SEQUANA
WATER ENVIRONMENT ENERGY

NORTH CENTRAL CMA STRATEGIC LEVEES PROJECT

CATEGORISATION REPORT



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1 INTRODUCTION / CONTEXT

In response to the 2022 Spring floods, the Victorian Government, through the Department of Energy, Environment and Climate Action (DEECA), initiated funding for a Strategic Levee Categorisation Assessment across northern Victoria. This effort involves collaboration among four northern Victorian Catchment Management Authorities (CMAs) - Goulburn Broken, North Central (North Central CMA), North East, and Mallee CMAs - and key partners including Local Government Authorities, Victoria State Emergency Service (VICSES), DEECA, and Public Land Managers such as Parks Victoria. The purpose of this assessment is to enhance flood intelligence and incorporate it into Municipal Flood Emergency Plans (MFEPs) for the region.

The project focuses on developing detailed flood intelligence surrounding key levees and floodplain features, with the objective of identifying and implementing practical emergency actions. This intelligence aims to strengthen flood protection for communities and infrastructure at high risk, ultimately improving flood preparedness and resilience across northern Victoria.

The initial phase of the levee categorisation project focused on identifying and assessing strategic levees and significant floodplain features within North Central CMA region, including the Campaspe and Avoca River basins, in addition to a section of the Murray River between Echuca and Tyntynder. The Loddon River catchment is within the North Central CMA regional boundary. However, assessment of levees in the Loddon River catchment is **not included** in the scope of this report.

The objective of this task was to locate and categorise strategic levees and features that influenced flood behaviour, such as elevated roads, railways, channels, natural levees, and lunettes. This phase began with a desktop approach conducted in close collaboration with CMAs, Victoria State Emergency Service (VICSES), and Local Government Authorities (LGAs).

The methodology for levee categorisation involved a series of steps that were completed to comprehensively identify and assess levee structures and floodplain features in the target areas. The following steps were implemented:

- Data collection and review was conducted, gathering essential topographic and flood-related information, including GIS layers, historical flood data, prior studies, inventories, and current flood mitigation and emergency management plans. This review incorporated crucial data from stakeholders such as North Central CMA and the LGAs, providing a foundation for mapping key levee structures and flood-influencing features.
- Data gap analysis was then completed to identify any missing information, particularly in urban areas and surrounding regions. Where gaps were identified, this information was requested via a Request for Information Register.
- Community engagement formed a key component of the project methodology. Engagement activities, including stakeholder workshops, site visits, and community drop-in sessions, were used to validate mapped data, refine levee classifications, and incorporate local knowledge into the assessment process. This ensured that the categorisation outcomes reflect both technical analysis and on-ground experience.
- Finally, the levees and floodplain features were assessed using advanced GIS tools to analyse the available Light Detection and Ranging (LiDAR), Digital Elevation Models (DEMs) and flood study data. This detailed assessment provided insights into the effectiveness and resilience of the identified levees in mitigating floods.

While the desktop-based strategic levee categorisation process offers a cost-effective and efficient method for initial assessments, it inherently comes with several limitations. These limitations stem primarily from the nature and quality of the available data and the constraints of remote analysis, which can impact the overall reliability and accuracy of the categorisation outcomes.

An ArcGIS layer that meets Spatial Data Specification (SDS) requirements, enabling future categorisation and review, has been prepared to accompany this report. This information will be used to support further review and discussion among project stakeholders as the next steps in the levee categorisation process unfolded.

The project area within Sequana's scope was not inclusive of the entire North Central CMA area. The below figures illustrate the project area and subsequently the information detailed in this report is limited to these areas.

This report has been updated to reflect reporting requirements provided by DEECA, ensuring consistency in reporting across all Catchment Management Authorities and alignment with current emergency management and floodplain planning frameworks.

