Mordialloc Bypass Project

Report of Rob Leslie

1 Introduction

My firm WSP prepared the impact assessment report titled Mordialloc Bypass – Surface Water Impact Assessment (Report) which is included as Appendix J to the Environment Effects Statement (EES) for the Mordialloc Bypass Project (Project).

The role that I had in preparing the Report was Principal Civil Engineer and Technical Reviewer. Other significant contributors to the Report and their expertise is set out as follows:

- Steve Horne – Associate Civil Engineer and Technical Lead for the flooding and drainage assessments;
- Eric Lam – Principal Hydrologist and Technical Lead for flow and water quality assessments;
- Zaki Matar – Hydrologist and Flood Modeller; and
- Michelle Gribler – Drainage and Water Quality Engineer.

I adopt the Report, in combination with this document, as my written expert evidence for the purposes of the Mordialloc Bypass Project Inquiry and Advisory Committee’s consideration and reporting in respect of the Project.

2 Qualifications and experience

Appendix A contains a statement setting out my qualifications and experience, and the other matters in accordance with Planning Panels Victoria's 'Guide to Expert Evidence'.

A copy of my curriculum vitae is provided in Appendix B.

3 Further work since preparation of the Report

Since the Report was finalised, the following further work has been undertaken:

- Supplementary analysis and preparation of a memo report undertaken by Steve Horne and Zaki Matar and reviewed by myself to assess the impacts of the Project under an appropriate climate change scenario. This memo report is provided in Appendix C.
- Qualitative assessment of the effects of the alternative Lower Dandenong Road / Mordialloc Bypass Freeway interchange on flooding and surface water quality. This assessment is provided in Appendix D.

4 Written Submissions

4.1 Submissions Received

I have read the public submissions in respect of the EES and draft Planning Scheme Amendment for the Project and identified those that are relevant to the Report and my area of expertise. These include the following submissions:

- 39: Private individual
4.2 Summary of Issues Raised

The submissions have raised the following issues relevant to my area of expertise:

- Flooding impacts on private properties.
- Adequacy of road drainage design.
- Contamination of wetlands/waterways from runoff from works area during construction.
- Contamination of wetlands/waterways from runoff from road pavement after construction.
- Flooding impacts of temporary works during construction.
- Flooding and drainage impacts under climate change.

4.3 Response to Issues Raised

Set out below are my comments and response to the issues raised by the written submissions relevant to my area of expertise.

4.3.1 Submission number 39: Private individual, concerned with flooding impact at private property

The drainage channel mentioned in the submission is known as the Bowen Road D.S. channel (part of the active Melbourne Water Bowen Road Drainage Scheme). The Land Subject to Inundation Overlay (LSIO) and properties in question are shown in Figure E-1 in Appendix E.

The sizing of culvert K1 has been determined based on the flood model and advice from Melbourne Water. The culvert has been designed to convey higher flow rates that will occur in the future when the catchment is more intensively developed under the ‘ultimate development’ condition (irrespective of this project). Culvert K1 provides more flow capacity than the existing channel that it replaces and therefore caused the increase in flood levels in the channel downstream when compared to existing conditions. However, this is a consequence of the culvert providing capacity for the future increased flow scenario and it is assumed that the channel has been designed to accommodate this increased flood level and future higher flood levels that will occur under the ultimate development condition.

The project will cause an increase in flood level of 0.055 m at most at this location for the 1% AEP event – refer to Map 4 in Appendix C-3 of the Report (also reproduced in Figure E-2 in Appendix E of this report). Under existing conditions, the flow depth occurring within the channel is between 0.5 and 1.0 m for the 1% AEP event – refer to Map 4 in Appendix C-2 of the Report (also reproduced in Figure E-3 in
Appendix E of this report). The project will cause an increase in flood depth of approximately 6 to 11%. This depth increase does not materially increase the risk of drowning within the channel.

The issue has been discussed with Melbourne Water during preparation of the EES and following submission of the EES and it has been agreed that further investigation of the issue will be undertaken at detailed design.

4.3.2 Submission number 47: Representative of Waterways Concerned Residents, concerned with adequacy of proposed road drainage

The drainage design has been based on achieving minimal change to the existing flooding and drainage processes and to meet Melbourne Water’s flood impact criteria. The transverse drainage system and associated flood impact mitigation measures (in the form of compensatory flood storage provided within the project boundary) have been designed to minimise changes to the existing flooding and drainage regime.

The impact assessment demonstrates that the project drainage infrastructure and flood mitigation measures successfully prevent flooding impacts at the Waterways Estate – refer to Map 4 in Appendix C-3 of the Report (also reproduced in Figure E-2 in Appendix E of this report).

4.3.3 Submission number 69: Private individual, concerned with impacts on wetland water quality

During construction the project will mitigate potential impacts on water quality in the adjacent waterways and wetlands though the following measures (refer also to Sections 7.4.3.2 and 7.4.4 of the Report):

- A Construction Environmental Management Plan to be approved by EPA Victoria and implemented prior to construction that will require application of best practice sedimentation and pollution control measures in accordance with EPA Victoria publication 480 _Environmental Guidelines for Major Construction Sites_ and EPA publication 275 _Construction techniques for sediment pollution control_.

- A water collection and treatment system to be designed and approved by Melbourne Water prior to construction that will require stormwater discharges comply with the _State Environment Protection Policy (Waters of Victoria) 2004_ (and subsequent updated policy _State Environment Protection Policy (Waters) 2018_) and Melbourne Water performance criteria.

For the operational phase, the drainage system has incorporated a range of stormwater quality management measures to treat runoff from the road corridor and protect the adjacent waterways and wetlands from pollution (refer also to Section 7.4.2 of the Report). These measures include the following:

- Vegetated swales to treat runoff from the road corridor.

- In addition to the swales, provision of additional bio-retention systems at road drainage outfalls into Edithvale, Waterways and Woodlands Industrial Estate Wetlands.

- Additional capacity within swales provided at areas where there is a moderate risk of oil and fuel spill occurring.

- Specific separate spill containment systems provided at areas where there is a high risk of oil and fuel spill occurring.

- All measures to be designed to comply with _VicRoads Integrated Water Management Guidelines (2013)_ and _CSIRO Best Practice Environmental Management Guidelines for Urban Stormwater (1999)_.

During construction and in operation, the project’s impacts on waterway and wetland health will be monitored and any observed water quality impacts will be addressed through the following processes:
Periodic inspection and maintenance of all stormwater quality management measures by the asset owner (VicRoads).

