Form A (version 2)

INDIVIDUAL EXPERT REPORT OF DR STEVE PERRENS

19 AUGUST 2016

COURT DETAILS	
Court	Land and Environment Court of New South Wales
Class	1
Case number	2016/159652 (formerly 2015/10898) & 2016/157848 (formerly 2015/10951)

TITLE OF PROCEEDINGS	
PROCEEDINGS 2016/159652	
Applicant	**Liverpool City Council**
First respondent	**Moorebank Recyclers Pty Ltd**
Second respondent	**Minister for Planning**

PROCEEDINGS 2016/157848	
First applicant	**Benedict Industries Pty Limited**
Second applicant	**Tanlane Pty Limited**
First respondent	**Minister for Planning**
Second respondent	**Moorebank Recyclers Pty Limited**

PREPARATION DETAILS	
Prepared for	**Moorebank Recyclers Pty Ltd,** First respondent in proceedings 2016/159652 and Second respondent in proceedings 2016/157848
Legal representative	Mark Gerard McDonald, Mark McDonald & Associates Lawyers Pty Ltd
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Land and Environment Court: Proceedings 2016/159652 and 2016/157848

Materials Recycling Facility, Moorebank

Expert Report: Sewage Management, Flooding and Stormwater

Dr Steve Perrens

19 August 2016

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1 Introduction

1 I have been briefed by Mr Mark McDonald of Mark McDonald & Associates Lawyers Pty Ltd to provide an expert report that addresses the matters relating to Land and Environment Court matters 2016/159652 and 2016/157848 (copy of my letter of instruction is included in Appendix 1). I have been specifically asked to address matters raised in:

- Amended Statement of Facts and Contentions filed on behalf of Liverpool City Council (**Council**) (24 June 2016), relating to sewage management, stormwater and flooding, and;
- Amended Statement of Facts and Contentions filed on behalf of Benedict Industries Pty Ltd (**Benedict**) and Tanlane Pty Ltd (**Tanlane**)(29 July 2016) relating to stormwater and flooding.

2 In relation to contentions referring to flooding matters (Council's amended Contention 8 [Particulars (a) to (f)]) and stormwater (Contention 9 [Particulars (a) to (g)]), Benedict and Tanlane have only adopted Particulars (a) to (d) in each case.

3 The matter relates to the Moorebank Recyclers Pty Ltd development application to the NSW Department of Planning for the construction and operation of a demolition and construction waste recycling facility (**the Development**) at Lot 6, DP 1065574 Newbridge Road, Moorebank, NSW (**the Site**). The Planning Assessment Commission (PAC) approved the Development on 11 September 2015. Liverpool City Council, Benedict Industries Pty Ltd and Tanlane Pty Ltd have since lodged appeals against the PAC decision. Prior to the development application for a demolition and construction waste recycling facility, consent was obtained from Live1pool City Council for the preparatory earthworks (DA1417-2005, Liverpool City Council 2006).

4 At the request of Mr McDonald, I met with Liverpool City Council's water expert, Dr Daniel Martens, on 24 June 2016 to initiate discussion of the flooding and stormwater management issues relevant to the proposed Development.

5 I have been instructed by Mr McDonald to review the expert report of Dr Martens dated 5 August and to reply to any issues raised in that report.

6 This report has been prepared by Dr Stephen Perrens. I am a consulting environmental engineer with over 40 years' experience in various aspects of engineering hydrology including effluent treatment and disposal, floodplain management and stormwater management and pollution control on waste management and recycling sites. A copy of my summary CV is attached as Appendix 2.

7 I have read, and agreed to be bound by, Part 31 Division 2 of the Uniform Procedure Rules 2005 and the Expert Witness Code of Conduct being Schedule 7 to the Uniform Civil Procedure Rules 2005.

8 For purpose of this report the following terminology has been adopted:

- The **Project** refers to the Project described in the *Preferred Project Report* for the proposed materials recycling facility (Nexus Environmental Planning, August 2013).
- The **Operational Area** refers to the northern section of the Site which is proposed to be developed for a materials recycling facility.

- The **Access Road** refers to an existing gravel Access Road that runs in a northerly direction between the main body of the Site and Newbridge Road.
- Annual exceedance probability (**AEP**) of a flood represents the percentage chance of it being equalled or exceeded in any one year (e.g. a 5% AEP flood has a 5% chance of being equalled or exceeded in any one year; a 1% AEP flood has a 1% chance etc). The probability can also be expressed in terms of 1 in X years (e.g. 1 in 20 years is equivalent to a 5% AEP). The term AEP is preferred because it more correctly describes the probability of occurrence of a flood.
- The **2006 consent** refers to the determination of a development application for earthworks on the Site by Liverpool City Council (**Council**), DA 1417/05 dated 29 June 2006.
- Probable maximum flood (**PMF**) is defined in the Liverpool LEP 2008 as having the same meaning as set out in the *NSW Floodplain Development Manual* (2005), namely:

  "The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions."

9 This report provides:

8.1 An outline of key features of the proposed Project as they relate to the management of sewage, flooding and stormwater and a summary of additional investigations (Section 2);

8.2 A summary of my opinions relating to the contentions raised by Council regarding sewage management and contentions raised by Council, Benedict and Tanlane regarding flooding and stormwater management (Section 0);

8.3 Consideration of each of the relevant contentions using the numbering system adopted in Council's Amended Statement of Facts and Contentions. This consideration includes any relevant matters raised in the expert report prepared by Dr Martens on behalf of Council. The three topics that are the subject of this report are considered in the following sections:

- Sewage management (Contention 2) - Section 0;
- Flooding (Contention 8) - Section 5;
- Stormwater (Contention 9) - Section 6;

8.4 Conclusions arising from my consideration of the relevant matters are set out at the end of Sections 0, 5 and 6.

8.5 A list of sources of information related to the proposed Project and relevant technical references (Section 7).

2 Project Outline and Further Investigations

10 Key features of the proposed Project that relate to matters addressed in this report are described in '*Water Management and Pollution Control Assessment*' (Evans & Peck, August 2013) (the '**Water Management Report**') that formed Attachment 14 to the *Preferred Project Report* (15 August 2013) and are summarised as follows:

10.1 Creation of an Operational Area which would be immune from flooding in a 1% AEP flood. Flood immunity would be provided either by perimeter mounds (which would act as flood levees) and/or raising the land level.

10.2 A low level Access Road between the Operational Area and the ramps to provide access to Brickmakers Drive. Because this road would be flooded about once every three years on average, a flood evacuation plan (Annexure D to the *Water Management Report*) has been prepared that provided for all personnel to evacuate the Site before the road becomes impassable.

10.3 Construction of ramps that would provide vehicle access from the Access Road to Brickmakers Drive.

10.4 On-site septic wastewater collection in tank(s) that would be emptied regularly by a licenced contractor.

10.5 A stormwater management system designed to maximise the re-use of stormwater collected on site and to provide an appropriate treatment of any overflow from the Site.

11 The PAC's conditions of Project Approval (11 September 2015) included the requirement for a Site Audit Statement prepared by a NSW Accredited Site Auditor. A *Remedial Action Plan* (**RAP**) has been prepared by Environmental Resource Management (**ERM**) that describes the works that are required to make the Site suitable for the proposed use. As a result of various matters identified during the course of the preparation of the RAP, a number of details of the Project described in the *Preferred Project Report* have been refined. The principle refinements that affect this report are:

11.1 Minor adjustments to detailed specifications for the new capping layer recommended in the report *'Geotechnical Investigation for Proposed Earthworks for New Development at Lot 6, DP 1065574 Newbridge Road, Moorebank, NSW'* prepared by Jeffery and Katauskas Pty Ltd (now trading as JK Geotechnics) dated 15 October 2010. These changes, which are described in the expert geotechnical opinion prepared by Mr Andrew Jackaman (17 August 2016), are proposed to ensure that the landfill cap complies with contemporary requirements as set out in *'Environmental Guidelines, Solid Waste Landfills'*, Second Edition, NSW Environmental Protection Authority (2016).

11.2 Penetration of the landfill cap will be restricted to a set of driven piles to support the proposed plant and structures. These piles will be founded in the fluvial sand profile below the landfill. The expert geotechnical opinion of Andrew Jackaman recommends that:

> *"...all pile heads must be covered with concrete slabs, which must include embedded perimeter edge beams and a gas drainage sub-base layer to capture gas emissions so that they can be appropriately vented. Covering the pile heads with concrete slabs will also prevent stormwater runoff from infiltrating into the landfill."*

11.3 As a result of the restriction on penetration of the landfill cap referred to in Paragraph 11.2, further details of the conceptual method for construction of the wastewater storage tank and stormwater collection sumps have been prepared. In summary:

- Wastewater holding tanks will be constructed above the landfill cap and will form a basement tank (supported on piles) located under the floor of the amenities building and the floor of the office (located adjacent to the weigh-bridges).
- All stormwater sumps will be of concrete construction and will be surrounded by a HDPE liner and compacted clay that conforms to the specifications for the landfill bund surrounding the waste.

Further details are provided Section 0 and Section 6 respectively.

11.4 Section 4 of the expert geotechnical opinion prepared by Mr Andrew Jackaman (August 2016) proposes replacement of the acoustic earth mounds with concrete panel walls. These mounds, located on the eastern, western and northern sides of the Development respectively, are shown on Lyle Marshall & Associates Pty Ltd Drawing Nos. 01 to 06 in Attachment 15 to the *Preferred Project Report*. In relation to the construction of the concrete panel walls, Mr Jackaman states:

> *"I understand that the proposed concrete panel walls will be appropriately designed and supported on piles which will penetrate the existing and proposed perimeter bund walls (that contain the landfill materials) and will be embedded into the underlying fluvial soils."*

11.5 The originally proposed acoustic earth mounds would also have functioned as flood levees to protect the Operational Area from flooding in a 1% AEP flood. Accordingly, flood levees will be required around those sections of the Operational Area where the finished level is less than the level of a 1% AEP flood plus an appropriate freeboard. Further details of the proposed crest level of the levees are provided in Section 5.

12 Figure 1 (next page) shows the indicative final site contours following reconstruction of the landfill bunds and capping. The figure does <u>not</u> include the proposed sound walls and flood levees referred to in Paragraphs 11.4 and 11. 5 above.

13 In preparing this report I have made further investigations/enquiries in relation to matters relevant to this report:

- Requested WMAwater to prepare out a further assessment of flooding conditions in the vicinity of the Site using a two dimensional (**2D**) hydrodynamic model. Details of this work are provided in Appendix 4 and discussed in Section 5.4.1.
- Obtained water quality data for the reach of the Georges River adjacent to the site. A summary of this data is provided in Appendix 5 and discussed in Section 6.1.
- Obtained water quality data for stormwater runoff from a site where demolition and construction waste are recycled (similar to the proposed activities on the Site). Summary data is provided in Appendix 6 and is also discussed in Section 6.1.