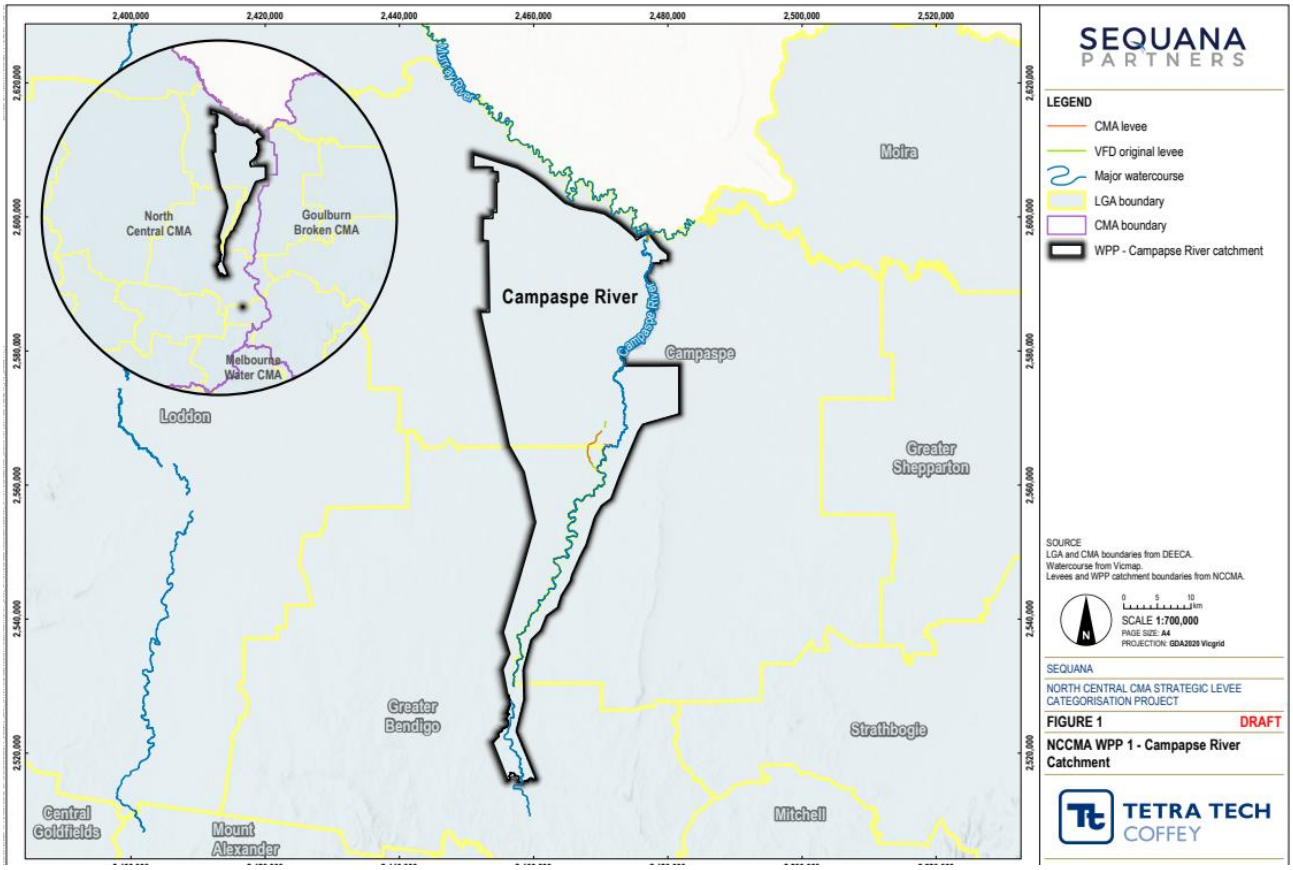


FIGURE 1. CAMPASPE AREA

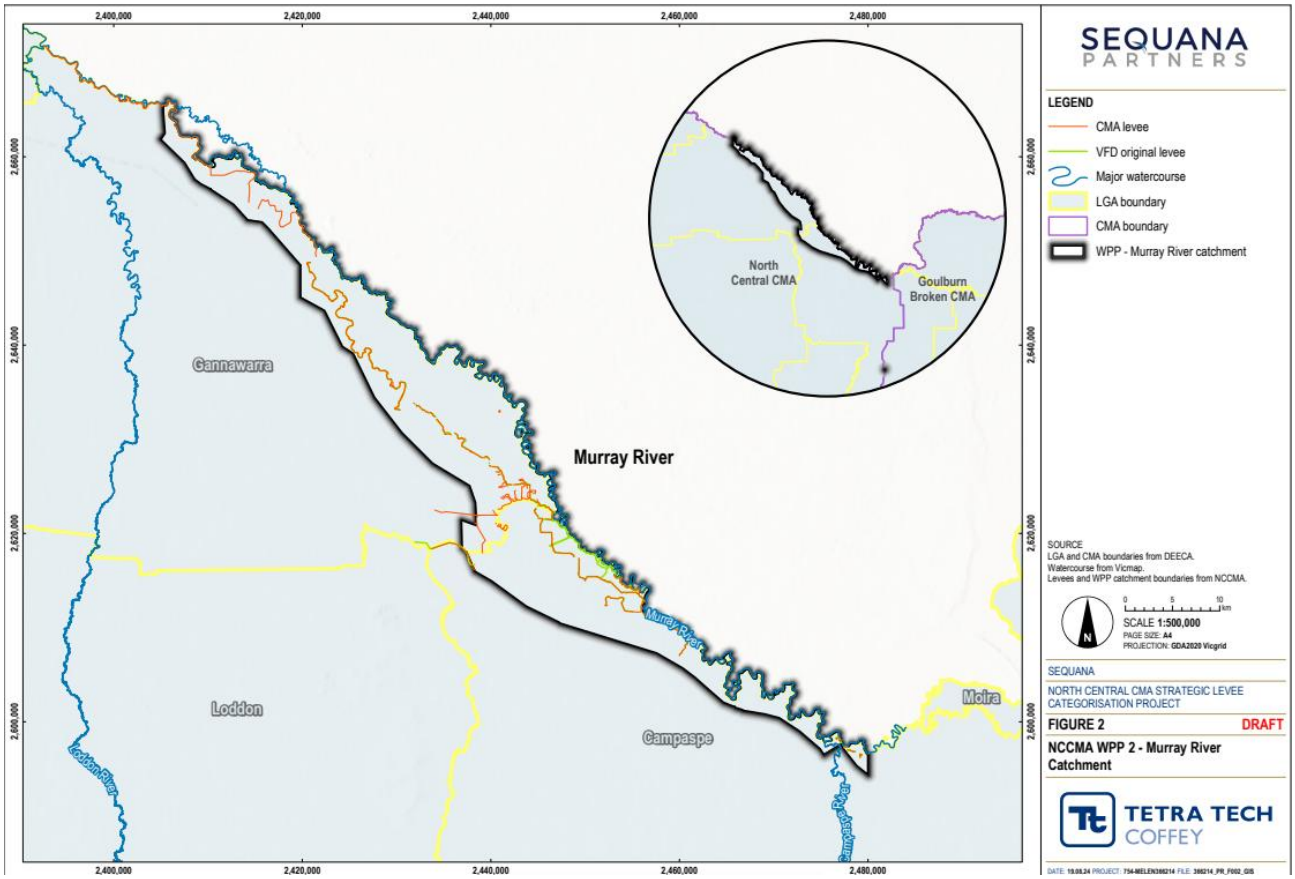


FIGURE 2. MURRAY AREA

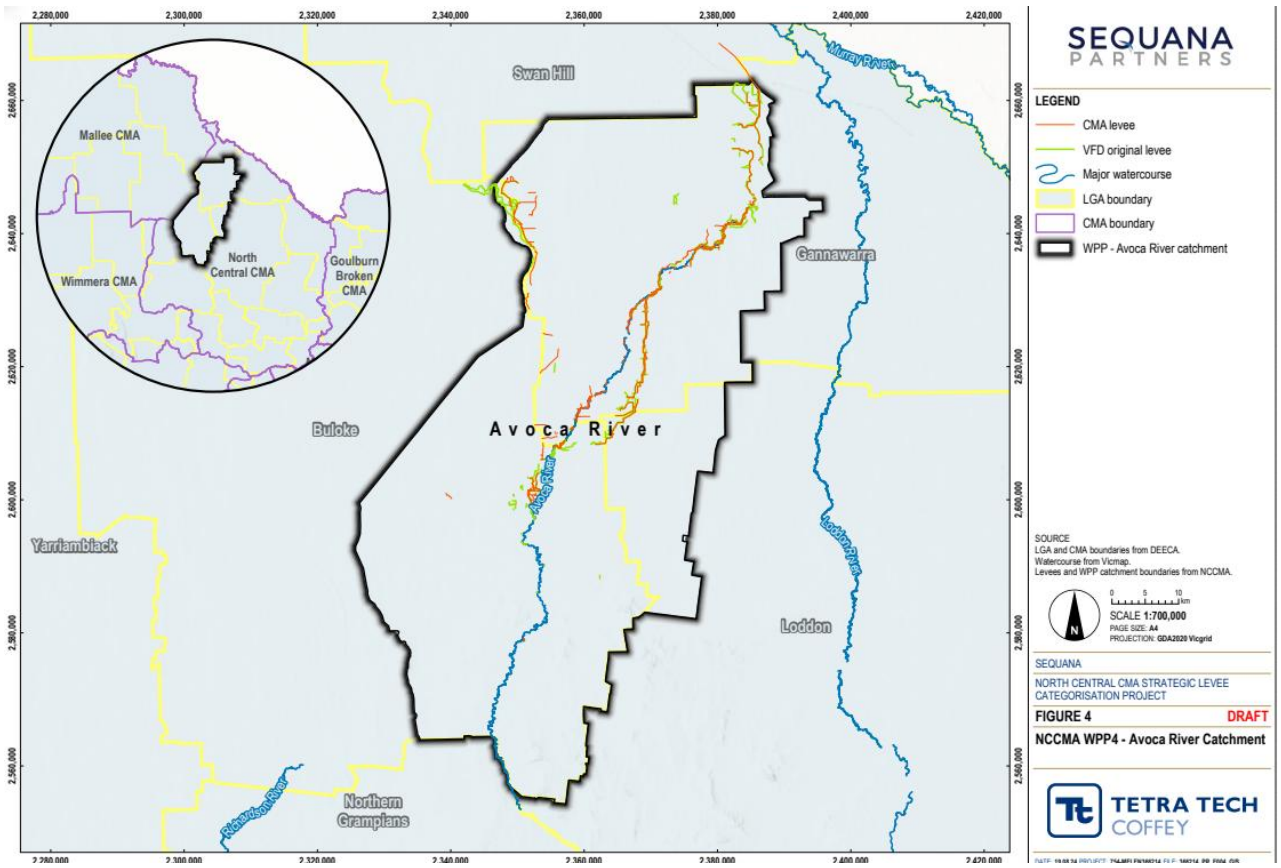


FIGURE 3. AVOCA AREA

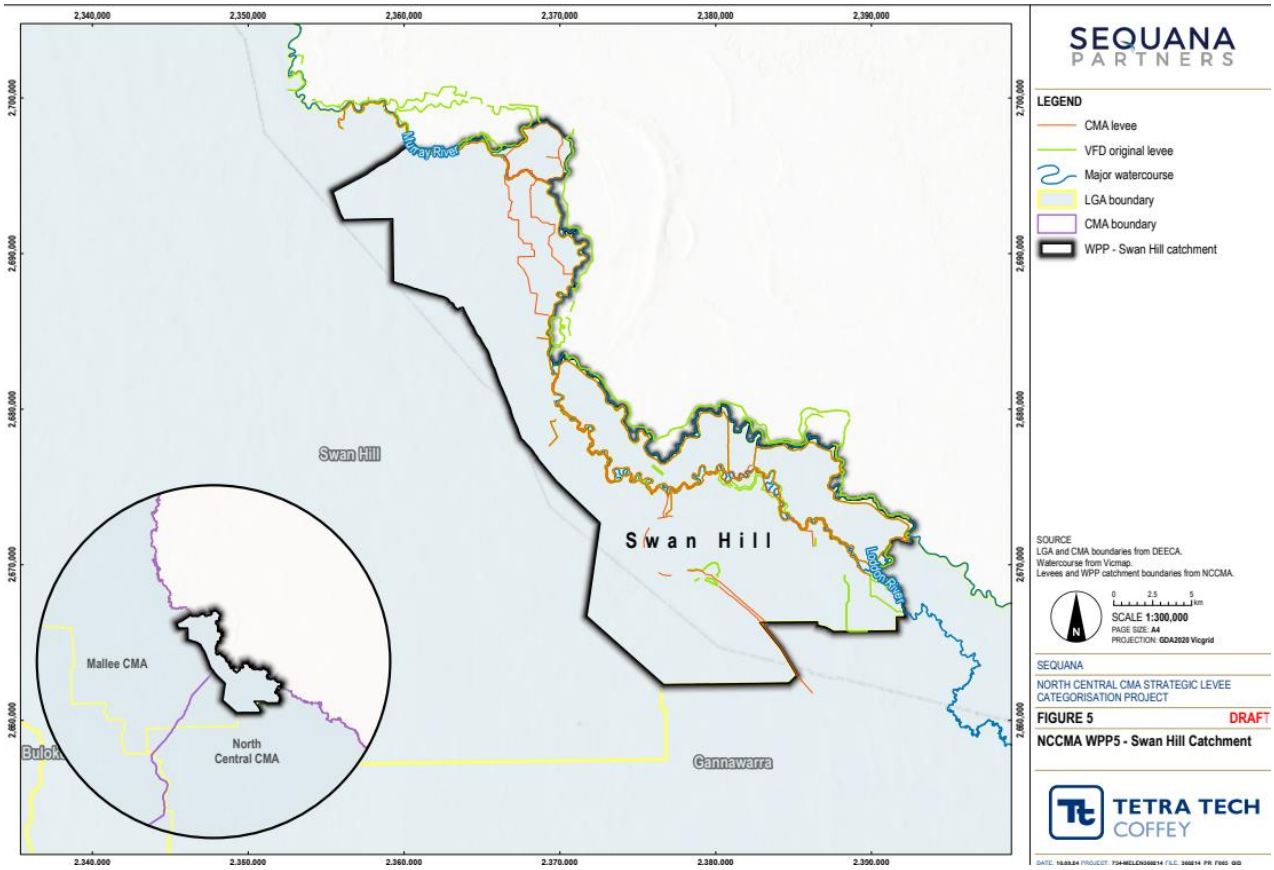


FIGURE 4. SWAN HILL AREA

2 BACKGROUND INFORMATION

Levee categorisation relied on a comprehensive collection of data sources and local insights. Critical to this effort was the relevant data and local knowledge provided by CMAs, LGAs and VICSES. Their understanding of the landscape and experience with past flood events ensured that the identification of levees and floodplain features was grounded in both technical data and practical, on-the-ground knowledge.

Flood studies and the Victorian Spatial Data Specification for flood data provided a standardised framework for mapping and assessing levee structures, ensuring that the data conformed to recognised specifications for flood planning and response across the state. Key GIS datasets acquired to support the assessment of individual levees are outlined in Table 1 below.

The Municipal Floodplain Emergency Plans (MFEPs) offered specific insights into the flood response strategies already in place, allowing alignment of the levee assessment with existing emergency plans, while helping identify areas where these plans could be strengthened with additional levee intelligence.

Known incident responses from recent flood events, including those in 2010, 2011, 2012, 2016, and 2022, were also reviewed which provided historical context for flood behaviour and levee performance. These records offered valuable insights into the specific challenges and effectiveness of previous mitigation efforts, highlighting which levee structures or floodplain features had effectively managed floodwaters and which areas required further attention or improvement.

Aerial flood photography, including imagery from Sentinel Satellite, VICSES event photos, and CMA flood records, allowed the identification of floodplain features and observation of the influence of levees on floodwaters during actual flood events. This imagery was crucial for verifying and refining the location and role of floodplain features identified during data analysis, helping to clarify areas where floodwaters were directed or restrained by natural and artificial levees.

Finally, available LiDAR and other topographical data served as the foundation for the detailed DEMs used to map and assess levee features. This high-resolution elevation data enabled visualisation of terrain features with greater accuracy, allowing for measurement and analysis of levee dimensions, such as crown height and width, and to assess each feature's effectiveness and resilience in flood mitigation. Together, these resources ensured a robust and well-informed approach to categorising levees and floodplain features across the study area.

A full description of the GIS methodology is provided in Appendix 1.

SIGNIFICANT FLOODPLAIN FEATURES

A topographic feature was deemed a significant floodplain feature when it satisfied the following criteria:

- The feature is an artificial structure (typically a road, railway or channel).
- The feature appears to impact the extent of flooding in the 2022 event. A combination of the observed 2022 Flood Extent layer and the 2022 Sentinel-2 satellite imagery was used to determine this.
- Where available, the digital elevation model indicates that there is a clear topographic barrier.

TABLE 1. GIS SOURCE DATA

DATASET NAME	DESCRIPTION	SOURCE
Levee datasets		
Levee Categorisation Layer	The consolidated levee alignment dataset that will be used to categorise, add and assess all levees within the project areas.	Tetra Tech Coffey (consolidated from various other data sources)
CMA Levee Layer	North Central CMA levee alignment dataset	North Central CMA
VFD Original Levee Layer	Victorian Flood Database original levee alignments.	North Central CMA
GMW Non-Backbone Channel CMA Assessment	Goulburn Murray Water channel assessment spatial layer.	North Central CMA
Reference datasets		
DEM (1m and 5m)	Digital elevation model (1 meter resolution)	DFSI NSW
Planning Overlay	Planning overlay classification, including land subject to inundation and floodways).	Vicmap
Planning Zone	Planning zone boundaries (urban floodway zones).	Vicmap
Railway	Road alignments and names.	Vicmap
Cadastre	Cadastral boundaries.	Vicmap
Observed 2022 Flood Extent	Estimated inundation extent from the 2022 flood event.	Emergency Management Victoria
Sentinel-2 Imagery (05.12.2022)	Sentinel-2 satellite imagery captured during the 2022 flood event.	European Space Agency
Sentinel-2 Imagery (15.11.2016)	Sentinel-2 satellite imagery captured during the 2016 flood event.	European Space Agency

3 PRELIMINARY CATEGORISATION PROCESS

The preliminary categorisation of levees will guide strategic decision-making in the next phases by establishing clear criteria to prioritise levee maintenance and emergency actions based on potential risk and resource availability. This categorisation process is grounded in the following key considerations of which will inform the development of a robust levee management and response framework.

1. **VICSES Operational Criteria**: The categorisation of levees will incorporate VICSES criteria, specifically their authority to direct emergency actions under the VICSES Act 2005 or the Emergency Management Act 2013. In events where the Regional Agency Commander (RAC) has declared a major flood imminent, prioritisation will focus on levees that serve to protect lives, critical infrastructure, public assets, and property. Category 2 levees, which play a significant role in safeguarding vital infrastructure and supporting life safety, will receive primary consideration given that Category 1 levees are in place with clear management responsibilities.

2. **Legal Context for Emergency Actions**: Since emergency levee operations involve complex legal considerations, legal counsel will play a pivotal role in confirming the permissibility of actions under emergency conditions, such as levee reinforcement or modification. This legal guidance will ensure that all actions planned for Categories 2 and 3 levees adhere to regulatory standards while maximizing effective flood response.

3. **Flood Scale and Magnitude Impact**: The geographic extent and magnitude of potential flood events are crucial in determining the practicality of emergency levee actions. For example, a localised flood event might allow for concentrated resources on a small number of high-priority levees, while a regional or statewide flood could strain resources and necessitate a more selective response. For rarer, large-magnitude flood events (e.g., with a 1 in 100 Annual Exceedance Probability), the scope of necessary emergency works might exceed available resources, requiring a focused strategy on the most critical levees to manage plant, time, and budget limitations effectively.

With the above key considerations in mind, a comprehensive categorisation approach was developed to incorporate Safety, Environmental and Economic impacts and considered the consequences of the flood inundation area. The levee categorisation approach considers:

- Responder safety
- Community safety
- The protection of key infrastructure
- Potential private residential loss
- Economic consequences
- Environmental impact (including biodiversity and wetland protection)
- Preservation of cultural heritage

The approach involved classifying levees based on their existing categories in current documents. If a levee was assessed as strategic but wasn't documented (and therefore not classified as Category 1 or 2), it was flagged for further review and possible re-evaluation. Table 2 below outlines the levee categories and their respective definitions. These categories and definitions were used to define the categorisation of each levee.

TABLE 2. LEVEE CATEGORIES

TYPE OF LEVEE	DESCRIPTION
Category 1	Defined as those levees that are formally managed whereby the operation and maintenance are in place that protect urban centres or defined areas.
Category 2	Defined as those levees that are not managed but provide flood protection to urban type centres, or rural areas where it meets the investment criteria outlined in the Victorian Floodplain Management Strategy (DELWP, 2016), and where it meets the VICSES threshold to act under the VICSES Act 2005 Section 32AC.
Category 2- Type A	Levees do not require significant work ahead of a major flood and may require active periodic monitoring. Levees are understood to be in generally acceptable condition and are likely to perform as intended during a major flood event, without the need for immediate remedial works. Active monitoring during flood events is advised.
Category 2- Type B	Levees require significant work ahead of major floods, or levees which have known issues (weaknesses) from past floods. Active monitoring is required during the flood event.
Category 2- Type C	Locality identified for a temporary levee ahead of a major flood and is removed post-flood
Category 3	Defined as strategic levees that provides unverified levels of flood protection to rural floodplain areas.
Private Levees	Levees which have been built by individuals solely for the protection of their own property and assets. These levees to do not protect public infrastructure or assets. Examples include ring levees around homes and property. Note, Private levees (where known) should be documented (not categorised) but identified as Private Levees.
Significant Floodplain Features	Features in the floodplain, which are not levees, but will have a significant impact on flow patterns during major floods that would result in significant changes in flood behaviour (i.e., elevated roads, irrigation channels, railway embankments, and the like). Such features were to fail or overtop may cause downstream impacts or cause the flood to move in unexpected directions

Table 3 & 4 outline the consequence metrics used to determine the total levee score which in turn can be used to Categorise the levee.

With six metrics being considered the total possible score is 30 however not all metrics will be applicable to all levees i.e. If a levee is specifically designed to protect a piece of key infrastructure it will not need to be assessed against private residential loss.

Thus, the total levee score is calculated as a percentage of the total possible score after removal of any metrics that are not applicable for any given levee.

In order to categorise a levee based on its overall consequence score the following ranges have been adopted in consultation with the CMA using worked examples.

TABLE 3. LEVEE CATEGORY VS CONSEQUENCE SCORE

LEVEE CATEGORY	SCORE
Category 1	> 60%
Category 2	> 35% and ≤ 60%
Category 3	≤ 35%

TABLE 4. LEVEE CATEGORISATION CONSEQUENCE MATRIX

			GUIDING METRIC DESCRIPTORS				
IMPACT	**CONSEQUENCE CATEGORY**	**EXAMPLES OF SUPPORTING EVIDENCE**	**VERY LOW**	**LOW**	**AVERAGE**	**HIGH**	**VERY HIGH**
			1	**2**	**3**	**4**	**5**
Safety	Responder Safety	ARR Book 6 - Flood Hydraulics, Section 7.2.7 - General Flood Hazard Curves (Figure 6.9.7) - depth for a flow velocity of 1.0 m/s	Levee height ≤ 0.25m	0.25m < Levee Height ≤ 0.5m	0.5m < Levee Height ≤ 1.0m	1.0m < Levee Height ≤ 4.0m	Levee Height > 4.0m
	Community Safety	Major evacuation route	More than three major evacuation routes are available to enable community evacuation to closest unaffected town	Three evacuation routes are available to enable community evacuation to closest unaffected town	Two major evacuation routes are available to enable community evacuation to closest unaffected town	One major evacuation route is available to enable community evacuation to closest unaffected town	All major evacuation routes are blocked preventing community evacuation to closest unaffected town
Economic	Key Infrastructure	The maximum of either duration or number of customers affected	Inconsequential short term failure of infrastructure and service delivery	Isolated loss of infrastructure for short periods resulting in localised inconvenience	Mid-term failure of infrastructure affecting some parts of community	Mid to long term failure of significant infrastructure affecting large	Long term failure of significant infrastructure such as one of the identified sub-category

				GUIDING METRIC DESCRIPTORS				
IMPACT	**CONSEQUENCE CATEGORY**	**EXAMPLES OF SUPPORTING EVIDENCE**		**VERY LOW**	**LOW**	**AVERAGE**	**HIGH**	**VERY HIGH**
				1	**2**	**3**	**4**	**5**
							parts of community	
		Services (Power, Communications, Water/Waste Water)	Duration of infrastructure failure	≤ 2 hrs	2 - 12 hrs	12 – 24 hrs	24 – 48 hrs	> 48 hrs
			Number of customers affected	≤ 100 people	100 – 200 people	200 – 1,000 people	1,000 – 5,000 people	> 5,000 people
	Private residential loss	Commercial buildings or dwellings protected by the levee		5 or less homes rendered temporarily uninhabitable	5 or less flooded over floor	6-20 flooded over floor	21-50 flooded over floor	>50 flooded over floor
	Agricultural Industries	Source data to be confirmed to confirm number of farms impacted.		Limited impact to 5 or less farms	Severe impact to 5 or less farms and/or limited impact to 6-20 farms	Severe impact 20-50 farms	Severe impact to 50-100 farms	Severe impact to >100 farms
	Economic Impact	Disruption to businesses impacting on Business operations and overall economy.		Disruption at the individual business level	Disruption at a business level	Disruption to selected business sectors impacting on the	Significant disruption across business sectors	Widespread business failure impacting on

			GUIDING METRIC DESCRIPTORS				
IMPACT	**CONSEQUENCE CATEGORY**	**EXAMPLES OF SUPPORTING EVIDENCE**	**VERY LOW**	**LOW**	**AVERAGE**	**HIGH**	**VERY HIGH**
			1	**2**	**3**	**4**	**5**
				impacting on the local economy	regional economy.	impacting on State economy.	National economy.

This systematic categorisation helps to identify and prioritise future resource and management requirements, enhancing the readiness of flood-prone areas to withstand varied flood conditions across northern Victoria.

4 LIMITATIONS

While the desktop-based strategic levee categorisation process offers a cost-effective and efficient method for initial assessments, it inherently comes with several limitations. These limitations stem primarily from the nature and quality of the available data and the constraints of remote analysis, which can impact the overall reliability and accuracy of the categorisation outcomes. Some of these challenges were partially overcome through stakeholder engagement, as local knowledge and identification of new information sources were incorporated into the review process.

Key limitations for this report include:

Accuracy of Existing Data

The accuracy of any desktop assessment is dependent on the quality of existing datasets, which may vary in precision and completeness. Outdated or erroneous data can lead to misclassification or incorrect mapping of levees, particularly in regions where updates to datasets have not been systematically performed.

Where multiple data sources were available, the review team were able to use cross referencing to validate levee locations. However, in some cases the available data is not sufficient for the purpose of identifying all errors in the source data.

Extent of Key GIS Layers

The level of confidence in the assessment of levee categories relies on the availability of key GIS layers at the location of the levee. For example, the location and extent of levees within the area mapped with a Digital Elevation Model (DEM) at 1 metre increments are able to be clearly identified, however 50% of the identified levees are not within the area where this data set is available. Other key GIS layers that are not available for the whole region include: flood modelling, observed flood extent and aerial photography.