Preparation of a Water Management and Monitoring Plan (WMMP) in consultation with EPA Victoria and relevant water authorities, which will be implemented prior to construction, during construction and for five years into operation. The WMMP must incorporate both surface and groundwater monitoring. Incorporating the baseline data collected to date, the WMMP must include:

- Detail of the monitoring parameters, including the frequency and location of surface water monitoring points and groundwater monitoring bores.
- Specific trigger levels (water quality in surface water bodies and groundwater bores) and details of contingency plans in the case trigger levels are exceeded.
- Detailed reporting requirements.
- Roles and responsibilities, not limited to:
  - The owner of the monitoring network assets (which will be MRPV during construction and VicRoads during operation).
  - The manager of the monitoring network assets and results (MRPV during construction and VicRoads during operation).
  - The party (or parties) undertaking monitoring (prior to construction, during construction and for the first five years of operation) (contractors working on behalf of the Principal Contractor and MRPV).

4.3.4 Submission number 78: Melbourne Water, concerned with climate change impacts and construction phase impacts on water quality

The following responses address the key issues raised in the submission:

- The climate change scenario flooding impacts can be mitigated at (1) south of Centre Dandenong Road and (2) north of Lower Dandenong Road through design refinements such as adjusting earthworks and/or pipe sizes and these measures will be investigated at the detailed design stage. For location (3) Braeside, the impacts to private properties only occur in the most conservative joint probability scenario considered. Lowering the vertical alignment to provide an overtopping pathway during extreme events could reduce this impact to some extent and would provide the best outcome of the mitigation measures tested (see Appendix C for further details). This measure also requires further investigation at the detailed design stage.

- As noted in Table 8.1 of the Report, during construction, the requirements of the guideline Melbourne Water standards for infrastructure in flood prone areas must be complied with. Measures must be implemented to the satisfaction of Melbourne Water and in consultation with any other relevant drainage authority, to ensure that temporary construction activities do not increase flood risks (including flood levels, flows and velocities) to the surrounding areas. A flood management plan must be developed in consultation with and not objected by Melbourne Water for any temporary works.

- During construction the project will mitigate potential impacts on water quality in the adjacent waterways and wetlands though the following measures (refer also to Sections 7.4.3.2 and 7.4.4 of the Report):
  - A Construction Environmental Management Plan to be approved by EPA Victoria and implemented prior to construction that will require application of best practice
sedimentation and pollution control measures in accordance with EPA Victoria publication 480 *Environmental Guidelines for Major Construction Sites* and EPA publication 275 *Construction techniques for sediment pollution control*.

- A water collection and treatment system to be designed and approved by Melbourne Water prior to construction that will require stormwater discharges comply with the *State Environment Protection Policy (Waters of Victoria) 2004* (and subsequent updated policy *State Environment Protection Policy (Waters) 2018*) and Melbourne Water performance criteria.

4.3.5 Submission number 83: City of Kingston, concerned with impacts on floodplain processes and downstream drainage systems

Responses to the key points made in the submission are as follows:

- **Floodplain capacity:** The design incorporates a combination of swale and depression basin storages to compensate for the loss of floodplain storage due to the new road embankments. The project changes flood levels to some extent in the vicinity but the EES flood impact assessment and flood mapping demonstrates that there are no adverse impacts on private properties. Up to 50mm of afflux occurs over an extensive area of Braeside Park. This impact occurs mainly within existing wetlands and drains with less extensive areas of footpath and open parkland affected. Parks Victoria and Melbourne Water have been consulted on this outcome and Melbourne Water has indicated that the impact is considered to be acceptable on the basis that the impact does not materially change the flood hazard category or the use of the land.

- **Stormwater flows:** Since inception, the project was required by Melbourne Water to (a) not increase the risk of flooding to people and property as a result of the project and (b) to address flood risk at both local and regional scales. The flood impact assessment has been guided by these requirements. The flood model captures the increase in hard surfaces resulting from the project and the subsequent effect this has across the surface water catchment. The modelling and impact assessment has also assessed the upstream and downstream effects on stormwater flows and flood levels. In addition, an assessment of impacts on local drainage systems (both major and minor) has been undertaken for each outfall of the proposed road drainage system and detention systems to mitigate local impacts have been incorporated into the design – refer to Section 7.1.3 of the Report.

- **Downstream drainage system capacity:** The flood model includes a representation of the downstream drainage systems and the EES has assessed the impacts of the project on the downstream drainage and floodplain systems and the change in flows and water levels that these systems will experience. The impacts were assessed against Melbourne Water’s guideline *Melbourne Water standards for infrastructure projects in flood-prone areas*. EPR W6 in Table 8.1 of the Report also commits to mitigating adverse impacts on the adjacent drainage networks and states the following: “The volume, peak flow and quality of surface water discharges during operation must have no adverse impact to the drainage network capacities in consultation with Melbourne Water, Kingston City Council and Greater Dandenong City Council, as appropriate”.

- **Cumulative effects with other planned developments in the catchment:** The project has assumed that Melbourne Water will typically impose conditions on development that would require downstream impacts to be mitigated. Future development would therefore be required to implement stormwater and flood management controls to avoid downstream impacts and to meet the same flood impact criteria set by Melbourne Water that this project has adhered to. This is discussed in Section 7.3 of the Report.
4.3.6 Submission number 84: Defenders of the South East Green Wedge, concerned with flow and water quality impacts on wetlands

Responses to the key points made in the submission are as follows:

- The EES has assessed changes to the normal flow and flooding regimes within the wetlands and impacts on the wetlands due to discharge of runoff from the new road corridor into the wetlands and connected waterways. The assessment demonstrates that the project will not adversely affect the volume of water draining to the wetlands and the wetland water level regimes. The project has also incorporated a number of design features to manage the quality of stormwater discharged from the new road corridor to the receiving waterways and wetlands.

- The project drainage system has incorporated a range of stormwater quality management measures to treat runoff from the road corridor and protect the adjacent waterways and wetlands from pollution. These measures include the following:
  - Vegetated swales to treat runoff from the road corridor.
  - In addition to the swales, provision of additional bio-retention systems at road drainage outfalls into Edithvale, Waterways and Woodlands Industrial Estate Wetlands.
  - Additional capacity within swales provided at areas where there is a moderate risk of oil and fuel spill occurring.
  - Specific separate spill containment systems provided at areas where there is a high risk of oil and fuel spill occurring.

