

Investigation Area 1



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Cover Photo: The existing Goulburn-Murray Water (G-MW) channel which runs through Investigation Area 1

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EXECUTIVE SUMMARY

The following report provides details on the flood behaviour study of an area of land at Kialla known as Investigation Area 1, which is proposed for future development. Water Technology was engaged by Greater Shepparton City Council (GSCC) to undertake this investigation. Investigation Area 1 contains a number of properties surrounding the Kialla Paceway, which incorporates the Shepparton Greyhound Racing Club, The Shepparton Harness Racing Club and the Shepparton Pony Club. t

Water Technology investigated the existing conditions flood behaviour for a 1% AEP flood event. This was compared to the proposed development conditions from a master plan developed by Urban Enterprise. The flood modelling showed that if this masterplan was implemented that it would result in unacceptable increases in flood levels in areas upstream and downstream of Investigation Area 1. A number of elements of the masterplan were found to be located in areas critical to floodplain function, and recommendations were made to change the masterplan to better accommodate the flood risk.

A revised masterplan was developed and was demonstrated through flood modelling that achieved an acceptable outcome with regards to managing flood risk. The revised masterplan seeks to strike a balance between the level of development and managing the flood risk for the safety of the community and future sustainable development.

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1. INTRODUCTION

Water Technology was commissioned by the Greater Shepparton City Council to prepare a detailed assessment of existing flood behaviour and the potential for proposed development with regards to riverine flooding at Kialla West. The site is referred to as Investigation Area 1, and is viewed as an area of potential development growth in both the near and long term future as part of the Kialla and Shepparton South Framework Plan shown in Figure 1-1.

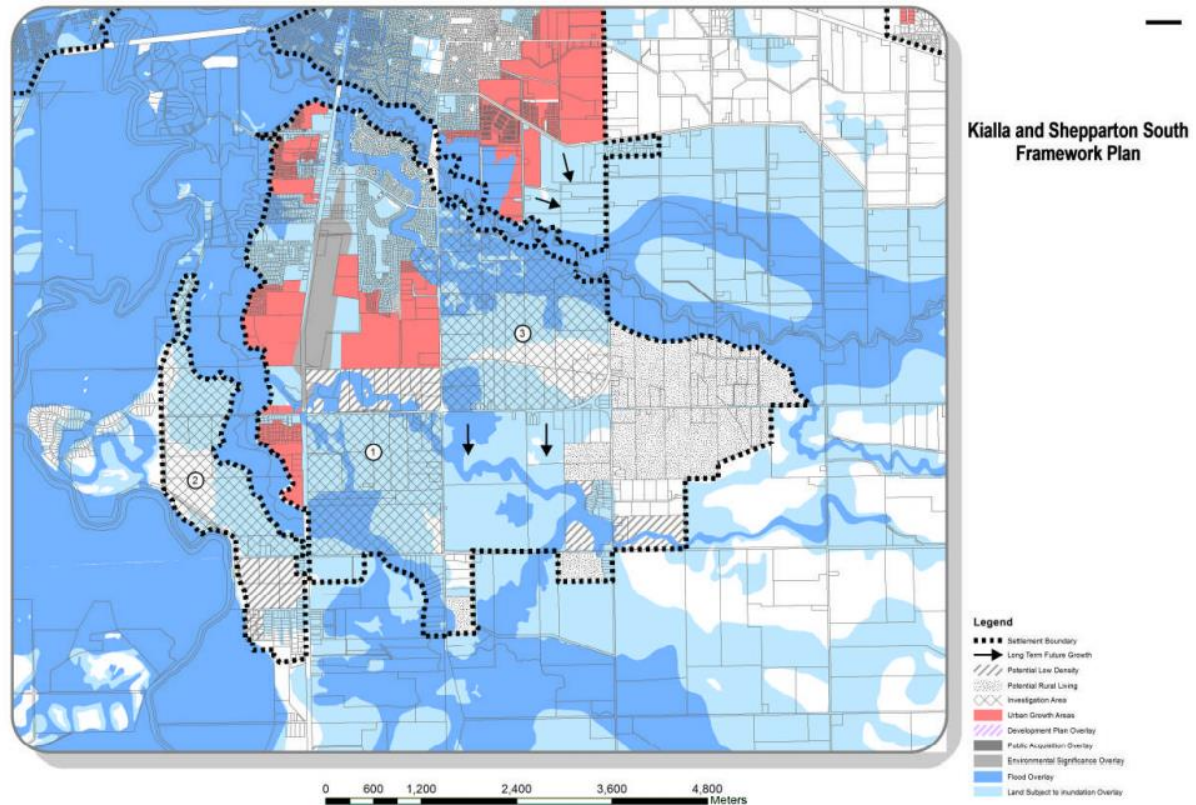


Figure 1-1 Kialla and Shepparton South Framework Plan (Greater Shepparton Planning Scheme)

A flood risk report for development within a flood prone area should take into account:

- State Planning Policy and Local Planning Policy Frameworks
- Consideration of existing use and potential development of the land
- Susceptibility of development to flooding
- Effect of development on obstructing drainage or reducing flood storage, levels or velocities

This report covers the relevant riverine flooding requirements and flood behaviour for the site. It has contributed to the design of a revised recommended development layout, which may allow for a future planning scheme amendment. The development layouts utilised in this assessment are at a conceptual design level and would require more detail in regards to location of services and roadways prior to construction. At a detailed design level, flood behaviour should again be assessed to ensure development is occurring in an appropriate manner with regards to flood risk associated with Seven Creeks.

1.1 Study Site

The study site is located at Kialla on the southern fringes of the Shepparton urban area covering 301 hectares which includes the Goulburn Valley Harness and Greyhound Racing Precinct. Much of the site is flood prone, with 209 ha currently covered by a Land Subject to Inundation Overlay (LSIO), 45 ha covered by Floodway Overlay (FO), as well as two small areas totalling 29.27 ha of Urban Floodway Zone (UFZ), as shown in Figure 1-2. The Seven Creeks flows across the south-west of Investigation Area 1, crossing Mitchell Road on the southern boundary and the Goulburn Valley Highway on the western boundary. A smaller anabranch of Seven Creeks runs through the north west of the site, however much of this anabranch has been modified into a straight channel. The anabranch travels north west across the site from Archer Road to River Road, where it travels through a series of on farm crossings, under the Goulburn Valley Highway, and continues in a north westerly direction through a large wetland before returning back into Seven Creeks. The anabranch inflow from Seven Creeks breaks away around 2 km upstream of Investigation Area 1 and is controlled by a subway beneath a G-MW channel.

The site slopes to the north west on a very flat gradient from around 115.50 m AHD through to 114.0 m AHD. Several G-MW channels traverse the site which form part of the 'backbone' and 'non-backbone' network of stock and domestic supply channels. Much of the site is used for low density agriculture, equine use and lifestyle farming.

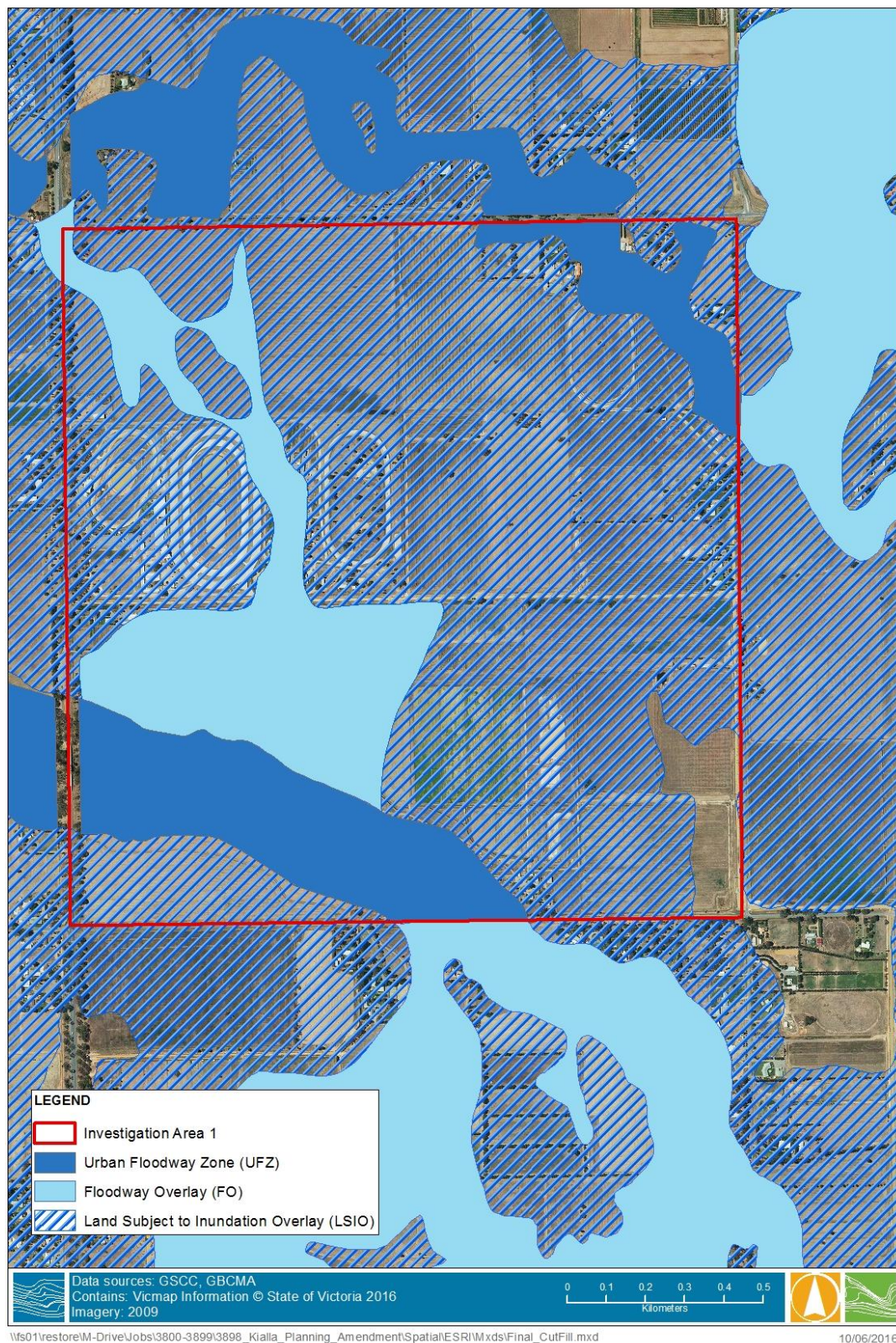


Figure 1-2 Existing Flood Controls in the Greater Shepparton Planning Scheme

1.2 Current Flood Behaviour

Much of the Investigation Area is included within the Floodway Overlay (FO) or Land Subject to Inundation Overlay (LSIO) as well as two separate areas zoned Urban Floodway Zone (UFZ). Under existing flood conditions, water from Seven Creeks backs up behind the Goulburn Valley Highway as the flow rate is constricted through the bridge. Water then spills over both the southern and northern channel banks before the Goulburn Valley Highway is overtopped. Flood waters then spill further north to the G-MW channel that runs east-west between the Harness Racing Club and Seven Creeks. In large floods the channel may be overtopped and spill into the Harness Racing Club, with flood waters draining to the northwest towards the intersection of River Road and the Goulburn Valley Highway.

A separate anabranch of Seven Creeks also runs through Investigation Area 1, however the flow rate of this anabranch is limited mainly due to flow restricted through a subway in the G-MW Channel located 2 km upstream of Investigation Area 1. The anabranch enters on the eastern side of Investigation Area 1 at Archer Road and travels northwest through three properties until exiting through a series of culverts at River Road.

The maximum flood depth (Figure 1-3) and maximum velocity (Figure 1-4) for the 1% AEP flood event are shown in the plots below.

The 1993 floods are considered the largest in recent history, with a number of other flood events in the area including 1974, 1995 and 2010. A streamflow gauge on Seven Creeks at Kialla West (on the southern boundary of Investigation Area 1) was installed in 1977. The streamflow gauge provides information on historical flood events and allows for an accurate estimation of these events to calibrate flood modelling results.

During the 1993 flood event, the flow at the Kialla West streamflow gauge peaked at 8.23 m with an estimated flow of 718 m³/s (62,000 ML/d). The modelled 1% AEP flood event for the Sevens Creek system was for a flow 834 m³/s (72,000 ML/d). This was accepted by the Goulburn Broken CMA as the 1% AEP flow at the Sevens Creek at Kialla West streamflow gauge. Aerial imagery of the 1993 event was captured around 48 hours after the peak flooding had passed through Investigation Area 1. This image requires careful consideration as the flood had receded by this time, but water can be detected in the paddocks across the area inundated. This was used to validate the flood modelling results for the Shepparton-Mooroopna Flood Mapping and Intelligence Study, along with a series of recorded peak flood height survey captured shortly after the flood event. This is discussed in more detail in section 1.3.

Local rainfall runoff generated from within the site was not assessed as part of the existing flooding conditions on the site. Any development plan should investigate local catchment runoff and stormwater drainage as part of a stormwater management plan.