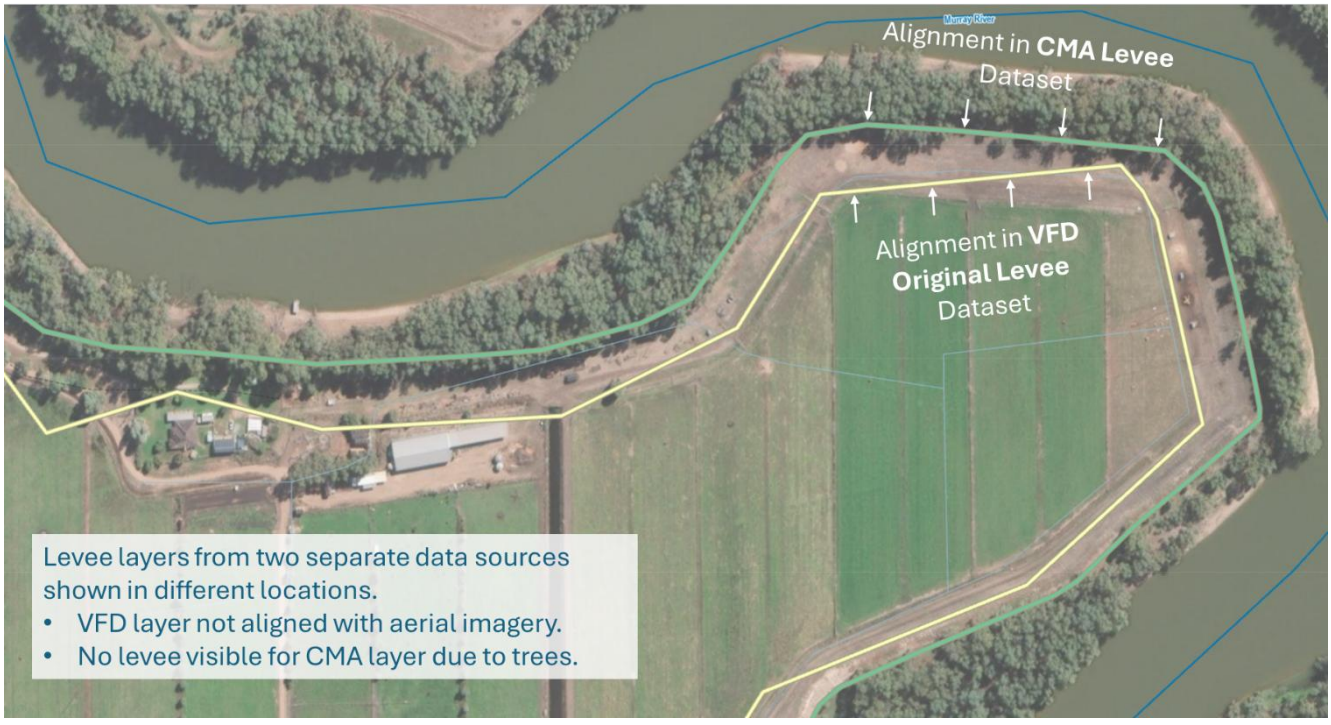


FIGURE 5. EXAMPLE OF CONFLICTING DATA IN EXISTING DATASETS



FIGURE 6. EXAMPLE OF USING THE DIGITAL ELEVATION MODEL TO ACCURATELY VERIFY LEVEE LOCATIONS

Quality and Timing of Aerial Imagery

The effectiveness of desktop-based assessments relies heavily on the quality of aerial imagery. Low-resolution or outdated imagery can hinder the ability to identify levee features, assess conditions, or detect recent changes. Furthermore, the quality of imagery may vary across different regions, impacting the consistency of the assessment.

Availability of Levee Height Information

A significant limitation is the availability and accuracy of levee height data. Levee height plays an important role in consequence assessments related to responder safety. However, precise height measurements are missing from the source datasets for most of the levees evaluated. In some cases, approximate levee heights can be inferred from contour lines in the 1m DEM layer. Overall, though, the lack of reliable height information means that most levees are assigned an average height status by default.

Availability of Levee Ownership Status

Ownership information for levees is not readily available for many of the levees included in this assessment. The absence of definitive ownership data complicates the identification of responsible parties for maintenance and can hinder strategic planning and decision-making. In particular, levees that are privately owned and maintained are not assigned as category 1,2 or 3, and instead would be flagged as 'private.'

For the purpose of completing this assessment without a comprehensive list of levee ownership, all levees identified were assigned a category unless there was clear evidence that the levee is exclusively used as a private asset.

Availability of Building Floor Elevation Data

Under the private residential loss criterion, the impact rating is based on the number of buildings where floodwater is likely to rise above the floor level. Detailed floor elevation data for dwellings is often scarce or inconsistent. Without a comprehensive data source for floor elevations, this assessment conservatively assumes that buildings within an area protected by a levee will be impacted.

Note: This assumption likely overstates the number of dwellings affected, particularly given that building approval requirements in recent decades have mandated that new homes be constructed with floors above historic flood levels.

Flood Path Modelling/Observations

Desktop assessments often rely on simplified flood models or historical observations, which may not fully capture the complexity of real-world flood behaviour. Limited access to detailed hydraulic modelling or field observations can result in less accurate assessments of flood pathways, overtopping risks, and potential levee failures.

Levee Maintenance Status

Category 2 subcategories A and B are assigned based on the levees' condition and maintenance requirements. However, existing documents and datasets provide limited information on the maintenance status of each levee. Additionally, emergency repairs during the 2022 flood event, as well as subsequent flood damage, have likely altered the condition of some levees in this category.

To assist in validating the assumptions made we undertook a series of engagements with Local Government, VicSES, CMA's and the local community. Stakeholder engagement improved the accuracy of Type A and B assignments by incorporating local knowledge and better identifying future maintenance needs. The outcomes from these stakeholder engagement activities can be found in sections 8 and 10.

5 CATEGORISATION RESULTS / FINDINGS

Using the process outlined in Section 3, an initial desktop review resulted in a preliminary category assignment for each levee. Levees previously identified in a MFEP as a high priority levee retained their Category 1 status. Private levees and Significant Floodplain Features did not need to be tested against the criteria. As such, the review process was mostly focused on determining whether the remaining levees met the criteria for Categories 2 and 3.

In the initial levee assessment, levees were examined in the GIS mapping system to identify whether dwellings, commercial buildings, or key community infrastructure were present in the potential impact zone in the event of a levee failure. For most levees, these elements were either absent or insufficient to meet the threshold for a rating above 'very low' in the relevant criteria. In such cases, where no pathway existed for assigning a category higher than 3, the levees did not undergo a full assessment against all criteria.

Levees with the potential for a classification of Categories 1 or 2 were then flagged for a more detailed assessment in consultation with CMA representatives prior to engagement with other stakeholders.

An overview of the category assignment process is shown in Figure 7.

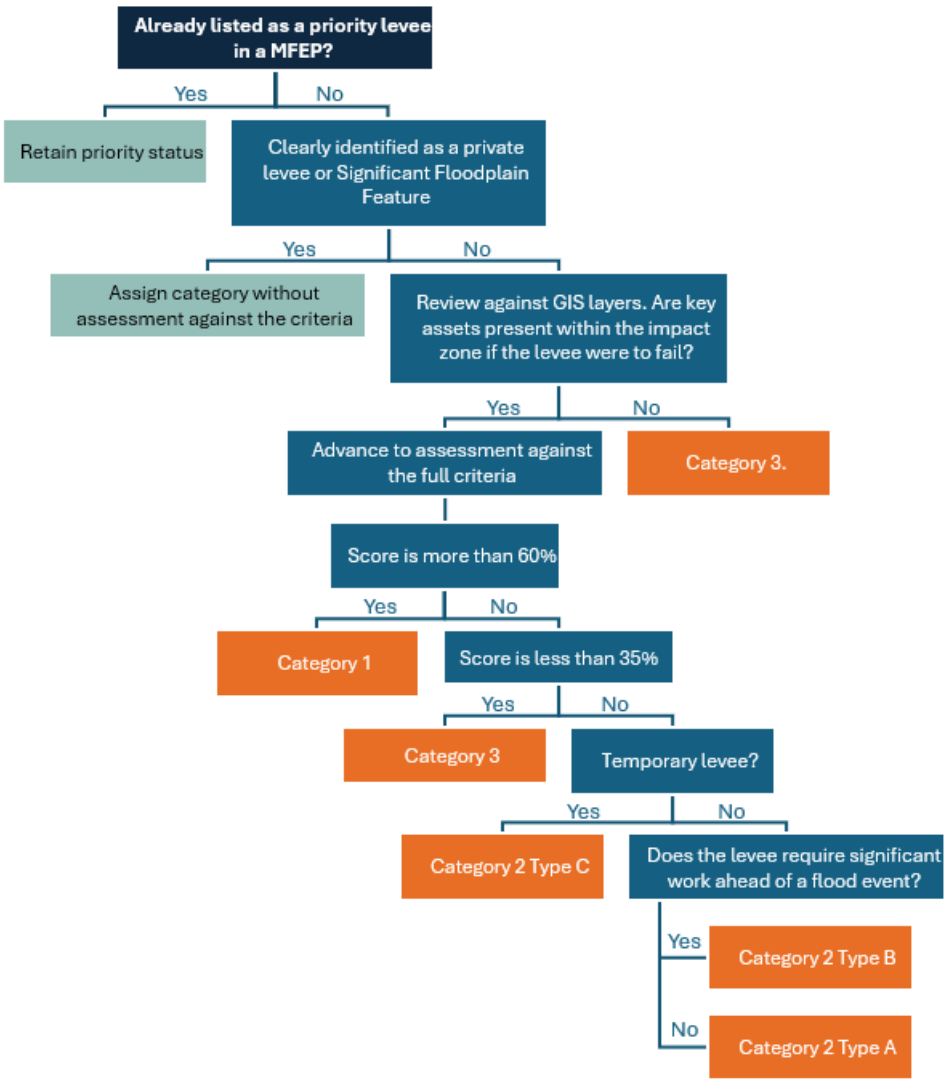


FIGURE 7. LEVEE CATEGORISATION WORKFLOW

Further refinement of the levee assignments took place in response to feedback through the engagement phase. In total, **1400 km** out of **1,764 km** of identified levees were classified as **Category 3**, **Private**, or **Significant Floodplain Features**. The remaining **364 km** (21% of the mapped levees) received a preliminary classification of **Category 1 or 2**. Figures 8 and 9 show a breakdown of levee category assignments. **The below figures are representing the Sequana project area only which is shown above in Figures 1-4.**

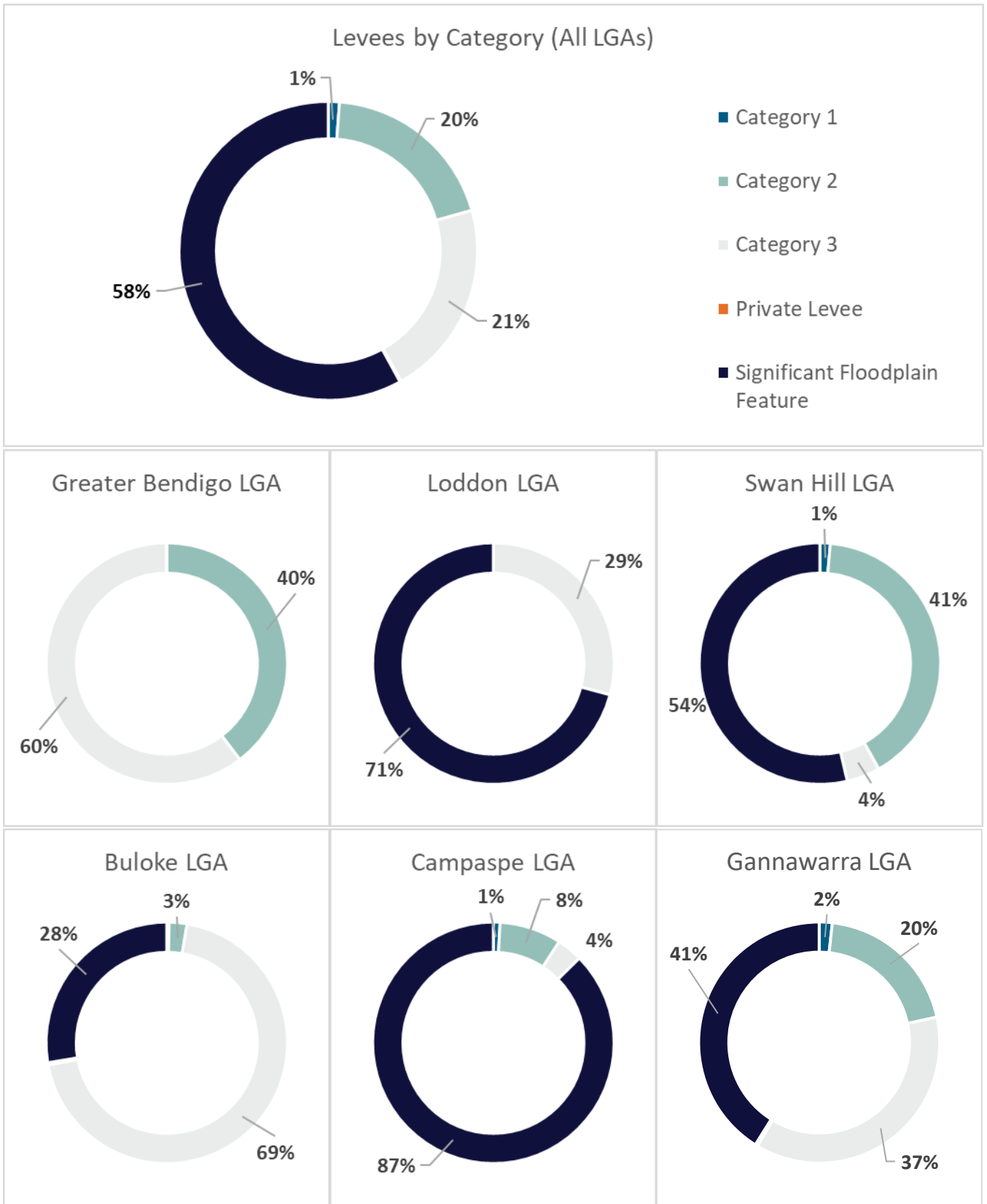


FIGURE 8. LEVEES CATEGORIES (% OF TOTAL LENGTH)

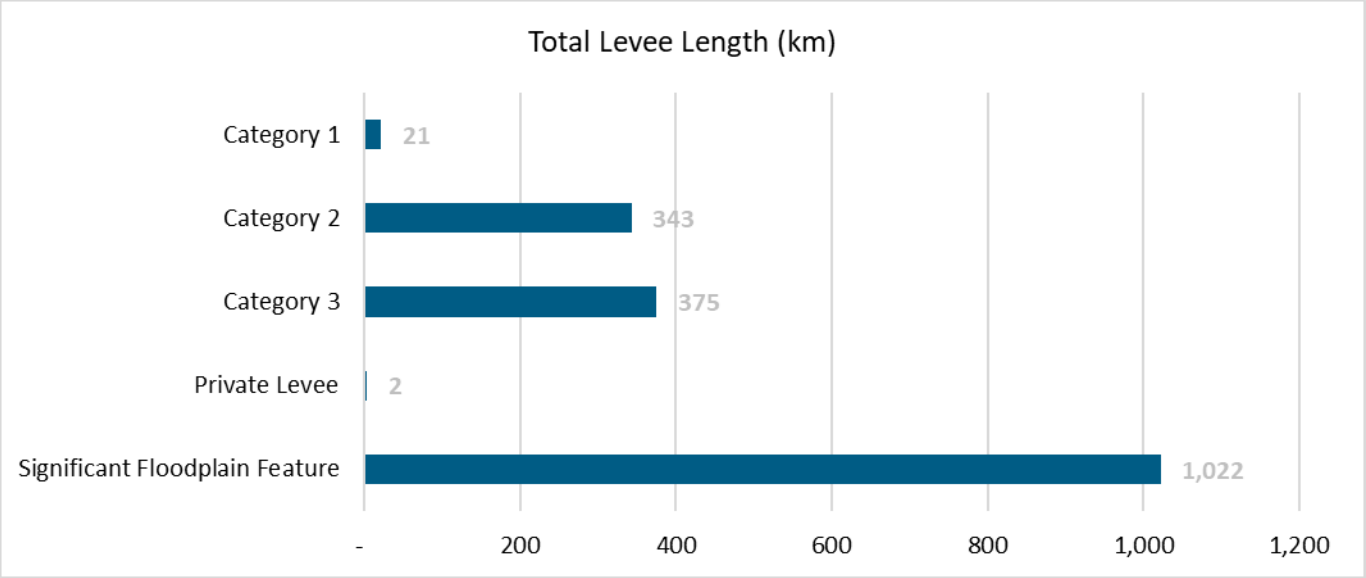


FIGURE 9. TOTAL LEVEE LENGTH (KM)

A critical observation from the levee review is that 343 kilometres of the total length assessed have been assigned a Category 2 designation. Notably, over 70% of these Category 2 levees belong to five major levee groups. Depending on the final outcome of the review process, these groups will play a significant role in influencing the extent of future Category 2 maintenance and monitoring actions due to their extensive lengths. Figure 10 provides a visual representation highlighting the longest levees that fall within the Category 2 classification.