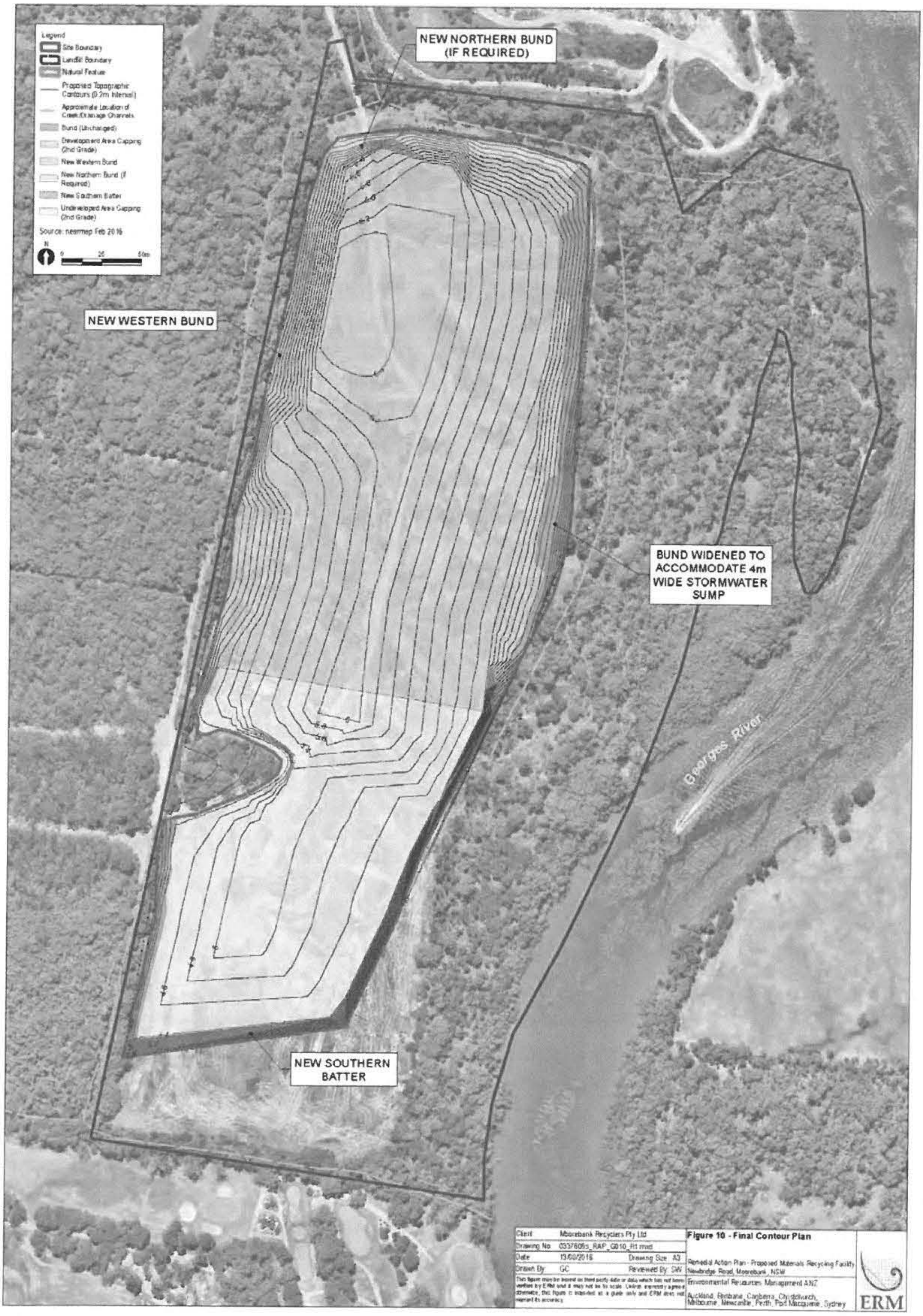

Figure 1: Indicative Final Contours Following Reconstruction of Landfill Bunds and Capping
(Source: Remedial Action Plan, ERM (August 2016))

3 Summary of Opinions

3.1 Proposed Sewage Management

14 In relation to Council's Contention No 2, I consider that Sections 4.1 to 4.3 of this report:

- Provide sufficient details of the size, location and management of the proposed pump-out septic wastewater system.
- Demonstrate that the system would be isolated from the groundwater and surface water systems and would, therefore, not pose a risk to local groundwater and surface water resources;
- Demonstrate that the environmental risks associated with the proposed system are lower and more manageable than the risks of a pumped sewerage pipeline.

15 I consider that the additional details of the proposed location and construction of the wastewater tanks set out in Section 4.1, including the an additional 50% contingency storage capacity, demonstrate that the system would pose minimal risk to the environment

16 I remain of the view that such a system provides the most practical and low risk system for wastewater management for the Development.

3.2 Flooding

17 In relation to Council's Contention No 8, I consider that the analysis set out in Sections 0 to 5.5 of this report demonstrate that:

- Previous flood modelling, including the modelling undertaken in relation to the 2006 Consent by Liverpool City Council, adequately characterised pre-development flood conditions and any the impacts associated with the Development. This has been confirmed by the recent flood assessment by WMAwater (Appendix 4);
- The proposed flood levees and land levels on the Site following implementation of the measures set out in the RAP would provide effective flood immunity to the Site in the event of a 1% AEP;
- The measures necessary to provide flood immunity to the Operational Area for a 1% AEP flood would have no effect on flood levels in the vicinity of the Site;
- Flood conditions in the vicinity of the Site in a 5% AEP flood would not be affected by the Development;
- The potential impacts on flood levels of sea level rise and alteration of rainfall intensity as a result of climate change have been fully considered;
- The existing *Flood Evacuation Plan* provides appropriate measures to evacuate the site in advance of an impending flood and adequately addresses the avoidance of an risk to life in major floods such as the 1%AEP flood or the PMF;

3.3 Stormwater Management and Treatment

18 In relation to Council's contention No 9 I consider that:

- sufficient details have been provided to show the arrangement and concept design of the proposed stormwater system to demonstrate that it is feasible;

- Sections 6.1 to 6.8, demonstrate that the proposed stormwater management system and the supporting analysis are consistent with current best practice having regard to the proposed operations on the Site The analysis is based on an appropriate stormwater quality model that is specific to the features of the site and has demonstrated that any discharge to the receiving environment will be of a suitable quality.
- I acknowledge that nitrogen and phosphorus were not specifically modelled in the analysis in the *Water Management Report*. However, the retention of 70% of site runoff for dust suppression purposes would capture 70% of any nitrogen and phosphorus. In addition, any overflow would be subject to further treatment in the bio-retention or vegetated swales.
- I consider the proposed 'treatment train' for treatment of stormwater is consistent with current 'best practice and would provide a suitable standard of treatment for water that eventually discharges to Georges River.

4 Consideration of Contentions Relating to Sewage Management

19 Council's amended contention Number 2 (24 June 2016) states:

'Sewage management at the Site is inadequate in light of the proximity to the Georges River.'

20 In addition, Dr Martens provides a series of observations and opinions in paragraphs 12 to 15 of his report. My response to the matters raised in Dr Martens' report and Council's contentions are addressed in the following paragraphs.

21 Based on Council's contention and the subsequent particulars, I consider the fundamental sewage management issues for the Development relate to:

- details of the capacity of the proposed septic wastewater system;
- the risk to local groundwater and surface water resources;
- the environmental risks associated with the proposed system compared to a pumped sewerage pipeline.

4.1 Proposed Sewage Management

22 The *Water Management Report* sets out the basic principles for management of sewage in sufficient detail for Project Approval and provides an appropriate basis for the development of further details during the detailed engineering design for the site works. Notwithstanding, for purposes of clarifying the proposal and responding to matters raised in paragraph 13 of Dr Martens' report, the paragraphs below provide further details that also take account of the geotechnical constraints outlined out in Paragraphs 11.2 and 11.3 above.

23 Two concrete wastewater holding tanks would be provided:

- one located under the floor slab of the amenities building; and
- one located under the floor of the office (adjacent to the weigh-bridges).

24 As described in Paragraph 11.3 above, these concrete tanks would be constructed on top of the landfill cap and would be supported on piles. Accordingly, the tanks will not be exposed to any landfill materials or leachate.

25 I have carried out preliminary sizing of the wastewater holding tanks based on the following assumptions:

25.1 Site employment would comprise (see page 2-87 of the *Preferred Project Report*):

- Six office based staff;
- One site foreman and 18 operational staff (plant operators and fitters);
- Twenty contract drivers who will be off site most of the time.

25.2 Water use per site based employee assuming 4 star WELS water fittings (http://www.waterrating.gov.au/consumers/water-efficiency):

- Full toilet flush (1 x 6 L) 6 L;
- Half flushes (4 x 3 L) 12 L;
- Tea/Coffee/washing-up (say) 10 L;

- Shower (7 L/min x 5 min) 35 L.

25.3 Based on the assumptions provided in Paragraph 25.2, Table 1 summarises the average daily water use, which is expected to approximately correspond to the volume of wastewater generated (ignoring the volume of water used for drinking). The estimates in Table 1 assume that only site operational staff will require showers and that the water usage by the truck drivers (who will be off-site most of the time) would be half that of site based staff.

Table 1: Estimated Daily Water Use (L)

	Office Based Staff (L)	Operational Staff (L)	Truck Drivers (L)
Staff Numbers	6	19	20
Full toilet flush (1 x 6 L)	36	114	60
half toilet flush (4 x 3 L)	72	228	120
Tea/Coffee (say, 10 L)	60	190	100
Shower (7 L/min x 5 min)	-	665	-
Totals	**168**	**1,197**	**280**

25.4 From Table 1, the average daily wastewater generation would be about 1,645 L/day or 9,870 L/week for a six day working week. This estimate (rounded to, say, 10,000 L/week) is likely to over-estimate the wastewater volume because there would be limited office based staff on Saturdays.

25.5 Assuming a regular weekly pump-out, with 50% contingency capacity, the required volume of the wastewater tanks would be 15,000 L (or 15 m^3) allocated as follows:

- 13 m^3 to be located under the floor of amenities building;
- 2 m^3 to be located under the floor of the office.

25.6 The only openings to the concrete wastewater tanks would be at, or above, floor level which is proposed to be a minimum of 6.0 m AHD in order to provide a freeboard of 0.5 m above the 1% AEP flood level (see Section 5 below). Accordingly, the proposed construction would ensure that there is no pathway for wastewater to drain to groundwater or stormwater.

26 The operation and management of the wastewater tanks would be detailed in a site environmental management plan. Because this would be a formal plan for a commercial operation, implementation of the plan in respect of routine pump-out would not be subject to the uncertainties associated with a domestic system. In addition, as noted in Paragraph 25.5, the wastewater holding tanks are proposed to have an additional 50% contingency capacity.

4.2 Particular 2a

The proposed sewage pump-out service is unacceptable because the storage of sewage on floodplains presents a risk to local groundwater and surface water resources. The Evans and Peck Report contained within the Preferred Project Report does not contain sufficient details to assess the risk posed by the system. At present, the size, storage capacity and management of the facility is unknown.

27 The proposed Operational Area would be immune from flooding in a 1% AEP flood with an additional freeboard of 0.5 m. Details to support this are provided in Section 5 below. Accordingly, the wastewater tanks will not be subject to the flood risk that would normally occur on a floodplain. In addition, as described above, the location of the tanks above the landfill capping and the concrete construction will ensure that there is no pathway for the escape of wastewater to the groundwater or surface water.

28 I consider that the additional details of the proposed location and construction of the wastewater tanks set out in Section 4.1 above, including an additional 50% contingency wastewater storage capacity, demonstrate that the system would pose negligible risk to the environment.

4.3 Particular 2b

The proposed sewage pump is also not in accordance with industry best practice given the location of the Site within flood liable land and its close proximity to the Georges River. Best practice sewage management on floodplains is for connection to sewer. That may be achieved with a properly designed and managed pump station or with the installation of gravity drainage to sewer where this is achievable. A risk assessment must be undertaken by the Respondent to enable Council to fully assess this issue.

29 In developing the concept for the wastewater pump-out system described in the *Water Management Report*, a range of factors were considered including:

28.1 The flood immunity provided by the proposed bunding and site levels;

28.2 To provide gravity feed, any sewage pumping station would need to be located outside the Operational Area in a location that would be likely to flood in a 20% AEP flood;

28.3 Times of flood are likely to be times when the power supply is most unreliable and, accordingly, may give rise to the overflow of sewage;

28.4 The sewer connection to the Site is at the Newbridge Road end of the access handle. This would involve a 1,000 m pipeline.

30 As noted in Paragraph 10.1, the Operational Area is proposed to be immune from a 1% AEP flood. Accordingly, the proximity to the Georges River is not a relevant consideration in this instance.

4.4 Specific Matters Raised by Dr Martens

31 Paragraph 13 of Dr Marten's report raises a number of questions regarding details of the capacity, location and management of the sewage management system. All these questions have been addressed in Sections 4.1 to 4.3 above.

32 Paragraph 14 of Dr Marten's report quotes sections of Liverpool City Council's DCP 47 and DCP 2008 and contends that because the wastewater generated on the Site would be 'domestic' in nature, Council's policies should apply. I note that the Council policies do not <u>prohibit</u> pump-out systems. I therefore disagree with Dr Martens' view that a pump-out system would be contrary to Council's policy. In addition, unlike a domestic household

pump-out system, the Site system will be subject to a site-specific environmental management plan and regular weekly pump-out by a licenced contractor.

4.5 Conclusions Relating to Sewage Management

33 Sections 4.1 to 4.3 above:

- provide details of the size, location and management of the proposed pump-out septic wastewater system;
- demonstrate that the system would be isolated from the groundwater and surface water systems and would, therefore, not pose a risk to local groundwater and surface water resources;
- demonstrate that the environmental risks associated with the proposed system are lower and more manageable than the risks of a pumped sewerage pipeline.