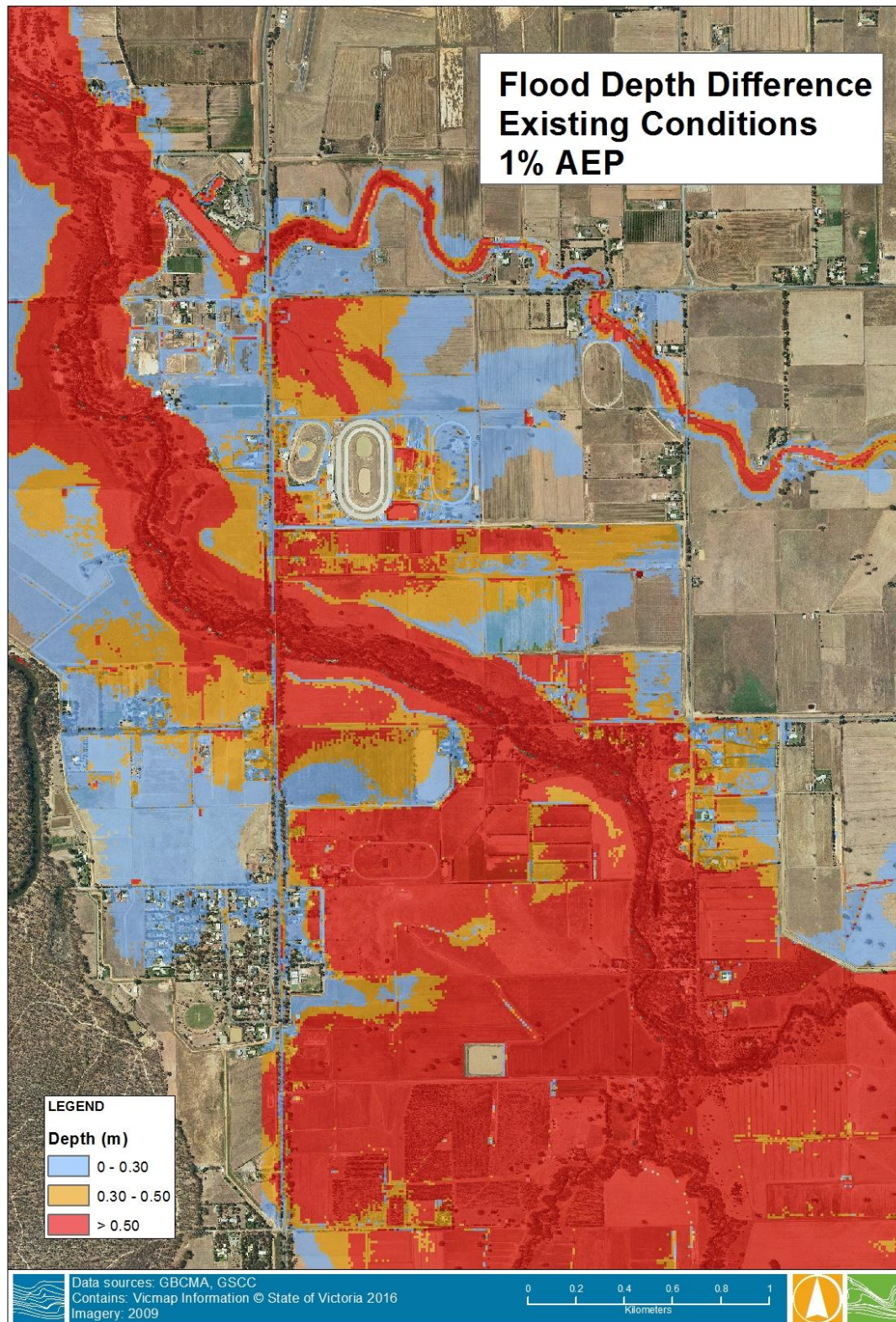


Figure 1-3 Existing Conditions Maximum Depth Plot

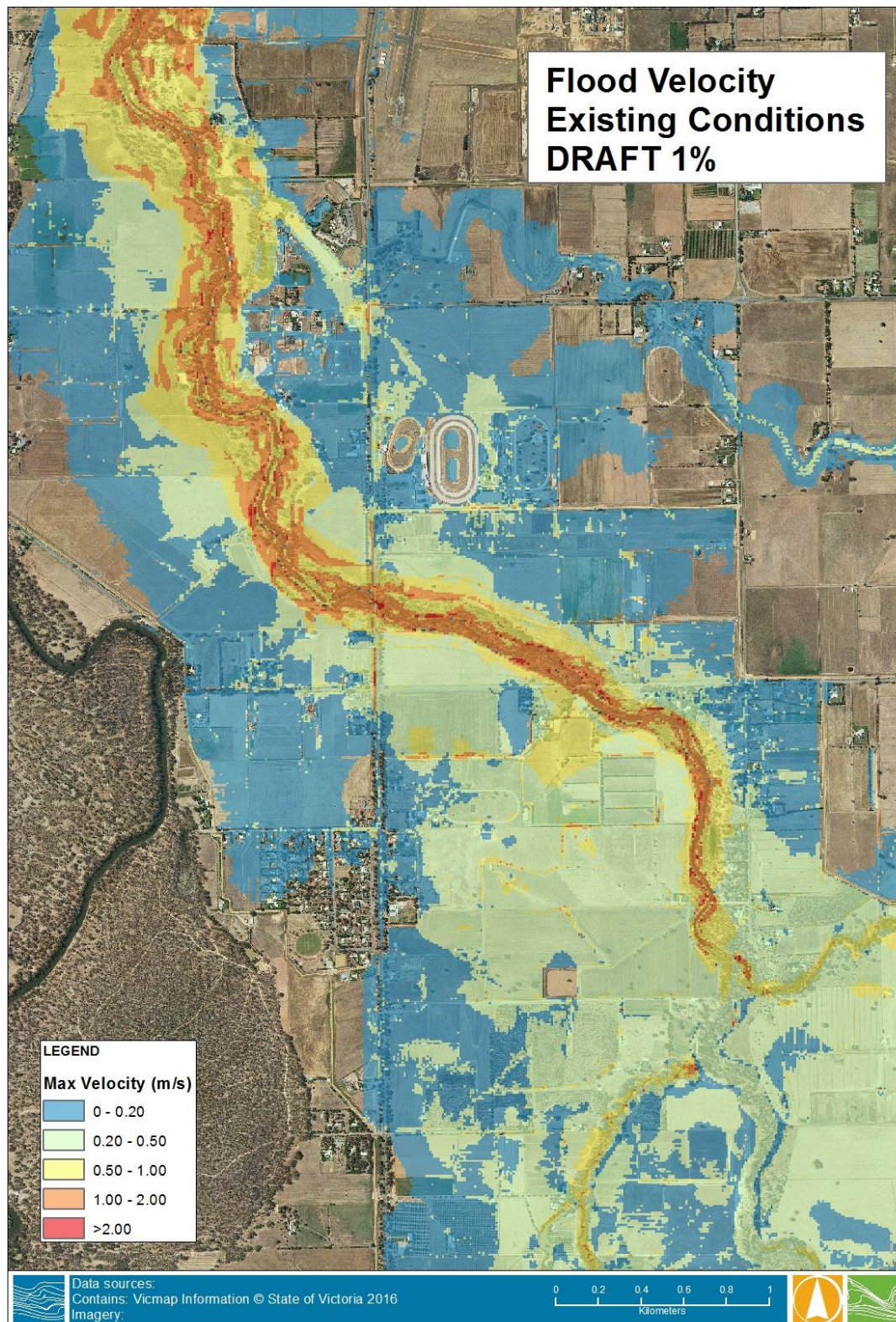


Figure 1-4 Existing Conditions Maximum Velocity Plot

1.3 History of Flood Investigations

1.3.1 Shepparton – Mooroopna Flood Study (1982)

A flood study undertaken by Sinclair Knight and Partners Pty Ltd was undertaken along with Kinhill Pty Ltd. This was prepared for the State Rivers and Water Supply Commission of Victoria, the City of Shepparton, the Shire of Shepparton, the Shire of Rodney and the Department of National Development and Energy. This study utilised much of the information gathered from the 1974 Goulburn River flood which caused extensive flooding through Shepparton.

1.3.2 Shepparton Mooroopna Floodplain Management Study (2002)

The Shepparton Mooroopna Floodplain Management Study was undertaken in 2002 by Sinclair Knight Merz in conjunction with Lawson and Treloar Pty Ltd. This study used computational floodplain modelling using MIKE 21 to calibrate the flood events of 1974 and 1993 to within +/- 500 mm. A model topography utilised photogrammetry flown in September 1999 and a model grid resolution of 12.5 m for the 'inner area' and a 25 m grid resolution in the 'outer area'. Investigation Area 1 sits in the 'outer area'.

The modelling undertaken in the 2002 flood study formed the basis for the current planning scheme. The existing 100 Year ARI flood level for the Investigation Area ranges from 115.4 m AHD at the south east of the property to 114.2 m AHD at the north west of the property.

1.3.3 Flood Warning and Emergency Management Report (2007)

Water Technology completed a Flood Warning and Emergency Management Report for Greater Shepparton City Council in 2007. This involved undertaking a number of recommendations from the 2002 SKM flood study around flood preparedness, flood warning, flood response and the development of improved information management systems. This project developed property specific flood charts for over 6,000 properties within the flood risk area, a flood monitoring plan and community flood alerting system.

1.3.4 Shepparton-Mooroopna Flood Mapping and Intelligence Study (ongoing)

Water Technology are currently undertaking flood modelling of the Shepparton-Mooroopna area; this will be used to update existing planning controls within the site. The modelling undertaken for Investigation Area 1 replicated the modelling being undertaken for the ongoing flood mapping and intelligence study. This involved utilising the same model parameters as used in the Shepparton-Mooroopna Flood Mapping and Intelligence Study and ensuring existing conditions flood levels matched the ongoing flood study results. The modelling for the Shepparton – Mooroopna Flood Mapping and Intelligence Study used high resolution Light Detection and Ranging (LiDAR) survey, resampled to a 10 x 10 m grid resolution. The model was calibrated using surveyed flood height marks from the 1974 and 1993 floods and further validated using aerial imagery from these events. Calibration of water levels for these events was aimed at within +/- 200 mm. The use of aerial imagery for validation was taken with some caution as often the timing of the photography does not coincide with the peak of the flood event. Additionally, local rainfall during the event can cause flooding in areas which may not be represented within the floodplain studies. At the time of the investigation, the calibration of the model to the historical events had been undertaken along with 1% AEP design modelling.

2. PROPOSED DEVELOPMENT

A proposed development masterplan, as illustrated in Figure 2-1 was developed by Urban Enterprise in consultation with Greater Shepparton City Council. This initial development layout was tested with regards to riverine flooding in this investigation, as well as testing against a number of other factors such as amenity and acoustics associated with the Kialla Paceway. These other investigations are reported separately.

The masterplan was exhibited and received public comment. These comments area addressed below in Section 2.1. The masterplan was implemented in the flood model and was subsequently revised, the results are discussed in Section 3.

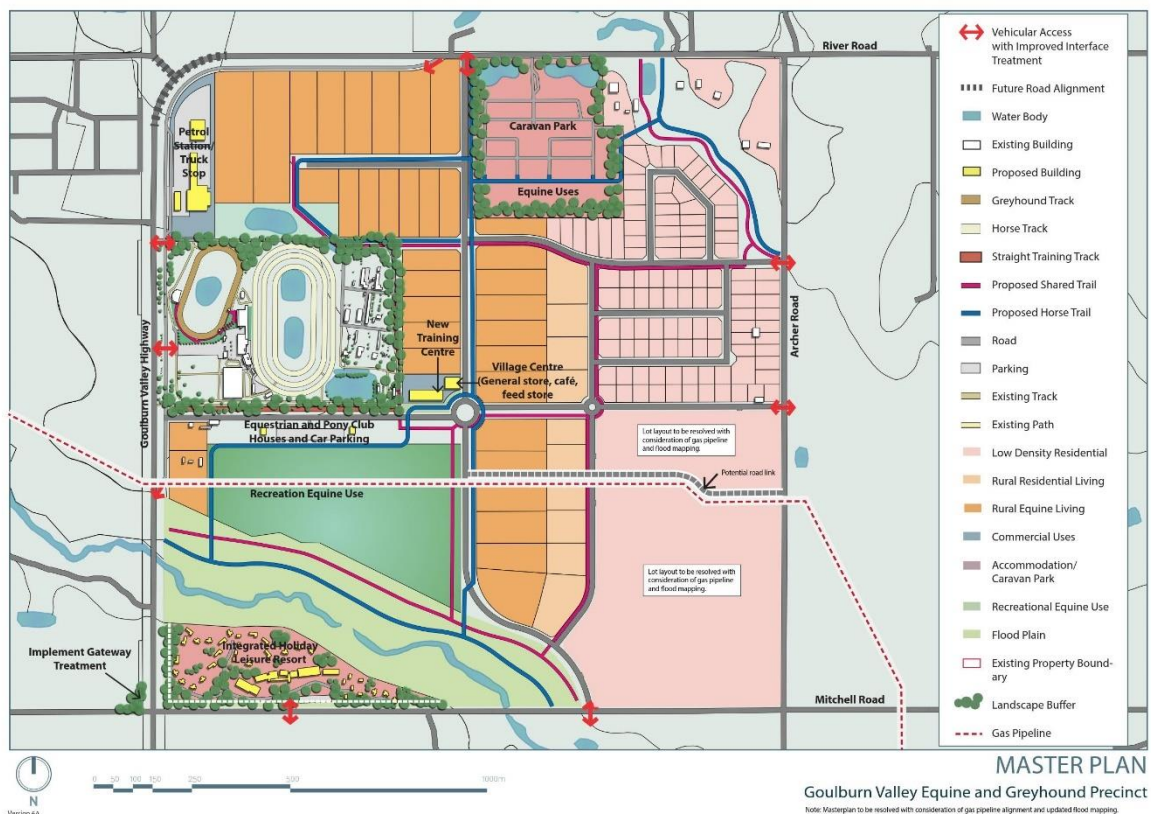


Figure 2-1 Initial Proposed Subdivision (Urban Enterprise)

2.1 Submissions to Proposed Development Precinct Masterplan

Greater Shepparton City Council received 23 written submissions to the Goulburn Valley Equine Precinct Masterplan. Water Technology was commissioned in the scope of works to provide a response to flood related issues within the submissions. Any flood related issues identified within the submissions are outlined below, while the submissions that did not relate to flooding issues are labelled as 'N/A'. Many of the submissions answered below in relation to flooding issues question the existing planning controls, including the Floodway Overlay. It is important to note that many of the submissions question the extent of the planning controls often in relation to the 1993 flood event. While this is one the largest events on the Seven Creeks system in recent history, the 1993 flood event is of smaller magnitude than the 1% AEP event. The 1% AEP event is the design event for which flood related planning controls are based upon in Victoria.

Submission 1 - N/A

Submission 2 - N/A

Submission 3 - 710 Archer Road, Kialla West - Flooding during the 1993 flood event came within 10-15 metres of the shed on the property. The submission has questions regarding the current zoning of LSIO on the property.

The property mentioned has an anabranch of Seven Creeks running through the property. Aerial imagery following the 1993 flood event as well as observed flood heights in the area tend to support the statement regarding the extent of the 1993 flooding.

It should be noted that while 1993 is one of the largest floods in recent history, the flow rates and flood heights obtained from design modelling show that it was of less magnitude than a predicted 1% Annual Exceedance Probability (AEP) flood event on Seven Creeks. The planning controls are based on the 1% AEP flood event, so are larger than the observed 1993 flooding.

Submission 4 - APA Group – An existing high pressure gas pipeline is within the masterplan precinct area.

Greater Shepparton City Council met with APA and discussed potential use and setback from the existing pipeline. This was taken into account by Urban Enterprise when developing a revised masterplan layout. No infrastructure related with the development, including roadways has been placed within the APA pipeline buffer zone. Passive floodplain infrastructure (floodplain storage) has been allocated for the area surrounding the APA pipeline, excavation depths around the pipeline buffer zone would need to be taken into consideration.

Submission 5 - N/A

Submission 6 - N/A

Submission 7 - 7560 Goulburn Valley Highway, Kialla - Flooding on the property occurred in 1993 as a result of overflow of the G-MW channel. The submission proposes the channel be piped as part of the masterplan.

This is outside the scope the Water Technology investigation, should decommissioning of the channel occur, a change in the flood behaviour is likely to occur. The Goulburn Broken CMA confirmed that the channel currently forms part of the 'backbone' G-MW channel system and there are no plans for decommissioning of the channel. The investigation highlighted that the channel banks form a critical hydraulic control in the area, and removal of the channel may cause negative impacts to properties downstream.

Submission 8 - Raised concerns over the accuracy of the existing floodway overlay in the southern section of the masterplan. The submission suggests that recent detailed survey levels show that 1% AEP flood levels quoted in the existing Goulburn Broken CMA flood map atlas would not result in flood depths of greater than 0.5 m in a 1% AEP flood event. The submission proposes that the G-MW channel height would have restricted flows heading north from Seven Creeks into the Harness/Racing Club stables.