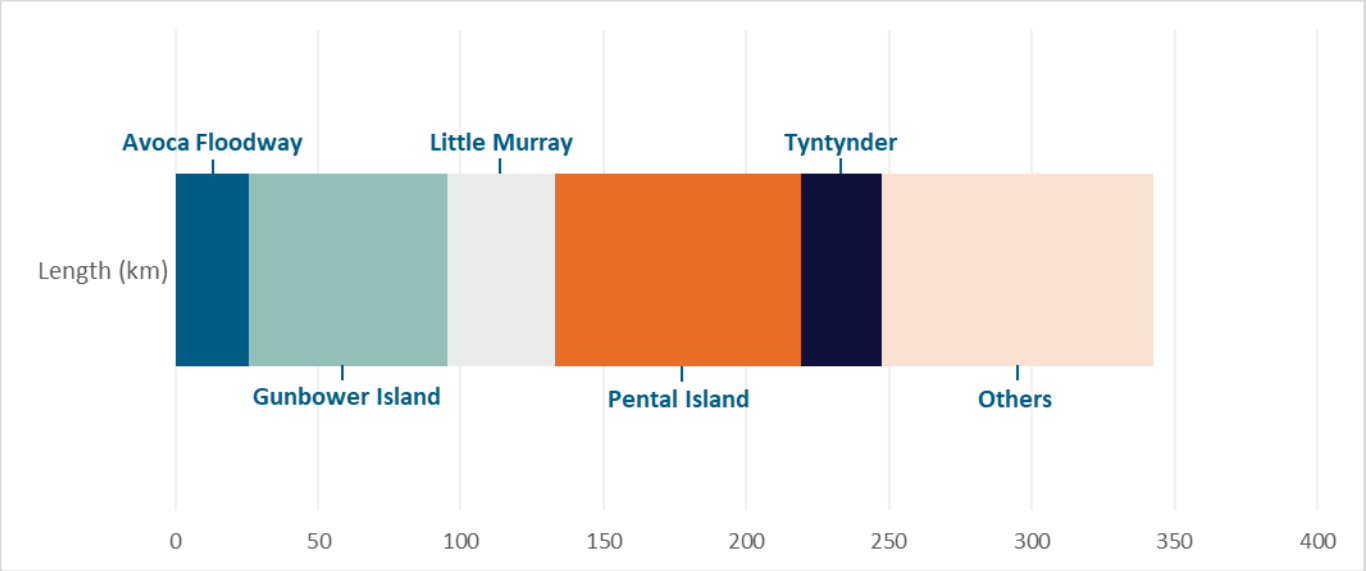


FIGURE 10. MAJOR LEVEES WITHIN THE CATEGORY 2 GROUP (KM)

Category 2 levees represent structures that provide important community or infrastructure protection but currently lack formal management or maintenance arrangements. Within this group, those with higher assessment scores indicate greater potential consequence of failure, higher exposure of assets, or stronger community reliance. These levees should therefore be treated as a higher priority for future investigation, funding, and potential transition into formal management schemes. Prioritising higher-scoring Category 2 levees ensures that limited resources are directed toward the areas of greatest risk reduction and public benefit, aligning with the principles of the Victorian Floodplain Management Strategy.

The below table outlines the initial levee Categorisation scores for the Category 2 and Category 3 levees.

TABLE 5. LEVEE CATEGORISATION SCORES

Levee Group	Levee Name	Categorisation Score	Categorisation
L0006	Campaspe R 6	60%	Category 2
L0022	Pental Island West	60%	Category 2
L0023	Pental Island East	60%	Category 2
L0059	Pental Island-Little Murray	60%	Category 2
L0029	Torrumbarry Levee	60%	Category 2
L0020	Tyntynder Flats	60%	Category 2
L0039	Wycheproof Levee	60%	Category 2
L0024	Little Murray	53%	Category 2
L0034	National Headworks Channel Bank	53%	Category 2
L0026	Rochester Flood Mitigation Works	53%	Category 2
L0015	Gunbower Island	50%	Category 2
L0036	Mystic Park Levee	50%	Category 2
L0025	Tyntynder Flats Flow Tube	47%	Category 2
L0037	Avoca Floodway	47%	Category 2
L0016	Campaspe Esplanade	40%	Category 2
L0035	Avoca Outfall	37%	Category 2
L0014	Quambatook Town	30%	Category 3
L0018	Eastern Flood Course Levee	30%	Category 3

6 ANALYSIS, MAPPING AND DATA INSIGHTS

The spatial analysis and mapping undertaken as part of this project provides important insights into the distribution, function, and relative importance of levees across the North Central CMA region. As outlined in Section 5, the assessment identified approximately 1,764 km of levees and floodplain features across the study area. Of this, approximately 1,400 km were classified as Category 3, Private Levees, or Significant Floodplain Features. The remaining 364 km (approximately 21% of the mapped levees) were identified as Category 1 or Category 2 levees, representing those assets with the greatest strategic importance in terms of community safety, agricultural productivity, infrastructure protection, and pre-planning for emergency response.

Spatial analysis indicates that:

- Category 1 levees are generally associated with established township flood mitigation infrastructure and formally managed flood protection systems.
- Category 2 levees are widely distributed throughout the rural floodplain and often protect extensive agricultural land, transport corridors, irrigation infrastructure, and smaller rural communities, despite many lacking formal management arrangements.
- Category 3 and Private levees represent the majority of levee structures across the region and are typically fragmented, locally constructed, or associated with historical flood response activities and providing isolated and uncoordinated agricultural protection.
- Significant Floodplain Features, including roads, irrigation channels, rail embankments, and floodways, were identified as having a substantial influence on flood behaviour and flood conveyance across the broader floodplain system and were therefore chosen to be recognised in the mapping produced by this project.

The mapping and analysis also identified several key regional trends:

- A relatively small number of major levee precincts account for a significant proportion of the Category 2 levee network, including Tyntynder Flats, Pental Island, Little Murray River, Gunbower Creek, and Torrumbarry.
- Many levee systems operate in conjunction with existing infrastructure such as irrigation channels, roads, regulators, and floodways, highlighting the interconnected nature of floodplain management across the region.
- The condition, continuity, and management status of levees varies significantly across the study area, particularly where levees have evolved incrementally over time without formal oversight.
- Gaps in available high-resolution datasets, including LiDAR coverage and detailed flood modelling, reduce confidence in some levee assessments and reinforce the importance of ongoing refinement.
- Community knowledge and historical flood experience played an important role in validating levee alignments, understanding flood behaviour, and identifying the practical function of levees and floodplain features during major flood events.

These insights reinforce the importance of a coordinated and regionally consistent approach to levee management, flood intelligence, and emergency planning across the North Central CMA region. The project also highlights the need for continued collaboration between CMAs, local government, emergency services, infrastructure managers, and local communities to support future flood preparedness and resilience outcomes.

7 GIS MAPS/ LAYERS

Maps were utilised in reviews with VICSES, the LGAs and subsequently through the community engagement process. The maps helped to ensure additional information was gathered and important details could be captured. These maps provided support to the online GIS portal which allowed for comments directly within, providing users with the opportunity to write their comments onto hard copy maps ensuring our levee information is as accurate as possible.

The maps utilised at the LGA and VICSES review workshops were taken at a higher level to reflect the template and typical output that can be produced from the GIS platform. Some example maps from these workshops have been included below. The maps produced for the community engagement sessions focused on target areas and zoomed into smaller sections for a more detailed review. These maps also merged private and Category 3 levees to ensure the focus of these sessions was directed to the significant and critical levees. The maps produced and utilised in the community engagement have been included in Appendix 3.

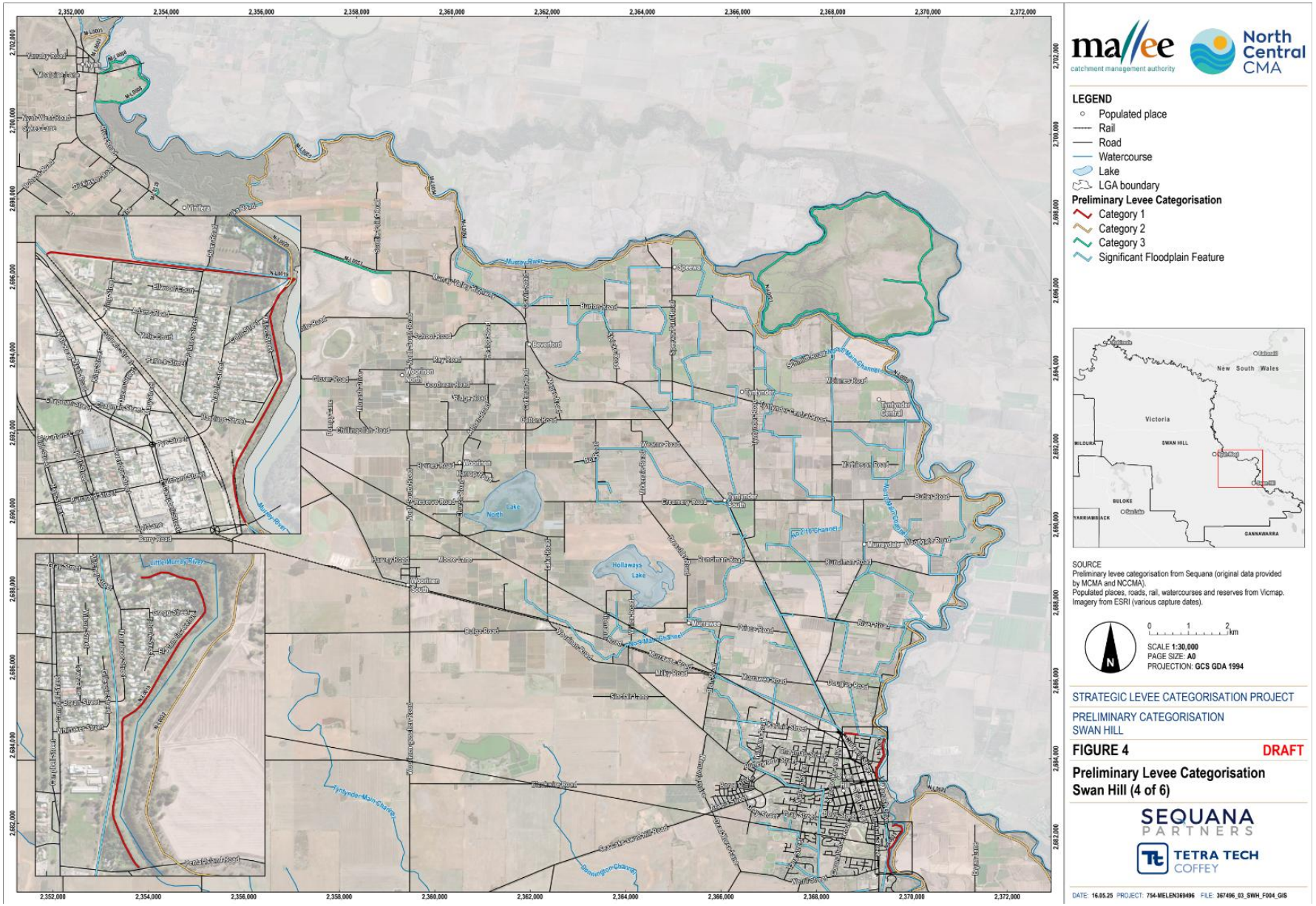


FIGURE 11. EXAMPLE OF WORKSHOP MAP (SWAN HILL)

8 LEVEE CATEGORISATION REVIEW WORKSHOPS- LOCAL GOVERNMENT AGENCIES

The purpose of the LGA workshops was to review the preliminary Levee Categorisation with the CMAs, VICSES and the LGAs. The workshops provided the opportunity to update the WebGIS data and refine the categorisation of individual levees based on local knowledge and ground-truthing.

The workshops were held with the following key stakeholders:

- **Buloke Levee review workshop:**
  25/02/2025, Mallee CMA, North Central CMA, DEECA, Buloke LGA, VicSES & Sequana
- **Swan Hill Levee review workshop:**
  26/02/2025, Mallee CMA, North Central CMA, DEECA, Swan Hill LGA, VicSES, Lower Murray Water & Sequana
- **Gannawarra Levee review workshop:**
  28/04/2025, North Central CMA, Gannawarra LGA, Sequana & Streamology
- **Campaspe Levee review workshop:**
  01/05/2025, North Central CMA, Campaspe LGA, Sequana, Goulburn Broken Catchment Management Authority (GBCMA) & Confluence Group (GBCMA levee review consultant)

Appendix 2 details the updates made to alignments, ownership status, category assignments and previously unmapped levees following the LGA sessions.

9 FLOOD MITIGATION PLAN AREAS- STRATEGIC LEVEES BY AREA

The North Central CMA region includes several significant levee precincts that were identified through the review process as having an important influence on regional flood behaviour, emergency response, and community resilience outcomes. These areas include Tyntynder Flats, Pental Island, Little Murray River, Gunbower Creek, and Torrumbarry.

The review identified that many of these precincts share common characteristics, including ageing infrastructure, varying levels of maintenance, evolving floodplain conditions, and differing governance or ownership arrangements. Community engagement and stakeholder consultation also highlighted the importance of these levee systems for protecting local communities and agricultural operations.

The summaries below provide an overview of the current understanding of each precinct based on available data, stakeholder input, flood history, and observations gathered during the project. The information is intended to support future investigation, planning discussions, and ongoing refinement of flood intelligence across the region.

9.1 TYNTYNDER FLATS

The Tyntynder Flats levee system extends approximately 34 kilometres from Arnoldt Street in Swan Hill through to Forest Road near Vinifera. It protects around 429 residential properties, 16 commercial properties, 8 public buildings, and over 7,600 hectares of farmland. Although it has successfully prevented flooding in major events such as 2011, 2016, and 2022, there is no formal management or maintenance framework in place. Historically, irrigation channels located behind the levee acted as secondary defences or ‘fall-back’ positions in the event of levee failure. However, due to irrigation system rationalisation and the removal or neglect of these channels, their effectiveness has declined. A high-level cost-benefit analysis undertaken by Sequana Partners and Frontier

Economics demonstrated that the economic benefits of upgrading and maintaining the levees may significantly outweigh the costs.

Community engagement undertaken as part of this review confirmed strong local interest in the ongoing performance and reliability of the levee system. The project identified opportunities for future investigation, including updated flood modelling, levee condition assessments, and further exploration of potential management approaches. Any future investigations would benefit from continued engagement with affected communities and stakeholders to improve understanding of flood behaviour, residual risk, and potential management considerations.

9.2 PENTAL ISLAND

The Pental Island levee network comprises two ring levees with a combined length of approximately 84 kilometres, protecting around 80 rural and lifestyle properties, including 62 dwellings. While the levees have performed effectively in recent floods, ongoing deterioration and a lack of formal maintenance remain key concerns.