4.3.7 Submission number 89: Private business and land owner, concerned with flood impacts to land ownership

The business owner commissioned Engeny Water Management to review the EES flooding assessment findings and undertake an assessment of the potential impacts on the land in light of recent topographic changes made by the owner that are not reflected in the 2008 LiDAR data used to construct the flood model. The responses to issues raised in the submission are as follows:

- Based on the 2008 LiDAR topographic data for this area, the EES flood model predicts no adverse impact on flood levels at the property (and upstream of the property south of Centre Dandenong Road interchange), and predicts a reduction in the 1% AEP flood level at the property – refer to Map 1 in Appendix C-3 of the Report (also reproduced in Figure E-4 in Appendix E of this report). Incorporation of the updated topography within the flood model is unlikely to change this outcome as the Engeny investigation indicates that topographic changes on the property do not affect the flood behaviour upstream and immediately downstream of the project area, and also the EES shows that the project will reduce flood levels on the property.

- The Engeny flood investigation shows that the true existing case 1% AEP flood level upstream of the property close to the project boundary is potentially up to 0.5m higher than predicted by the EES flood model. This revised flood level is unlikely to affect the project infrastructure or change the EES predictions of flood impacts in the land adjacent to the project but this should be confirmed at the detailed design stage by updating the EES flood model to incorporate the changed topography at the property.

4.3.8 Submission number 92: Friends of Mordialloc Catchment, concerned with maintenance of flows and water quality in receiving catchments

The submission raises concerns regarding maintenance of water flows and water quality for the ongoing health of local waterways. The Report demonstrates that water flows and water quality are maintained through the following measures:
Protection of water flows through provision of drainage infrastructure to avoid diversion of sub-catchments and to maintain existing flow regimes (refer also to Section 7.1.1.2 of the Report).

Protection of water quality through the following stormwater quality management measures to treat runoff from the road corridor and protect the adjacent waterways and wetlands from pollution (refer also to Section 7.4.2 of the Report):

- Vegetated swales to treat runoff from the road corridor.
- In addition to the swales, provision of additional bio-retention systems at road drainage outfalls into Edithvale, Waterways and Woodlands Industrial Estate Wetlands.
- Additional capacity within swales provided at areas where there is a moderate risk of oil and fuel spill occurring.
- Specific separate spill containment systems provided at areas where there is a high risk of oil and fuel spill occurring.

4.3.9 Submission number 98: EPA Victoria, concerned with management of water quality impacts during and post construction

The following responses address the key issues raised in the submission:

- Need to manage potential water quality impacts during and post construction:
  - During construction the project will mitigate potential impacts on water quality in the adjacent waterways and wetlands though the following measures (refer also to Sections 7.4.3.2 and 7.4.4 of the Report):
    - A Construction Environmental Management Plan to be approved by EPA Victoria and implemented prior to construction that will require application of best practice sedimentation and pollution control measures in accordance with EPA Victoria publication 480 Environmental Guidelines for Major Construction Sites and EPA publication 275 Construction techniques for sediment pollution control.
    - A water collection and treatment system to be designed and approved by Melbourne Water prior to construction that will require stormwater discharges comply with the State Environment Protection Policy (Waters of Victoria) 2004 (and subsequent updated policy State Environment Protection Policy (Waters) 2018) and Melbourne Water performance criteria.
  - For the operational phase, the drainage system has incorporated a range of stormwater quality management measures to treat runoff from the road corridor and protect the adjacent waterways and wetlands from pollution (refer also to Section 7.4.2 of the Report). These measures include the following:
    - Vegetated swales to treat runoff from the road corridor.
In addition to the swales, provision of additional bio-retention systems at road drainage outfalls into Edithvale, Waterways and Woodlands Industrial Estate Wetlands.

- Additional capacity within swales provided at areas where there is a moderate risk of oil and fuel spill occurring.
- Specific separate spill containment systems provided at areas where there is a high risk of oil and fuel spill occurring.

- Need to establish a surface water monitoring plan and program in consultation with EPA Victoria:
  - Refer to response to submission 78 above (Section 4.3.4) which sets out the requirements of the WMMP.

The EPA submission notes that EPR W1 refers to the SEPP (Waters of Victoria) 2004 which has now been replaced by SEPP (Waters) 2018. To address this recent change, I recommend that this EPR be reworded to reflect the latest 2018 policy.

The submission notes that the CSIRO Best Practice Environmental Management Guidelines for Urban Stormwater (1999) is under review. Although the document is under review, I am not aware of any changes to the guidelines or related policies and the current references in the EPRs to the guideline are appropriate.

The submission also mentions that the EPRs could also refer to the Australian Rainfall and Runoff and Australian Runoff Quality guidelines. I believe that the more specific State and technical guidelines referred to by the EPRs are sufficient and account for the guiding principles and objectives set out in the Australian guidelines.

**Declaration**

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Inquiry and Advisory Committee.

[Signature]

Signed

Date: 15/02/2019
Appendix A   Matters Raised by PPV's Guide to Expert Evidence

(a) The name and address of the expert

Rob Leslie, Principal Civil Engineer, WSP, Level 27, World Square, 680 George Street, Sydney, NSW 2000

(b) The expert's qualifications and experience

Bachelor’s degree in Civil and Environmental Engineering, Master of Science in Civil and Environmental Engineering (both from Trinity College Dublin, Ireland), Chartered Civil Engineer with Engineers Ireland, 22 years of experience as a consulting civil engineer in the field of hydrology, flooding and stormwater management.

(c) A statement identifying the expert's area of expertise to make the report

I have 22 years of experience as a consulting engineer working on studies, analyses and design projects relating to hydrological and hydraulic modelling, flood risk management, stormwater management and drainage design.

(d) A statement identifying any other significant contributors to the report and where necessary outlining their expertise

No other significant contributors.

(e) All instructions that define the scope of the report (original and supplementary and whether in writing or oral)

Instructions included written instructions in emails from Clayton Utz dated 11/12/18, 18/12/18, 19/12/18 and 18/01/19 and oral instructions received during face to face meeting with Clayton Utz on 22/11/18.

(f) The identity of the person who carried out any tests or experiments upon which the expert has relied on and the qualifications of that person

Not applicable.

(g) A statement setting out any questions falling outside the expert's expertise

Not applicable.