The model developed by Water Technology for the Shepparton-Mooroopna Flood Mapping and Intelligence Study utilises a more detailed grid resolution than previous hydraulic modelling. The most recent model also utilises a higher level of vertical and horizontal accuracy topography compared with the previous hydraulic model. In addition, the channel crest heights obtained from the LiDAR and feature survey have been included as separate break lines to ensure the correct heights of the channel are included in the model topography. The current modelling represents a significant advancement in the model detail compared to the previous study which 1% AEP flood levels have previously been based on.

While it is noted that 1993 flood levels are not likely to cause flooding over the G-MW channel and into the Harness Racing Precinct (of which the hydraulic model calibration event of 1993 shows), the flow rates and flood heights obtained from design modelling show that the 1993 flood event was of less magnitude than a 1% AEP flood event on the Seven Creeks. The updated flood model results suggest that flooding on the properties to the south of the racing precinct are likely to be within an important overland flow path once water levels exceed the G-MW backbone channel.

The updated flood model results suggest that flooding on the properties to the south of the racing precinct are greater than 0.50 m in depth and the channel is overtopped resulting in flooding of the Harness/Racing Club stables during a 1% AEP flood event.

Submission 9 - 7560 Goulburn Valley Highway, Kialla - Flooding occurred on the property in the 1993 flood event as a result of overflow of the G-MW channel to the north of the property. The submission questions the existing floodway overlay on the property.

See response to Submission 8

Submission 10 - N/A

Submission 11 - 212-225 Mitchell Road, Kialla - Proposes a process to review and update the flood behaviour modelling prior to the master plan being finalised.

Water Technology agrees with this submission.

Submission 12 - 7560 Goulburn Valley Highway, Kialla - Flooding occurred on the property in the 1993 flood event as a result of overflow of the G-MW channel to the north of the property. The submission questions the existing floodway overlay on the property.

See response to Submission 8

Submission 13 - 780 Archer Road & 110 River Road Kialla. The submission questions the floodway overlays on the property.

See response to Submission 8

Submission 14 - N/A

Submission 15 - The submission suggests the proposed masterplan has ignored existing FO and that the existing FO and LSIO controls are inconsistent with the hydraulic and hydrologic flood maps contained in the approved Shepparton Mooroopna Flood Study (2002).

In regards to the existing FO, the submission suggests that where the FO applies to are inconsistent with the land survey work submitted on behalf of the 3 land owners who own land south of the Harness Precinct. This clearly demonstrates that the bulk of this area is above the accepted 1 in 100 year ARI level.

The model developed by Water Technology for the Shepparton-Mooroopna Flood Mapping and Intelligence Study utilises a more detailed grid resolution than previous hydraulic modelling. The most recent model also utilises a higher level of vertical and horizontal accuracy topography compared with the previous hydraulic model. In addition, the channel crest heights obtained from the LiDAR and feature survey have been included as separate break lines to ensure the correct heights of the channel are included in the model topography. The current modelling represents a significant advancement in the model detail compared to the previous study which 1% AEP flood levels have previously been based on.

In regards to the existing FO, the submission suggests that where the FO applies to is inconsistent with the statutory declarations submitted by several of the land owners who own land south of the Harness and Greyhound precinct (as part of this submission process), that the low level flooding which occurred on the bulk of this land in the 1993 flood event was caused by water spilling onto the land

from the adjacent Goulburn-Murray Water irrigation channel and from flood water flowing uphill from Seven Creeks.

Water Technology flood modelling of the 1993 flood event, which has been calibrated to observed flood heights in the surrounding area and validated using aerial imagery and anecdotal evidence suggests that the 1993 flood levels recorded would not have resulted in the G-MW channel being overtopped from flows from Seven Creeks.

It should be noted that while 1974 and 1993 are two of the largest floods in recent history, the flow rates and flood heights obtained from design modelling show that it was of less magnitude than a 1% Annual Exceedance Probability (AEP) flood event on Seven Creeks. The 1% AEP is the event which planning controls are based on, which explains why the flood controls are larger than that observed in the 1993 event. Flood modelling of the 1% AEP event suggest that the G-MW backbone channel is overtopped and the site in question becomes part of an overland flow path for water travelling from Seven Creeks.

In regards to the existing FO, the submission suggests that where the FO applies to is inconsistent with the hydraulic and hydrologic flood maps contained in the approved Shepparton Mooroopna Flood Study (2002), that represents the best available flood evidence and the models relied upon to apply the current flood controls.

The existing planning controls were based on hydraulic flood maps developed from the 2002 study were the best available flood evidence to apply to flood controls at the time. However, the model currently being used for the Shepparton-Mooroopna Flood Mapping and Intelligence Study offers significant improvements and is much more accurate. It is representing the local topography including the channel heights to a far greater level of detail, including survey of the bank crest level.

In regards to the existing FO, the submission suggests that land currently within the FO is inconsistent with the fact proven by recent survey work conducted on behalf of the 3 separate land owners south of the harness precinct, that shows the majority of the land covered by the FO is actually higher than the adjacent Goulburn Valley Highway levels. The survey indicates that in a Seven Creeks flood event, any flood water would simply flow over the highway instead of flowing north, rising 500 mm above the highway level and flowing over and into the irrigation channel.

This simply did not happen in either 1974 nor the 1993 flood events that form the basis of the current flood overlays.

It should be noted that while 1974 and 1993 are two of the largest floods in recent history, the flow rates and flood heights obtained from design modelling show that it was of less magnitude than a 1% Annual Exceedance Probability (AEP) flood event on Seven Creeks. I is this larger 1% AEP flood event that planning controls are based on.

The model developed by Water Technology for the Shepparton-Mooroopna Flood Mapping and Intelligence Study utilises a more detailed grid resolution than previous hydraulic modelling. The most recent model also utilises a higher level of vertical and horizontal accuracy topography compared with the previous hydraulic model. In addition, the channel crest heights obtained from the LiDAR and feature survey have been included as separate break lines to ensure the correct heights of the channel are included in the model topography. The current modelling represents a significant advancement in the model detail compared to the previous study which 1% AEP flood levels have previously been based on.

While it is noted that 1993 flood levels are not likely to cause flooding over the G-MW channel and into the Harness Racing Precinct (of which the hydraulic model calibration event of 1993 shows), the flow rates and flood heights obtained from design modelling show that the 1993 flood event was of less magnitude than a 1% AEP flood event on the Seven Creeks. The updated

flood model results suggest that flooding on the properties to the south of the racing precinct are likely to be within an important overland flow path once water levels exceed the G-MW backbone channel.

The crest levels of the Goulburn Valley Highway range from 114.74 to 114.94 m AHD through the Seven Creeks flow area. It is important to note that under high flows, not all the water travelling along Seven Creeks would pass over the highway. Water would back up and overtop the G-MW channel and into the Harness Racing Club. Crest levels along the G-MW backbone channel range from 114.71 to 115.12 m AHD. The results shown in the model of flood behaviour during the 1% AEP event that the channel is overtopped resulting in water flowing north through the Paceway. The 1% AEP flood level immediately upstream of the Goulburn Valley Highway and south of the G-MW channel ranges from 114.90 to 115.05 m AHD. This demonstrates why the model shows flood water overtopping both the Goulburn Valley Highway and the G-MW Channel in a 1% AEP event.

No storage has been assumed in the channel, as conditions within the system can vary significantly so no available storage within the system should be considered for design conditions.

Submission 16 - 7560 Goulburn Valley Highway, Kialla - Flooding occurred on the property in the 1993 flood event as a result of overflow of the G-MW channel to the north of the property. The submission questions the existing FO on the property.

See response to Submission 8

Submission 17 - Suggest water being pumped into the channel system along Archer Road and during the 1993 flood event and that the flooding caused on the property (7560 GV highway, Kialla) was a result of the channels overflowing at the time and not from Seven Creeks.

While it is noted that 1993 flood levels are not likely to cause flooding over the G-MW channel and into the Harness Racing Precinct (of which the hydraulic model calibration event of 1993 would suggest), the flow rates and flood heights obtained from design modelling show that it was of less magnitude than a 1% Annual Exceedance Probability (AEP) flood event on Seven Creeks. The updated flood model results suggest that flooding on the properties to the south of the racing precinct are likely to be within an important overland flow path once water levels exceed the G-MW backbone channel in a 1% AEP event.

Submission 18 - Suggest water being pumped into the channel system along Archer Road and during the 1993 flood event and that the flooding caused on the property (7560 GV highway, Kialla) was a result of the channels overflowing at the time and not from Seven Creeks.

See response to Submission 17

Submission 19 – 100 River Road, Kialla. The submission suggested the concept plan shows much of the land as flood affected. The submissions suggested whilst it may convey irrigation or rainfall runoff, it has never conveyed floodwater, and water lying on the property after heavy rainfall is due to poor drainage.

Despite 1993 being one of the largest floods in recent history, the flow rates and flood heights obtained from design modelling show that it was of less magnitude than a 1% Annual Exceedance Probability (AEP) flood event on Seven Creeks. Flood modelling suggests that for flow events of the larger 1% AEP event, the site contains an overland flow path from Seven Creeks that is engaged once flood levels overtop the G-MW channel to the South of the Paceway. It is this larger 1% AEP event that forms the basis of the flood controls not the smaller 1993 event.

Submission 20 - N/A

Submission 21 - N/A

Submission 22 - 7550 Goulburn Valley Highway, Kialla - Flooding occurred on the property in the 1993 flood event as a result of overflow from the G-MW channel to the north of the property. The submission questions the floodway overlay on the property.

See response to Submission 8

Submission 23 - 7550 Goulburn Valley Highway, Kialla - Flooding occurred on the property in the 1993 flood event as a result of overflow from the G-MW channel to the north of the property. The submission questions the floodway overlay on the property.

See response to Submission 8

3. DEVELOPMENT FLOOD RISK

The flood model was updated to include the proposed masterplan. Fill pads were raised to reflect the intended development of the masterplan. The flood model was run for the 1% AEP event and compared to current conditions model results. The key criteria assessed included:

- No negative impact to flood levels outside of the Investigation Area.
- Any loss of floodplain storage be compensated with the addition of 130% of the floodplain storage volume removed.

To understand the impact the development would have on water levels, depths and extents, a direct comparison is drawn between the flood levels for existing conditions and proposed developed conditions. This comparison is calculated as follows:

$$\text{Developed flood levels} - \text{Existing flood levels} = \text{Flood level difference}$$

This comparison shows the impact of the development in terms of a change in flood levels. A positive change implies an increase in flood levels after development for the 1% AEP event. A negative change implies a decrease in flood levels after development during the 1% AEP event. The comparison will also show areas which were previous inundated and are now dry after the development and areas which were dry and are now inundated.

3.1 Development Scenario 1

The development layout for scenario 1 is shown in Figure 2-1, with Low Density Residential Zone (LDRZ), Rural Living Zone (RLZ) and 'equine living'. A caravan park in the north of the site along with a leisure centre in the south west of the site are also included. The low density residential zone, caravan park and leisure centre were all raised above the 1% AEP flood level.

The results of the modelling are shown in Figure 3-1, the development impact is shown in Figure 3-2, which highlights an increase in flood levels upstream of the Investigation Area (south of Mitchell Road) as well as West of the Goulburn Valley Highway. These increases are in the magnitude of 50-200 mm. An isolated area south of Mitchell Road shows increases in flood levels greater than 200 mm. These increases in flood levels are not acceptable, as they are disadvantaging other landholders.

Additionally, Figure 3-3 shows the change in maximum velocity within close proximity of the site. There is a considerable increase in maximum flood velocities across the Goulburn Valley Highway.

Under existing conditions, the parcel of land in the south west of the site plays an important role in conveying flood flows across the site and over the Goulburn Valley Highway.

The initial proposed masterplan is clearly inappropriate when considering floodplain risk management principles and performance criteria on new development. The development layout required redesign.