North Central CMA is currently progressing investigations associated with the historical management arrangements of the levee system, including consideration of historical governance and funding mechanisms. Community engagement highlighted ongoing interest in the long-term performance and maintenance of the levees and identified the value of continued discussion regarding future management considerations and responsibilities.

9.3 LITTLE MURRAY RIVER – SWAN HILL LGA

The levees along the south bank of the Little Murray River extend from Cooper Road, Winlaton, to their junction with the Swan Hill Township Levee near River Oaks Drive. These levees protect over 170 properties and 10,000 hectares of land, with interdependent performance linked to the Lake Boga Outfall and floodway systems.

The review identified opportunities for future investigation relating to flood behaviour, levee performance, drainage interactions, and the role of surrounding infrastructure within the broader floodplain system. Community discussions also highlighted the importance of understanding how roads, channels, and existing floodways influence flood movement and residual flood risk within the precinct.

9.4 MURRAY RIVER / GUNBOWER CREEK – GANNAWARRA LGA

The Gunbower Forest Perimeter Levees extend from Deep Creek near Gunbower through to Kerang-Koondrook Road at Koondrook, protecting agricultural and residential areas from Murray River flooding. While these levees have successfully contained floods in recent decades, their ageing condition and absence of a formal management framework pose ongoing risks to flood resilience.

The review identified the value of further investigation into flood behaviour, levee condition, and broader floodplain interactions within the precinct. Community and stakeholder engagement highlighted the importance of coordinated management approaches across agencies and infrastructure systems to support future flood preparedness and response discussions.

9.5 TORRUMBARRY – CAMPASPE LGA

The Torrumbarry levees extend from Richardsons Lagoon through to Deep Creek, protecting agricultural land and townships across Torrumbarry, Patho, Gunbower, and Leitchville. These levees play a crucial role in preventing Murray River flooding from impacting the Murray Valley Highway, Ghow (Kow) Swamp, and Gunbower Creek. The network includes both perimeter levees along the forest edge and river levees adjacent to the Murray River.

Although the system has performed well during past floods, significant emergency works were required in 2022 to prevent overtopping. These works created further legacy issues across land tenures and resulted in expensive and complex flood recovery operations – highlighting the risks associated with unplanned emergency responses.

The review identified opportunities for additional technical investigation into levee condition, hydraulic performance, and floodplain interactions within the precinct. Stakeholder discussions also highlighted the importance of considering environmental, cultural heritage, infrastructure, and community perspectives in any future planning or assessment activities associated with the levee system.

10 COMMUNITY ENGAGEMENT

As part of the North Central Levee Review, community engagement played a key role in verifying mapped information, building local awareness, and identifying any additional flood mitigation infrastructure or concerns. A series of targeted landowner meetings and public drop-in sessions were held across the region to provide opportunities for local residents to view draft levee maps, ask questions, and provide feedback.

10.1 COMMUNITY DROP-IN SESSIONS

Drop-in session locations were selected by North Central CMA in consultation with local government representatives. Sites were prioritised based on their proximity to levee systems where local interest and past community advocacy for improved management had been noted—particularly in areas without formal levee management arrangements already in place. Rather than simply targeting larger population centres, the team focused on locations where discussions were more likely to lead to meaningful input relevant to the review.

The following community drop-in sessions were conducted:

- **Bridgewater – 4 June 2025, Bridgewater Recreation Reserve**
- **Boort – 4 June 2025, Boort Resource and Information Centre**
- **Pyramid Hill – 5 June 2025, Pyramid Hill Community Centre**
- **Kerang – 5 June 2025, Kerang Memorial Hall (Notably, over 50 people attended this event)**
- **Cohuna – 26 June 2025, Cohuna Community Meeting Room**
- **Murrabit – 27 June 2025, Murrabit Public Hall**

Representatives from North Central CMA, local Councils and VicSES were present at the sessions to support discussions and respond to questions. These sessions were advertised by North Central CMA and promoted through local council channels i.e. social media, community flood recovery contact lists. All sessions were well attended and emergency managers received valuable feedback on the strategic levee maps and many other aspects of flood emergency management.

An additional session was held with the Gannawarra Shire Council's Flood Observers Network on 1 August 2025. The Flood Observers are a group of community members with a long-standing history of involvement in local flood planning and flood event management within the framework of the Gannawarra Shire's Municipal Flood Emergency Plan. This network is a valuable source of flood history and knowledge, floodplain management ideas and actions, and community champions for the work of Council and North Central CMA. Over 50 people attended the session in Kerang which covered a range of topics including North Central CMA's levee review project.

Additional individual or small group discussions were also conducted with landowners at Tyntynder, Murrabit West, Capels Crossing, Benjeroop, Koroop, Mead, Dingwall, Tragowel, Pyramid Hill, Tandarra, Kamarooka,

Raywood, Torrumbarry. These field visits and discussions with local landowners were highly valuable in assessing the value and purpose of levees assessed under the strategic levee review project.

10.2 OVERVIEW OF COMMUNITY FEEDBACK

Overall, community members showed interest in reviewing the maps and understanding which levees had been identified near their properties. While the sessions were valuable for raising awareness, they generally did not result in:

- The identification of new levees not already captured in the existing datasets.
- Significant disagreement with the preliminary classifications assigned to the levees.

Most feedback focused on clarifying levee alignments or understanding how the mapped data might influence future flood preparedness and emergency planning.

10.2.1 TYNTYNDER FLATS

Community discussions indicated strong local interest in confirming the levee's effectiveness and reliability following the 2022 flood. There was general concern about the condition of the levee system and the reliability of the older "flow tube" structures once used as fall-back defences. These structures appear degraded or partially removed, meaning they can no longer provide dependable protection. The community supported a structured approach to verifying flood levels, updating flood models, and exploring formal levee management arrangements once clearer data and funding are secured. It was noted that residents have limited awareness of their flood exposure due to the levee's historic success, highlighting the need for public communication alongside technical work.

10.2.2 PENTAL ISLAND

Engagement confirmed broad support for North Central CMA's current efforts to investigate formal management options for the Pental Island levees. Participants recognised that the existing system, which was originally managed under a River Improvement Trust, has deteriorated since those arrangements ceased. While the levees continue to perform, concerns remain about long-term maintenance and the ability to fund and govern the system sustainably. Community sentiment favours the CMA's structured approach to exploring governance and cost-sharing models, with clear acknowledgment that future management will require both technical upgrades and community buy-in.

10.2.3 LITTLE MURRAY RIVER

Community engagement over a long period of time has indicated support to examine formal management options for the levee systems along the south bank of the Little Murray River. Although the levees continue to provide functional flood protection (as observed in late 2022), there is concern about coordination of flood and levee management, how levees will be maintained into the future and whether sustainable funding and governance models can be secured to provide a confident level of ongoing flood protection.

Similar to Pental Island and Tyntynder Flats, a structured approach to assessing flood protection benefits, levee integrity, and future governance and cost-sharing arrangements is required in collaboration with the local community.

If the area cannot justify any scheme of formal management, the flood risk to existing development from levee failures needs to be explored and could be collaboratively managed between community and emergency

management agencies. Local flood modelling indicates that flood risk could possibly be managed through a series of localised 'flood containment areas' – which are formed by a network of naturally high ground, raised local roads, and raised public and private irrigation channels. Mapping indicates that these structures could contain flood impacts to isolated areas local to where any levee breaches occur, ensuring that a single levee breach doesn't result in catastrophic impacts for the whole area from Fish Point through to Swan Hill. Whilst initial flood waters may be contained in an emergency, residual challenges related to drainage of any ponded water, and the need for and responsibilities around any potential flood regulators or raised roads or channels would need to be addressed. Future engagement would need to test community willingness to maintain their local sections of levee informally while exploring how public assets could serve as reliable fall-back barriers to limit flood impacts in future emergencies.

10.2.4 MURRAY RIVER / GUNBOWER CREEK

Engagement across this precinct revealed a mix of operational and community perspectives. Participants emphasised the interaction between Murray River and Gunbower Creek levees, especially regarding the need to manage flow conveyance into and out of forest areas. There was recognition that unregulated flood flows have previously caused complications for downstream communities such as Cohuna and Koondrook. Concerns were raised about how infrastructure changes, blocked drains, and road crossings can alter local flood behaviour. The discussion reinforced the need for detailed flood modelling and collaborative management across CMA, GMW, and local government boundaries to ensure consistent approaches to levee height, maintenance, and environmental considerations.

10.2.5 TORRUMBARRY

Engagement at Torrumbarry confirmed that both community and agency stakeholders regard the levee system as a critical regional asset. Modelling presentations showed that the river levees play an important role in influencing the division of flood flows between New South Wales and Victoria, while perimeter levees protect local properties and agricultural land. Discussions highlighted that while raising sections of the levee during the 2022 flood helped protect assets, inconsistent height and condition now present ongoing uncertainty prior to the next major flood. Some sections of the works have also since been removed, requiring additional future emergency actions for the levee system to provide any ongoing flood protection function. Participants agreed that a full investigation is required to determine the most viable levee alignment, the beneficiaries of flood protection, and options for sustainable management. Coordination between agencies and the community was identified as essential to balance environmental, cultural heritage, and flood mitigation objectives.

10.2.6 DRAINAGE

Effective drainage is a critical component of flood mitigation, particularly in areas where levees overtop or fail. Engagement across the region consistently highlighted that prolonged inundation and residual ponding often cause greater disruption and damage than the initial flood peak itself. In several locations, floodwaters were unable to drain back into waterways for weeks or months due to physical constraints within the floodplain, resulting in extended isolation, delayed recovery, and ongoing impacts to agriculture, infrastructure, and communities. These issues were commonly exacerbated once levee breaches occurred and water became trapped behind downstream barriers.

Road infrastructure, raised embankments, undersized culverts, modified crossings, and irrigation channels were frequently identified as contributing to poor drainage outcomes. While many of these assets serve essential transport or water delivery functions, their cumulative effect can significantly impede floodwater recession when not designed or managed with floodplain drainage in mind. Engagement also highlighted that channel rationalisation and decommissioning have altered historic drainage pathways, sometimes removing informal fall-back options that previously assisted floodwaters to move away more efficiently.

Recognising drainage as a core element of the flood mitigation toolkit provides important context for future investigations and precinct planning. Addressing drainage constraints, identifying priority flow paths, and reducing artificial obstructions to floodplain conveyance can materially reduce the duration and severity of flood impacts, particularly in areas where formal levee management is not feasible. Integrating drainage considerations with levee planning, road design, and channel management will be essential to improving flood resilience and recovery outcomes across the region.

10.3 ENGAGEMENT SUMMARY

The community engagement sessions provided an important checkpoint in the levee review process. They confirmed a general alignment between the mapped data and local knowledge, while also helping to surface a few specific issues requiring further attention. The feedback received will be used to help finalise levee classifications and inform future communication with residents.

Beyond the specific levee-level changes identified, the community engagement process played a broader role in shaping the overall project outcomes. Feedback from community members helped to validate the general accuracy of the mapped levee network and preliminary classifications, while also reinforcing the importance of certain assets that may not have been fully captured through desktop analysis alone. The engagement process highlighted areas where community reliance on levees is higher than initially assumed, as well as locations where expectations regarding levee management differ from current governance arrangements. These insights informed refinements to the categorisation approach, improved confidence in the final dataset, and reinforced the need for clear communication regarding levee function, limitations, and responsibilities in future flood events.

11 REGIONAL EMERGENCY DOCTRINE (MFEP'S)

A key objective of the Strategic Levee Categorisation project is to support the integration of improved flood intelligence into regional emergency management frameworks, particularly Municipal Flood Emergency Plans (MFEPs).

Across the project area, MFEPs are at varying stages of update and refinement. The outcomes of this project are intended to inform these updates by providing:

- Improved spatial data on levee locations and understanding of levee importance priority
- Enhanced understanding of levee function and performance during flood events
- Identification of priority levees that require monitoring or intervention during flood events

A summary of MFEP status across the region is provided below:

LGA	MFEP STATUS	NOTES
Swan Hill Rural City Council	Levee Appendices Updated	The North Central CMA region does not fully encompass this LGA. Additional MFEP updates required through the neighbouring CMAs corresponding project
Buloke Shire Council	Levee Appendices Updated	The North Central CMA region does not fully encompass this LGA. Additional MFEP

		updates required through the neighbouring CMAs corresponding project
Campaspe Shire Council	Levee Appendices Updated	The North Central CMA region does not fully encompass this LGA. Additional MFEP updates required through the neighbouring CMAs corresponding project
Gannawarra Shire Council	Levee Appendices Updated	Additional MFEP updates required through the corresponding project completed by a different consultant
City of Greater Bendigo	Levee Appendices Updated	The North Central CMA region does not fully encompass this LGA. Additional MFEP updates required through the neighbouring CMAs corresponding project
Loddon Shire Council	Levee Appendices Updated	Additional MFEP updates required through the corresponding project completed by a different consultant

The integration of levee categorisation outputs into MFEPs supported the following outcomes:

- Clearer articulation of flood intelligence
- Ability to improve decision-making during emergency events
- Better alignment between agencies regarding levee roles and responsibilities

As part of the package of works undertaken through this project, a separate supporting document has also been prepared outlining recommendations and considerations for improving the structure, consistency, and integration of levee-related information within future Municipal Flood Emergency Plan (MFEP) updates across the region.

Updates to MFEP templates are currently being progressed by VICSES and local government will further support the consistent inclusion of levee data and categorisation outcomes.

12 CONCLUSION AND RECOMMENDATIONS

The Strategic Levee Review undertaken by the North Central CMA followed a consistent and evidence-based approach to identify, categorise, and validate levees across the region. The review process drew on existing datasets, flood modelling, and 2022 satellite imagery, with levees assessed against defined criteria relating to safety, economic, environmental, infrastructure, and cultural factors.

Stakeholder and community engagement were central to the review. Agency workshops helped refine classifications and align findings with current emergency management practices. Community drop-in sessions allowed residents to view draft maps, clarify alignments, and raise local issues. While most community feedback affirmed the proposed categories, a small number of cases generated further discussion or requests for reclassification.

At a regional level, the review found that levees warranting formal management arrangements are largely recognised and integrated into existing Municipal Flood Emergency Plans (MFEPs). However, Category 2 and 3 levees, particularly those with a small beneficiary base, remain contentious. In the absence of clear oversight, these structures can create uncertainty during flood events about whether they will perform or be maintained by emergency services.

Strategically, it is generally agreed that communal assets should be managed by relevant authorities, while levees offering private benefit fall to individual responsibility. Yet in practice, roles are not always clearly understood, and expectations can differ, highlighting the need for clearer communication, guidance, and coordination.

12.1 CATEGORY 1 LEVEE MANAGEMENT AND ACCOUNTABILITY

Category 1 levees represent those assets that are formally managed and are critical to the protection of communities, infrastructure, and essential services.

As part of this project, Category 1 levees were identified through a combination of existing MFEP classifications, stakeholder engagement, workshop outcomes, and desktop assessment. These levees are generally associated with established township flood mitigation systems or infrastructure where ongoing management responsibilities are understood.

A summary of Category 1 levees and their management responsibilities is provided below:

LEVEE NAME	LOCATION	RESPONSIBLE AUTHORITY
Swan Hill Township	Swan Hill LGA	Swan Hill Rural City Council
Charlton Swimming Pool	Buloke Shire LGA	Buloke Shire Council
Coliban Raw Water Pump Station levee	Campaspe Shire LGA	Coliban Water
Coliban Water Treatment Plant	Campaspe Shire LGA	Coliban Water
Coliban Water Treatment Plant levee	Campaspe Shire LGA	Coliban Water
Moama Street 3	Campaspe Shire LGA	Campaspe Shire Council
Goulburn Road 4	Campaspe Shire LGA	Campaspe Shire Council

Watson Street 5	Campaspe Shire LGA	Campaspe Shire Council
Campaspe River 6	Campaspe Shire LGA	Campaspe Shire Council
Campaspe River 7	Campaspe Shire LGA	Campaspe Shire Council
Rochester Flood Mitigation Works	Campaspe Shire LGA	Campaspe Shire Council
Quambatook Town	Gannawarra Shire LGA	Gannawarra Shire Council
Koondrook Township levee	Gannawarra Shire LGA	Gannawarra Shire Council is transitioning to formal management through upgrades and maintenance - subject to successfully obtaining grant funding.