(h) A statement setting out any key assumptions made in preparing the report

Key assumptions made in preparing this report are as noted in the Mordialloc Bypass Surface Water Impact Assessment (refer to various assumptions noted throughout Sections 4, 5 and 7 and Appendices B1 and B3 of the Report).

(i) A statement indicating whether the report is incomplete or inaccurate in any respect

The report is complete and accurate in all respects.
ROB LESLIE
Principal Engineer & Water Resources Section Executive

PROFILE
Rob is a Chartered Civil Engineer with 20 years’ experience in the water sector, covering river management and engineering, stormwater and flood risk management and design, hydrological and hydrodynamic modelling, water supply engineering and water quality modelling. Rob has gained experience in Ireland, the UK and Australia, with his most recent experience in Australia focussed on surface water management and stormwater design in the Transportation and Mining Sectors.

Rob is the Section Executive for WSP’s Water Resources Team which consists of over 20 consultants in the fields of hydrology, hydrogeology, surface water engineering and environmental science, and coordinates all project work and business development activities undertaken by the team.

EDUCATION
Trinity College Dublin, Ireland: MSc Civil Engineering 1996
Trinity College Dublin, Ireland: Bachelor of Civil & Environmental Engineering (Hons) 1994

PROFESSIONAL ASSOCIATIONS
Chartered Civil Engineer with Engineers Ireland
Work Cover General Induction for Construction Work in NSW (Green Card)
Rail Industry Safety Induction (RISI Card)

PROFESSIONAL EXPERIENCE
Flooding, stormwater and surface water management – design
--- Inland Rail Narrabri to North Star Detailed Design, NSW, Australia (2017 to present); ARTC, Hydrology & Drainage Lead.
  Responsible for delivery of flooding analyses, cross drainage detailed design and longitudinal drainage detailed design for 100km upgrade of the Inland Rail network between Narrabri and North Star.
--- Inland Rail Parkes to Narromine Detailed Design, NSW, Australia (2017 to present); ARTC, Hydrology & Drainage Lead.
  Responsible for delivery of flooding analyses, cross drainage detailed design and longitudinal drainage detailed design for 100km upgrade of the Inland Rail network between Parkes and Narromine.
--- Pacific Complete (Woolgoolga to Ballina Pacific Highway Upgrade), NSW, Australia (2016); Roads & Maritime Services, Flooding and drainage coordinator.
  Responsible for direction of regional flood modelling and coordination and technical review of drainage designs by detailed design consortia.
--- Newcastle Light Rail Concept Design, Newcastle, NSW, Australia (2016); Transport for NSW, Flooding and drainage technical lead.
  Responsible for flood risk assessment and development of concepts for flood risk mitigation, light rail corridor drainage and road corridor drainage modifications.
--- Capital Metro (Canberra Light Rail Project) Tender Design, Canberra, ACT, Australia (2015); Downer, Team leader for drainage and hydrology.

LANGUAGES
English
Responsible for delivery of tender design of track and road drainage, stormwater quantity and quality management systems and flooding impact assessments and mitigation measures.

- **WestConnex Stage 2 New M5 Tender Design, Sydney, NSW, Australia (2015);**
  Lend Lease Acciona, Team leader for drainage and hydrology.
  Responsible for delivery of tender design of transverse and pavement drainage, water quality management systems and flooding impact assessments.

- **WestConnex Stage 1b M4 East Tender Design, Sydney, NSW, Australia (2014);**
  Lend Lease, Team leader for drainage and hydrology.
  Responsible for delivery of tender design of transverse and pavement drainage, water quality management systems and flooding impact assessments.

- **WestConnex Stage 1a M4 Widening Tender Design, Sydney, NSW, Australia (2014);**
  Lend Lease, Team leader for drainage and hydrology.
  Responsible for delivery of tender design of transverse and pavement drainage, vegetated swales and spill basins, flood modelling and bridge and viaduct scour protection design.

- **Pacific Highway Upgrade Tender Design, Warrell Creek to Nambucca, NSW, Australia (2013):**
  Lend Lease, Team leader for drainage and hydrology.
  Responsible for delivery of tender design of transverse and pavement drainage, sedimentation and runoff treatment basins, flood modelling and impact assessment and bridge scour protection design.

- **Leppington Precinct Flooding Assessment, Riparian Corridor Study & Water Cycle Management Strategy, NSW, Australia (2013):**
  Department of Planning & Infrastructure, Project Manager.
  Responsible for a flooding assessment, riparian corridor study and an integrated water cycle management strategy for the Leppington Precinct. The project involved flood modelling and flood risk mapping, definition and mapping of stream orders and riparian corridors, assessment of existing vegetation communities, geomorphological assessment of streams and development of an integrated water cycle management strategy for the future precinct to inform the Precinct Masterplan.

- **Pacific Highway Upgrade Detailed Design, Lisarow to Ourimbah, NSW, Australia (2012/2013):**
  Roads and Maritime Services, Technical reviewer.
  Hydrology and Drainage discipline, which involves hydrologic and hydraulic analysis, flood modelling, scour assessment and detailed drainage design for 1.7 km section of Pacific Highway upgrade.

- **Strangers Creek Rehabilitation, Sydney, NSW, Australia (2013):**
  Sydney Water Corporation, Project director and technical reviewer.
  A 2km creek rehabilitation project in North West Sydney, the project involves design of creek channel capacity and stability improvements and requires management of a range of disciplines and elements, including: hydraulic modelling and flood risk assessment; civil design, landscape and ecological design; Review of Environmental Factors; geotechnical and contaminated land investigations; topographic and features survey and stakeholder engagement.

- **Sydney Light Rail Inner West Extension Tender Design, Sydney, NSW, Australia (2011–2012):**
  Leighton Contractors, Design lead.
  Design lead for station and stabling facilities drainage, flood impact assessment and discharge risk assessment.
Technical reviewer for longitudinal drainage design for 10km of new highway construction.

Coordinator of flooding assessment and detailed design of the cross drainage for the rail corridor expansion and station upgrade at Glenfield, West Sydney. Responsible for review of design reports, drawings and approvals from water authorities for the drainage infrastructure. Also responsible for coordinating the flooding assessment to investigate impacts of the works on local flood processes and potential mitigation options.

Coopernook to Heron’s Creek Pacific Highway Upgrade, NSW, Australia (2010): Roads & Traffic Authority, Coordinator and technical reviewer.
Construction phase services to address landowner concerns with modified drainage patterns as a result of highway works through analysis and design of mitigation measures. Solutions included adaptation of water quality control systems to provide flow attenuation functions, improved erosion control systems and reinstatement of pre-development flow paths.