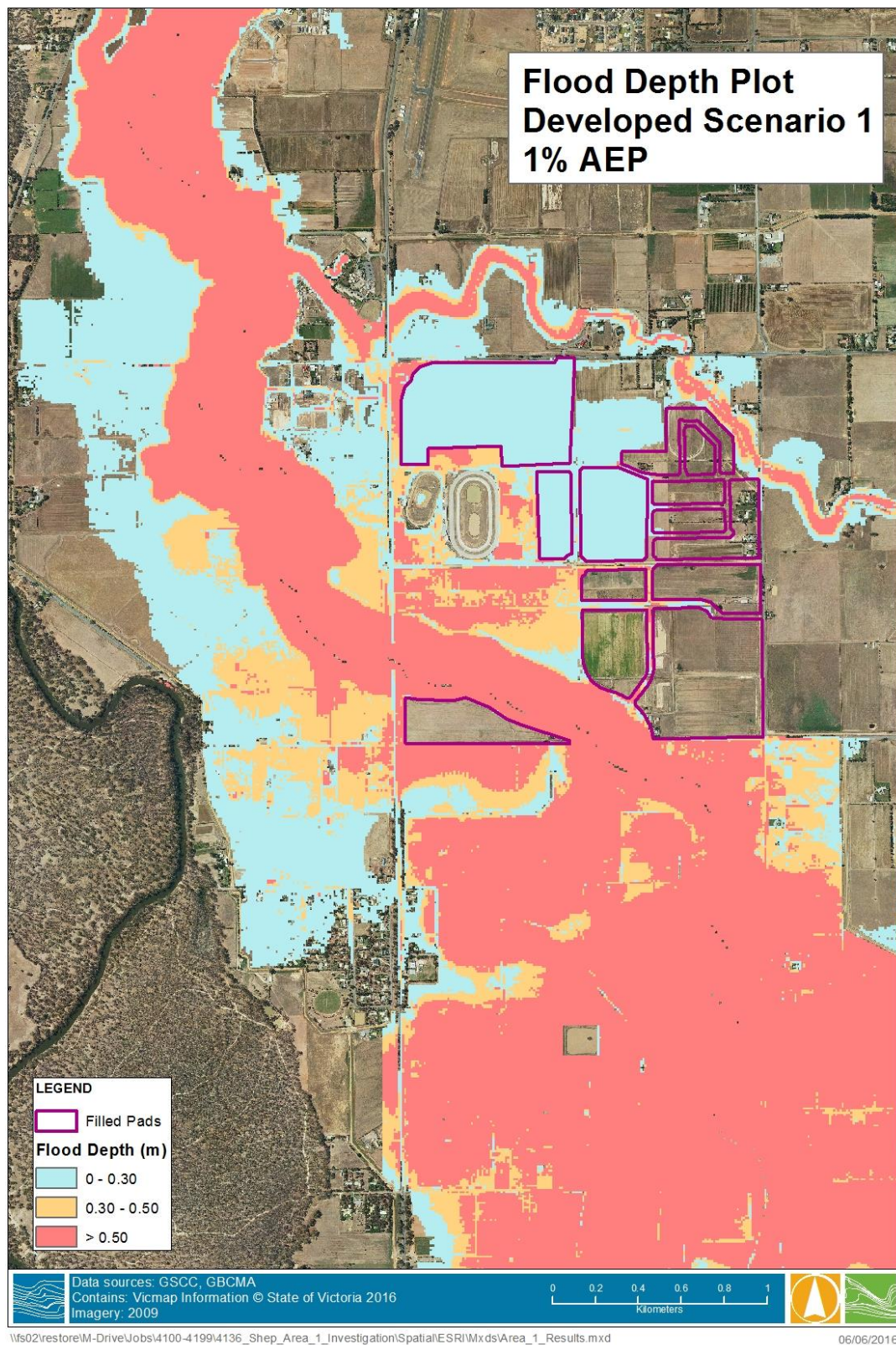


Figure 3-1 Development Scenario 1 - Flood Depth Plot

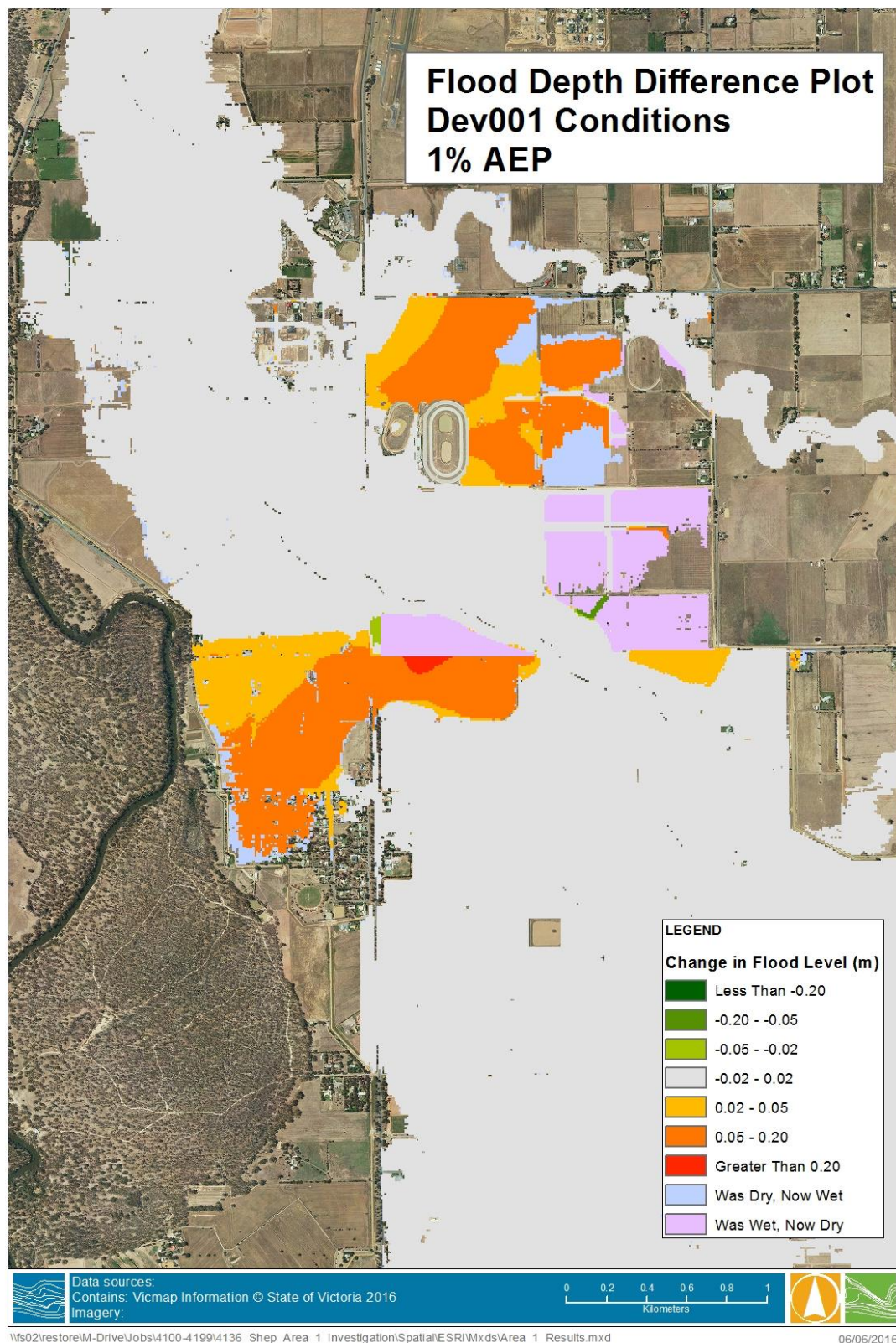


Figure 3-2 Development Scenario 1 - Flood Level Difference Plot

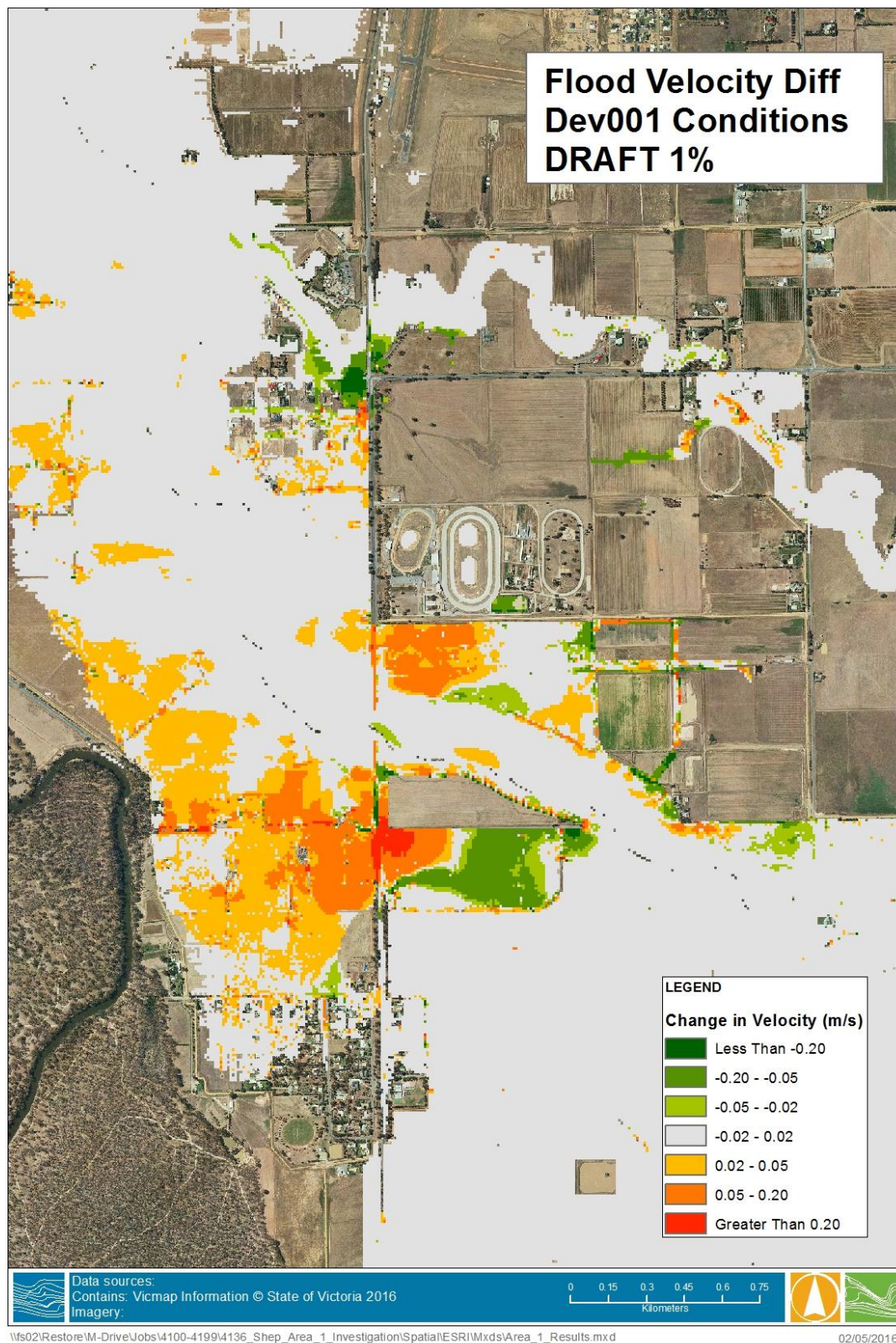


Figure 3-3 Development Scenario 1 - Flood Velocity Difference Plot

3.2 Development Scenario 2

Development Scenario 2 reflected the same conditions as Development Scenario 1 with the inclusion of the existing equine recreation area as a filled pad to accommodate development.

The results of the modelling are shown in Figure 3-4, the development impact is shown in Figure 3-5, which highlights an increase in flood levels upstream of the Investigation Area (south of Mitchell Road) as well as West of the Goulburn Valley Highway. These increases in flood depth are greater than the results from Development Scenario 1. Increases in the magnitude of 20-50 mm are widespread upstream of Mitchell Road covering existing dwellings. Increases of 50-200 mm are observed to the south and west of the Investigation Area, as well as an isolated area of greater than 200 mm increase south of Mitchell Road.

Additionally, Figure 3-6 shows the change in maximum velocity within close proximity of the site. there is a considerable increase in maximum flood velocities across the Goulburn Valley Highway.

Under existing conditions, the parcel of land in the south west of the site plays an important role in conveying flood flows across the site and over the Goulburn Valley Highway. The additional area raised in Development Scenario 2 also plays a major role in conveying flood flows from Seven Creeks across the Investigation Area. In a 1% AEP event, the additional area raised (to the north of Seven Creeks and south of the Paceway), blocks a large overland flow path which drains flows which overtop the G-MW backbone channel in a north westerly direction. As shown in the results, this site should not be raised as it will reduce the conveyance of the flow path across the site in a 1% AEP flood event.

The revised development is clearly inappropriate when considering floodplain risk management principles and performance criteria on new development. The development layout required redesign.