34 I consider that the additional details of the proposed location and construction of the wastewater tanks set out in Section 4.1 above, including the an additional 50% contingency storage capacity, demonstrate that the system would pose minimal risk to the environment.

35 I remain of the view that such a system provides the most practical and low risk system for wastewater management for the Development.

5 Consideration of Matters Relating to Flooding

36 Council's amended contention Number 8 (24 June 2016) states:

'There is insufficient information to properly assess the impact of flooding on the Development.'

37 In addition, Dr Martens (paragraphs 27, 31 and 32 of his report) has called into question a range of matters relating to the levels of proposed perimeter mounds and the adequacy of the flood modelling to assess the potential impacts of the Development on flooding.

38 Based on Council's contention and the subsequent particulars, I consider the fundamental flooding issues for the Development relate to:

- the adequacy of previous flood modelling to characterise pre-development flood conditions and any impacts associated with the Development;
- the effectiveness of the proposed measures to provide flood immunity to the Site in the event of a 1% AEP flood;
- the impact of measures to provide flood immunity to the Site on flood levels in the vicinity of the Site, including consideration of a 5% AEP flood and the PMF;
- the potential impacts on flood levels of sea level rise and alteration of rainfall intensity as a result of climate change;
- the adequacy of measures to evacuate the Site in the event of an impending flood.

39 In view of the concerns expressed by Dr Martens regarding the validity of the flood assessment that accompanied the 2006 Consent and the report *'Moorebank Recyclers: Proposed Works – Flood Impact Assessment'* (WMAwater, 2013) which formed Annexure C to the *Water Management Report*, I have asked WMAwater to prepare an additional flood assessment that examines:

39.1 A **'base case'** which assesses the flood levels associated with the land levels depicted on a plan prepared by Asher McNeil in 2005 (Drawing 9226-02) entitled *'Earthworks Approval Plan #1'*. A copy of this plan is included in Appendix 3.

39.2 **Scenario A** in which the Operational Area is excluded from the area that would be flooded in a 1% AEP flood. This area is designated 'Area 1' on a plan prepared by Asher McNeil in 2005 (Drawing 9226flood01) entitled *'Flood Levels, Lot 1 DP 336613, Newbridge Road, Moorebank'*. A copy of this plan is provided in Appendix 3.. Scenario A involves maintenance of the levels depicted on Drawing 9226-02 for Areas 2, 3 and 4 and construction of access ramps to Brickmakers Drive (as depicted in Figure 8 of the *Water Management Report*).

39.3 **Scenario B,** which is the same as Scenario A with the addition of excavation to a level of 1.6 m AHD for Areas 3 and 4, approximately corresponding to natural ground level prior to construction of the landfill.

39.4 **Scenario C,** which includes construction of access ramps to Brickmakers Drive and all of Areas 1, 2, 3 and 4 excluded from flooding in a 1% AEP flood.

40 The report also assesses the impact of sea level rise (arising from predicted climate change effects) on flood levels in vicinity of the Development.

41 A copy of the 2016 report prepared by WMAwater is attached as Appendix 4 to this report. The key findings of the analysis are:

41.1 Flood conditions for the 1% AEP flood for the Base Case are consistent with the flood levels depicted in Figure 9 of the 2013 WMAwater report in that a flood level of 5.5 m AHD would encroach to a minor degree into the northern boundary of the Site. The flood levels are also consistent with the flood levels that were adopted for the 2006 Consent for earthworks.

41.2 Results for Scenario A indicate that exclusion of flooding from 'Area 1' (the proposed Operational Area) would have no impact on flood levels in the vicinity of the Site.

41.3 Results for Scenario B also indicate that exclusion of flooding from 'Area 1' and the excavation of 'Area 3' and 'Area 4' would have no impact on flood levels in the vicinity of the Site. In other words, the increase in floodplain storage associated with excavation of 'Area 3' and 'Area 4' provides no benefit in terms of flood levels.

41.4 Results for Scenario C also indicate that exclusion of flooding from Areas 1, 2, 3 and 4 would have no impact on flood levels in the vicinity of the Site.

41.5 An assumed sea level rise of 0.41 m would lead to an increase in the flood level at the site of only 0.05 m in the Georges River adjacent to the Site.

42 Flood characteristics presented in the WMAwater report indicate that:

42.1 Flood depths (as implied by the 1% AEP flood levels) range from 0.1 m near the northern boundary to about 1 m on the edge of the embankment that delineates the edge of the landfill area, with the majority of the landfill area being flooded to a depth of 0.3 m or less. The flood gradient in the vicinity of the Site is about 0.016%. Based on the flood gradient and the assumed hydraulic roughness of the existing Site (n = 0.035), the velocity at the peak of a 1% AEP flood can be expected to be in the following range:

- 0.08 m/s for depth of 0.1 m;
- 0.16 m/s for a depth of 0.3 m;
- 0.36 m/s for a depth of 1.0 m.

42.2 The flood depths listed in Paragraph 42.1 do not constitute *"significant inundation"* as alleged in paragraph 24 of Dr Martens' report.

42.3 Figure 2 below shows the relationship between flood depth, flood velocity and flood hazard as set out in the *NSW Floodplain Development Manual*. The figure shows that the majority of the landfill area would be classified as having *'Low Hazard'* conditions at the peak of a 1% AEP flood.

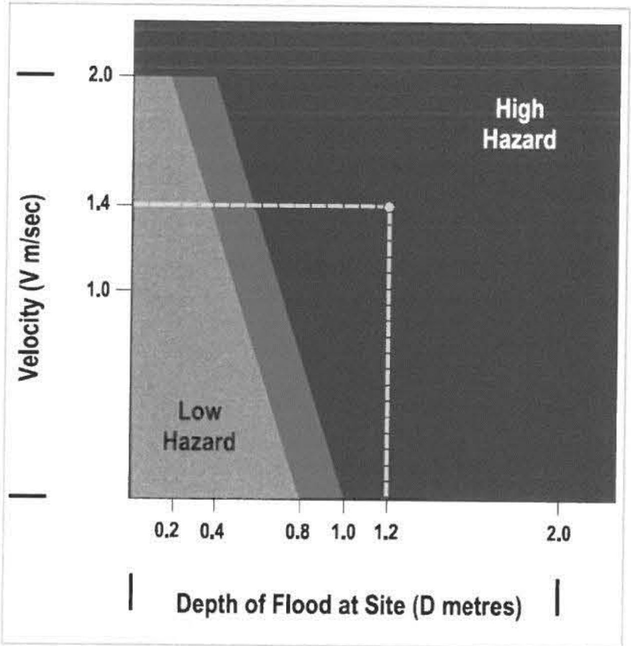

Figure 2: Flood Hazard Categories
(Source: Figure L2, NSW Floodplain Development Manual, 2005)

42.4 None of the scenarios (A, B or C) would lead to any impact on flood levels at the Site or on surrounding land.

42.5 In particular, Scenario B indicates that the increase in flood storage associated with the excavation of Areas 3 and 4 to levels comparable to the original natural levels would have no impact on flood levels.

5.1 Particular 8a

The Development relies largely on a flood study prepared for the filling and earthworks at the site. Insufficient information has been provided to show how that study relates to, and can be validly relied upon, for the current development proposal. It is unclear what level (in mAHD) any previously approved 'bunds' is relied upon by the Development.

43 The earthworks that were the subject of Liverpool Council's DA consent dated 29 June 2006 (the 2006 Consent) were based on creating a flood free area for development by means of bunds around "Area 1" and "Area 2". Attached as Appendix 3 are copies of three approved plans that are relevant to this issue:

- *Design Levels, Lot 6 DP106554, Newbridge Road, Moorebank* (Asher McNeil, Drawing 9226-02, 14/3/05);
- *Perimeter Mounding, Lot 6 DP106554, Newbridge Road, Moorebank* (Asher McNeil, Drawing 9226-03, 14/3/05);
- *Flood Levels, Lot 1 DP336613, Newbridge Road, Moorebank* (Asher Consulting Drawing 9226flood01, 18/5/05).

44 Asher McNeil Drawing No. 9226-03 shows a 4 m high perimeter bund around the perimeter of Areas 1 and 2 (as defined on Asher Consulting Drawing No. 9226flood01) except for the north-west corner and an area marked "Tree Outcrop" on the western boundary. By reference to the levels around the perimeter of the Site, the crest level of the bund would vary from about 8 m AHD on the eastern side of the Site to 9 m AHD on the western side.

45 At the time of the 2006 DA I was employed by Hughes Trueman and was responsible for establishing the flood levels applicable to the Site based on modelling undertaken by Patterson Britton & Partners and documented in a letter report dated 11 February 2004. Flood levels (as shown on Drawing No 9226flood01) were established by reference to a flood model of the reach of the Georges River determined using a contemporary MIKE-11 quasi-two dimensional model, which was the standard hydraulic model at that time. The flood levels identified for a 1% AEP flood ranged from 5.48 m AHD at a location about 65 m from the northern end to 5.39 m AHD at a location about 140 m from the southern end. These flood levels are consistent with the flood levels determined in the latest flood modelling carried out by WMAwater (summarised in Paragraph 41).

46 For purposes of assessing the potential impact of filling on flood levels, the Hughes Trueman flood assessment assumed that the 'usable area' (defined as 'Areas 1' and 'Area 2' as shown on Drawing No 9226flood01) would be made flood free in a 1% AEP flood by either construction of perimeter bund or filling. This assessment formed part of the DA documentation which led to the 2006 consent by Liverpool City Council.

47 The subsequent flood modelling using a two dimensional hydrodynamic flood model undertaken by WMAwater in 2013 (Annexure C to the *Water Management Report)* showed a 1% AEP flood level of 5.5 m AHD at the northern end of the Site. This level is consistent with the levels derived from the modelling undertaken in 2003 and 2004.

48 The proposed levels for the current proposal (as modified to accommodate the requirements of the RAP) are consistent with achieving a site that is free from flooding in a 1% AEP flood (5.5 m AHD at the northern end of the Site) as follows:

- Site entrance level grading upward to levels above 6.0 m AHD (a freeboard of at least 0.5 m above the 1% AEP level);
- Flood levees (crest level 6.0 m AHD) around the boundaries of the Site where the finished land level is less than 6.0 m AHD. The maximum height of these levees would be 1.6 m.

49 The 2016 flood assessment prepared by WMAwater (outlined in Paragraphs 39 to 42 above and provided in full in Appendix 4) indicates that the proposed exclusion of flooding from the Operational Area and the construction of the ramps to provide access to Brickmakers Drive would have no impact on flood levels.

50 I acknowledge that the perimeter mounds depicted in the drawings prepared by Lyle Marshall & Associates (Attachment 15 to the *Preferred Project Report*) differ from those depicted in Asher McNeil Drawing No. 9226-03 in terms of location and finished level (as

per paragraph 29 of Dr Martens report). Notwithstanding, from a flooding perspective, the flood analysis reported by Hughes Trueman (exclusion of flooding), the bunds depicted in the drawings by Lyle Marshall & Associates, and the revised layout as described in Paragraph 11 above lead to the same outcome; namely, the exclusion of flooding from the Operational Area of the Site in a 1% AEP flood.

51 Based on the analysis above, I consider that there is no ambiguity regarding the consistency of the previously approved levels and the currently proposed levels in regard to impacts of flooding on the proposal or the impacts of the proposal on flooding in the vicinity.

5.2 Particular 8b

Insufficient information has been provided in relation to the extent of proposed earthworks within the Georges River flood plain.

52 The extent of the proposed earthworks described in the PPR is clearly shown on the plans prepared by Lyle Marshall & Associates (Attachment 15 to the *Preferred Project Report*). The changes to accommodate revisions arising from the preparation of the RAP (as described in Paragraph 11) would require flood levees to be constructed to a crest level of 6.0 m AHD along the boundaries of the Operational Area where the finished land level is less than 6 m AHD.

53 The earthworks associated with the construction of ramps to provide access to Brickmakers Drive are shown on the drawings in Annexure 8 to the *Preferred Project Report*. These earthworks remain unchanged.

54 I note that the term 'Georges River flood plain' is not defined in the Liverpool LEP 2008 which provides the following definitions:

- "**flood planning level** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard, or other freeboard as determined by any floodplain risk management plan adopted by the Council in accordance with the Floodplain Development Manual.
- '**flood prone land** is land susceptible to flooding by the largest flood that could conceivably occur at a particular location estimated from the probable maximum precipitation."

55 Liverpool LEP maps FLD-014 and FLD-015 distinguishes:

- 'Flood prone land'; and
- 'Flood planning area'.