Note: The identification of Category 1 levees is based on available data, stakeholder input, and workshop outcomes. In several instances, levees that function as critical assets are not currently subject to formal management arrangements. These levees have been identified as potential Category 1 levees, subject to further investigation and confirmation of ownership, governance, and maintenance responsibilities.

Establishing clear accountability for Category 1 levees is critical to ensuring effective maintenance, preparedness, and response during flood events.

12.2 LEVEE OPPORTUNITIES AND ALIGNMENT WITH RFMS PRIORITIES

The project has identified a number of opportunities to improve flood risk management outcomes through targeted investment, improved governance, and enhanced community engagement.

These opportunities align with the objectives and principles of the Regional Floodplain Management Strategy (RFMS), particularly in relation to:

- Reducing flood risk to communities and infrastructure
- Supporting informed land use planning
- Improving emergency management capability
- Strengthening community resilience

Key opportunities identified include:

- Further investigation of Category 2 levees to determine suitability for formal management arrangements
- Targeted upgrades or formalisation of levees protecting critical infrastructure or population centres
- Improved data collection and asset management systems to support decision-making
- Enhanced engagement with communities to support shared understanding of levee function and limitations

Future community consultation will be an important component of progressing these opportunities, particularly in areas where levee classification or management status may change. Engagement will ensure that local knowledge continues to inform decision-making and that community expectations are appropriately managed.

These opportunities will inform future prioritisation under RFMS-aligned programs and funding streams.

12.3 POLICY CHALLENGES IDENTIFIED

The Strategic Levee Categorisation project has identified a number of policy and governance challenges that influence the management and effectiveness of levees across the region.

These key challenges include:

- Unclear Ownership and Responsibility-
  In many cases, levee ownership and management responsibility has not been clearly defined until this project. This is particularly evident for Category 2 identified rural levees which have been constructed informally over time. The absence of clear accountability creates uncertainty during both maintenance and emergency response.
- Rural Levee Management-
  Levees in rural areas often provide benefits to multiple landholders or communities but do not fall under formal management arrangements. This creates challenges in determining who is responsible for maintenance, upgrades, and emergency actions. In the absence of coordinated planning, some landowners will undertake works themselves without a full understanding of the potential risks, impacts or benefits of their actions.
- Funding and capability limitations of Local Governments-
  Local governments have consistently expressed concerns about their capacity to adequately resource levee management and maintenance. These concerns relate both to constrained funding in a rate-capped and inflationary environment, and to the availability of staff with appropriate skills in levee construction, management, and ongoing maintenance. Many rural councils operate with limited engineering and works teams, despite their expanding responsibilities and high community expectations for existing and expanded service delivery. While there may be an acceptance of levee-ownership and maintenance responsibilities for Category 1 levees as determined through this project, the practical reality is that only minimal on-ground levee maintenance is likely to be occurring over time. This will result in more emergency works being required when flooding is imminent and may reduce confidence that critical levees will perform effectively when needed.
- Inconsistent Data and Asset Records-
  The lack of a consistent, statewide levee database limits the ability to effectively monitor levee condition, manage levee assets and plan for future investment. Data gaps and inconsistencies also impact the reliability of assessments and decision-making in future flood events.
- Community Expectations-
  Community expectations regarding levee performance and management do not always align with current governance arrangements. This can create challenges during flood events where assumptions are made about the level of protection provided or the level of assistance communities will receive from emergency agencies.

These challenges highlight the need for continued collaboration between CMAs, DEECA, local government, and emergency services to improve policy clarity and support more effective levee management across the region.

12.4 NEXT STEPS/ ACTIONS

Updates to the MFEP documents are currently underway through VicSES and local government collaboration. The outcomes of this review should be incorporated into future MFEP updates, ensuring consistency in how levees are mapped and described. Continued collaboration between CMAs, councils, emergency services, and local communities will be key to ensuring effective, locally supported levee management into the future.

In response to the review's findings and the issues identified through stakeholder engagement, the following recommendations and opportunities have been identified to guide future planning and investment:

Next steps and possible Actions

The North Central CMA Strategic Levee Review has identified a suite of possible actions to strengthen flood preparedness, governance, and asset management across the region. These recommendations integrate stakeholder feedback, community engagement outcomes, and further refinements developed through subsequent technical review.

1. **Adopt Final Levee Classifications**

The project has developed a consistent framework for levee categorisation across the region. It is recommended that the classifications documented in this project be adopted across relevant systems, including FloodZoom and Municipal Flood Emergency Plans (MFEPs), to support consistent interpretation of current levee function and importance. Ongoing review and refinement of classifications should be anticipated as new data becomes available or conditions change in the future.

2. **Investigate Category 2 Levees for Formal Management Arrangements**

The assessment has identified a number of Category 2 levees that provide protection to communities, infrastructure, or key assets but are not currently subject to formal management arrangements. Further investigation may be undertaken to better understand the feasibility, costs, and benefits associated with potential management options for these levees, particularly where they align with the investment principles of the Victorian Floodplain Management Strategy. Detailed precinct-level Flood Mitigation Plan (FMP) assessments are recommended for identified high-value levee systems. In multiple cases the Categorisation score outlines a Category 1 assessment score which subsequently suggest a greater potential consequence of failure, higher exposure of assets and/or stronger community reliance. These levees should therefore be treated as a higher priority for future investigation.

3. **Targeted Field Surveys of Priority Levee Assets**

While this assessment has relied primarily on desktop analysis, there are opportunities to improve confidence in levee data through targeted field validation. This may be particularly valuable for levees where data gaps exist, where condition is uncertain, or where recent flood events may have altered asset performance.

4. **Develop a Regional Levee Asset Database**

The project has highlighted the value of maintaining consistent and up-to-date levee information. Opportunities exist to further develop and maintain a regional levee dataset that supports improved data sharing, ongoing updates, and alignment with state data standards. This may include capturing additional attributes such as ownership, condition, and maintenance status over time.

5. **Map Floor Levels in High-Risk Levee Areas**

A prioritised, layered approach is recommended for mapping building floor levels. Stage 1: continue desktop location mapping of dwellings within Category 2 levee zones. Stage 2: undertake targeted on-ground floor-level surveys in high-risk localities. Priority should be given to areas behind unmanaged Category 2 levees. Integration into FloodZoom and MFEPs will enhance emergency response planning.

6. **Clarify Roles and Responsibilities for Low-Priority Levees**

A statewide communication product would be useful for community education, developed collaboratively by CMAs and DEECA, to clarify levee ownership, maintenance responsibilities, and emergency management roles. This material should distinguish publicly managed levees from private or unregulated structures.

7. **Explore Permanent Levee Options for Frequently Reinstated Sites**

In some locations, temporary levees are repeatedly constructed during flood events. These locations may warrant further consideration to better understand whether alternative approaches could improve efficiency and reduce the need for repeated emergency works.

8. **Establish a Regular Review Cycle for Levee Classifications**

Given the dynamic nature of flood risk, land use, and infrastructure, it is recommended that levee classifications be subject to periodic review. This may occur on a defined cycle or following significant flood events to ensure that classifications remain current and reflective of on-ground conditions.

9. **Identify Strategic Drainage Systems**

Identify and document key regional drains that are important for the removal of residual flood water from the landscape after major flood events. Engage with rural water authorities and local government on possible maintenance regimes for key regional drains.

10. **Levee Data Enhancement**

A data field could be added in the regional levee asset database to identify whether a levee currently exists or historically existed. This supports improved record-keeping and aligns with community discussions referencing legacy levee structures.

11. **Supporting the Gannawarra Community Resilience Flood Recovery Action 2023-25**

The Gannawarra Shire's *Community Resilience Flood Recovery Action Plan 2023-2025* outlines a locally developed program of actions that interrelate with the strategic levee project findings. Key initiatives include enhancing flood flow conveyance, regulators for post-flood drainage, improved culvert design, and evaluating new floodways or flood storage options through Kerang Lakes, Pyramid Creek, and Lower Loddon systems. This plan is evidence based and community-led, and may provide useful information when considering levee management policy options and shaping future investment that demonstrates support for locally driven initiatives where they exist.

12. **Road Resilience Coordination with DTP**

Collaboration with the Department of Transport and Planning (DTP) to identify flood-affected road sections may provide opportunities for road raising or drainage improvements that support faster recovery and reduced isolation during flood events.

13. **Levee Performance Information Sharing**

The project has reinforced the importance of collaboration between CMAs, local government, emergency services, and other stakeholders. Continued coordination may support improved consistency in data management, emergency response, and long-term planning related to levee systems.

14. **Understanding the impacts of Channel Infrastructure**

There would be benefits in further work to identify irrigation channels that also function like levees and further evaluate their role in floodplain performance. Coordination is required with rural water authorities to recognise where this occurs and discuss maintenance and inspection protocols, or possible emergency management actions, which acknowledges their potential to influence flood flows (positively or negatively).

15. **Floodplain Alignment Considerations**

The review identified that existing roads, irrigation infrastructure, and historical levee alignments already influence floodplain behaviour in several locations. Future floodplain investigations may further examine how existing infrastructure corridors interact with flood mitigation outcomes and long-term floodplain management considerations.

16. **Isolated Rural Property Flood Risk**

Community discussions highlighted the challenges associated with managing flood risk for isolated rural dwellings where broader levee schemes may not be present or frequently fail. These discussions reinforced the importance

of ongoing consideration of locally appropriate flood mitigation approaches and emergency preparedness measures within dispersed rural areas.

17. Private Levee Management Considerations

Community engagement identified that some private landholders experience uncertainty regarding levee maintenance responsibilities, permit requirements, and approval processes associated with floodplain works. This highlights the importance of clear communication and accessible guidance relating to private levee management within flood-prone areas.

18. Channel Decommissioning Engagement

Continued collaboration with rural water authorities is required to ensure that channel decommissioning projects assess and mitigate floodplain impacts, recognising that many legacy irrigation channels influence flood behaviour and should be investigated and managed accordingly.

Specific Levee and Precinct Recommendations

The following levee systems have been identified as strategic priority areas for further investigation or targeted action. These recommendations integrate community feedback, recent flood observations, and cost-benefit insights and align with the existing policies of the Victorian Floodplain Management Strategy 2016 and actions within the North Central Regional Floodplain Management Strategy 2018-2028.

LEVEE AREA / PRECINCT	SUMMARY OBSERVATION
Tyntynder Flats (Swan Hill LGA)	The precinct was identified as an area where further technical investigation may improve understanding of levee condition, flood behaviour, and community flood risk. Community engagement indicated strong local interest in the future performance and reliability of the levee system.
Tyntynder Flats Flow Tubes (Swan Hill LGA)	Community feedback and field observations indicated that the historical flow tube structures may no longer provide reliable flood mitigation functionality and may warrant further assessment.
Pental Island (Swan Hill LGA)	The levee system continues to play an important flood mitigation role within the precinct. Ongoing investigations associated with governance, maintenance history, and long-term management considerations were noted through the review process.
Little Murray River (Swan Hill LGA)	The precinct was identified as an area where further assessment of floodplain interactions, drainage behaviour, and levee performance may improve regional flood intelligence and emergency planning understanding.
Gunbower Creek / Murray River (Gannawarra LGA)	Stakeholder engagement highlighted the complexity of flood behaviour interactions between levees, floodways, infrastructure, and environmental systems within the precinct.
Torrumbarry (Campaspe LGA)	The levee system was identified as having significant regional floodplain influence, with opportunities for future

	investigation into flood behaviour, levee condition, and floodplain interactions.
Banks of Gunbower Creek	Community and stakeholder engagement reinforced the importance of these levees in influencing regulated flow behaviour and broader floodplain function.
Echuca East Levees, Koondrook Town Levees and Torrumbarry Levees	Stakeholder discussions identified the importance of ongoing emergency preparedness planning and understanding potential temporary flood response arrangements within these townships.

APPENDIX 1. GIS METHODOLOGY

File Name: 754-MELEN366214-NCCMA GIS Methodology for Strategic Levee Categorisation

NOTE: The GIS Methodology outlined in the Tetra Tech Coffey memorandum covers GIS development for both the North Central CMA project area and the corresponding Mallee CMA Strategic Levee review.

APPENDIX 2. LGA WORKSHOP LEVEE EDITS

Buloke Shire Local Government Area

Added Levees or Significant Floodplain Features

N-SSF862- Reinstated Road, Charlton South



N-L0067- Private Levee, Charlton East



N-SSF863- Railway Line, Charlton South



N-L0068- Category 1 Levee, Charlton Swimming Pool & N-SSF864- Culvert under Mildura Way Road



N-SSF865- Charlton Racecourse



Edited Levee Alignment

N-L0011- Charlton South Levee

Before:



After:

Alter extent of levee and add additional private levee



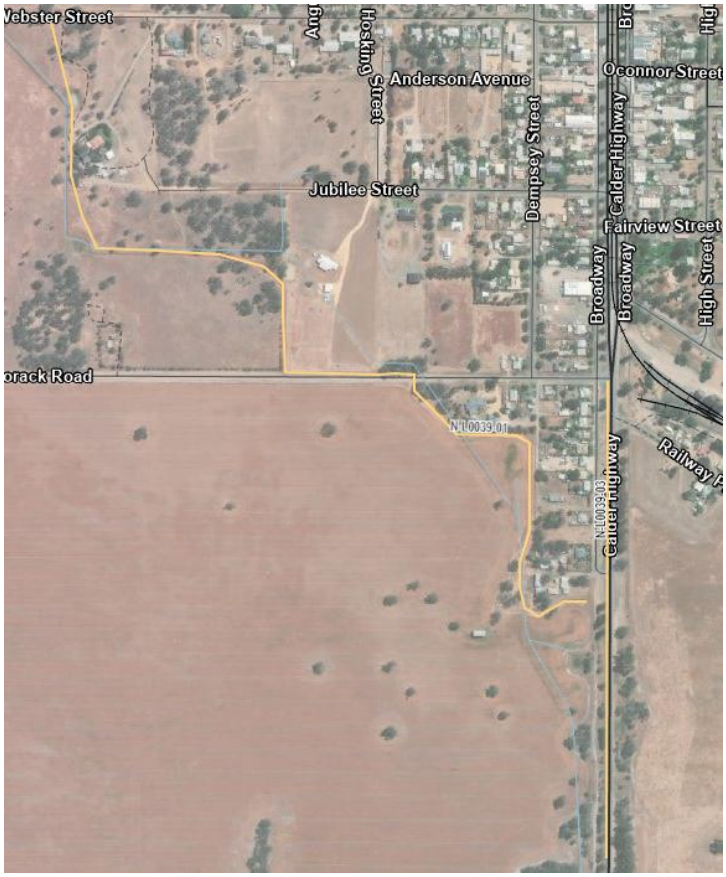
N-L0039- Wycheproof Levee

Before:



After:

Alter extent of levee and add additional temporary (Type C) levees



Additional workshop actions that did not involve changing the alignment or adding additional Levees (and therefore were not captured in map screenshot) are listed the table below.

Levee ID	Levee Name	Workshop Action/ Comment
N-L0069	Yeungroon Creek Dam	Remove, new location identified.