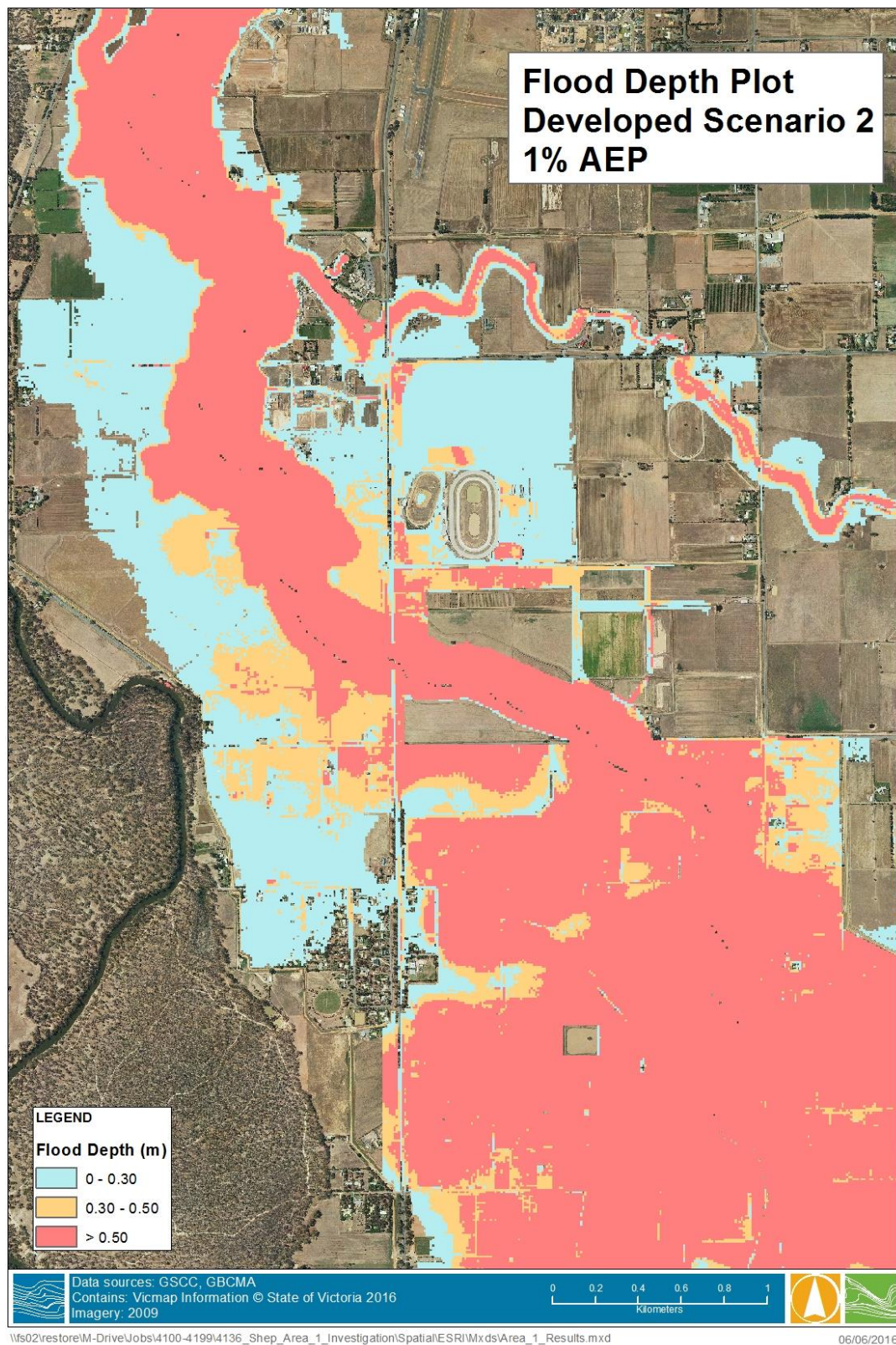


Figure 3-4 Development Scenario 2 - Flood Depth Plot

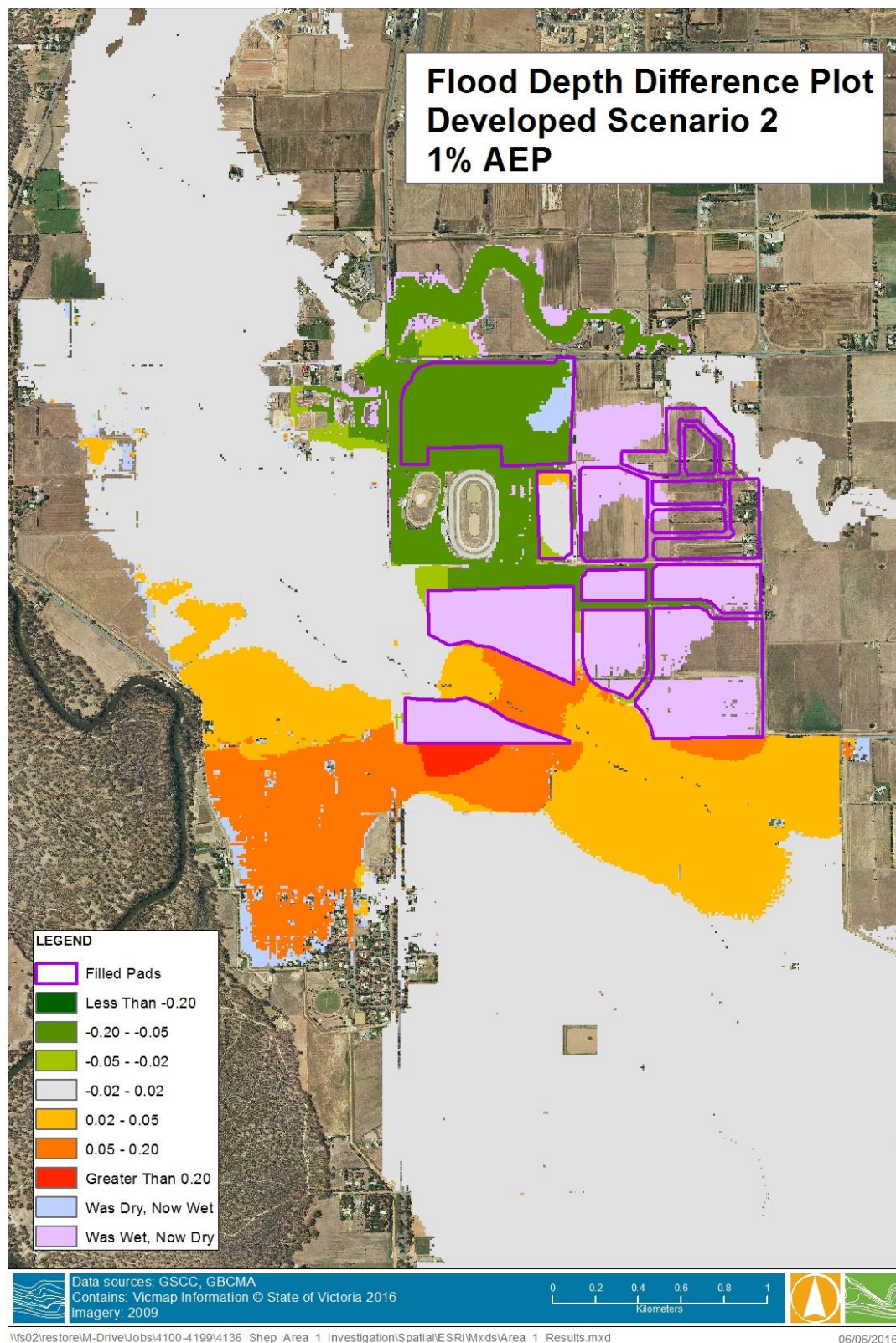


Figure 3-5 Development Scenario 2 - Flood Level Difference Plot

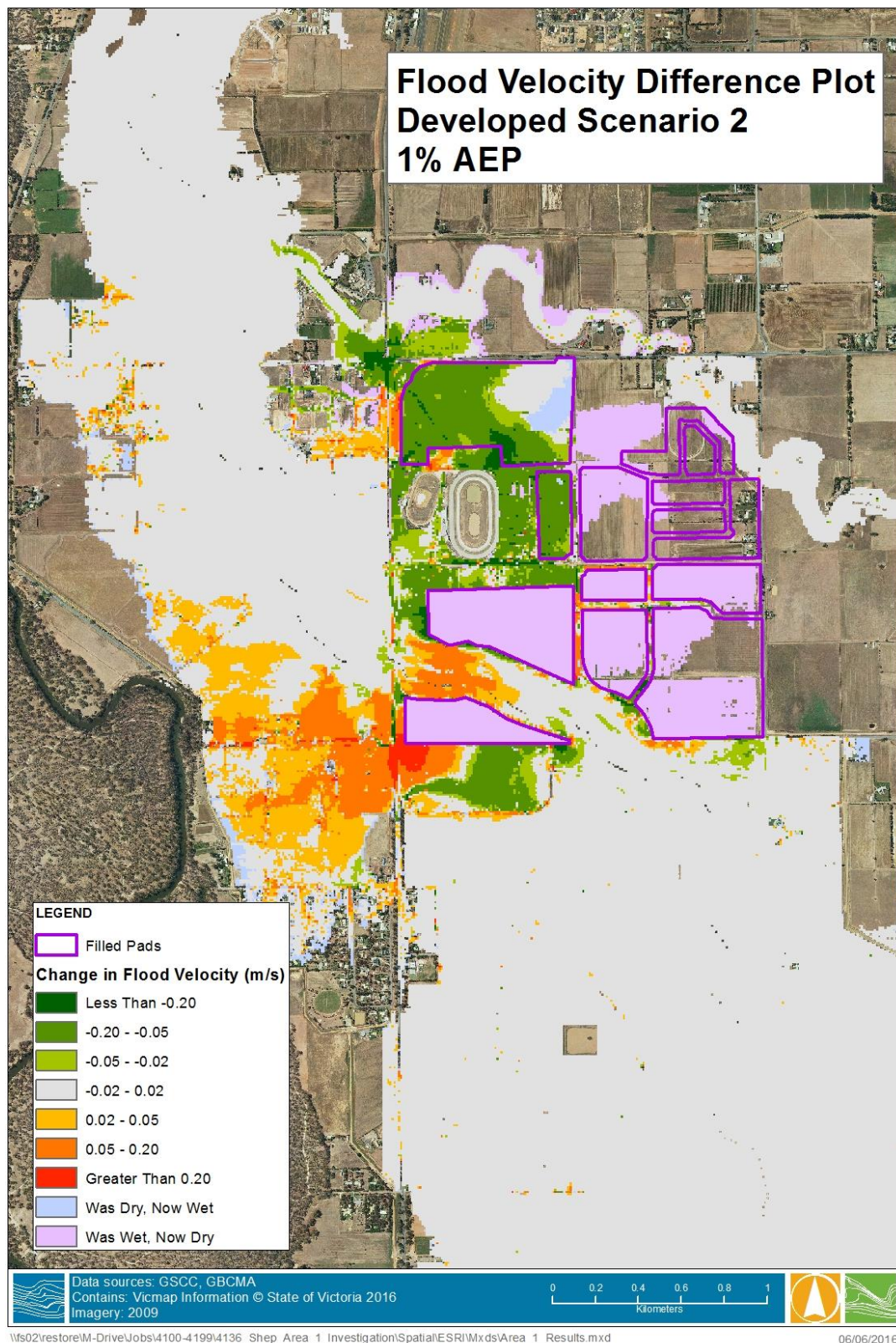


Figure 3-6 Development Scenario 2 - Flood Velocity Difference Plot

3.3 Development Scenario 3

Given the results of Development Scenarios 1 and 2, several changes were made to the masterplan to reduce the volume of earthworks and to meet Goulburn Broken CMA requirements of no increased flood levels outside of the Investigation Area.

The results of the first two scenarios identified the south west of the Investigation Area as an important flow path. Restricting the flow as was undertaken in the previous development scenarios (1 & 2) caused significant increase in flood levels upstream of the site. Under existing conditions, there are high velocities across this area as well as depths greater than 0.50 m in a 1% AEP event. It is likely that any significant development in this area will lead to adverse impacts on properties south of Mitchell Road or west of the Goulburn Valley Highway. For Development Scenario 3, this area was reverted back to existing conditions to maintain the overland flow path.

Additionally, the area immediately north of Seven Creeks which was modelled as potential equine recreation area in Development Scenario 1 and then raised in Development Scenario 2 was also identified as having a crucial flow path through the site. When water levels overtop the banks in Seven Creeks a large amount of water flows north through this area, overtopping the G-MW backbone channel and flows across the north of the site through the Paceway. For Development Scenario 3, this area was utilised as additional floodplain storage to provide the balance of 130% of floodplain storage removed through the filling of other areas of the development. An average depth of 1.10 m was removed from the existing surface to provide floodplain storage.

Additional floodplain storage was also provided in the south east of the site, where waters overtop the Seven Creeks channel banks and flow north. The area was modelled with 1.10 m removed from the existing surface.

A fill pad in the north west of the site to accommodate a petrol station was retained in the Development Scenario 3 layout. This was raised above the floodplain. To accommodate the floodplain storage area requirements, a smaller basin was placed to the east of the petrol station fill pad. Under existing conditions, this area drains much of the northern area of Investigation Area 1. This additional floodplain storage basin could also accommodate stormwater runoff and treatment options.

The RLZ and 'equine living' properties were refined from filling the entire parcel above the floodplain to having an area of 2,500 m² raised above the floodplain to allow for development of a dwelling and shedding infrastructure on a 50 m x 50 m area. This significantly reduced the volume of fill material required across the Investigation Area. The layout for Development Scenario 3 is shown in Figure 3-7.



Figure 3-7 Development Scenario 3 Layout (Urban Enterprise)

The flood model results for Development Scenario 3 are shown in Figure 3-8, while the flood level difference plot is shown in Figure 3-8. The flood level difference plot shows there is no negative impact greater than 1 cm outside of the Investigation Area. There are several increases in flood levels across the site. An increase of around 30 cm in the north east of the site occurs along the anabranch and along the edge of the roadway as a result of the anabranch floodplain width being reduced. The water level in this area is controlled upstream by Archer Road and River Road on the downstream end. Other increases in the north of the Investigation Area are a result of the fill pads of the RLZ and 'equine living' as well as the petrol station restricting flow. These increases are relatively minor with no increases greater than 100 mm from existing flood levels. The fill pads were raised to above the flood level for this scenario.

Figure 3-10 shows the change in maximum flood velocity in the vicinity of the Investigation Area. There are a number of increases, the largest being in the location of the floodplain storage area which had the surface levels reduced by over 1.00 m. Further detailed design of the storage basin would likely

reduce the flood velocities in this area. The floodplain storage basin also causes an increase in maximum velocities upstream of the site due to increased efficiency as the floodwaters overtop the banks of Seven Creeks and heads north into the basin.

Increases to the north of the site occur in both the anabranch (due to increased levels in the anabranch within the Investigation Area) as well as on the north east and north west of the Goulburn Valley Highway/ River Road Intersection. This is likely a result of the flow paths leaving Investigation Area 1 being squeezed through a smaller flow path due to the development footprint. Should the petrol station shown within Development Scenario 3 be included at a detailed design level, further investigation into maintaining drainage from the site via a large culvert would be required as a measure to reduce the increased flood velocities downstream of the site. Almost all velocity increases greater than 0.20 m/s are contained within the Investigation Area, with increases of between 0.05 and 0.20 m/s occurring outside of the Investigation Area. Further investigation at a detailed design level is likely to provide mitigation solutions to these velocity increases. Figure 3-11 shows only minor areas of velocities greater than 0.50 m/s outside of the main Seven Creeks waterway.