Flood risk assessment of proposed highway bypass. Analysis included hydrologic and hydraulic modelling of Ten Mile Creek and key overland flow paths and assessment of flood risk impacts on the proposed bypass and existing properties within Holbrook.

Victorian Desalination Project, Wonthaggi, Vic., Australia (2009-2010): Department of Sustainability & Environment, Coordinator.
Detailed design of the site-wide drainage package for the desalination plant site at Wonthaggi, VIC. Responsible for review of design reports, drawings and approvals from water authorities. The drainage includes pit and pipe systems, swales and Water Sensitive Urban Design (WSUD) elements including sedimentation and bio-retention systems to treat site runoff, an irrigation pond to recycle stormwater for irrigating the plant’s green roof and constructed wetlands to treat site runoff and create new floodplain habitat adjacent to the site.

Flooding and drainage assessment and reference design of flood mitigation measures for tunnel entry points on the Sydney West Metro alignment. The design involves consideration of flood risk to tunnel entry points from watercourses and local catchment runoff and identification of appropriate standards of protection and associated flood mitigation measures.

Concept design of cross drainage systems for a new / realigned access road downstream of a mine tailings dam in northern NSW. The design used hydrologic and hydraulic modelling to estimate discharge from the dam under a range of scenarios and to size the required cross drainage elements.
Flooding, stormwater and surface water management - environmental assessment

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Technical reviewer for the surface water assessment, which included flooding and drainage impact assessment; water quality and flow regime impact assessment, drainage and water quality management system concept design. Duties also included performing the role of Expert Witness for the Surface Water Assessment for the Project Panel Hearing.

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**Hume Coal Mine Project Environmental Assessment, Southern Highlands, NSW, Australia (2013–2018): Hume Coal, Project manager and technical lead for surface water assessment.**

Project manager and technical lead for the surface water assessment, which included flood impact assessment; mine surface water management and water balance modelling; water quality and downstream flow impact assessments.

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**Cobbora Coal Mine Project Environmental Assessment, Cobbora, NSW, Australia (2011–2013): Cobbora Holding Company, Technical reviewer.**

Flood impact assessment and project manager and technical coordinator for the overall surface water and groundwater assessments, which included flood impact assessment; mine surface water management and water balance modelling; water quality and downstream flow impact assessments; surface water licencing requirements; groundwater modelling; groundwater drawdown and groundwater use impact assessment; and groundwater licencing requirements.

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**Boggabri Coal Mine Environmental Assessment Modifications, Boggabri, NSW, Australia (2011–2012): Boggabri Coal, Project manager and technical coordinator.**

Surface water assessments for various modifications to the Part 3A Environmental Assessment, which included flood impact assessment; mine surface water management and water balance modelling; water quality and downstream flow impact assessments; and surface water licencing requirements.

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**Sydney Light Rail Extension - Stage 1: Lilyfield to Dulwich Hill Environmental Assessment, Sydney, NSW, Australia (2010): Transport Construction Authority, Coordinator and technical reviewer.**

Flooding and drainage constraints and impact assessments for a 5.6 km extension of the existing Sydney light rail from Lilyfield to Dulwich Hill. The project involves construction and operation of the light rail along the existing Rozelle goods freight line, as well as the GreenWay, a shared bicycle/pedestrian path between Iron Cove and Cooks River. The assessment included consideration of construction and operational phase impacts and key flood risks to the alignment posed by Hawthorne Canal.

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Independent technical review of flood and coastal risk assessments and stormwater management plans for two major combined residential and commercial developments on the NSW coast. The review involved critical appraisals of hydrodynamic modelling analyses undertaken by the environmental assessment consultants against the Director General’s Requirements (DGRs) for the projects. Recommendations were made on extensions and refinements of the analyses to fully satisfy the DGRs.

Assessment of the environmental values of and potential impacts on watercourses within the study area and associated drainage and flooding processes for a proposed 106km long water supply system in QLD, which crosses a total of 21 watercourses.

— **Kerosene Vale Coal Mine Preliminary Surface Water Assessment, Kerosene Vale, NSW, Australia (2009): Centennial Coal, Review engineer.**

Desktop surface water study for the proposed mining of coal from the Kerosene Vale site, for the purposes of an application for project approval under part 3A Major projects of the NSW Environmental Assessment and Planning Act 1979. The study used hydrologic modelling to assess the impacts of the proposed operations on the existing surface water regime and recommended measures for impact mitigation and improvement works to the local watercourses.

**Water resource management**


Hydrodynamic modelling study of the Great Cumbung Swamp to investigate options to modify the current distribution of channel and floodplain flow within the swamp to realise benefits of available environmental water. The options include removal of artificial flow diversion features (such as levees and channels) to restore the natural flow distribution within the swamp.

**Selected previous experience**

**Infrastructure design**


From March 2007 to December 2008, leader of the river edges design team for the enabling works phase of the London 2012 Olympic Park, which involved improvement works to approximately 12 km of river bank and included maintenance and rehabilitation of existing river walls, soft river bank enhancements and creation of new wetland habitat areas. Responsible for management of the entire design process from feasibility to detailed design, client and Stakeholder liaison and coordination of issue of construction drawings, planning applications and land drainage consents for planned works.


Supporting infrastructure element of a pre-feasibility study for an iron ore mining development in West Africa (confidential). The study involved power, fuel, water and workforce demand assessments for support of the mining operations and development of conceptual designs for the required road, power, fuel storage, telecommunications, water resource, supply, and wastewater infrastructure.

**Flood alleviation scheme feasibility studies**


Feasibility study of a coastal flood protection scheme along a small frontage on Hayling Island. Options were assessed on the basis of technical, environmental and economic viability and the preferred option was identified, progressed to outline design and environmental impact assessment.

Flood alleviation scheme feasibility study for the village of Wallington in Hampshire. The study area is subject to both fluvial and tidal flooding, with significant numbers of residential and commercial properties at risk. A number of flood management options were assessed for technical, environmental and economic viability, including provision of upstream flood storage, raising existing river defences and improving channel conveyance. Outline designs and construction cost estimates were developed and the preferred option identified.


Development of an ISIS hydraulic model of 14km of the Alconbury Brook to examine the effectiveness of a range of flood defence options and outline design of flood storage reservoirs, relief culverts and defences.