Swan Hill Rural City Council

Edited Levee Alignment

N-L0019- Swan Hill Township Levee

Before:



After:

Levee extent to follow road, add temporary levee (Type 2C) to Swan Hill Rd. Levee noted as Road (Significant Floodplain Feature) along Monash Drive



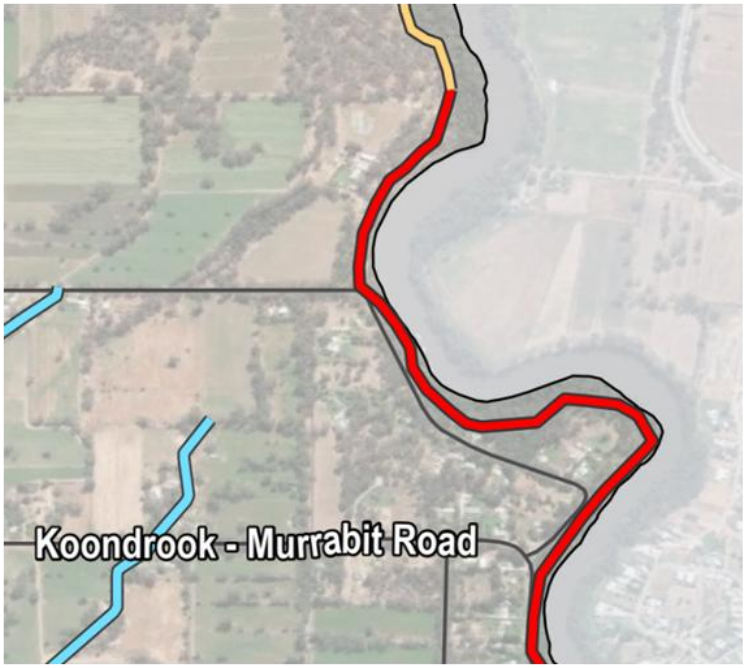
Additional workshop actions that did not involve changing the alignment or adding additional Levees (and therefore were not captured in map screenshot) are listed the table below.

Levee ID	Levee Name	Workshop Action/ Comment
N-L0020	Tyntynder Flats	Agreed further investigation is required. **No change**
N-L0022	Pental Island West	Agreed further investigation is required. **No change**
N-L0023	Pental Island East	Agreed further investigation is required. **No change**
N-L0024	Little Murray	Agreed further investigation is required. **No change**
N-L0025	Tyntynder Flats Flow Tube	Determined through field truthing these are in poor condition and should not be relied upon. **Change to SFF**
N-L0037	Avoca Floodway	Talk to Roads regarding this levee, does the highway provide protection? Is it raised? **No change**
N-L0066	Lower Loddon Levee	Agreed further investigation is required. **No change**

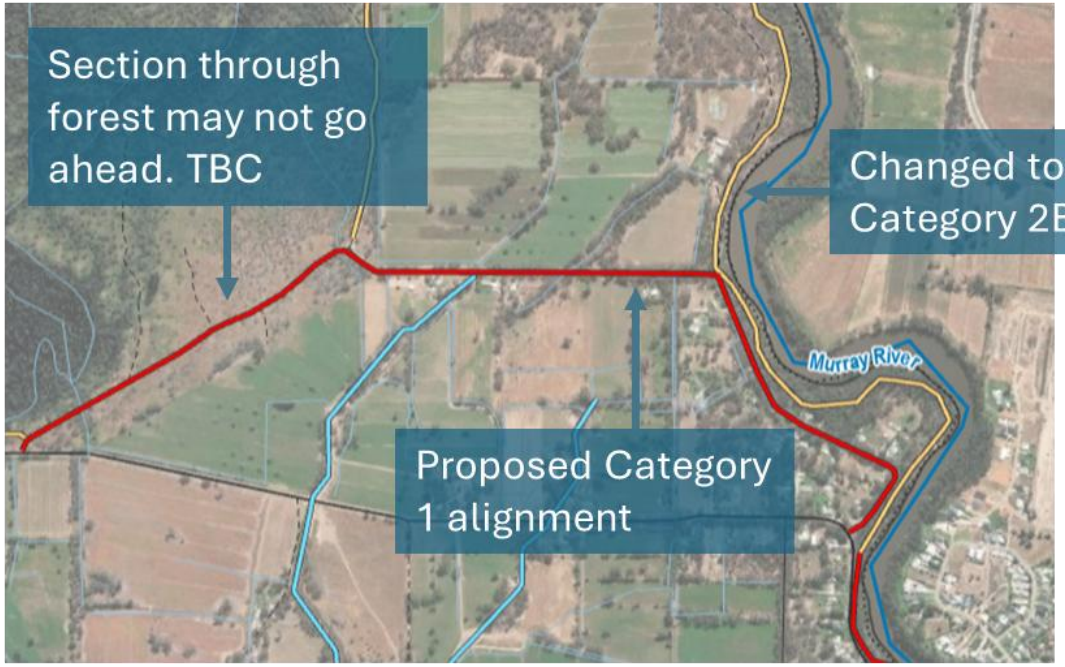
Gannawarra Shire Council

Koondrook Township Levee – Northern End

Workshop Map



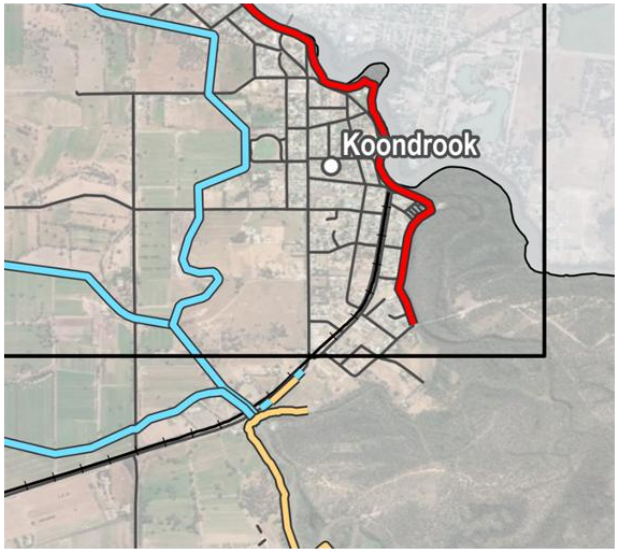
Revision



Feedback: Refer to GSC plans to show the proposed future levee.

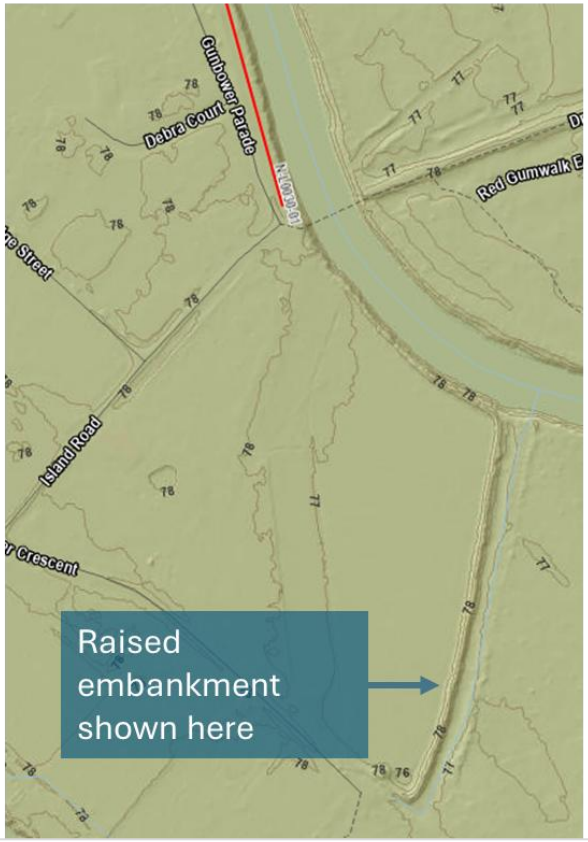
Koondrook Township Levee – Southern End

Workshop Map

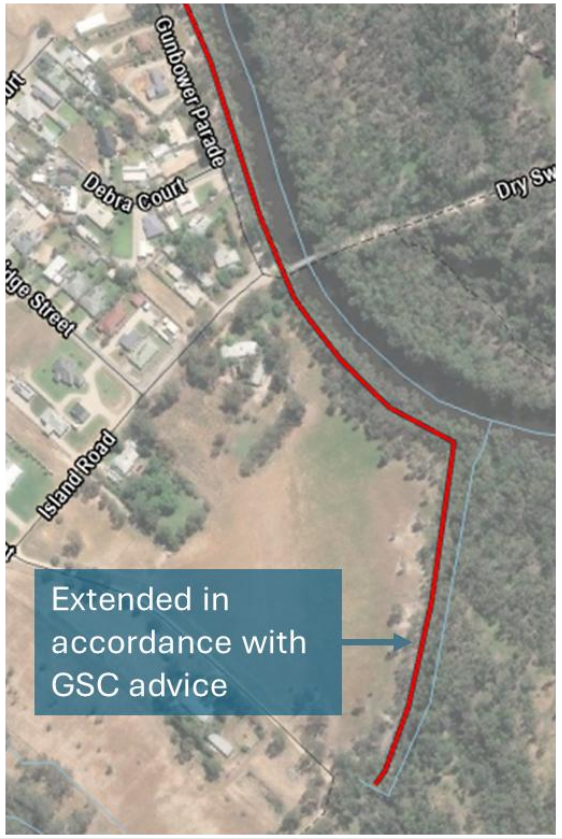


Feedback: Town levee extends further south.

Lidar



Revision



Koondrook Township Levee – Southern End (cont.)

Future consideration



Golf Road - Cohuna

Workshop Map



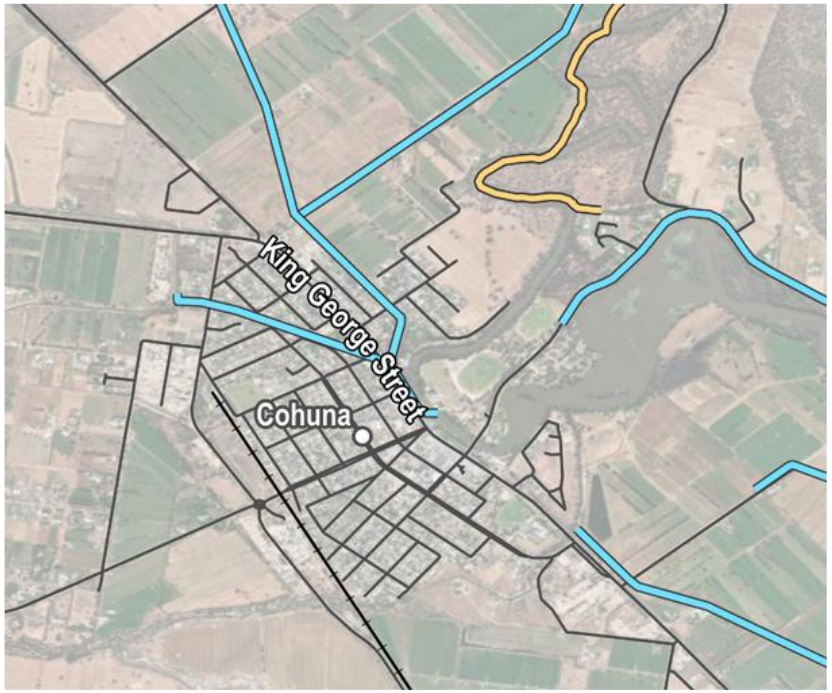
Feedback: The levee shown off Golf Road (NL0015-04) is not a permanent levee. Sandbags have been used to protect homes on the past

Revision



Coliban Water Treatment Plant - Cohuna

Workshop Map



Feedback: Add Coliban Water Treatment Plant Levee

Revision



Quambatook Town Levee

Workshop Map



Feedback: The Cat 1 levee has an extension to the south which is constructed ahead of floods and removed afterwards – Add as RED

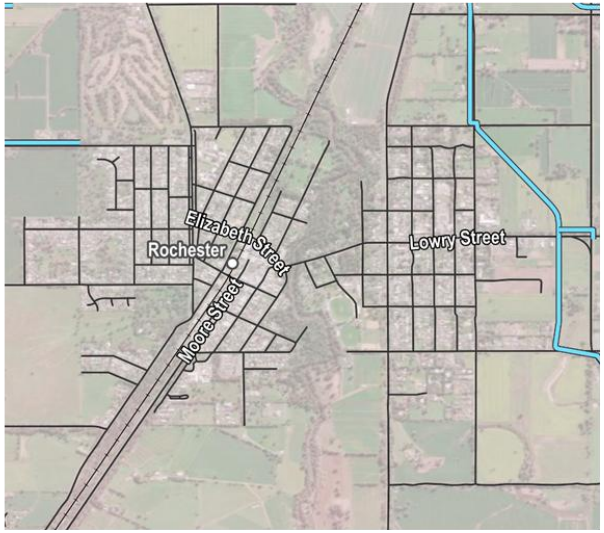
Revision



Campaspe Shire Council

Coliban Water Treatment Plant - Rochester

Workshop Map



Feedback: Add Coliban Water Treatment Plant Levee



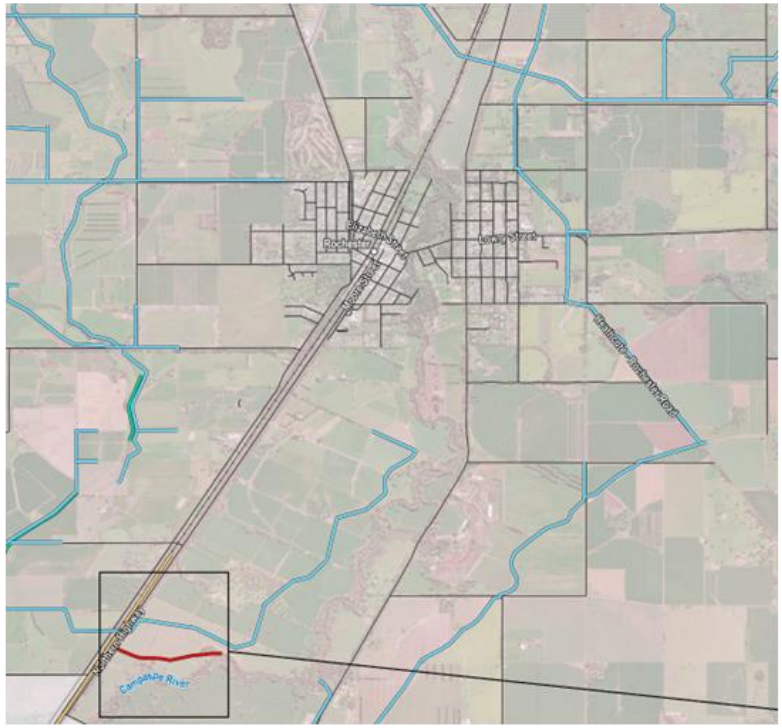
Concrete wall with drop in barriers at the entry points surrounds the treatment plant