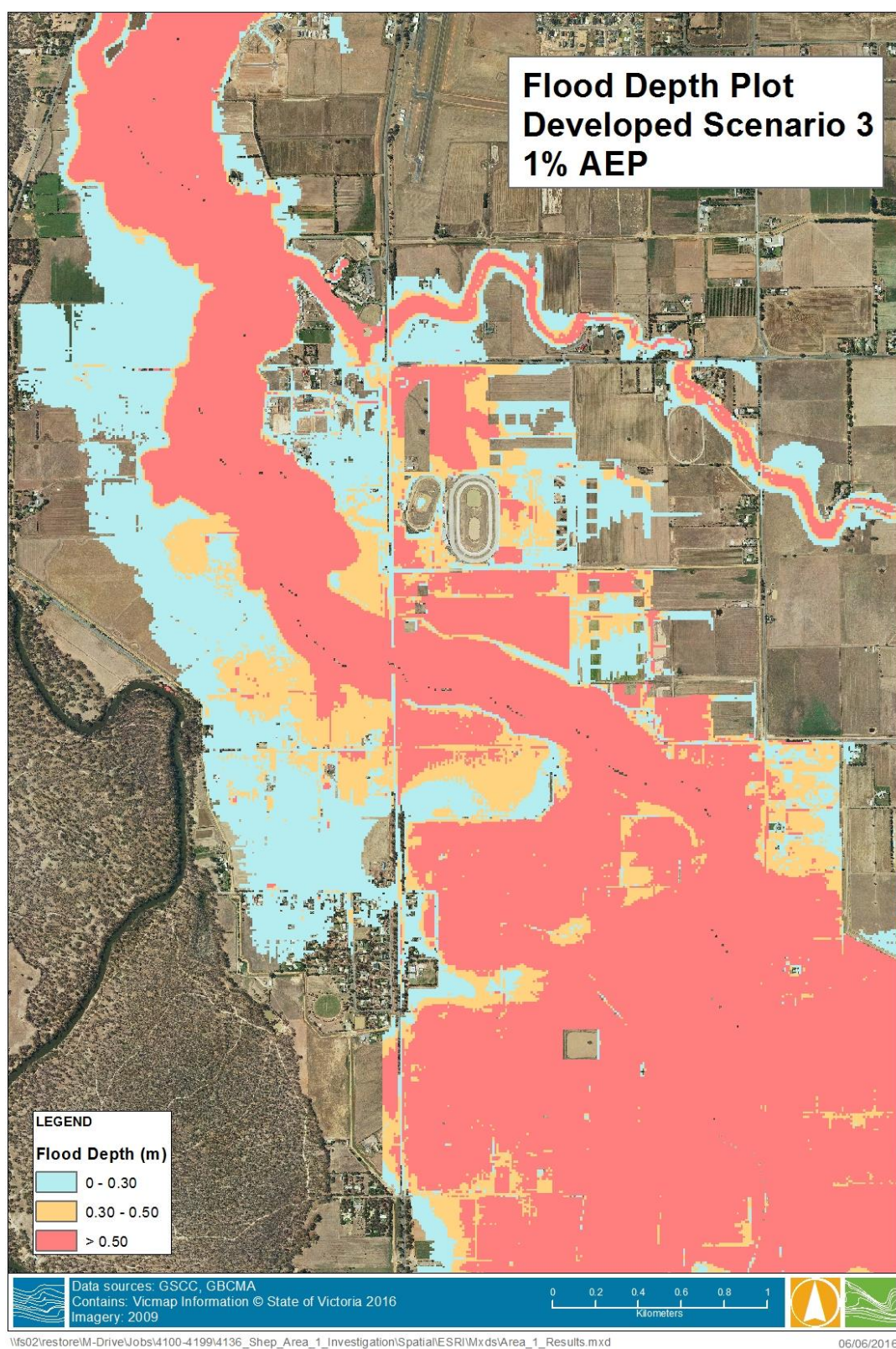


Figure 3-8 Development Scenario 3 - Flood Depth Plot

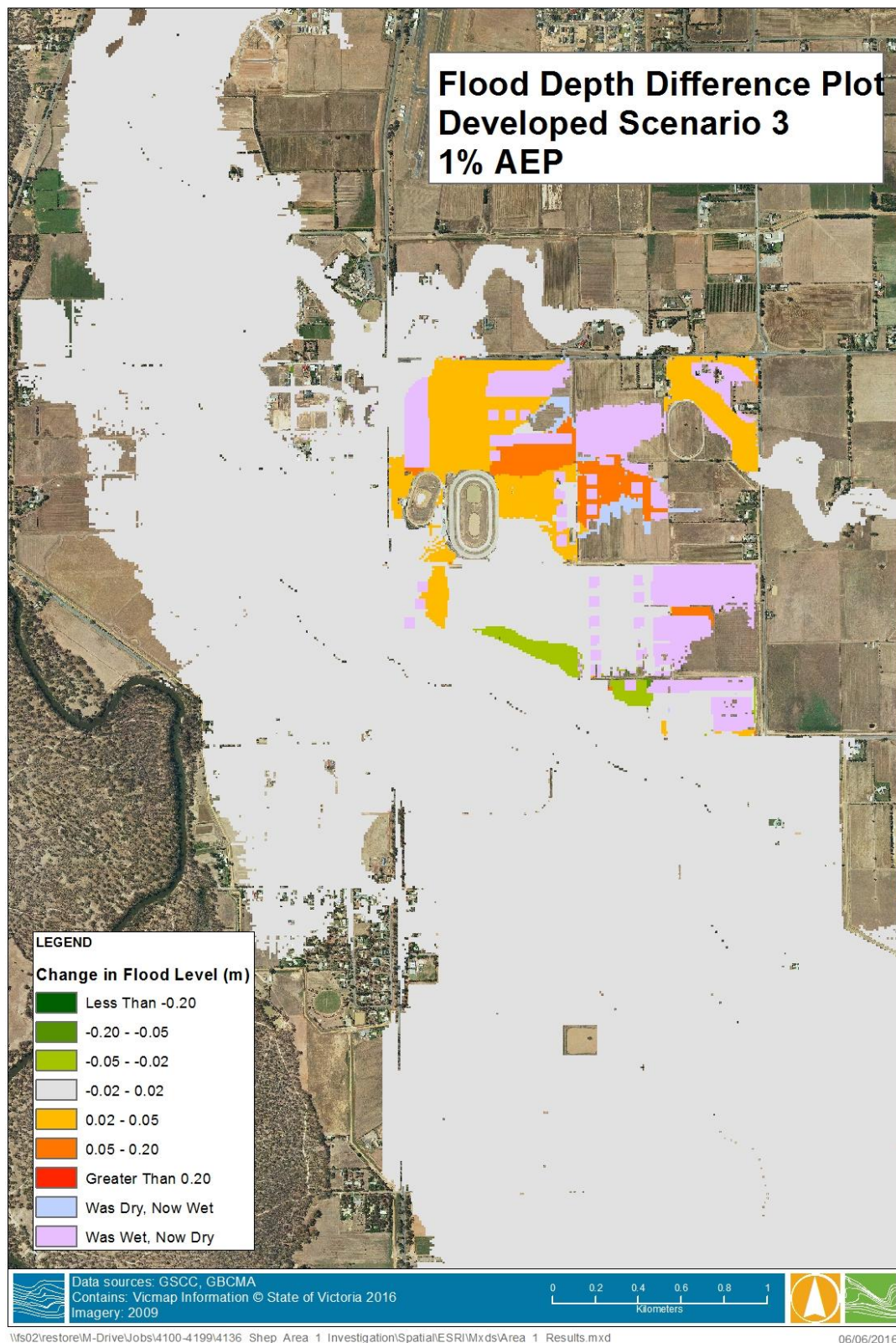


Figure 3-9 Development Scenario 3 - Flood Level Difference Plot

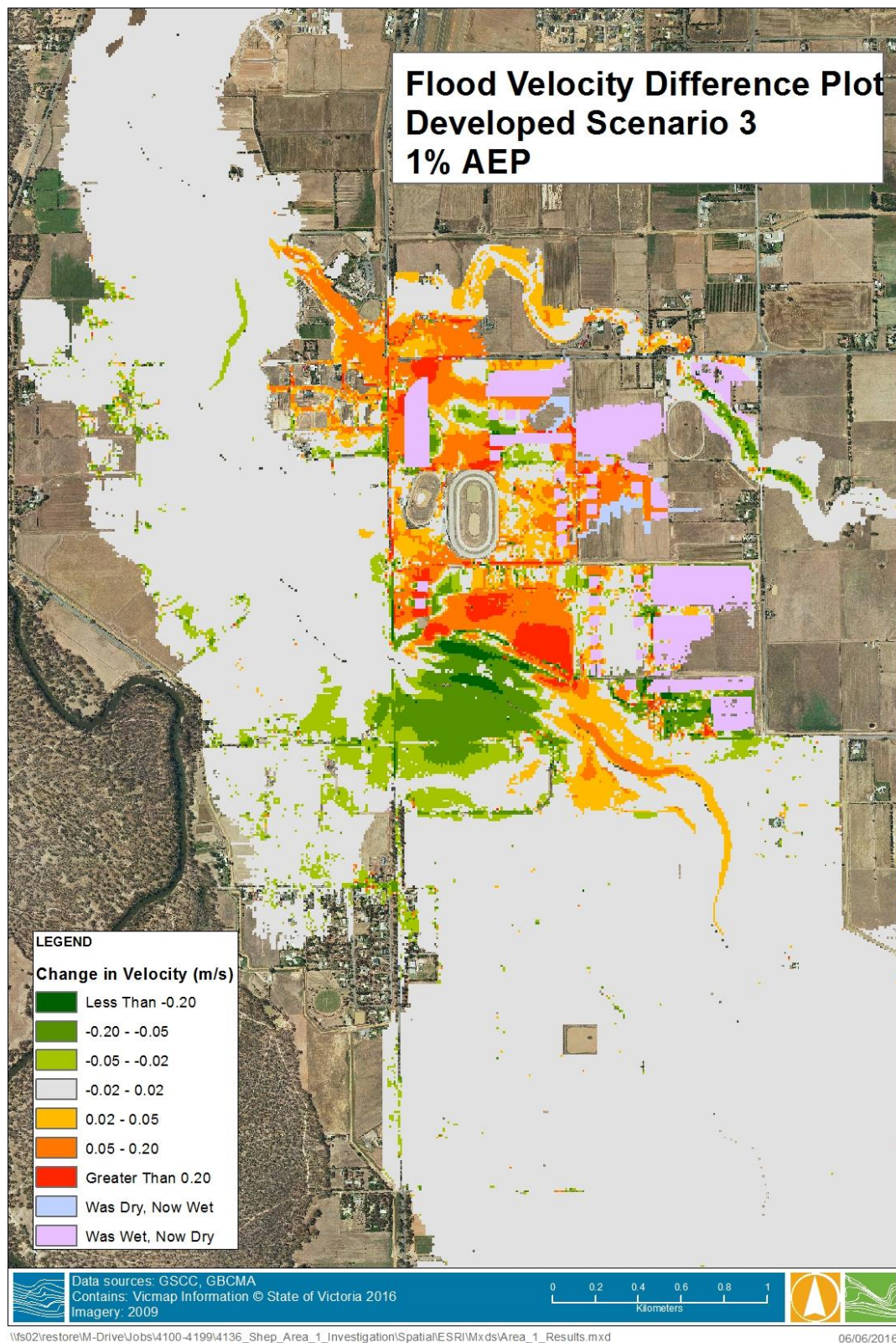


Figure 3-10 Development Scenario 3 - Flood Velocity Difference Plot

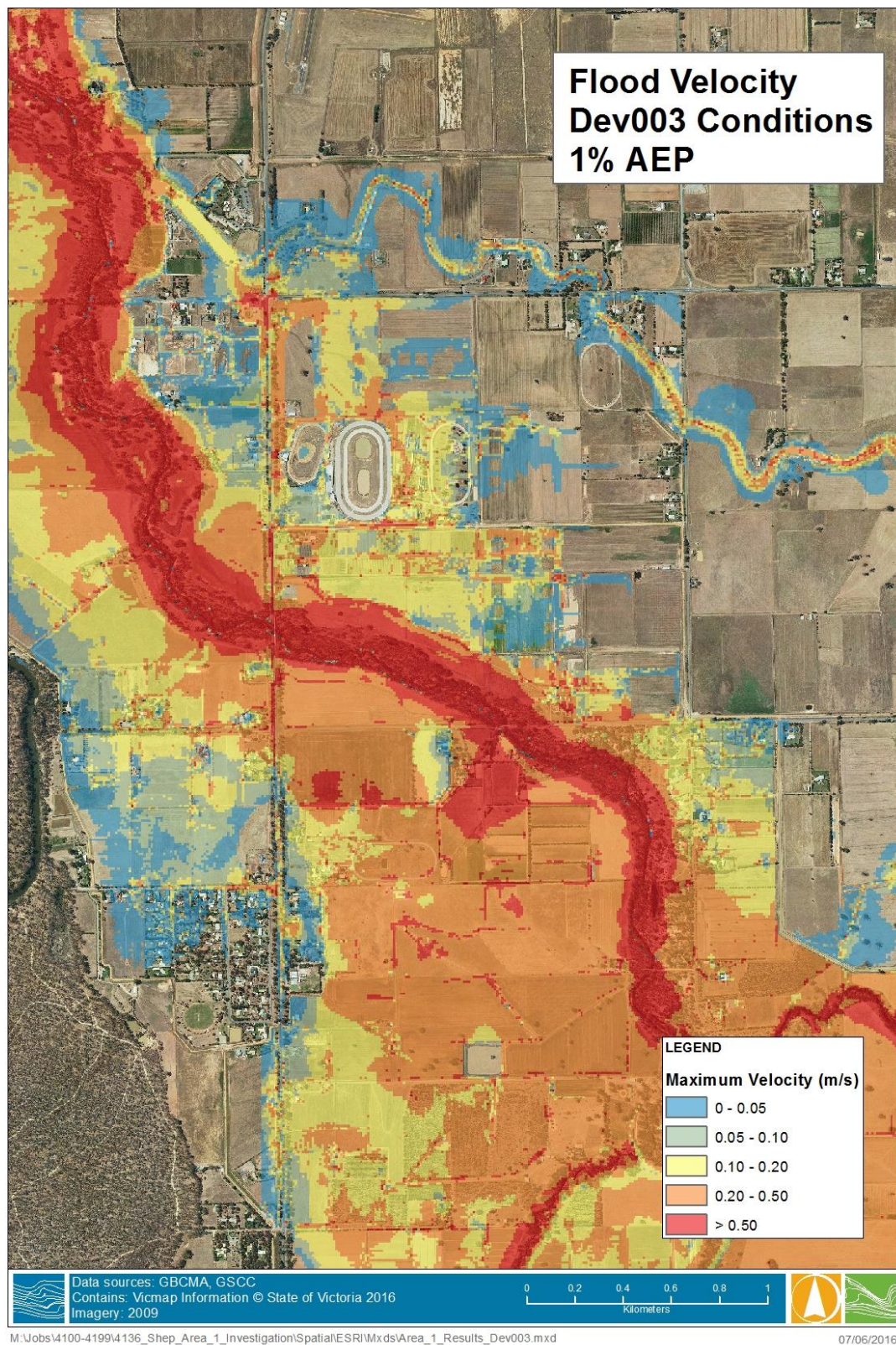


Figure 3-11 Development Scenario 3 Maximum Flood Velocity Plot

3.4 Development Scenario 4

Development Scenario 4 was identical to Development Scenario 3 as shown in Figure 3-7 with the removal of the petrol station in the northwest of the Investigation Area. This change was to reflect the importance of maintaining the overland flow path exiting the Investigation Area at the lowest area of the site. This also lowered the required fill volume, as the site identified for the petrol station would be required to be filled close to 1.00 m across much of the site. The floodplain storage adjacent to the petrol station in Development Scenario 3 was maintained as it was felt this area was suitable to accommodate stormwater infrastructure for retention and water quality treatment.

The flood depth plot for Development Scenario 4 is shown in Figure 3-12, again this shows similar results as per Development Scenario 3 with the additional flooding in the north west of the Investigation Area. Figure 3-13 shows there is no increase greater than 1 cm on properties outside of the Investigation Area. Similar to Development Scenario 3, there is an increase in flood levels of between 1-2 cm in an isolated section of Mitchell Road. The increases in flood depths shown in Development Scenario 3, immediately north of the Paceway been removed as the existing flow path to the north west of the site has now been reinstated. The increase in the north west of the Paceway is still shown as an increase of up to 100 mm from existing conditions as a result of the building envelopes being raised above the flood levels. Providing access to these building envelopes should be investigated at a detailed design level, however the location of these building envelopes and access roads should utilise the existing modelling to provide the most suitable location. The addition of the roads and relocation of building footprints is unlikely to have a major impact on flood levels however this will still need to be assessed to meet Goulburn Broken CMA requirements.

Figure 3-14 shows the maximum velocities during a 1% AEP flood event, while Figure 3-15 shows the change in maximum velocity compared to existing conditions. Similar to Development Scenario 3, increases downstream of the site are caused as the flow path is squeezed through the north west of the site and over River Road and the Goulburn Valley Highway. Further investigation at detailed design could reduce the velocities back to existing conditions.