Flood management strategic studies


Responsible for overseeing technical work on definition of existing fluvial and coastal flood risk and identification of flood risk management options for the catchment. Also Project Manager for the flood modelling and mapping element of the project which delivered calibrated hydrodynamic models and design flood extent maps and flood hazard data for the 107 km² river catchment and Bembridge Harbour.


Flood management strategy study of the River Wey in Thames Region. The study involved a review of strategic options for managing flood risk at six urban areas in the catchment. High level management options appraised included provision of upstream flood storage and individual flood alleviation schemes for the flooding hotspots. Other assessments included determining the effect of climate change, increasing urbanisation in the catchment, influence of navigation structures on flood levels and effects of increased and decreased channel maintenance.


Provided hydraulic modelling input to Strategy Study of the Thames Barrier and associated moveable gates on the Thames and Thames tributaries. The objective of the Study was to make strategic recommendations on all aspects of the operation and maintenance of the structures over a 100 year planning horizon. Responsible for hydraulic modelling analyses and preparation of technical appendices to reports on the standards of protection provided by the existing gates and fixed defences and the standards of reliability provided by the moveable gates. Also responsible for providing advice to the Project Team on the appropriateness and use of modelling techniques for analyses to support the Strategy Study.


Strategic study of overspilling and breaching of river flood defences on the Bedford and Ely Ouse systems in Anglian Region for flood events with return periods in excess of 100 years. The study involved coarse hydrological and hydraulic modelling to identify potential overspill and breaching areas, preliminary estimates of resulting...
damages due to property damage, disruption and loss of life and development of an economic justification for progression to a Strategy based on simplified cost:benefit analysis.


Responsible for assessing the suitability of existing hydraulic and hydrological models of the River Stort in Thames Region for the purposes of the Flood Management Strategy and reviewing data on flood risk to identify the appropriate focus of strategic options. Acted as Technical Manager on 4 associated Flood Defence Pre-Feasibility Studies responsible for coordinating hydrological and hydraulic modelling. Also undertook separate studies on the hydraulic effect of dredging for navigation purposes and hydrological sensitivity analyses.

**Strategic and site-specific flood risk assessments**


Strategic study of flood risk and associated planning constraints for a region of South Hampshire that includes 10 planning authorities. The study delivered outputs that will assist planners in steering future development away from areas with the highest probability of flooding, assessing the level of risk to existing communities and identifying future strategies to reduce that risk. The study addressed all of the diverse sources of flooding in the region, which include those associated with rivers, coasts, groundwater, overland flow and drainage infrastructure.


Flood risk assessment for the upgrade of a major bridge crossing on the River Thames at Walton. The project involved assessment of the impacts of the new bridge design on floodplain storage, assisting with design of the floodplain storage compensation scheme, use of a hydraulic model to determine impacts of the new bridge on flood levels and assessment of the changes to surface water drainage and direction of storm runoff from the new bridge.

— **Fairways Daycare Centre Flood Risk Assessment, Staines, UK (2006): Surrey County Council, Project manager.**

Flood risk assessment for re-development of an existing daycare centre in Staines adjacent to a local drain and also lying within the Thames flood risk zone. The assessment included identification of the sources of flood risk, flood flow paths, potential evacuation routes, the impacts of the development on floodplain storage and site drainage and development of recommendations on surface water drainage for the re-developed site.

— **Thurrock Master Plan Flood Risk Assessments, Thurrock, UK (2004): Thurrock Urban Development Corporation, Technical lead for flood management.**

Provided technical advice on flood risk for 3 Master Plan Development Areas in Thurrock, South Essex. As the development areas are located within the flood risk zone of the Thames, the assessments include determining the standard of protection afforded by existing flood defences, assessing potential inundation of development areas under overtopping and breaching scenarios and determining risk mitigation measures. Responsible for advising the Client on all aspects of flood risk and liaison with the Environment Agency in agreeing scope of assessments.

Responsible for production of a Hydrological Impact Assessment of a major theme park development adjacent to the Thames. The analysis involved assessing the impact of proposed infilling of gravel pit lakes on flood risk, flood flow routes and local groundwater levels.

Flood modelling and mapping studies


  Study which involved refinement of an existing model of the canal to include representation of waste weirs, bridges, lock gates, sluice gates and intake structures. The model was also used to assess the effects of extreme river and surge tide floods in the River Severn and Severn Estuary on the canal and potential routing of floodwater through the canal and adjacent land.


  Flood risk modelling and mapping study of the River Wey in Thames Region which has a total catchment area of 900km². The study was carried out under the Strategic Flood Risk Management Framework Agreement and involved management of the channel and floodplain surveying contract, construction and calibration of hydrological and hydraulic models of the urban and rural sub-catchments of the Wey, generation of design hydrological inputs and production of design flood extent maps and flood hazard datasets for the catchment.


  Flood modelling and mapping study of the Tidal River Ouse in Sussex. The study involved construction and calibration of a two-dimensional hydrodynamic model of the 160km² catchment and simulation of extreme fluvial and tidal events. The resulting flood outlines and flood hazard datasets were then mapped using GIS techniques.


  Flood modelling and mapping study of the River Adur in Sussex. The catchment area of 420km² was modelled using a combination of one-dimensional hydraulic modelling to represent fluvial flooding processes in the upper catchment and two-dimensional hydrodynamic modelling to represent tidal flooding processes in the lower catchment. The study also involved commission and management of the channel survey and mapping a large number of design flood outlines and flood hazard datasets using GIS techniques.

Water supply strategic studies

— **Galway Rural Water Strategic Plan, County Galway, Ireland (2000): Galway County Council Assistant project manager.**

  High-level study of all public and private water supply schemes in County Galway. The Study incorporated a total of 700 schemes ranging from small rural 2-3 house private schemes to large urban schemes serving >10,000 consumers. Responsible for the identification of a wide range of water quality and supply problems and solution measures, preliminary investment prioritisation and preparation of Final Report.


  High-level study of all public water supply schemes serving more than 5,000 persons for the Department of Environment and Local Government. Responsible for
development and population of source, demand and asset databases, estimation of baseline and forecast demands by sector and estimation of drought severity and source yields. Also responsible for the preparation of County Reports for Cork, Galway, Kerry, Limerick, Mayo, Meath, Waterford, Wexford and Wicklow.