56 The maps show the Site is lying within both the 'flood prone land' and the 'flood planning area'.

57 In view of Council's 2006 Consent (DA -1417/2005) that effectively provides a flood free area in a 1% AEP flood, I consider that the Site should <u>not</u> be classified as lying within the 'flood planning area'.

58 Section 3.3 of the *Water Management Report* provides details of the proposed earthworks, specifically:

- the proposed earthworks on the operation area site;
- the proposed ramps to provide access to Brickmakers Drive.

59 As noted in Paragraph 50, the mounds depicted in drawings prepared by Lyle Marshall & Associates (Attachment 15 to the *Preferred Project Report*) differ from those depicted in Asher McNeil Drawing No. 9226-03. Notwithstanding, from a flooding perspective, both sets of drawings depict a situation in which the Operational Area would be immune from flooding in a 1% AEP flood. The Site levels and revised flood levees described in Paragraph 11 would have the same effect in terms of providing flood immunity to the Operational Area while having no effect on surrounding flood levels.

5.3 Particular 8c

The impact of the proposed earthworks, roadworks and associated structures in the 1 in 100 year flood and PMF flood extents, levels and character of flows has not been properly assessed.

60 The impact of earthworks on a 1% AEP (1 in 100 year) flood have been assessed on several occasions as follows:

59.1 Impacts associated with excluding flooding from the Operational Area of the Site have been previously assessed for the 2006 DA (as outlined in Paragraphs 43 to 46);

59.2 Impacts associated with the proposed ramps and bridge abutments have been included in the flood modelling undertaken by WMAwater in 2013 (Annexure C to the *Water Management Report*). This modelling also takes account of the earthworks that have the effect of exclude flooding from the Operational Area.

59.3 Impacts associated with various options for excluding flooding from the landfill area and the construction of the access ramps have been further assessed by WMAwater in 2016 using a 2D hydrodynamic model (see Appendix 4).

61 The flood modelling outlined in Paragraph 60 provides consistent results that demonstrate that the proposed earthworks associated with excluding the 1% AEP flood from the Operational Area would have no impact on flood levels.

62 The detailed analysis relating to the impact of the proposed access ramps quoted in the *Water Management Report* can be summarised as follows:

61.1 For a 1% AEP flood in the Georges River, the proposed bridge embankment and ramps would cause a localised flood increase of 2-3 mm.

61.2 For a 1% AEP flood from the local catchment, the maximum flood level increase would be 30 mm immediately upstream of the bridge. The area affected by any increase would be confined between the elevated land on the site operated by Benedict Sand & Gravel to the east and Brickmakers Drive to the west.

61.3 For a 1% AEP flood from the local catchment combined with the 5% AEP flood in the Georges River, the flood level increase at the bridge and ramps would be 1.5 mm immediately upstream of the bridge. The flood level would be 4.77 m AHD, which is 0.73 m lower than the 1% AEP flood in the Georges River

63 It should also be noted that Figure 9 of the 2013 WMAwater report shows a 1% AEP flood level at the northern end of the Operational Area of 5.5 m AHD. This flood level accounts for the effect of the earthworks associated with the Operational Area and the proposed access ramps. The 2016 2D modelling by WMAwater (Appendix 4) confirms this flood level.

64 Section 2.5 of the *Water Management Report* notes that the level of the probable maximum flood (PMF) in the vicinity of the Site is estimated to be about 10.3 m AHD. At that flood level large areas of Georges Fair, Moorebank and adjoining suburbs will be flooded to depths of the order of 4 m. At this depth of flooding, the major influence on flood levels and flow patterns would be the existing urban, industrial and residential development. The proposed Development itself would not have any measurable effect. Accordingly, I consider that consideration of PMF flood conditions is not relevant for the Project.

65 Based on the analysis set out in the *Water Management Report*, I consider that the impacts of the proposed works on 1% AEP flood have been properly assessed. The 2016 2D flood modelling carried out by WMAwater confirms the results of the earlier 2013 modelling.

66 The analysis set out above demonstrates that appropriate investigation has been undertaken to prove that the proposed earthworks will have no impact on flood levels.

5.4 Particular 8d

A 2D flood model has not been prepared for existing and proposed conditions, including the effects of climate change and sea level rise, in order for the impacts of the development proposal, including all proposed earthworks within the floodplain on the 20 year, 100 year and PMF flood events to be assessed.

i. Without this information, it is not possible to assess the risks, impacts and possible mitigation requirements of the proposal in terms of the surrounding road network, adjoining land owners and the Georges River, including ancillary riparian zones.

ii. Without this information, it is not possible to assess the continued suitability of any previously approved earthworks for the site.

67 This contention contains three separate issues that are addressed under the following sub-headings:

- use of a 2D model to assess the impact of earthworks;
- climate change and sea level rise;
- the range of floods to be considered.

5.4.1 2D Flood Modelling

68 WMAwater have carried out two sets of flood modelling using 2D hydrodynamic models:

68.1 *Moorebank Recyclers: Proposed Works – Flood Impact Assessment* (July 2013) which formed Annexure C to the *Water Management Report*. The primary purpose of this report was to confirm the impact of the proposed access ramps to Brickmakers Drive in the context of flooding from a local catchment in combination with flooding in the Georges River. This analysis was carried out in the context of broader scale modelling that included excluding the Operational Area from flooding in a 1% AEP flood..

68.2 *Moorebank Recyclers – Flood Impact Assessment* (August 2016) – Appendix 4 to this report. As noted in Paragraph 39, the most recent report has been prepared in response the concerns expressed by Dr Martens regarding the validity of the flood assessment that accompanied the 2006 Earthworks Consent and the report '*Moorebank Recyclers: Proposed Works – Flood Impact Assessment*' (WMAwater, 2013) which formed Annexure C to the *Water Management Report*.

Both these models confirm the 2004 flood assessment by Hughes Trueman and demonstrate that the exclusion of flooding from the Operational Area would have no effect on 1% AEP flood levels at the surrounding road network, adjoining land owners, the Georges River or ancillary riparian zones.

5.4.2 Climate Change and Sea Level Rise

69 The *Climate Change in Australia, East Coast Cluster Report, Projections for Australia's NRM Regions* (CSIRO, 2015) states that there is high confidence that the intensity of heavy rainfall events will increase. However the magnitude of change, and the time when any change may become evident compared to natural variability, cannot be reliably projected.

70 The NSW Government does not prescribe state-wide sea level rise projections for use by councils and recommends that councils determine their own sea level rise projections to suit their local conditions. Table 2 of the *Climate Change Risk Assessment,* prepared by SLR for Liverpool Council in June 2012, recommends adopting a planning benchmark sea level rise of 40 cm by 2050.

71 More recently, CSIRO's *East Coast Cluster Report* (CSIRO, 2015) states that there is very high confidence that sea levels in the Sydney region will continue to rise during the 21st century. In the near future (2030), the projected range of sea level rise for the Sydney region coastline is 0.08 m to 0.18 m above the 1986–2005 level. I note that the range of projected sea level rise in the 2015 CSIRO report has a lower 'trajectory' than the estimate prepared for Liverpool City Council in 2012.

72 For purposes of assessing potential impacts of sea level rise, the 2016 report by WMAwater has utilised the currently available MIKE-11 flood model that considers the full reach of the Georges River down to Botany Bay. The effect of a sea level rise of 0.41 m was shown to be a 0.05 m increase in the 1% AEP flood level at the Site.

73 It is common practice to provide 'freeboard' above the assessed level in order to provide reasonable certainty that the risk associated with a selected flood is actually provided. As noted in Section K5 of the *NSW Floodplain Development Manual* (2005), freeboard provides for:

- *"uncertainties in the estimates of flood levels. These can arise from a relatively short database Of past floods and past storm surges in coastal waters, together with uncertainties and simplifications in the models used to predict flood discharges and flood levels,*
- *changes in rainfall patterns and ocean levels as a result of climate change."*

74 Common practice for setting of residential flood levels provides for freeboard of 0.3 m. On the basis of the flood modelling, sea level rise is not an important consideration for the Site and any increase in rainfall intensity is uncertain. Notwithstanding, the Site is proposed to have a freeboard of 0.5 m above the assessed 1% AEP flood level.

5.4.3 Range of Floods Requiring Assessment

75 Council's requirement for separate assessment of the impacts 20 year ARI (5% AEP) flood and the PMF is not warranted for the following reasons:

75.1 If there is no impact on the 1% AEP flood (as shown in the analysis summarised in Paragraphs 43 to 48) there would be no impact on the 5% AEP flood. Figure 3 is the flood frequency record for Milperra Bridge derived from a combination of recorded levels (blue) and a physical hydraulic model constructed by the PWD (olive green). The figure shows that at the bridge, the 5% AEP (20 year ARI) flood can be expected to be about 1 m lower that the 1% AEP (100 year ARI) flood. Accordingly, the 5% AEP flood level in the immediate vicinity of the Site would be about 4.5 m AHD. This level would only encroach onto the lowest levels of the surface of the landfill (see Asher McNeil in 2005 Drawing 9226-02 in Appendix 3).

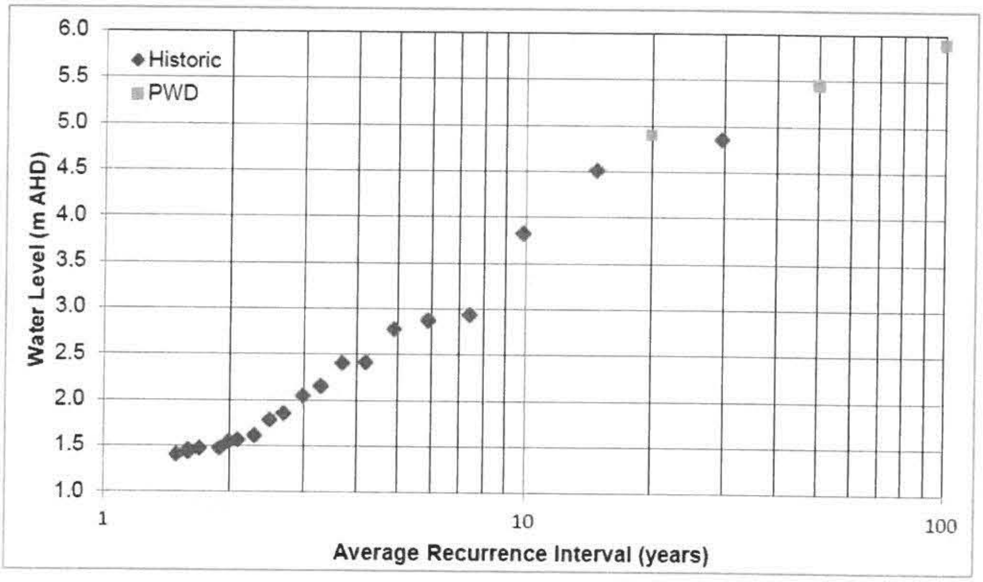

Figure 3: Flood Frequency Record for Milperra Bridge
(Source: Figure 5 from the Water Management Report)

75.2 PMF flood conditions are of no practical relevance to the proposed Project. The Development would have no effect on the PMF flood, which would inundate wide areas of Georges Fair, Milperra and the surrounding suburbs.

75.3 Because of the low level of the Access Road, the *Flood Evacuation Plan* (Annexure D to the *Water Management Report*) provides for evacuation of the Site to commence in the event of a preliminary flood warning issued by the Bureau of Meteorology for 'minor' flooding on the Georges River, corresponding to a flood level which would reach 2.0 m AHD at Milperra Bridge within 6 hours of the warning being issued. The Site will be fully evacuated well before any significant flood, let alone the PMF.

5.4.4 Conclusions in Relation to Particular 8d

76 The analysis provided above indicates that:

- Appropriate 2D modelling has been undertaken;
- Sea level rise is not an important consideration for the Site and any increase in rainfall intensity due to climate change is uncertain and not able to be quantified. Uncertainties associated with sea level rise possible increase in rainfall intensity are taken into account in the proposed freeboard of 0.5 m;
- Consideration of the 5% AEP flood and PMF is not relevant to assessing the impacts of the Project.

77 Therefore, the analysis demonstrates that appropriate investigation has been undertaken to establish that:

- the risks, impacts and possible mitigation requirements of the proposal in terms of the surrounding road network and adjoining land owners have been adequately assessed;
- the Georges River and ancillary riparian zones have been adequately taken into account;
- the analysis confirms the continued suitability of the previously approved earthworks for the Site.