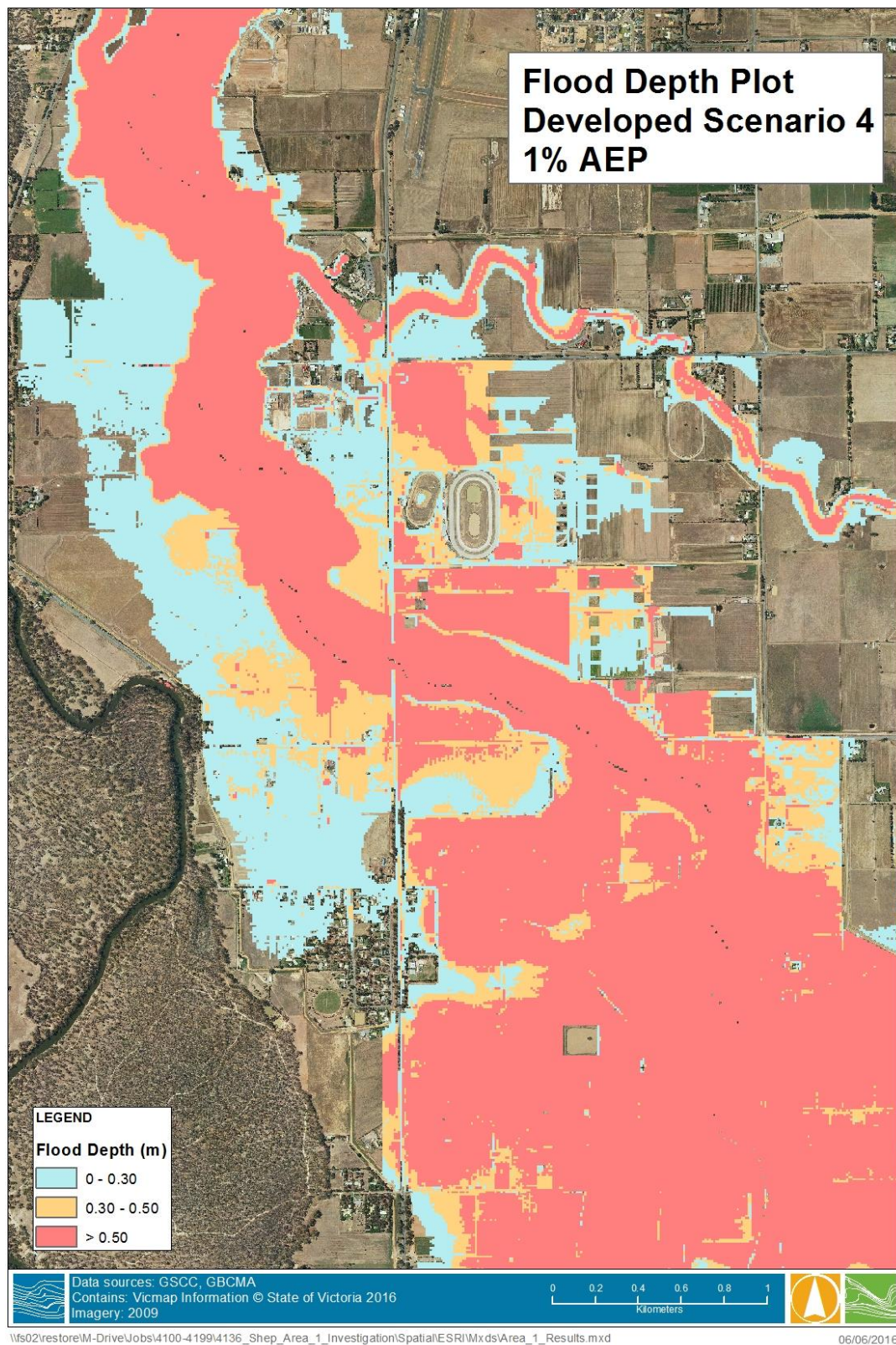


Figure 3-12 Development Scenario 4 - Flood Depth Plot

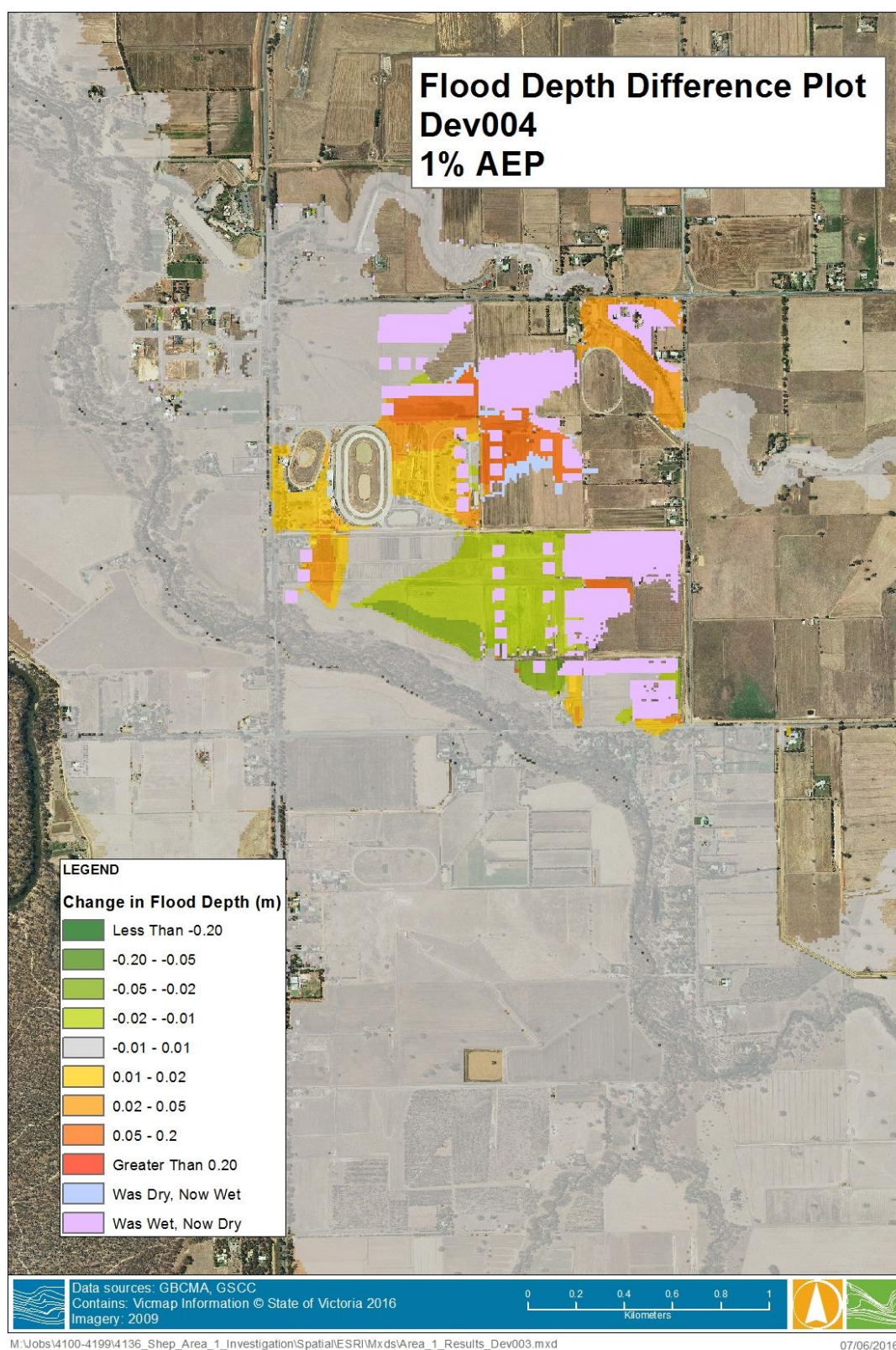


Figure 3-13 Development Scenario 4 – Flood Level Difference Plot

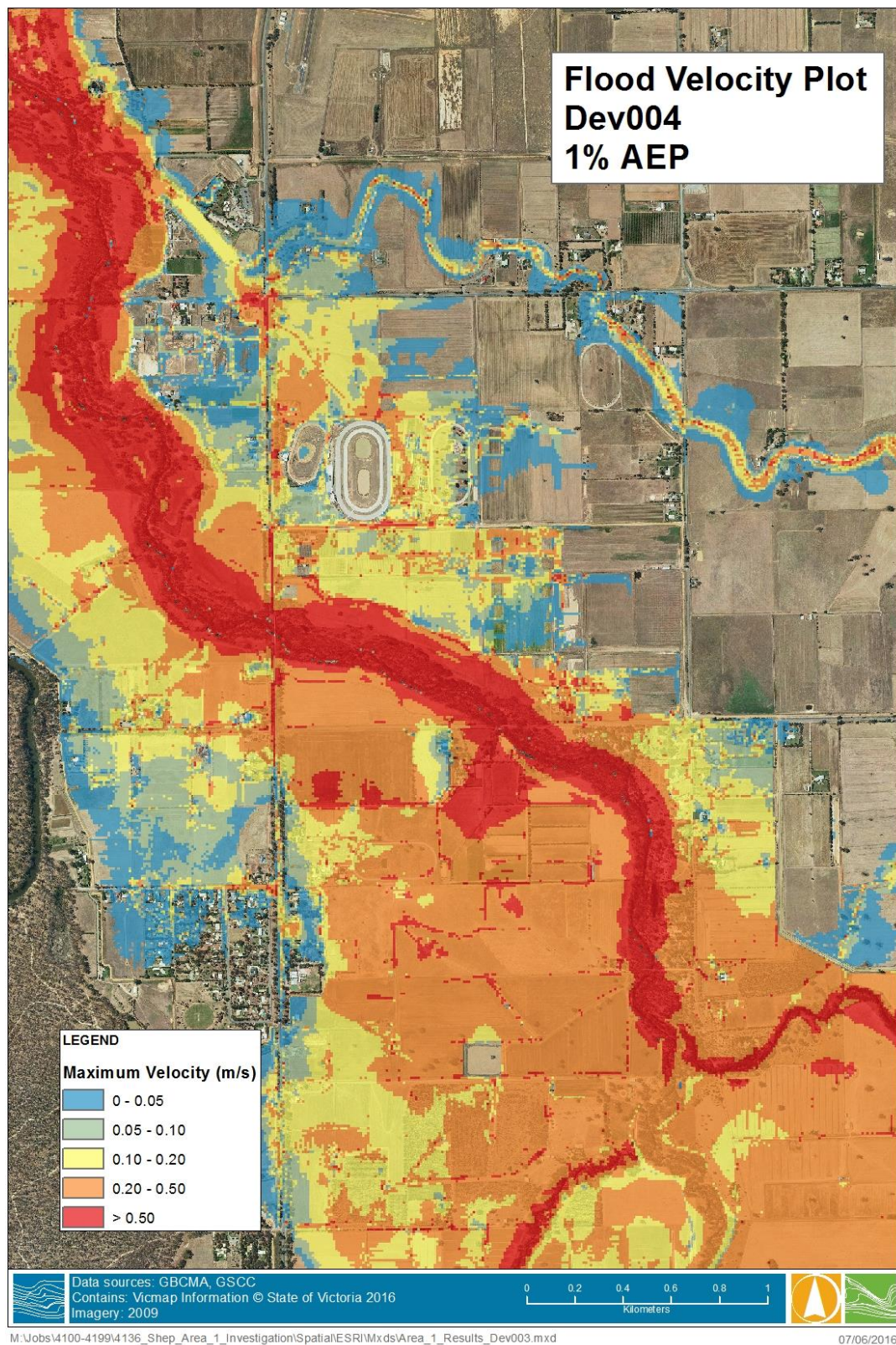


Figure 3-14 Development Scenario 4 Maximum Velocity Plot

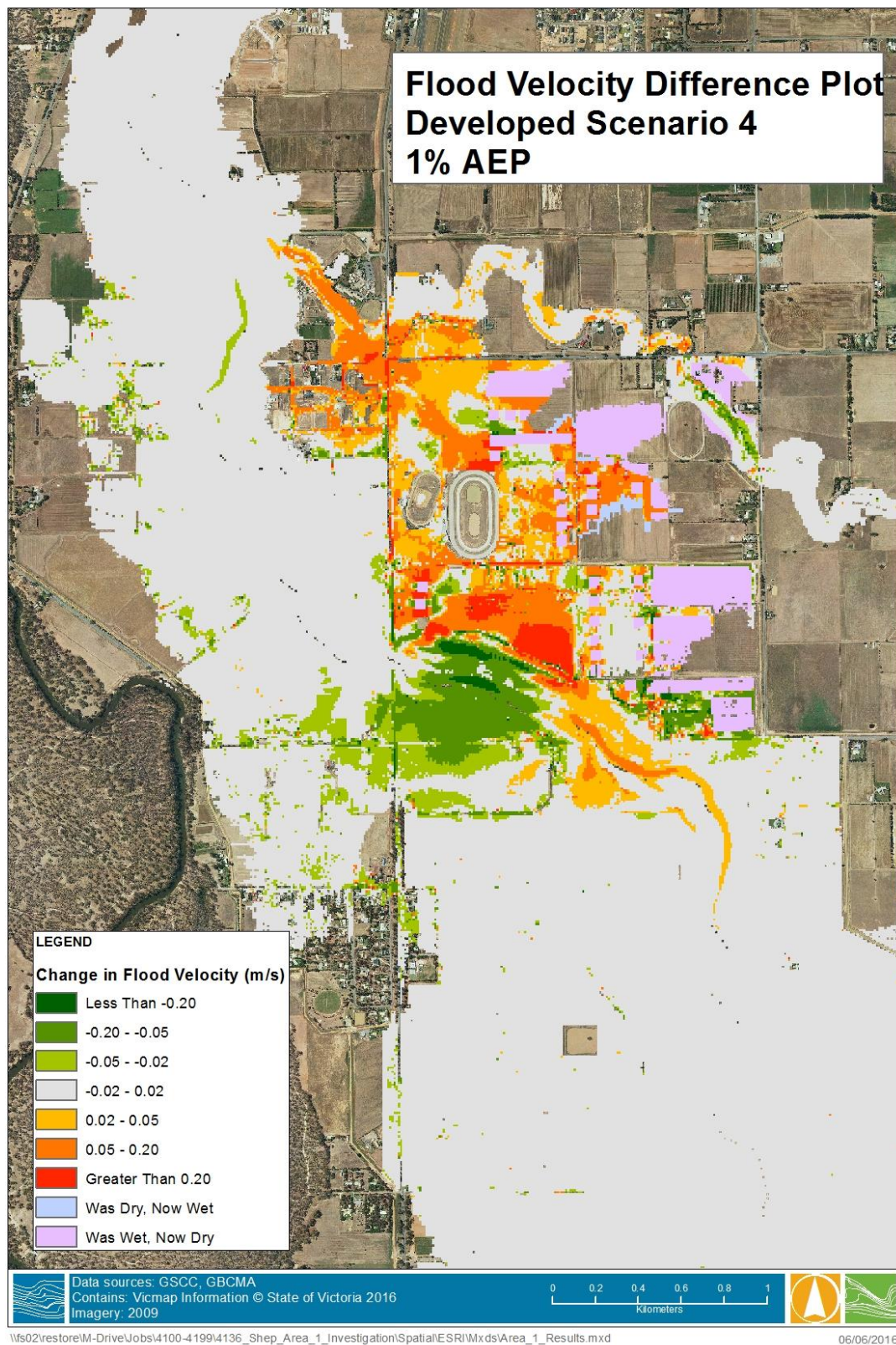


Figure 3-15 Development Scenario 4 - Flood Velocity Difference Plot

3.5 Land Development

The final developed Scenario (developed scenario 4) was chosen as the preferred development layout. This layout appears to meet the Goulburn Broken CMA requirements for no increase in water levels outside Investigation Area 1, this is shown in Figure 3-16.

The floodplain storage lost in the final development layout totalled 152,000 m³. This was offset through the inclusion of three floodplain storage basins across the site, providing an additional 248,000 m³ of compensatory floodplain storage. This meets the Goulburn Broken CMA requirements of replacing 130% of floodplain storage lost due to development fill.

It is important to note that the largest floodplain storage is located where the APA pipeline currently sits. This is a passive form of flood mitigation and can be accommodated by achieving deeper cut to the basin where the pipeline is not located. Furthermore, the two remaining basins could be modified to accommodate the required floodplain storage should earthworks along the pipe alignment not be suitable.

Safe egress throughout the site appears to be achievable with access to the four roads surrounding the site.

The G-MW backbone channel running east-west through the centre of the site plays an important hydraulic control under existing conditions. The channel restricts the amount of water travelling north from Seven Creeks across the north of the Investigation Area. Given the current status of the channel as being a 'backbone' channel, it is not scheduled for decommissioning in the near future. Any development within Investigation Area 1 would be required to accommodate the existing channel and ensuring the current crest levels are not reduced.

Preliminary investigations into raising the channel crest level and formalising it into a flood protection levee were undertaken. Discussions with Greater Shepparton City Council and Goulburn Broken CMA suggested that under the current planning environment, levees were not encouraged as a way to develop greenfield areas and are often only used as a way to protect legacy development in flood prone areas.