Water quality modelling studies


Development of hydrodynamic and nutrient cycle model studies of Cork Harbour and Wexford Harbour to assess the effects of nutrient balance on water quality.


Development of hydrodynamic and water quality models of Killybegs Harbour as part of an Environmental Impact Assessment (EIA) for a proposed new sewage treatment and disposal facility.


PROFESSIONAL HISTORY

WSP 2009 – Present
Atkins UK 2001 – 2008
Atkins Ireland 1998 – 2001

REFEREES

Chris Davis, Construction Manager, Laing O’Rourke, Tel. +61 (0) 434 606 007
Glenn Berrill, Director, Thompson Berrill Landscape Design, Tel. +61 (0) 2 9977 6444
Appendix C  Supplementary climate change assessment report (prepared post EES)
MEMO

TO: Con Gantonas (Melbourne Water)
FROM: Steve Horne
SUBJECT: Mordialloc Freeway, climate change flood impacts summary
OUR REF: 2135645A-SE-26-WAT-MEM-006 RevB.docx
DATE: 27 November 2018

1. PURPOSE

This memorandum summarises the flood assessment relating to project works under a climate change scenario. It provides a concise summary of the flood modelling undertaken, Melbourne Water performance criteria, and the relevant impacts and mitigations associated with climate change.

Full details of the hydrologic and hydraulic (flood) modelling are provided in:
- Mordialloc Freeway, Hydrologic and Hydraulic Modelling report
- Mordialloc Bypass, Surface Water Impact Assessment report.

The latter of these reports formed part of the Mordialloc Bypass (Freeway) Environmental Effects Statement (EES) and has been made publicly available.

2. MODELLING OVERVIEW

RORB hydrologic and TUFLOW hydraulic modelling has been completed covering the study area to define existing flood conditions, undertake an impact assessment and develop flood mitigation options.

Melbourne Water provided RORB models and a TUFLOW model, developed for the Mordialloc Settlement Drain Flood Mapping Study (GHD, 2013), to assist with this assessment. The RORB hydrologic models provided by Melbourne Water were reviewed and have been adopted largely unchanged for the assessment. Several changes were made to the TUFLOW model, including an update to latest software version, incorporating the latest feature survey, and changing the static downstream boundary to a dynamic boundary to better represent tidal variations. This updated model forms the Base-Case scenario, representing existing or pre-project conditions.

The Base-Case model was modified using the project’s design finished surface and drainage elements (swales, pipes, and culverts) to form the Proposed Scenario model.

The models were used to simulate flood behaviour in the Base-Case and Proposed Scenarios for the 1%, 5% and 20% Annual Exceedance Probability (AEP) design flood events (100, 20 and 5 year Average Recurrence Interval (ARI) in the old terminology). A climate change sensitivity scenario, incorporating sea level rise and rainfall intensity increase parameters provided by Melbourne Water, has also been simulated.
3. REQUIREMENTS

Melbourne Water provided their flooding requirements for the project in June 2017, as documented in *Performance Criteria for Waterways and Floodplain Planning and Management – Mordialloc Bypass, June 2017*.

Melbourne Water provided updated requirements for the project in August 2018, as documented in *Melbourne Water standards for infrastructure projects in flood-prone areas*. A key guiding principle in this document is that flood risk to people and property must not increase as a result of the project.

The Major Road Projects Authority (MRPA) / VicRoads adopted flood immunity standard for the Project mainline is the 1% AEP relative to the edge of shoulder.

4. FLOOD IMPACTS UNDER CLIMATE CHANGE

The scientific and engineering communities understanding of the impact of climate change on flood risk is evolving. The magnitude of sea level rise and rainfall intensity increase parameters are different in the *Mordialloc Settlement Drain Flood Mapping Study (GHD, 2013)*, *Performance Criteria for Waterways and Floodplain Planning and Management – Mordialloc Bypass, June 2017*, and *Melbourne Water standards for infrastructure projects in flood-prone areas*.

The Reference Design and EES has adopted the climate change factors set out in *Performance Criteria for Waterways and Floodplain Planning and Management – Mordialloc Bypass, June 2017*, being 0.8 m sea level rise (SLR) and 19% increase in rainfall intensity. Peak flood level impact (afflux) maps for the 1% AEP plus climate change scenario are attached. Impacts can be divided into three areas:

- South of Centre Dandenong Road: up to 220 mm afflux impacting seven properties
- North of Lower Dandenong Road: up to 110 mm afflux impacting three properties
- Braeside: 15 to 27 mm afflux impacting up to 50 properties. The Parks Victoria office is also impacted by around 45 mm afflux.

Further commentary and mitigation options for each area are discussed below.

4.1 SOUTH OF CENTRE DANDENONG ROAD

At Centre Dandenong Road, changes to flow conveyance is the primary cause of afflux, with areas of negative afflux observed north of Centre Dandenong Road. It is likely that impacts can be mitigated through design refinement (e.g. adjusting earthworks or pipe sizes) in detailed design.

One possible mitigation option is to introduce a minor bund (less than 0.5 m high), or elevate the proposed footpath, adjacent the impacted properties and therefore restrict flood impacts to within the road reserve. This option was simulated in Tuflow with the results shown in Figure 4.1.
4.2 NORTH OF LOWER DANDENONG ROAD

At Lower Dandenong Road, changes to flow conveyance is the primary cause of afflux and it is likely that impacts can be mitigated through design refinement (e.g. adjusting earthworks or pipe sizes) in detailed design.

4.3 BRAESIDE

At Braeside, the afflux occurs due to loss of floodplain storage rather than obstruction to conveyance, hence providing additional transverse-drainage capacity will have a negligible impact on the results. The magnitude of afflux in the climate change event is less than the current climate 1% AEP event (27 mm compared to 44 mm), presumably due to some overtopping of the proposed freeway, although the impacted extent is larger.

Several options have previously been investigated to mitigate the flood impact to the Braeside area, under the current climate 1% AEP event. These include:

- Flood gates: not preferred due to failure risk and ecology impacts
- Additional storage within Right of Way:
  - Bridge: based on storage volumes (i.e. no modelling), a bridge with a total span of approximately 440 m would be required to reduce afflux by around 30 mm. The additional cost of this option is estimated to be in excess of $54M
  - Bridge and retaining wall hybrid: extending the Governor Road overpass bridge by approximately 200 m and providing retaining walls to reduce fill into the floodplain would be required to reduce afflux by around 30 mm. The additional cost of this option is estimated to be excess of $30M. Bunding required as part of this option means that mitigation across a range of events would be difficult
- Additional compensatory storage outside Right of Way: would result in delays to the overall project and is a significant risk to the state in terms of cost and reputation.
main foreseeable delays include the EES, EPBC and Cultural Heritage Management Plan and related studies and assessments.