Revision



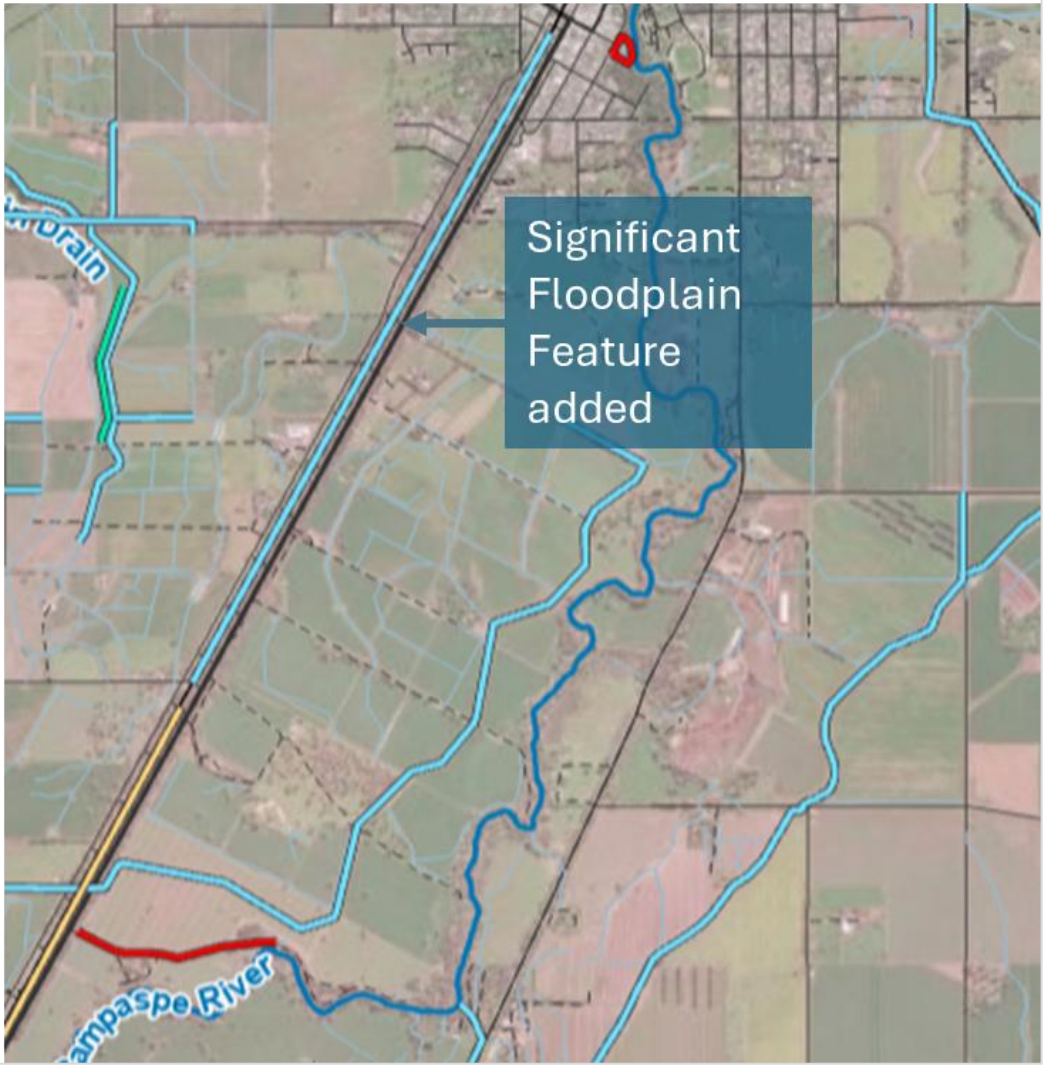
Railway line south of Rochester

Workshop Map



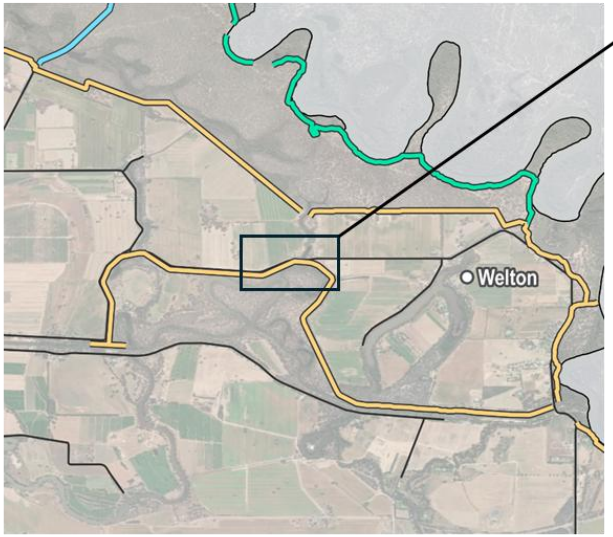
Feedback: Map the railway line as a Significant Floodplain Feature

Revision



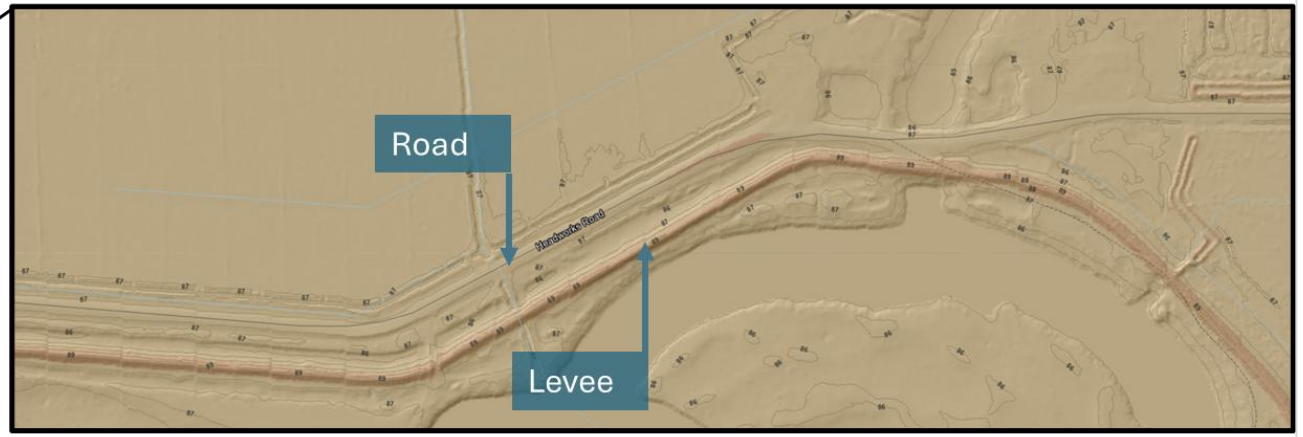
National Channel

Workshop Map



Feedback: Confirm whether the bank around the National Channel is a levee or Significant Floodplain Feature

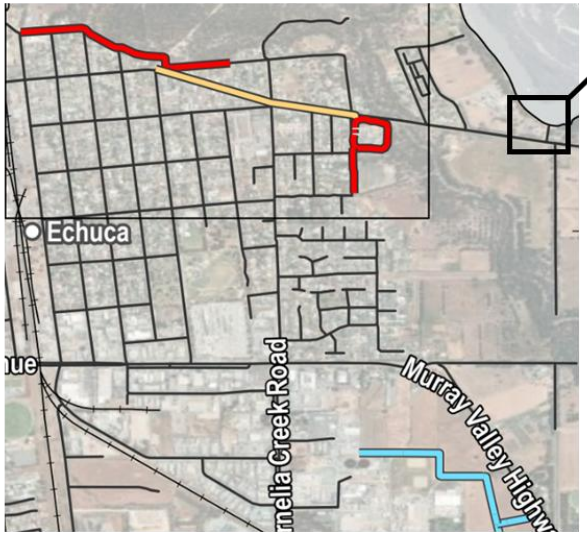
Lidar





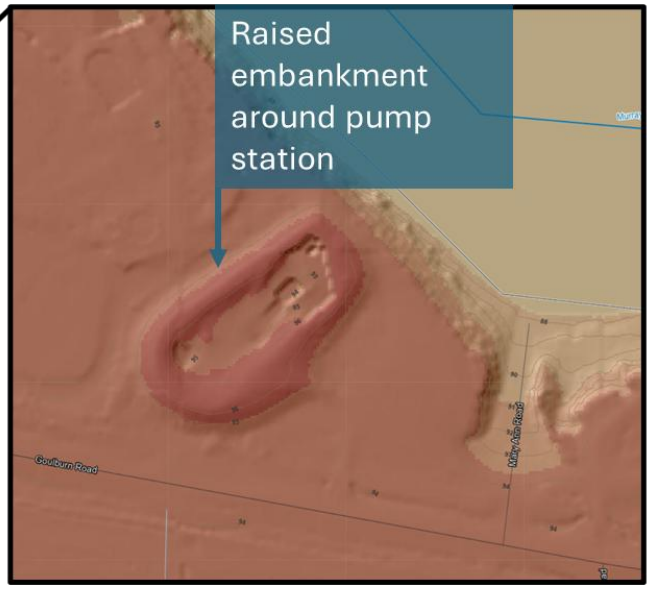
Coliban Raw Water Pump Station - Echuca

Workshop Map

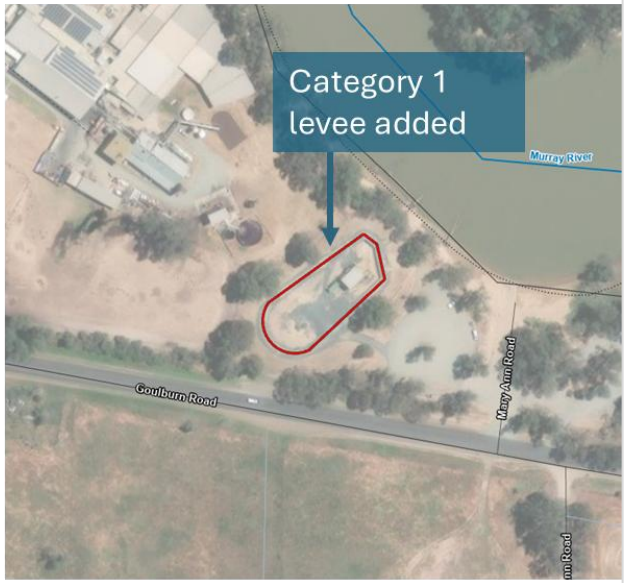


Feedback: Post meeting correspondence with Coliban Water identified additional levee

Lidar

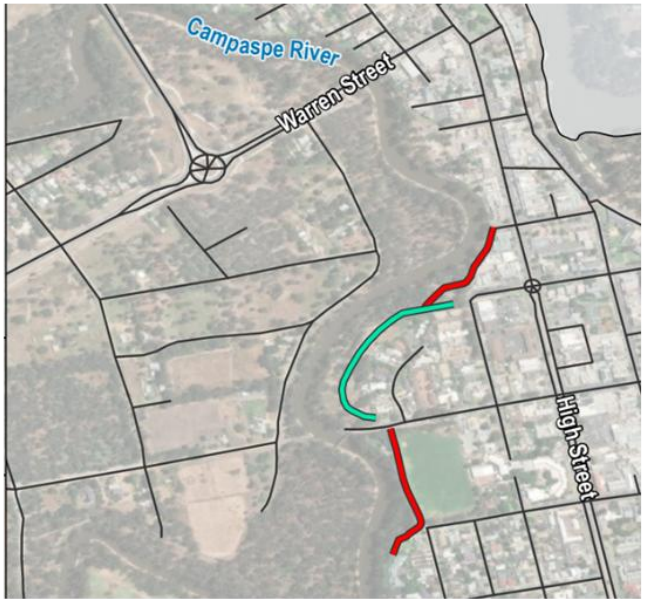


Revision



Echuca Primary School Oval

Workshop Map



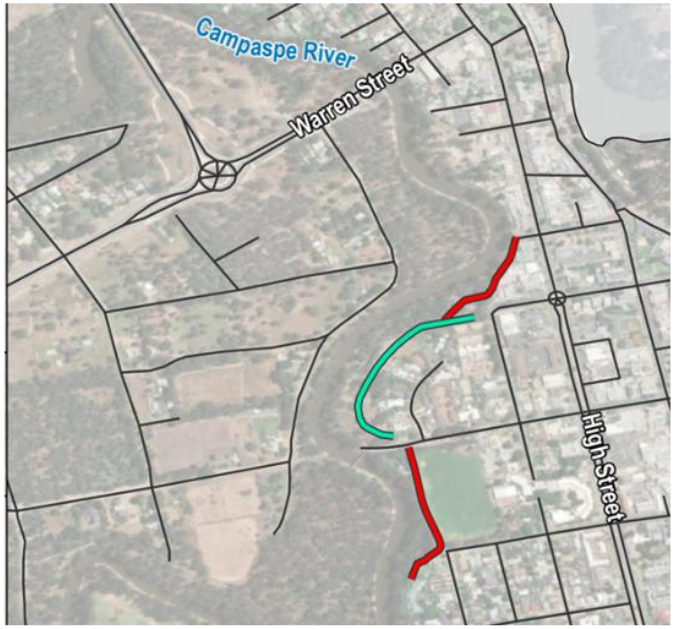
Feedback: Clarified the extent of levee behind the primary school oval

Revision



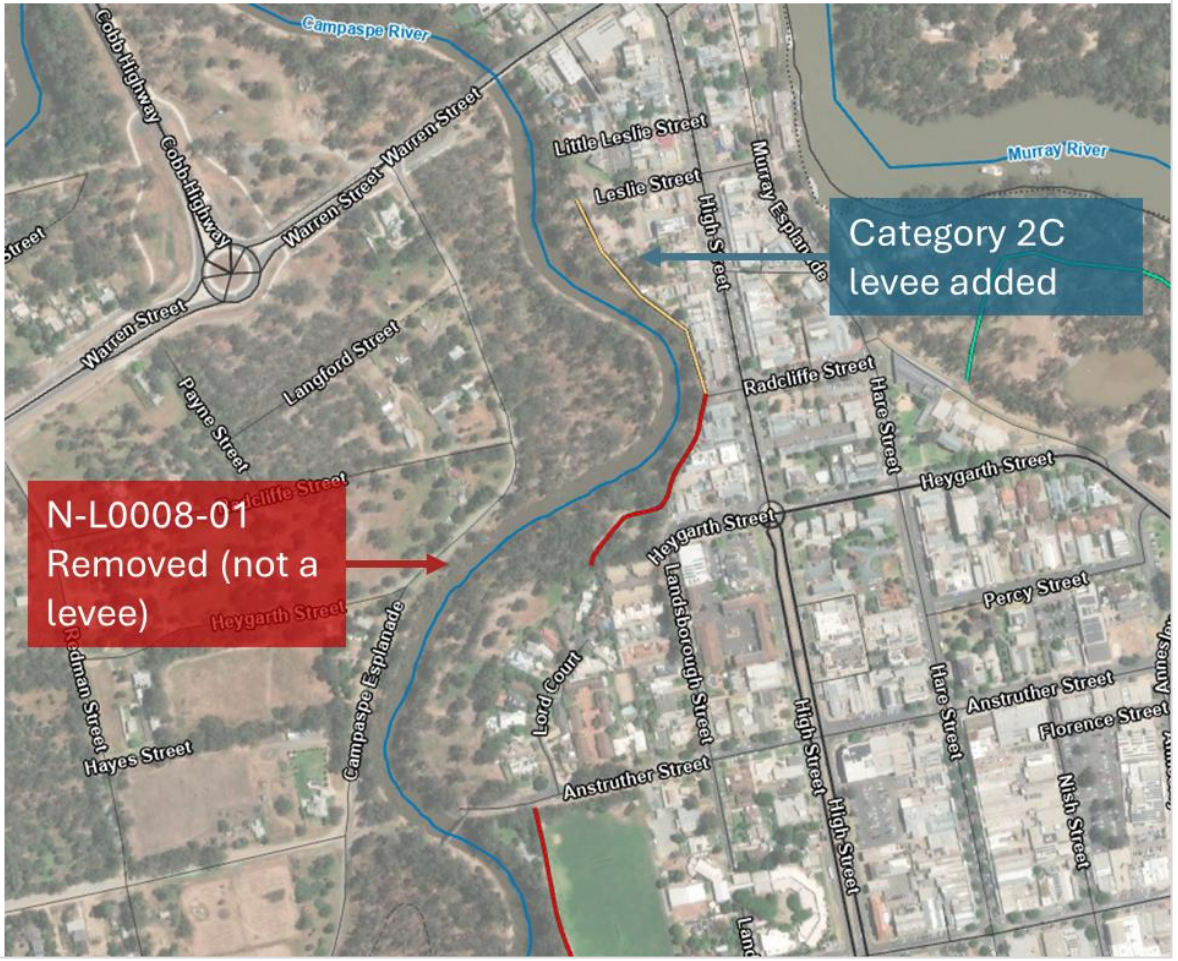
Radcliffe Street

Workshop Map



Feedback: Add and remove levees along the east bank of the Campaspe River

Revision



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