5.5 Particular 8e

Flood evacuation requirements and risks under a PMF event have not been properly assessed. A flood risk assessment of the proposed evacuation has not been prepared, being the risk to life and property/infrastructure for a full range of event return intervals and durations up to the PMF. Based on the information to hand, it is not possible to determine the full extent of risks to persons and infrastructure at the facility.

78 Annexure D to the *Water Management Report* is a *Flood Evacuation Plan: Warning System and Site Emergency Response* prepared using the SES *Business Floodsafe Toolkit* as a guide. This Plan was prepared after careful consideration of the risk to workers remaining on the Site during a flood. The frequency and depth of flooding of the Access Road and the available flood warning time were carefully considered in formulating the Plan.

79 As set out in Section 3.3.3 of the *Water Management Report*, part of the Access Road has a minimum level of 1.96 m AHD and would be flooded to a depth of 0.1 m in a 33% AEP (1 in 3 year) flood. In a 25% AEP (1 in 4 year) flood the depth of flood water over the lowest point in the road would be about 0.45 m and would be an impediment to light vehicles.

80 The *Flood Evacuation Plan* contains:

- a flood warning and evacuation preparation protocol;
- site evacuation trigger and actions to evacuate the Site several hours before the Access Road becomes impassable; and
- recommendations to protect the site facilities in the event of a rare flood that might enter the Site.

81 Evacuation of the Site would commence in the event of a preliminary flood warning issued by the Bureau of Meteorology for minor flooding on the Georges River, corresponding to a flood level which would reach 2.0 m AHD at Milperra Bridge within 6 hours of the warning being issued.

82 The information outlined in Paragraphs 78 to 81 and presented in greater detail in the *Flood Evacuation Plan* demonstrate that the risk to life and site facilities have been carefully considered for the full range of floods in excess of the 50% AEP (1 in 2 year) flood. Because the Site will have been evacuated many hours before a PMF, the water level associated with such a flood (estimated to be 10.3 m AHD) will pose no greater risk to life than that already considered in the Plan.

5.6 Specific Matters Raised by Dr Martens

83 Paragraph 27b) of Dr Martens' report notes that the flood study prepared by Hughes Trueman (2004) did not consider climate change effects. I concur with this statement but

note that this issue has now been considered in the 2016 flood assessment by WMAwater (Appendix 4).

84 The criticisms by Dr Martens in paragraph 27c) regarding the limitations of the 2013 flood assessment have now been largely addressed in the 2016 flood assessment by WMAwater which includes consideration of sea level rise. As set out in Paragraph 75, I do not consider the 5% AEP or PMF to be relevant considerations in this instance.

85 I disagree with Dr Martens' contention in paragraph 28 of his report that "some portions of the approved bunds in these areas may be less than 5 m AHD. As set out in Paragraph 44 above, my analysis shows that the crest level of the bund would vary from about 8 m AHD on the eastern side of the Site to 9 m AHD on the western side

86 From a flooding perspective, I do not consider the details of the precise location or height of any flood bunds are relevant (see Dr Martens' paragraph 29). The key issue (as demonstrated in the 2016 analysis by WMAwater), is that flood-proofing of the Site for a 1% AEP flood would not have any effect on flood levels in the vicinity of the Site. Accordingly, flood proofing of the Site would not adversely affect flood behaviour (Dr Martens' paragraph 30a).

87 The analysis in Paragraph 42 demonstrates that even without the proposed flood protection works, the majority of the Operational Area would be classified as having *'Low Hazard'* conditions at the peak of a 1% AEP flood. With the proposed flood protection works, the Operational Area would not be subject to flooding. Notwithstanding, I acknowledge that in floods greater than about 10%, flood conditions on the Access Road would be in the *'High Hazard'* category on account of the depth of water. For this reason the *Flood Evacuation Plan* provides for evacuation of the Site well in advance of any flood that might impede evacuation along the Access Road.

5.7 Conclusions Relating to Flooding

88 The analysis set out in Sections 5.1 to 5.5 above demonstrate that:

- previous flood modelling, including the modelling undertaken in relation to the 2006 Consent by Liverpool City Council adequately characterised pre-development flood conditions and any the impacts associated with the Development. This has been confirmed by the 2016 flood assessment by WMAwater (Appendix 4);
- the proposed flood levees and land levels on the Site following implementation of the measures set out in the RAP would provide effective flood immunity to the Site in the event of a 1% AEP;
- the measures necessary to provide flood immunity to the Operational Area for a 1% AEP flood would have no effect on flood levels in the vicinity of the Site;
- flood conditions in the vicinity of the Site in a 5% AEP flood would not be affected by the Development;
- the main consideration for a PMF would be ensuring no risk to life. The existing *Flood Evacuation Plan* adequately addresses this issue;
- the potential impacts on flood levels of sea level rise and rainfall intensity as a result of climate change have been fully considered;
- the existing *Flood Evacuation Plan* provides appropriate measures to evacuate the Site in advance of an impending flood.

6 Consideration of Matters Relating to Stormwater

89 Council's amended contention number 9 states:

There is insufficient information with respect to stormwater collection and its management for a proper assessment of the impacts of the Development to be undertaken.

90 Based on Council's contention, the subsequent particulars and Dr Martens' report, I consider the fundamental stormwater management issues for the Development relate to:

- Whether sufficient details have been provided to demonstrate the feasibility of the arrangement and concept design of the proposed stormwater system;
- Given the nature of the proposed use of the Site, whether appropriate analysis has been undertaken to demonstrate that the performance of the stormwater management system would provide appropriate control of the quality of any overflow discharge from the Site;
- The standard of water quality treatment that is required.

91 In order to provide a technical basis for consideration of these matters, Section 6.1 provides some background data for the water quality in the receiving environment (the Georges River) and the pollutant sources in a typical facility that carries out the same operations as those proposed for the Site.

92 Section 6.2 provides further details of the proposed stormwater facilities that reflect the matters arising from the joint conferencing in relation to leachate management and contamination and the consequent the minor amendments to the site layout as set out in the RAP and reflected in Paragraph 11.

93 Sections 6.3 to 6.8 provide my response to each of the particulars and the relevant matters raised in the expert report prepared by Dr Martens.

6.1 Stormwater and River Water Quality Characteristics

94 The particulars set out in Council's Amended Statement of Facts and Contentions and the views expressed in paragraphs 19 to 23 of Dr Martens' expert report are predicated on there being significant sources of pollutants of concern other than sediment. Accordingly, I have carried out further investigations to obtain relevant water quality data.

95 I have been provided with water quality data collected by Bankstown City Council at the following three locations in the Georges River:

- Garrison Point (4.0 km upstream of the Site);
- Raboul Road (3.4 km upstream of the Site);
- The Deepwater Motor Boat Club (1.9 km downstream of the Site).

The water quality data for these three sites are summarised in Appendix 5 and an overview provided in Table 2.

Table 2: Summary Statistics for Water Quality in the Georges River

Analyte	Units	Statistic	Garrison Point (2004-2006)	Rabaul Road (1997-2002)	Deepwater Motor Boat Club (1997-1999)	ANZECC Default Trigger Values for Ecosystem Protection in Estuaries
pH	pH unit	*Count*	*22*	*58*	*19*	
		Mean	7.39	7.18	7.57	7.0 - 8.5
		20%ile	7.21	6.73	7.15	
		80%ile	7.56	7.46	7.68	
Conductivity	µS/cm	*Count*	*17*	*55*	*20*	
		Mean	13,285	11,151	21,885	N/A
		20%ile	4,325	2,460	7,160	
		80%ile	20,772	17,920	32,740	
Total P	mg/L	*Count*	*22*	*61*	*25*	
		Mean	0.08	0.09	0.09	0.03
		20%ile	0.04	0.04	0.05	
		80%ile	0.12	0.12	0.11	
Total N	mg/L	*Count*		*60*	*24*	
		Mean		0.86	1.05	0.30
		20%ile		0.40	0.61	
		80%ile		1.31	1.63	
Turbidity	NTU	*Count*	*22*	*57*	*18*	
		Mean	28	27	80	0.5 - 10
		20%ile	0	2	11	
		80%ile	44	30	79	
Suspended Solids	mg/L	*Count*	*22*	*60*	*24*	
		Mean	32	16	17	N/A
		20%ile	13	7	8	
		80%ile	41	20	23	

96 Key features of the water quality data for the Georges River in Table 2 are:

- this reach of the river is tidal, as evidenced by the elevated salinity values;
- pH is within the range of ANZECC default trigger range for estuaries;
- Total nitrogen and total phosphorus significantly exceed the ANZECC default trigger values for estuaries;
- 20th percentile turbidity is generally within or close to ANZECC default trigger value for estuaries, but the mean and 80th percentile considerably exceed the default trigger value.

97 To address the issue of the stormwater water quality characteristics associated with a site that recycles demolition and construction waste, I have obtained copies of water quality monitoring data collected from the main storage dam at the Sustainable Resource Centre located at the corner of Hassall Street and Widemere Road, Wetherill Park. This water receives no pre-treatment before entering the dam. The main activity at the Sustainable Resource Centre comprises recycling of demolition and construction waste. Water samples were collected at two locations the dam in December 2015. I also requested Environmental

Investigation Services Pty Ltd to arrange for collection and laboratory analysis of an additional water sample from the site. A sample was collected on 10 August 2016 following 34.6 mm of rain since the beginning of the month.

98 Appendix 6 contains a summary table of the water quality samples collected from Sustainable Resource Centre. In summary, the data shows:

- pH averages 8.3 which is within the range specified in the ANZECC default trigger range for estuaries;
- Electrical conductivity is 727 µS/cm. The ANZECC default trigger values do not specify a limit for estuaries;
- Total nitrogen averages 1.7 mg/L, which is higher than the ANZECC default trigger value for estuaries (0.3 mg/L). The source of the nitrogen, normally associated with landscaping or organic wastes, is unknown;
- Only one analysis of total phosphorus was carried out. The concentration of 0.05 mg/L is above the ANZECC default trigger value for estuaries (0.03 mg/L). The source of the phosphorus is also unknown;
- All concentrations of metals, including heavy metals, are less than the ANZECC trigger values for 80% species protection in marine environments (no values are given for estuaries);
- Only two samples were analysed for oil and grease. These gave concentrations of 5 mg/L and 8 mg/L respectively.

99 On the basis of the water quality data summarised in Table 2 and Paragraph 98, the main stormwater quality issues for the Development, in order of priority, are:

- Suspended solids;
- Oil and grease;
- Nitrogen and phosphorus.

100 I acknowledge that the stormwater analysis set out in the 2013 *Water Management Report* focussed on suspended solids and hydrocarbons. Nevertheless I contend that the proposed stormwater 'treatment train' would also significantly reduce any nitrogen or phosphorus loads originating from the Development. I also consider that the stormwater modelling undertaken for the Operational Area is appropriate for the specific conditions.

6.2 Stormwater Management System

101 The important features of the proposed stormwater management system are described in Section 3.9 of the *Water Management Report* and illustrated schematically in Figure 9 and Figure 10 of the same report, including:

- Catchment areas and runoff characteristics of various surface types within the Operational Area;
- Capacity of the systems for collection and storage of stormwater, and discharge of overflow;
- Quantification of water requirements for Site operations (principally dust suppression) based on published relationship between water requirements and observed water usage at a comparable site.

102 As a result of the restriction on penetration of the landfill cap referred to in Paragraph 11.2 and related refinement of the Site grading, further consideration has been given to the layout and construction of the stormwater management system:

- Stormwater runoff will be directed to three stormwater collection sumps, each of which will have approximately equal contributing catchment area.
- The stormwater collection sumps will be constructed using inverted concrete box culvert sections which will be sealed between sections and surrounded by a HDPE liner. In turn the HDPE liner will be surrounded by compacted clay that conforms to the requirements for landfill capping.
- To ensure integrity of the landfill cap and the clay bund surrounding the landfill, the stormwater sumps will be located adjacent to the landfill clay bund. Accordingly, the clay surrounding the stormwater sumps will be continuous with the landfill bund. Figure 4 shows an indicative cross section of the southern stormwater sump and flood levee adjacent to the eastern leachate bund (at the location where the height of the leachate bund would be a maximum).