For the Reference Design and EES, it was concluded that the current proposed design solution (which does not incorporate any of the above mitigation options), provides the best overall outcome for the state, balancing flood risk with cost, ecology and program impacts.

In addition to the above mitigation options, an additional option was identified to mitigate flood impacts under the 1% AEP plus climate change scenario:

- Lower vertical alignment: optimise vertical alignment to 1% AEP flood level at edge of shoulder to increase amount of overtopping in 1% AEP plus climate change event. A preliminary model setup for this option has been simulated in Tuflow. The results (shown in Figure 4.2) show that only a minor decrease in afflux is achievable due to road geometry constraints. While the afflux reduction is minor, it is recommended that this option is adopted in order to provide an overtopping path in the climate change or other extreme events.

4.3.1 JOINT PROBABILITY

Extreme rainfall and storm surge processes are statistically dependent; therefore their interaction needs to be considered for areas affected by both processes.

Australian Rainfall and Runoff 2016 (ARR 2016) provides guidance on the joint probability between riverine and coastal processes. As there is some uncertainty in the water levels in the downstream reach of Mordialloc Creek, corresponding to the TUFLOW model downstream boundary, a conservative approach has been adopted for the Reference Design and EES and the results represent a 1% AEP rainfall with 1% AEP tailwater with peak values of each aligned. This scenario represents the full dependence case where flood peaks in the Braeside West and Mordialloc Creek systems occur simultaneously.

To represent a range of possible scenarios, two combinations of 1% AEP plus climate change rainfall with more frequent tailwater events have been simulated. Afflux results are shown in Figure 4.3 and Figure 4.4. Each combination accounts for a sea level rise of 0.8 metres per Melbourne Water requirements.

The results show that when a 1% AEP plus climate change rainfall event occurs simultaneously with a 2% AEP plus climate change or more frequent tailwater event, the afflux is confined to parkland and does not impact private property. This is consistent with the 1% AEP current climate flood impact assessment results.
Figure 4.2  1% AEP plus climate change rainfall with 1% AEP plus 0.8 m SLR tailwater

Figure 4.3  1% AEP plus climate change rainfall with 2% AEP plus 0.8 m SLR tailwater
5. STAKEHOLDER CONSULTATION

Melbourne Water, being the designated waterways, regional drainage and floodplain management authority for the area, is the key referral authority for floodplain management. Melbourne Water have been consulted throughout the Reference Design and EES phase and have reviewed several revisions of the Hydrologic and Hydraulic Modelling Report and Surface Water Impact Assessment technical report.

Melbourne Water have previously been consulted specifically regarding flood impacts under a climate change scenario. This memorandum aims to address the issues raised by Melbourne Water to facilitate reaching the best outcome for the project.

6. CONCLUSION

This memorandum summarises the flood assessment relating to project works under a climate change scenario.

At Centre Dandenong Road and Lower Dandenong Road, it is likely that impacts can be mitigated through design refinement (e.g. adjusting earthworks or pipe sizes) in detailed design.

At Braeside, flood impacts to private properties only occur in the most conservative joint probability scenario considered. While optimising the freeway vertical alignment to provide an overtopping path during extreme events is recommended, other mitigation options are not considered to provide the best overall outcome for the state.

ATTACHMENTS

— Mordialloc Freeway, Proposed case conditions, climate change scenario, 1% AEP peak flood level impacts maps (2135645A_GIS_993_B)
Appendix D  Qualitative assessment of the effects of the alternative Lower Dandenong Road / Mordialloc Bypass Freeway interchange on flooding and surface water quality (prepared post EES)
Introduction

The alternative Lower Dandenong Road / Mordialloc Bypass Interchange arrangement has been assessed qualitatively by comparing the alternative road layout to the Reference Design layout and determining how both layouts compare in terms of interaction of infrastructure with drainage and floodplain flows, and road pavement surface area and road drainage outfall locations.

Operational phase impacts

Flooding

The subject area interfaces with the Gartsides Drainage Scheme and Gartsides South Drainage Scheme drainage pipelines, Braeside West Drainage Scheme channel and an overland flow path along Woodlands Drive. The area is subject to flooding under both frequent (20% AEP) and rare (1% AEP) flood events. The extent of existing conditions flooding under a 1% AEP flood event is given in the figure below. The main overland flow path travels from North to South by firstly overtopping Lower Dandenong Road before being contained and conveyed within the Woodlands Drive road reserve.

Figure D-1: Existing conditions 1% AEP flood extent around interchange area (Reference Design alignment shown)

The Reference Design has an afflux impact within the Braeside West Drainage Scheme channel which is identified in the Report as requiring further investigation at the detailed design stage into mitigation.
measures that may include reduction in the size of the cross drainage culvert upstream of the impacted area and reinstatement of an existing overland flow path west of the proposed freeway.

The alternative arrangement would not produce significantly different effects to those of the Reference Design. The northbound exit ramp and modification of Woodlands Drive would constitute a different interaction with flooding and drainage processes but this would be managed through maintaining the vertical alignment of the modified Woodlands Drive as closely as possible to existing road/ground levels. A similar impact on the Braeside West Drainage Scheme channel to the Reference Design would be expected and similar mitigation measures to those proposed for the Reference Design would need to be investigated at detailed design.

Therefore, the flooding effects of the alternative arrangement are assessed to be very similar to those of the Reference Design.

**Water body health**

The alternative arrangement has a very similar amount of road pavement (and new impervious) area to the Reference Design. The alternative arrangement would also discharge road runoff to the same receiving systems. Some minor changes to road drainage outfall layouts would be required under the alternative arrangement but the effects of the alternative arrangement on water quality in receiving catchments would be very similar to those of the Reference Design.

**Construction phase impacts**

The alternative arrangement would require very similar construction phase flooding and water quality management / control measures to the Reference Design, as the same catchments and drainage assets are affected by both designs.
Appendix E  Figure attachments
FIGURE E-1

Properties of concern

KINGSTON

ASPENDALE GARDENS

WATERWAYS
FIGURE E-2

Zoomed view of properties at Maidenhair Mews
FIGURE E-4