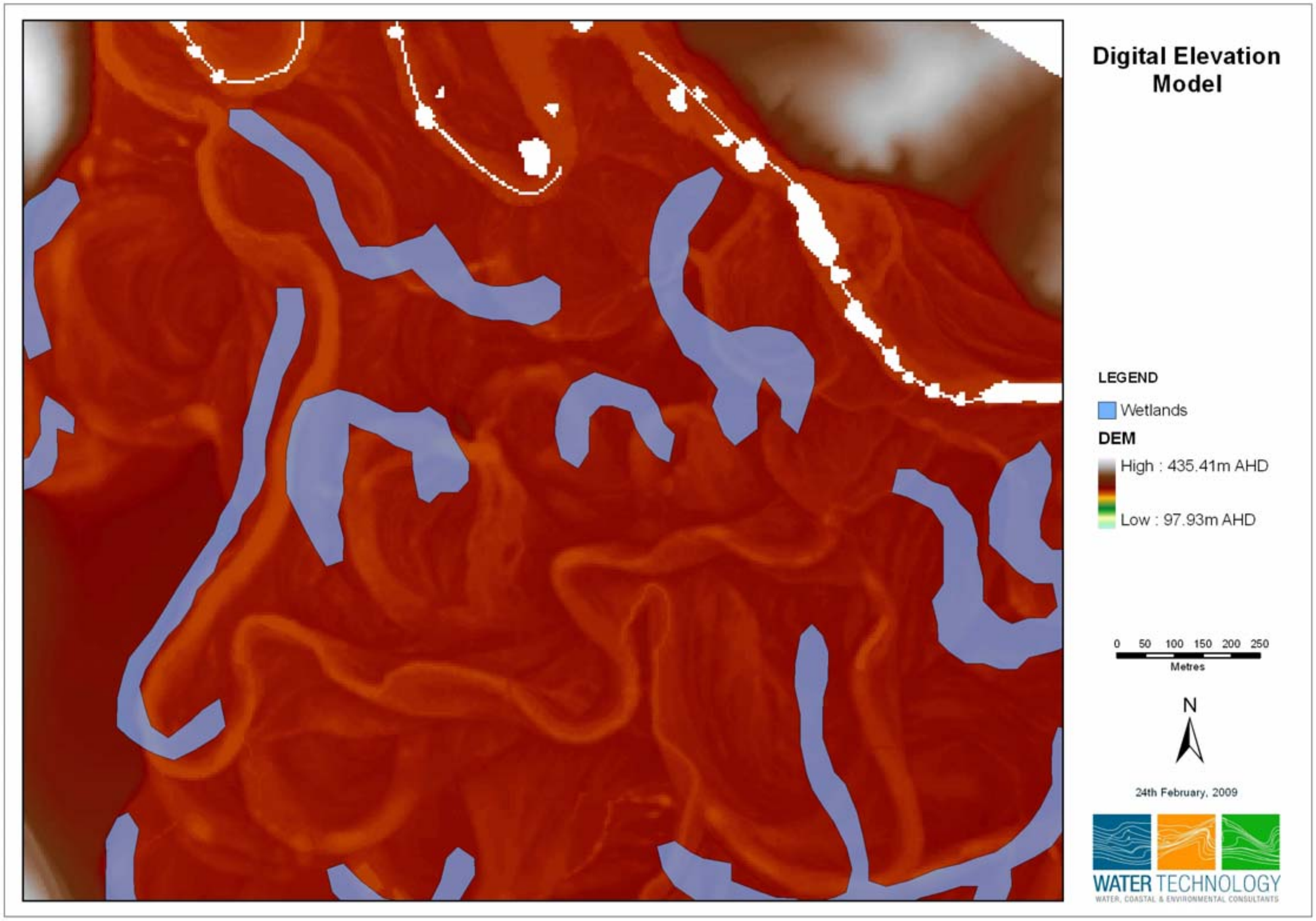

Figure 4-5 Stretched DEM with wetlands – Goulburn River near Ghin Ghin

4.3 Preparing a layer describing built assets

Initially it was thought that the buildings layer provided by the CFA would be comprehensive, and spatially accurate enough to define building locations to the level required for this study. As this was not the case, a method was required to create a new layer which did meet standards for this project. It was expected that some manual edits would be required to do this.