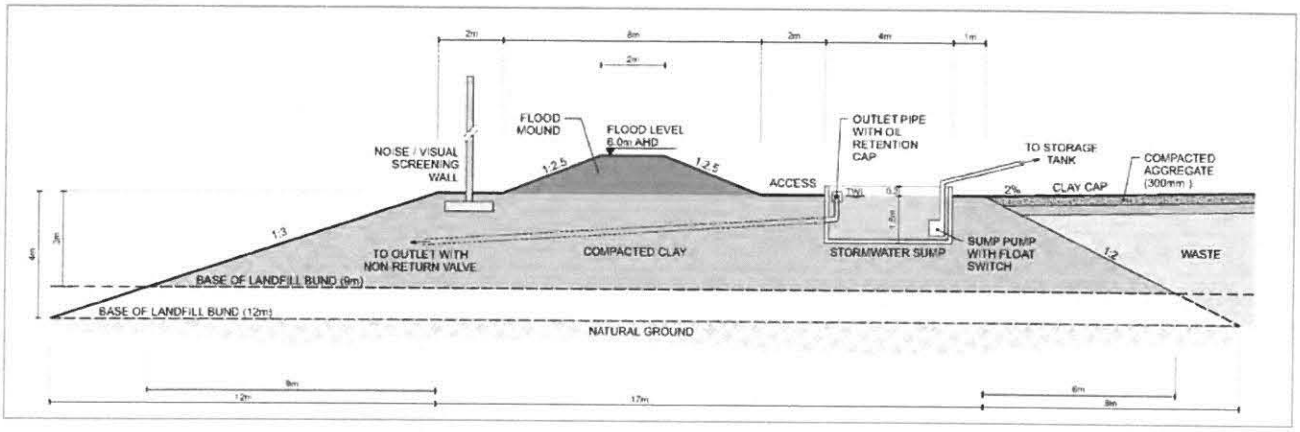

Figure 4: Indicative Arrangement for the Southern Stormwater Sump and Flood Levee Adjacent to the Eastern Leachate Bund

(Source: Remedial Action Plan, ERM (August 2016))

- Each stormwater collection sump will have internal dimensions of 3.6 m x 1.8 m x 45 m with the 15 m at the northern end constructed as a ramp to permit access by machinery for removal of collected sediment. Water level in each sump will be limited to 1.5 m by the inlet and outlet levels. The holding capacity of each sump before overflow occurs will be approximately 200 m^3 (equivalent to about 12 mm of runoff from the contributing catchment). The actual volume capable of being collected from any one rainfall event will be significantly greater than the volume of the sumps because the transfer pumps (to transfer water to the holding tanks) will start as soon as there is water in the sump.
- Inflow to each sump will occur at the northern end only in order to provide the maximum flow path length for settlement of coarse sediment.
- The inlet for the pumps to transfer water to holding tanks (1,000 m^3 for the three sumps) for reuse within the Site will be configured in a similar manner to the conceptual arrangement shown in Figure 9 in the *Water Management Report*. The transfer pumps will be controlled by a float switch.
- The overflow at the southern end of each sump will be configured in a similar manner to the conceptual arrangement shown in Figure 10 in the *Water Management Report*. Key features will include:

   - an inverted cap on the overflow to retain any floating hydrocarbons;
   - a non-return 'flap' on the outlet to prevent backflow into the site from floodwater.
- Scour protection will be provided at each outlet.
- Overflow from the sump on the western side of the Site will drain in a northerly direction along an existing drainage line before draining eastward along a drain that also conveys stormwater overflow from the Georges Fair development. The total travel distance between the outlet and the Georges River is about 600 m.
- Overflow from the two sumps on the eastern side of the Site will drain in a southerly direction to existing drainage depressions before draining into the Georges River near the southern boundary of the landfill area. The minimum travel distance between an outlet and the Georges River is about 450 m. It should be noted that the natural drainage between the landfill and the river drains in a direction approximately parallel to the river (not directly to the river as implied in paragraph 17d of Dr Martens' report).

103 Notwithstanding the refinements to the physical layout of the stormwater management system, the water re-use and pollution control performance would remain substantially the same as that set out in Section 3.5 of the *Water Management Report.*

6.3 Particular 9a

No water quality model, developed in accordance with current best practice and relevant guidelines, has been prepared to support the application. Current best practice having regard to the proposed use of the Site is to include an appropriate stormwater quality model which is capable of demonstrating that any discharges to the receiving environment will be of a suitable quality. The relevant guidelines include the Australian Runoff Quality, MUSIC Modelling Guidelines, the National Water Quality Management Strategy and any applicable planning instruments including Greater Metropolitan Regional Environmental Plan No 2- Georges River Catchment.

104 The key issues raised by this particular are:

- What is the appropriate model for assessing the quality of any discharge that drains to the Georges River?
- What are the appropriate water quality standards for any discharge that drains to the Georges River?

105 The publications *Australian Runoff Quality* and *MUSIC Modelling Guidelines* represent generally accepted approaches to the design of stormwater management for urban land development, largely for residential development. I am not aware of any published pollutant generation rates specifically applicable to recycling of demolition and construction waste and consider MUSIC does not provide an appropriate representation of the key processes, particularly stormwater capture and re-use that are important for this Development.

106 The proposed stormwater pollution control system is based on current 'best practice' in stormwater management involving a 'treatment train' approach. As set out in the *Water Management Report*, the treatment train involves:

- Capture of stormwater runoff for re-use within the Site (which accounts for over 70% of the runoff);
- Stormwater collection sumps that provide for sediment settlement and retention of any hydrocarbons prior to discharge of any overflow; and

- Overflow conveyance through a bio-retention swale or natural grass swales for further removal of sediment, nitrogen and phosphorus before discharge to the Georges River.

107 The capture and re-use of stormwater runoff is fundamental to the proposed water management system. Realistic representation of water re-use is a key factor which governs the proportion of site runoff that can be retained for re-use. For the water balance analysis presented in the *Water Management Report* the day-to-day variation in water required for dust suppression was modelled using an algorithm based on the work of Thompson and Visser (2002) that demonstrated a robust relationship between water requirements for dust suppression and the potential evaporation on the day, while taking into account any incident rainfall.

108 In the case of the proposed Development, the main source of water borne pollutants will be sediment resulting from the crushing of masonry. Accordingly, the stormwater control system for the Site has been based on the principles applied to sites where sediment control is the primary concern, such as urban land during the development stage, road construction, mines and quarries. The established guidelines for mines and quarries are set out in Volume 2E of *Managing Urban Stormwater: Soils & Construction* (DECC, 2008). Because these guidelines specifically address the control of sediment, they have been adopted for the Operational Area.

109 Council's contention 9a refers to the *National Water Quality Management Strategy* (NWQMS) but fails to identify which specific aspect(s) it considers relevant. The NQWMS is, in fact, a joint national approach to improving water quality in Australian and New Zealand waterways and includes 24 individual guidelines dealing with a wide range of water management issues. Council's contention in relation to the NWQMS is not sufficiently specific to provide a basis for a response.

110 Similarly, the *Greater Metropolitan Regional Environmental Plan No 2-Georges River Catchment* is a high level strategic planning document which provides general aims and objectives for management of the catchment. *Clause 9: Specific planning principles* requires that:

> *"When this Part applies, the following must be taken into account:*
> *...(5) Land degradation processes, such as:*
> *(a) erosion,*
> *(b) sedimentation,*
> *(c) deterioration of soil structure,*
> *(d) significant loss of native vegetation,*
> *(e) pollution of ground or surface water,*
> *(f) soil salinity and acidity, and*
> *(g) adverse effects on habitats and sensitive natural environments (aquatic and terrestrial) within the Catchment,*
> *must be avoided where possible, and minimised where avoidance is not possible."*

111 The stormwater management strategy for the Site and the modelling undertaken to demonstrate its performance have been specifically developed to address the stormwater management issues relevant to the Development. The performance of the water management system is consistent with the requirement to minimise erosion and sedimentation.

112 On the basis of the matters canvassed in Paragraphs 104 to 111 above, I consider that the stormwater management system and the supporting analysis are consistent with current best practice having regard to the proposed operations on the Site and includes an appropriate stormwater quality model that is specific to the features of the Site. The analysis has demonstrated that any discharge to the receiving environment will be of a suitable quality.

6.4 Particular 9b

There is insufficient information to be able to assess the management and potential impact of nutrients, salts, hydrocarbons, heavy metals and other relevant contaminants that are likely to reach the groundwater system or the Georges River and associated riparian zone. Any discharge of contaminated water from the site to the receiving environment should be in accordance with current best practice, which is to have a neutral or beneficial impact on the environment.

113 It is unclear whether this contention relates to drainage or infiltration of runoff from the Site into the groundwater or contamination as a result of drainage of leachate from within the landfill into the groundwater. Also, the basis on which Council has identified the pollutants of concern is not specified.

114 Notwithstanding the ambiguity of the contention, the paragraphs below address the issue of the pollutants that are likely to be present in stormwater runoff and the proposed treatment of stormwater runoff from the Site (to the extent it has not already been addressed above).

115 The data presented in Paragraphs 96 to 99 demonstrates that the list of potential pollutants listed in Council's particulars is speculative:

- Salts are not an issue because the Georges River is tidal and has elevated salinity levels and, also, runoff from demolition and construction waste does not have high salinity levels;
- Heavy metals are also not an issue because runoff from demolition and construction waste mainly has concentrations that are less than the detection limit or less than the ANZECC trigger values for 80% species protection in freshwater and marine ecosystems.

The data indicates that the stormwater runoff can be expected to contain a range of common stormwater pollutants. In my opinion these do not constitute "contaminants".

116 By way of background, I note that the Liverpool DCP 2008, Part 1, Section 6.4 includes the following requirements for stormwater discharge from development sites:

"The post development water quality shall be reduced to the following targets when compared to pre development water quality:
- *45% reduction in the mean annual load of total nitrogen.*
- *45% reduction in the mean annual load of total phosphorus.*
- *80% reduction in the mean annual load of total suspended solids."*

117 I consider the water quality objectives listed above to be reasonable and appropriate. However, they are inconsistent with the requirement for *'neutral or beneficial impact'* referenced in the last sentence of Particular 9b.

118 As noted in Paragraph 99, the main pollutants to be considered, in order of priority, are:

- Suspended solids;
- Oil and grease;
- Nitrogen and phosphorus.

119 The assessment of the performance of the stormwater management system has therefore been carried out with reference to the following two key reference documents relating to sediment control:

- *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004); and
- *Managing Urban Stormwater: Soils and Construction Volume 2E Mines and Quarries* (DECC, 2008).

120 The proposed stormwater management system described in the *Water Management Report* takes account of the possibility of hydrocarbon spillage. As illustrated in Figure 10 of the *Water Management Report*, any spillage of hydrocarbons would be captured by the cap arrangement on the top of the overflow pipe within each stormwater collection sump.

121 The stormwater model prepared specifically for this Site takes full account of the main stormwater pollution control process, namely the retention and recycling of stormwater runoff for dust control purposes. The capture and re-use of runoff will also have the effect of retaining any pollutants contained in the stormwater within the Site.

122 The results of the water balance model described in Section 3.5 of the Water Management Report demonstrate that the system would capture at least 70% of all pollutants. It would also achieve the sediment control efficiency required for a site with an operational life in excess of three years that drains to a sensitive environment, as set out in Table 6.1 in '*Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries*' (DECC, 2008).

6.5 Particular 9c

There has been no review of stormwater runoff impacts from crushed concrete, nor are there any proposed mitigation measures in place to control or minimise any impacts of high pH runoff.

123 The Sustainable Resource Centre at Wetherill Park carries out recycling of demolition and construction waste. Data in Paragraph 98 shows that the pH of stormwater that has not received any pre-treatment averages 8.3 and is within the range that would be suitable for discharge to the Georges River.

124 In the case of the proposed stormwater management system for the Development, overflow from the Site would only occur after a 'first flush' of runoff (at least 12 mm) had been captured in the stormwater sump. Any effects of elevated pH from crushed concrete would be diluted by this stage.

6.6 Particular 9d

The water quality management system relies on the outcomes of the Site water balance assessment. There is insufficient material to assess the risks to the receiving environment, which includes the environment that receives either groundwater or surface water discharges from the Site, during periods where there is limited demand for Site water. Further *information about water balance modelling assumptions and results, together with expected water quantity and quality released into the receiving environment is required.*

125 The measures described in Paragraph 102 will ensure that there is no risk of interchange between surface runoff and groundwater or leachate within the landfill. (Matters relating to management of leachate within the landfill and any groundwater risks are the subject of a separate report by the contamination consultant.)