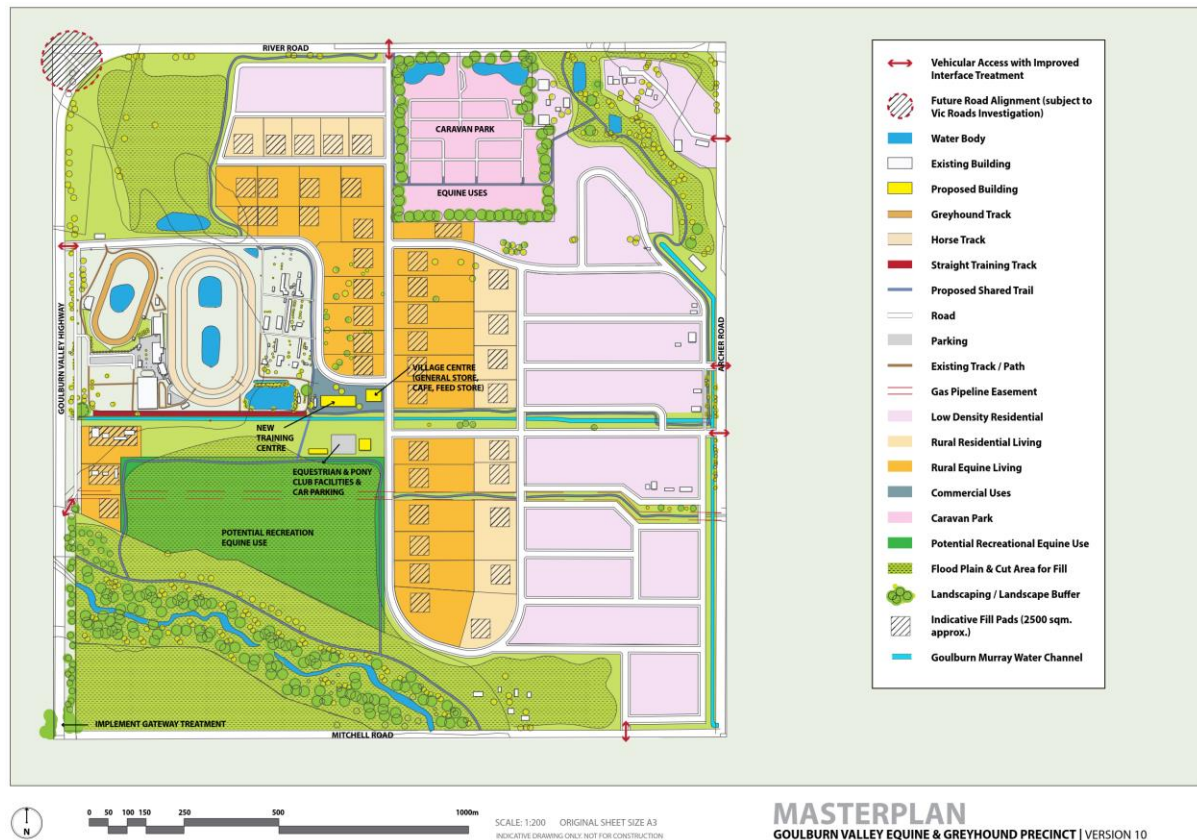


Figure 3-16 Proposed Development Plan (Urban Enterprise)

3.6 Planning Framework

Based on the flood modelling undertaken for the ongoing Shepparton-Mooroopna Flood Mapping and Intelligence Study and Investigation Area 1, one of the recommendations expected to be in the final report will be updating the flood controls in the planning scheme to reflect the most recent flood modelling. Water Technology has prepared an example layout of the expected recommended LSIO and FO for Investigation Area 1 under the final masterplan development layout shown in Figure 3-16. This is based on the Australian Rainfall and Runoff (ARR) guidelines explained below. This map is an example only and does not take into account the frequency at which the area becomes inundated as the previous control criteria did. This overlay example does not include any reference to the Urban Floodway Zone (UFZ) which has not been assessed as part of the ARR guidelines and is used as an example of potential use of flood controls in the planning scheme.

The Victoria Planning Provisions (VPPs) contain a number of controls that can be employed to provide guidance for the use and development of land that is affected by inundation from floodwaters. These controls include the Floodway Overlay (FO), the Land Subject to Inundation Overlay (LSIO), the Special Building Overlay (SBO), the Urban Floodway Zone (UFZ) and the Environmental Significance Overlay (ESO).

Section 6(e) of the Planning and Environment Act 1987 enables planning schemes to 'regulate or prohibit any use or development in hazardous areas, or likely to be hazardous'. As a result, planning schemes contain State planning policy for floodplain management requiring, among other things, that flood risk be considered in the preparation of planning schemes and in land use decisions.

Guidance for applying flood controls to Planning Schemes is available from the Department of Environment, Land, Water and Planning (DELWP) Practice Note on Applying Flood Controls in Planning Schemes.

Planning Schemes can be viewed online at <http://planningschemes.dpcd.vic.gov.au/home>. At the completion of the Shepparton-Mooroopna Flood Mapping and Intelligence project, it is recommended that the planning scheme for Greater Shepparton be amended to reflect the flood risk identified by the most recent flood mapping.

The method used to delineate the proposed FO is broadly based on the new Australian Rainfall and Runoff Project 10 'Appropriate Safety Criteria for People'. Criterion for delineating the FO considers both vehicle and people safety, and are as follows, based on the 1% AEP flood:

- Depth > 0.3 m
- Velocity > 1.5 m/s
- Depth x velocity > 0.3 m²/s.

The Goulburn Broken CMA may approve development guidelines which adopt a depth threshold of 0.30 m for safety requirements, and as such the example FO has been defined using the above criteria. This is currently under consideration and may change. Previously a threshold of 0.5 m was adopted across the floodplain management industry, but based on new research the industry is moving towards the lower depth threshold.

The LSIO includes the area outside of FO and bounded by the 1% AEP flood extent. The example overlay plot is shown in Figure 3-17.

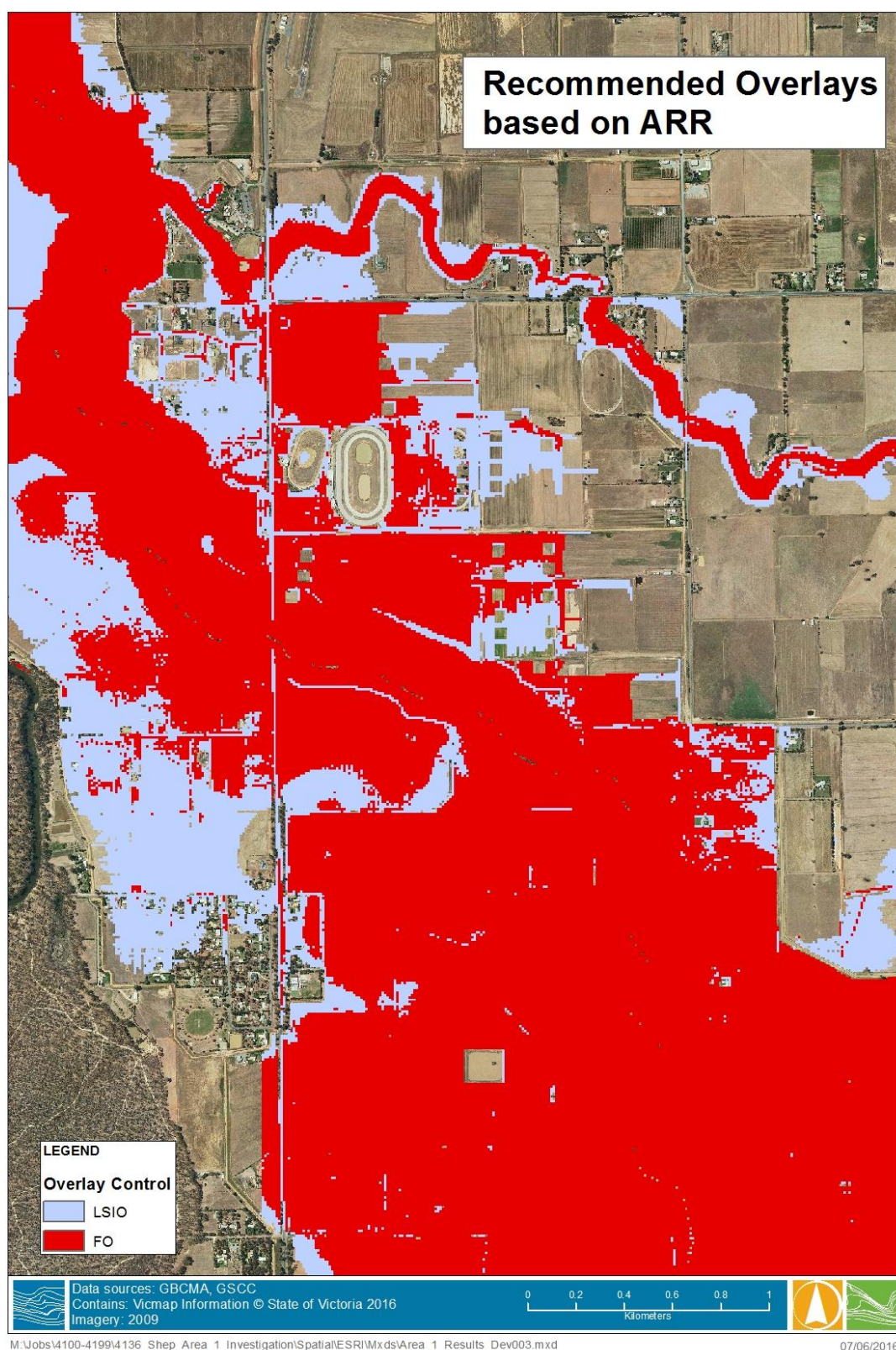


Figure 3-17 Example Overlays based on ARR guidelines

*Please note Figure 3-17 does not include delineation of UFZ and is an example of the LSIO and FO delineation based on ARR guidelines

3.7 Potential Flood Risk with Future Development

The model of flood behaviour developed by Water Technology has shown that areas within Investigation Area 1 may be suitable for residential development, largely on the eastern side of the site fronting onto Archer Road. The model of flood behaviour also showed that several areas within the original masterplan were not suitable for the level of development outlined. The existing G-MW backbone channel running through the site was shown to be an important hydraulic control and changes to crest levels are likely to have a negative impact on properties downstream of the channel.

3.7.1 Flood Warning Time

Investigation Area 1 has considerable flood warning time from a Seven Creeks flood. There are currently streamflow gauges on Seven Creeks at Kialla West, Euroa, and further upstream at Polly McQuinn Weir. These gauges provide a good indication of expected peak flooding as well as estimated flood levels at Kialla West.

Flood peak travel times from the gauge upstream of Euroa to Kialla West is estimated at 24-48 hours based on historical floods including 1993, 1995 and 2010.

3.7.2 Site Egress

Currently three of the four roads surrounding the site provide unimpeded site egress, in that flood depths in a 1% AEP event do not exceed 0.30 m. Mitchell Road to the south of the investigation does not provide safe egress to and from the Investigation Area. The Goulburn Valley Highway is overtopped in a 1% AEP flood event but at depths less than 0.30 m. River Road and Archer Road also provide safe egress to and from the Investigation Area. Access to the Goulburn Valley Highway during a flood event would be via Archer Road heading North and onto River Road. Access of Archer Road in a southerly direction towards Mitchell Road is not possible as flood depths are greater than 0.30 m.

Internal roadways were not modelled in the final development layout as raised roadways at this conceptual stage of the project. The results showed two minor areas on the roadways which would require raising to ensure safe egress for several RLZ and 'equine living' properties. This fill is likely to be minor in terms of the overall project and have minimal difference to the flood behaviour of the final development layout assuming appropriate culverts are incorporated into the design. Further investigation of the flood behaviour at a detailed design level which utilises final road levels would be required to show safe egress to all properties within the Investigation Area.

3.7.3 Flood Conveyance and Storage

Flood conveyance across the site was maintained by locating fill sites in areas with the least impact on the main flow paths across the site.

Floodplain storage across the site was reduced through an increase in the fill levels at the areas identified within the masterplan layout as LDRZ, the fill pads of 'equine living' and RLZ as well as the caravan park in the north of the site. A total volume of 152,304 m³ of floodplain storage was removed through the raising of fill pads above the 1% AEP flood level.

A net balance of flood storage is achieved easily across the site with the inclusion of three floodplain storage basins. Goulburn Broken CMA guidelines suggest that 130% of compensatory storage needs to be replaced for any floodplain development fill. This has been achieved and is shown in Table 3-1. The floodplain storage added to the Investigation Area is around 50,000 m³ more than the Goulburn Broken CMA required value of 130%. The average cut depth of the three floodplain storage basins could be reduced provided they provide at least 198,000 m³ of floodplain storage.

Table 3-1 Floodplain Storage Summary

| Area | Floodplain Storage Reduced (m ³) | Floodplain Storage Added (m ³) |
|------------------------------|--|--|
| Low Density Residential Zone | 109,650 | 0 |
| Rural Equine Living | 25,567 | 0 |
| Rural Living Zone | 9,329 | 0 |
| Caravan Park | 7,758 | 0 |
| Basin 1 | 0 | 154,420 |
| Basin 2 | 0 | 30,756 |
| Basin 3 | 0 | 63,235 |
| Total | 152,304 | 248,411 |

3.7.4 Earthworks

The total earth works differ from the floodplain storage summary provided above. These earthworks are based on the final development layout. The LDRZ properties, the caravan park and the 2,500 m² fill pads of RLZ and 'equine living' are raised above the 1% AEP flood level. These are summarised in Table 3-2 and have been separated into the three main zonings, the caravan park and the three floodplain storage basins. This shows a net balance of around 28,233 m³ of additional fill required to meet the final masterplan development layout. Roadways were not modelled as raised from the existing topography and were not included in this calculation as final road levels were not set at this conceptual stage of the project. It would also be assumed that the suitable fill material required for the roadways would be sourced offsite.

Table 3-2 Earthworks Summary

| Area | Total Cut (m ³) | Total Fill (m ³) |
|------------------------------|-----------------------------|------------------------------|
| Low Density Residential Zone | 0 | 185,466 |
| Equine Living | 0 | 38,090 |
| Rural Living Zone | 0 | 14,647 |
| Caravan Park | 0 | 38,241 |
| Basin 1 | 154,420 | 0 |
| Basin 2 | 30,756 | 0 |
| Basin 3 | 63,235 | 0 |
| Total | 248,411 | 276,644 |

4. CONCLUSION

Based on the information provided by Greater Shepparton City Council, the final development layout appears to meet the requirements of the Goulburn Broken CMA in regards to floodplain management principles and performance criteria. Should development occur, the fill pad areas identified within the final development layout should be raised above the 1% AEP flood level.

Further detailed design may modify the layout of a development and therefore cause a change to flood levels and floodplain storage volumes quoted within this report. Further investigation of the flood behaviour should be addressed at detailed design stage of the development.