Two VICMAP layers were reviewed as a means of bypassing the CFA layer and minimising the amount of digitising required. The IN_BUILDING_POINT layer has a good spatial accuracy, and appears to pick up most dwellings and other buildings within the study area (see Figure 3-5). It also includes more detail such as schools and hospitals. However it is less accurate over built up areas such as Thornton and Seymour.

In built up areas, the IN_BUILDING_POINT layer could be supplemented with the VICMAP_ADDRESS layer. As mentioned, this is a layer contains geocoded addresses for other purposes, and so it’s spatial accuracy is not relevant. However in a built up setting where land parcels are smaller, it does generally pick up all buildings (see Figure 3-6).

For this study, the methodology decided on was to edit the IN_BUILDING_POINT layer only. This seemed the simpler than incorporating the VICMAP_ADDRESS layer too, as these points would all need to be checked regardless. The IN_BUILDING_POINT layer was checked within the 60,000 ML/day scenario along the length of the study area. Any points which did not line up precisely with building locations were moved, and any missed buildings added. This was done on a localised scale, comparing against the aerial photography. Buildings were classified as ‘house’ or ‘other’ to reflect the higher economic importance of dwellings.

The spatial accuracy is expected to be good. It is expected that some buildings were probably missed, due to them being obscured by trees. This is unavoidable when using aerial or satellite imagery for digitising purposes.

5. CONCLUSIONS

For this study, spatial layers describing wetland features, native vegetation, land use classes, and built assets along the river were required. In all, the best and most appropriate datasets available have been acquired, or created to describe these features. A summary is provided below.

Wetlands

The existing DSE wetlands layer is considered too inaccurate to be of use in this study. The native vegetation layer was also found to not be useful in locating wetlands. To this end, some effort has already gone into trying to derive the locations of wetlands through other means. Wetlands were not able to be suitably derived by using the Digital Elevation Model alone.

The methodology used was to flood and drain the floodplain in the hydraulic models, identify areas retaining water, and then to eliminate shallow or small inundated areas. This was relatively accurate in locating significant wetlands, although did not locate other obvious wetland areas. This data set is adequate for initial scoping of the wetland inundation from different flooding scenarios, but could contain significant biases due the wetlands not identified.

Native Vegetation

The "highly likely native vegetation – woody" layer was reasonably accurate and complete in identifying obvious tree covered areas. It will be useful for assessing the quantity of native vegetation that is inundated in different flood scenarios.

Land use

The DPI and DNRE land use layers are considered reasonably accurate and detailed enough to provide overall statistics on areas of different land use inundation of this study. Dryland and irrigated pastures in particular seem interchangeable, which may reflect the difficulty in identification, or in changing landuse patterns in response to recent drought conditions.

Built assets

On its own, the CFA building layer will not be suitable for this study. Many buildings are not included, or are not located accurately when viewed on the aerial photos.

The VICMAP layer IN_BUILDING_POINT layer was adopted for the study area. All buildings which fell within 100m of the 60,000 ML/day scenario were manually checked, and added if missing, using the aerial photography to determine their locations. Buildings were broken down into two classifications, 'house' and 'other'.

Roads and bridges

Roads and bridges were defined using the Vicmap layer, 'TR_ROADS'. This layer contained detailed attribute data which classified the roads into 11 different categories, and further distinguished sealed from unsealed roads, and also included bridges. No changes were made to this dataset as it's spatial accuracy was good.

Overall

The asset mapping data available is not highly accurate for use in flood inundation mapping. Data sets have been assembled which are reasonable for the initial scoping work being undertaken in this study, but need to be seriously improved for more detailed work. The identification of wetlands on the floodplain particularly needs substantial attention in the future, given it is one of the prime targets of environmental flooding.