126 The stormwater quality data collected at the at the Sustainable Resource Centre at Wetherill Park (see Paragraph 98) demonstrates that, even without any treatment, the water is not highly polluted.

127 The water balance analysis summarised in Table 7 of the *Water Management Report* shows that the proposed system would retain at least 70% of the runoff from the site together with the associated pollutants.

128 As noted in Paragraph 124 above, discharge from the Site would only occur after the capture of a minimum of 12 mm of runoff.

129 Full details of the basis for the water balance modelling including climate data, assumed runoff characteristics and water use for dust suppression are set out in Section 3.5 of the *Water Management Report*. Any 'overflow' of water that cannot be used on Site will be discharge into grass swales or a bio-retention swale before draining towards the Georges River. Annexure E of the *Water Management Report* sets out the basis for the assessment of the performance of these swales.

6.7 Particular 9e

There is insufficient material to assess the risk and likely consequences of the proposed stormwater collection sumps intercepting potentially contaminated groundwater and driving the generation of landfill leachate. The consequence of this risk on groundwater flow rates and quality has not been determined. There is insufficient information in relation to the construction and operation requirements of the stormwater sump system. Council notes that Dr Sophie Woods (the contamination expert for Moorebank Recyclers), in her Expert Contamination Report filed 6 June 2016, in section 4. 1 in response to Council's contention 10(d), agreed that "the position of the sumps above the landfill cap, and the sealing to prevent water infiltration into the cap was not clearly presented" and she relied on verbal information regarding the proposed design. In her assessment, Dr Woods has recommended particular details for the design of the sumps which are not reflected in the current design.

130 As noted in Paragraph 102 the stormwater collection sumps will be constructed using inverted concrete box culvert sections which will be sealed between sections and surrounded by a HDPE liner. In turn the HDPE liner will be surrounded by compacted clay that conforms to the requirements for landfill capping. To ensure integrity of the landfill cap and the clay bund surrounding the landfill, the stormwater sumps will be located adjacent to the landfill clay bund as illustrated in Figure 4. Accordingly, the clay surrounding the stormwater sumps will be continuous with the landfill bund.

131 The features of the stormwater sumps described above have been developed in consultation with Dr Woods and are documented in the RAP prepared by ERM. Accordingly, the issues raised in Particular 9e have been fully addressed.

6.8 Particular 9f

No information has been provided to identify how oil and water are to be separated. There is no information to enable an assessment of measures required to ensure that any oil contamination trapped in a sump is removed when required.

132 Figure 10 of the *Water Management Report* illustrates the outlet arrangements for retention of any hydrocarbons by means of a cap in the top of the overflow pipe that would allow water to overflow, but retain any floating oil. The same arrangement is illustrated in Figure 4 above (see Paragraph 102).

133 As described in Paragraph 102, each stormwater collection sump will have a ramp at the northern end to permit access by machinery for removal of collected sediment.

134 The site environmental management plan (to be prepared following consent for the Project) would include procedures for monitoring the sumps and removal of collected sediment. If hydrocarbons are observed, procedures for removal and disposal of sediment and associated hydrocarbons would be followed.

6.9 Specific Issues Raised by Dr Martens

135 For the sake of certainty regarding the proposed overflow outlet arrangements (paragraph 18c) of Dr Marten's report), I confirm that a non-return 'flap' valve would be placed on the stormwater outlet pipes to prevent the ingress of flood water.

136 I disagree with Dr Marten in relation to his paragraph 19b) in that the data presented in Appendix 6 and summarised in Paragraph 98 show that heavy metals are not present in stormwater runoff from a site which carries out recycling of demolition and construction waste.

137 I disagree with Dr Marten in relation to his paragraph 19c) concerning the merits of MUSIC to characterise the operation of the water management system compared to the adopted methodology which is widely used to assess the effectiveness of water and sediment control of sites where sediment is the primary pollutant of concern.

138 In Paragraph 99 I acknowledge that nitrogen and phosphorus need to be considered in addition to suspended solids and oil and grease that were specifically considered in the analysis in the *Water Management Report*. Nevertheless I contend that the proposed stormwater 'treatment train' would also reduce any nitrogen or phosphorus loads originating from the Development by at least 70% because of the proportion of water retained on site.

139 I note that a MUSIC model has been prepared under instructions from Dr Martens (paragraph 20 and 21 of his report). The diagram of the MUSIC model configuration in Attachment B to his report is difficult to read but appears to show the following features:

- the operational catchment areas are represented as 'unsealed roads';
- runoff from operational catchment areas is directed to sumps;
- water from the sumps drains to either grass swales or to a bio-retention swale before discharging to the river.

140 However, no details of the critical assumptions regarding runoff and pollutant generation characteristics are provided. (The modelling simply assumes that the runoff and pollutant

generation of 'unsealed roads' adequately reflects the variety of surfaces that would occur on the Site as set out in Table 6 of the *Water Management Report*.) The capacity of the sumps is not stated. From paragraph 20d) in Dr Martens' report I note that an arbitrary uniform 43.3 kL per day has been adopted for dust suppression water use. The use of a constant water re-use value misrepresents the variation of water use that would occur in practice and is one of the key limitations of a MUSIC model for operations such as those proposed.

141 For effective dust suppression, working surfaces and stockpiles need to be kept moist and, because the working surface will be well compacted, carry-over of moisture from day-to-day cannot be relied on. An analysis of the climate data used for the water balance analysis in the *Water Management Report* shows that the days when rain exceeds evaporation range from an average of 3.5 days in August to 7.5 days in May with an overall average of 6 days per month. This data shows that there would be relatively few days when water for dust suppression is not required. This reflects a key limitation of the MUSIC model which does not have the capability to realistically distribute water for dust suppression according to the requirements dictated by evaporation and rainfall.

142 On the basis of my comments in Paragraph 141 I disagree with Dr Martens' contention in paragraph 22a-iv) that the re-use of water for dust suppression cannot be relied on a day-to-day basis and, therefore, his 'Scenario 2' is more appropriate. 'Scenario 2' described by Dr Martens assumes no stormwater re-use and is therefore unrepresentative of site conditions. The results of this scenario (presented in Dr Martens' Table 2) are, at best, fictitious.

143 Notwithstanding the uncertainties and limitations of the MUSIC model developed under Dr Martens' instructions, I note that his 'Scenario 1' demonstrates that the Development would lead to a reduction in the annual loads of suspended solids, nitrogen and phosphorus.

144 On the basis of my observations in Paragraphs 139 to 142 I do not consider that the conclusions drawn by Dr Martens in his paragraphs 22 have any validity.

145 On this basis and matters set out in Sections 6.1 to 6.8, I consider D Martins is incorrect in relation to matters raised in his paragraph 23:

145.1 Paragraph 23a). The existing Access Road is unsealed (as shown in Dr Martens' MUSIC model) and drains into roadside drains that also convey runoff from the Georges Fair development. The road will be sealed and will therefore not be a significant source of pollutants that warrant treatment.

145.2 Paragraph 23b). Given the limitations of Dr Martens' MUSIC model, I do not consider it provides a reliable basis for his claim that the model (based on untested assumptions) *"demonstrates that the development has the capacity to generate a range of pollutants that may be discharged within stormwater released from the site"*. The fact that there would be a range of pollutants that would be discharged when an overflow occurs is not in dispute. However the range of pollutants considered in the existing MUSIC is only speculation.

145.3 Paragraph 23c). I consider the analysis in the Water Management Report contains sufficient detail to warrant project approval (subject to conditions). Nevertheless, the material provided in this report addresses Dr Marten's concerns.

145.4 Paragraph 23d). The mechanism for protection of back-flow into the site is consistent with Dr Martens' suggestion.

145.1 Paragraph 23e). I consider Dr Martens' suggestions in this paragraph to be excessive and not justified.

6.10 Conclusions in Relation to Stormwater

146 Based on Council's contention the subsequent particulars and Dr Martens' report, I consider that:

146.1 sufficient details have been provided to show the arrangement and concept design of the proposed stormwater system to demonstrate that it is feasible;

146.2 on the basis of the matters canvassed in Sections 6.1 to 6.8 above, I consider that the stormwater management system and the supporting analysis are consistent with current best practice having regard to the proposed operations on the Site The analysis is based on an appropriate stormwater quality model that is specific to the features of the site and has demonstrated that any discharge to the receiving environment will be of a suitable quality. Although nitrogen and phosphorus were not specifically modelled, the retention of 70% of site runoff for dust suppression purposes would capture 70% of any nitrogen and phosphorus. In addition, any overflow would be subject to further treatment in the bio-retention or vegetated swales.

146.2 the proposed 'treatment train' for treatment of stormwater is consistent with current 'best practice and would provide a suitable standard of treatment for water that eventually discharges to Georges River.

7 Sources of Information and References

147 In preparing this report, I have relied on information related specifically to the Site taken from the reports and documents listed in Section 7.1. Other supporting technical references are listed in Section 7.2 below.

7.1 Sources of Information

Asher McNeil (14/3/05). *Design Levels, Lot 6 DP106554, Newbridge Road, Moorebank Drawing 9226-02.*

Asher McNeil (2005). *Earthworks Approval Plan #1 Drawing 9226-02.*

Asher McNeil (14/3/05). *Perimeter Mounding, Lot 6 DP106554, Newbridge Road, Moorebank Drawing 9226-03.*

Asher Consulting (18/5/05). *Flood Levels, Lot 1 DP336613, Newbridge Road, Moorebank Drawing 9226flood01.*

Cardno (2013), *Report on Ramp Access to Moorebank Recyclers Pty Ltd*

Environmental Resource Management (2016), *Proposed Materials Recycling Facility, Newbridge Road, Moorebank, NSW: Remedial Action Plan*

Evans & Peck (August 2013). *Water Management and Pollution Control Assessment.* (the *Water Management Report*). Attachment 14 to the Preferred Project Report.

Jackaman, Andrew (17 August 2016). Expert geotechnical opinion.

Jeffery and Katauskas Pty Ltd (October 2010). *Geotechnical Investigation for Proposed Earthworks for New Development at Lot 6, DP 1065574 Newbridge Road, Moorebank, NSW.*

Liverpool City Council (27 June 2006). DA-1417/05 Development Consent for Bulk Earthworks at Lot 6, DP 1065574, Newbridge Road, Moorebank.

Lyle Marshall & Associates Pty Ltd (2013). *Reduced copies of amended site layout plans.* Attachment 15 to the Preferred Project Report.

Martens D (2016), *Land and Environment Court proceedings 159652 and 157848 of 2016: Drainage and Flooding Expert Report,* 5 August 2016

Nexus Environmental Planning (February 2013). *Environmental Assessment - Materials Recycling Facility, Newbridge Road, Moorebank.* Prepared on behalf of Concrete Recyclers.

Nexus Environmental Planning (August 2013). *Preferred Project Report - Materials Recycling Facility, Newbridge Road, Moorebank.* Prepared on behalf of Concrete Recyclers.

Planning Assessment Commission (September, 2013). *Determination Report – Resource Recovery Facility, Moorebank (05-0157).*

WMAwater (2013). *Moorebank Recyclers: Proposed Works – Flood Impact Assessment.* Annexure C to the Water Management Report (Attachment 14 to the Preferred Project Report).

WMAwater (2016). *Moorebank Recyclers – Flood Impact Assessment.*

7.2 References

Australian Government Water Efficiency Labelling and Standards (WELS) scheme website http://www.waterrating.gov.au/consumers/water-efficiency. Accessed 16 August 2016.

Australian and New Zealand Environment and Conservation Council (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (1998). *National Water Quality Management Strategy (NWQMS) National Water Quality Management Strategy: Implementation guidelines.*

Bewsher Consulting Pty Ltd (1999), *Georges River Model Study*, Prepared for Liverpool City Council

BMT WBM Pty Ltd (August 2010). *Draft NSW MUSIC Modelling Guidelines.*

CSIRO (2015). *Climate Change in Australia, East Coast Cluster Report, Projections for Australia's NRM Regions.*

Engineers Australia (2006). *Australian Runoff Quality Australian Runoff Quality: A Guide to Water Sensitive Urban Design.*

Greater Metropolitan Regional Environmental Plan No 2-Georges River Catchment

Landcom (2004). *Managing Urban Stormwater: Soils and Construction - Volume 1.*

Liverpool City Council (June 2016). *Development Control Plan 2008. Part 1 General Controls for all Development.*

Liverpool City Council (July 2002). *Development Control Plan 47. Domestic On-Site Sewage Management.*

NSW Department of Environment and Conservation (2006). *Using the ANZECC Guidelines and Water Quality Objectives in NSW.*

NSW Department of Environment and Climate Change (2008). *Managing Urban Stormwater: Soils and Construction – Volume 2B: Waste Landfills.*

NSW Department of Environment and Climate Change (2008). *Managing Urban Stormwater: Soils and Construction – Volume 2E: Mines and quarries.*

NSW Environmental Protection Authority (2016). *Environmental Guidelines, Solid Waste Landfills, Second Edition.*

NSW Government (2005). *Floodplain Development Manual.* Department of Infrastructure, Planning and Natural Resources.

NSW SES. Business Floodsafe Toolkit. http://www.ses.nsw.gov.au/communitysafety/floodsafe/bus-floodsafe/about

SLR (June 2012). *Climate Change Risk Assessment.* Report prepared by for Liverpool Council.

Thompson and Visser (2002), *Benchmarking and management of fugitive dust emissions from surface mine haul roads*, Trans. Inst. Min. Metal. V110, SA, A28 –A34.

Appendix 1

Letter of Instruction

MARK MCDONALD & ASSOCIATES
LAWYERS PTY LTD
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MARK MCDONALD-DIRECTOR
Town Planning & Environment Lawyer
Accredited Specialist Local Government & Planning Law

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17 August 2016

Dr Steve Perrens
Advisian
Level 17
141 Walker Street
NORTH SYDNEY
NSW 2060

By Email

Dear Sir

MOOREBANK RECYCLERS PTY LTD ATS LIVERPOOL CITY COUNCIL & ORS; LAND AND ENVIRONMENT COURT PROCEEDINGS 2016/159652 & 2016/157848

I refer to the above proceedings.

I am instructed by Moorebank Recyclers Pty Ltd (**Moorebank**) in respect of the above proceedings.

I am instructed to retain you to prepare an expert report in the above proceedings.

I note that my firm has previously provided you with a copy of documents, including:

1. Division 2 of Part 31 of the Uniform Civil Procedure Rules 2005 (**UCPR**);

2. The Expert Witness Code of Conduct at Schedule 7 of the UCPR;

3. The amended Statement of Facts and Contentions filed on behalf of Liverpool City Council (**Council**) in the above proceedings (**Council SOFAC**);

4. The amended Statement of Facts and Contentions filed on behalf of Benedict Industries Pty Ltd and Tanlane Pty Ltd (**Benedict**) in the above proceedings (**Benedict SOFAC**); and

5. The expert report of Dr Daniel Martens dated 5 August 2016 (**Martens Report**) which has been filed on behalf of the Council in the above proceedings.

You report should:

(a) respond to the contentions in the Council SOFAC in respect of sewage management, flooding and storm water collection (see paragraphs 2, 8 and 9 of Part B of the contentions);

(b) respond to the contentions in respect of flooding and storm water collection at paragraphs 10 and 11 in Part B of the Benedict SOFAC; and

(c) respond to the matters identified in the Martens Report.

Yours faithfully

Mark McDonald

Mark McDonald
Townplanning & Environment Lawyer
Acc. Spec. (Loc. Govt. & Plan. Law)

Appendix 2

Curriculum Vitae – Dr Stephen Perrens

Advisian

WorleyParsons Group

Dr Steve Perrens

Specialist Advisor

Overview

Dr Perrens is an environmental engineer with over 40 years' experience in consulting and applied research related to water resource assessment, engineering hydrology and natural resource management. In particular, Steve has extensive experience in stormwater management and pollution control. Steve has consulting experience throughout Australia and has extensive overseas experience, particularly in Southeast Asia, including assignments for United Nations and other international agencies.

He has managed a range of major projects including the design of water resource systems for irrigation, water supply and power generation; integrated water servicing strategies for urban development, land rehabilitation for mines, quarries, landfills and industrial sites; integrated land and water management in urban and rural settings; stormwater quality control and effluent disposal; urban and rural floodplain management; environmental impact assessment and environmental management for industrial and mining projects.

Steve is a recognised expert in a wide range of aspects of water resources, catchment management and pollution control. He has undertaken technical peer reviews of development projects on behalf of the NSW Planning Assessment Commission and the NSW Department of Planning & Environment. He has also prepared and given evidence in the District Court, Supreme Court and Land & Environment Court and has presented evidence to Commissions of Inquiry.

Areas of Expertise

- Floodplain management
- Stormwater pollution control
- Effluent treatment and disposal
- Water resources and catchment management
- Environmental water management
- Environmental risk assessment and management
- Environmental approvals and audit
- Irrigation and drainage
- Project planning and delivery
- Expert evidence

Examples of Relevant Experience

Effluent Treatment and Disposal

- Water management and on-site effluent treatment and disposal, wholesale flower nursery, Maroota
- Court appointed expert: effluent disposal for proposed recreation facility, Maroota
- On-site sewage treatment and disposal system for proposed cabin development, Berry
- On-site sewage treatment and effluent re-use system for proposed youth camp, Nowra
- Best Practice Effluent Irrigation Guidelines - Meat & Livestock Australia
- Stormwater Pollution Control Manual - Meat & Livestock Australia
- Water cycle management and effluent re-use strategy, urban release area Western Sydney
- Stormwater pollution control and effluent disposal, proposed residential development, Cambewarra
- Effluent treatment and disposal: proposed meat processing facility, Western Sydney
- Assessment of effectiveness of buffer strips for pollution control, Meat & Livestock Australia
- Effluent re-use strategy for Ballarat North Sewage Treatment Plant
- Environmental management plan for sewage treatment plant and effluent re-use, Corindi
- System design: revised effluent re-use scheme for Cowra abattoir
- Effluent re-use scheme for Milton abattoir

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- Environmental management plan for sewage treatment and effluent re-use, Marulan
- System performance analysis for effluent re-use scheme Gerringong/Gerroa
- Soil and groundwater assessment, and effluent disposal review, Casino Abattoir
- Concept and detailed design, McGraths Hill wetland and effluent reuse project
- Efluent recycling system design and operation, Picton Sewerage Scheme
- Feasibility assessment, wetland polishing for sewage effluent, Gerringong/Gerroa
- Wetland concept design for polishing of sewage effluent, Nowra
- Abattoir Effluent Re-use Manual for Australian Meat Research Corporation.
- Effluent re-use system and environmental management plan for export abattoir, Cooma
- Runoff capture, treatment, storage and re-use for proposed 50,000 head feedlot, St George
- Assessment of the volume and reliability of water supply for proposed feedlot, northern NSW
- Review of NSW EPA draft guidelines for reuse of effluent for Australian Meat Research Corporation

Stormwater Management and Pollution Control:
Recycling and Waste Management Sites

- Best practice guidelines for erosion and sediment control on landfill sites for Department of Environment & Conservation
- Stormwater recycling and pollution control, construction waste recycling facility, Camellia
- Stormwater recycling and pollution control for concrete recycling depot, McGraths Hill
- Water Management Plan, building waste recycling facility, Bays Park
- Sediment control guidelines for expansion of Buttonderry Waste Management Facility, Wyong
- Stormwater management and pollution control, plastics recycling facility, Wetherill Park
- Water recycling and pollution control system, metals recycling facility, Blacktown
- Water recycling and pollution control, green waste composting facility, Cooranbong
- Surface water management and re-use plan, organic waste recycling facility, Tumut
- Effluent recycling and pollution control for green waste composting facility, Wyong
- Effluent recycling and pollution control for green waste recycling depot, Hornsby
- Stormwater recycling and pollution control system, metals recycling facility, Blacktown
- Stormwater management plan - horticultural products facility, Terrey Hills
- Rainwater and stormwater recycling scheme: Eden Gardens Nursery
- Environmental management plan, garden products centre, Terrey Hills
- Stormwater reuse and pollution control: green waste recycling depot, Hornsby
- Water management for expansion of green waste recycling facility, Eastern Creek
- Surface water management plan, organic waste recycling facility, Tumut
- Leachate storage and disposal strategy, Buttonderry Waste Management Facility, Wyong
- Stormwater treatment facilities, Lucas Heights waste management centre
- Effluent recycling and pollution control for green waste composting facility, Wyong
- Effluent recycling and pollution control for green waste recycling depot, Hornsby
- Stormwater recycling and pollution control system, metals recycling facility, Blacktown
- Stormwater management and pollution control – waste recycling facility, South Strathfield
- Water management and pollution control, waste composting facility – southern NSW
- Surface water management plan: Regional waste facility, Molong
- Flood management and stormwater recycling for waste processing facility, Eastern Creek WMC
- Stormwater management plan, organic waste recycling facility, Browns Creek
- Assessment of final landform and drainage, Castlereagh Toxic Waste Management Centre

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- Landform and surface drainage design, Awaba Waste Management Centre, Lake Macquarie
- Surface water management and landform development concept, Lucas Heights Waste Management Centre
- Surface Water Management Plan, Awaba Waste Management Centre, Lake Macquarie
- Landfill Environmental Management Plan, Castlereagh Toxic Waste Management Centre
- Closure Management Plan, Castlereagh Toxic Waste Management Centre
- Surface water management strategy, Eastern Creek Waste Management Centre
- Surface water management strategy, Belrose Waste Management Centre.
- Design of stormwater treatment facilities, Lucas Heights Waste Management Centre
- Stormwater recycling and pollution control for green waste composting facility, Wyong
- Stormwater recycling and pollution control for green waste recycling depot, Hornsby
- Design of stormwater pollution control facilities, Castlereagh Waste Management Centre
- Surface water quality management strategy, Lucas Heights Waste Management Centre
- Water management and pollution control facilities for waste transfer depot, St Marys
- Water management and pollution control facilities for waste transfer depot, Blacktown
- Water management for expansion of green waste recycling facility, Eastern Creek Waste Management Centre

Erosion and Sediment Control

- Erosion and sediment control plan, Buttonderry Landfill
- Audit of erosion and sediment control: Bateau Bay landfill
- Assessment of sediment basin performance – RTA and DECC
- Erosion and sediment control on landfill sites – Chapter for DECC best practice manual
- Review of erosion and sediment control: Bateau Bay landfill
- Soil and water management plan: Bickham mine
- Soil and water management plan: Caves Beachside development
- Soil and water management plan: Pipeworks Estate, Woodcroft
- Soil and water management plan: Tathra River Estate
- Soil and water management plan: St Patrick's Estate, Manly.
- Stormwater drainage and pollution control: Byles Creek, Pennant Hills
- Soil and water management plan: Bay & Basin Leisure Centre
- Soil and water management plan: Mt Gilead Estate, Camden
- Soil and water management plan: Kilbride Estate, Camden
- Water management plan, Dunmore Quarry
- Surface water assessment and management plan, Calga Quarry
- Water management plan, East Guyong Quarry
- Water management plan, Penrose Quarry
- Surface water management, sand quarry, Peats Ridge
- Surface water management, sand quarry, Kulnura
- Surface water management, hard rock quarry, Basalt Hill
- Erosion and sediment control plan: Castlereagh landfill
- Erosion and sediment control plan: Eastern Creek landfill
- Erosion and sediment control plan: Belrose landfill
- Erosion and sediment control plan: Awaba landfill
- Erosion and sediment control plan: Buttonderry landfill

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- Erosion and sediment control plan: Jacks Gully landfill

Floodplain Management

- Review of flooding and evacuation issues: Lakes Estate, Coffs Harbour - NSW DP&I
- Review of flooding and evacuation: proposed Tallawarra land development - NSW DP&I
- Review of flooding and evacuation: proposed Shepherds Bay development - NSW DP&I
- Review of flooding and evacuation: proposed development Church Street, Parramatta - NSW DP&I
- Review of flooding and drainage issues: Allied Mills site - NSW DP&I
- Impact of filling for residential development on flooding, Bungendore
- Flood modelling expert review, Mandalong Valley
- Flood Study, Crooked River, Gerroa
- Warrah Creek Floodplain Management Plan, upper Namoi valley
- Blackville Floodplain Management Plan, upper Namoi valley
- Expert evidence - design standards: Nyngan Levee prior to the 1990 flood
- Flood risk and evacuation strategy: Moruya East Village
- Revision and up-date of Wellington Floodplain Management Plan
- Revision and update of Austral Floodplain Management Plan
- Flood effects of February 2008 storm: Shell Cove
- Flood assessment: Crooked River Golf Course
- Options assessment, proposed Murrurundi levee
- Stormwater drainage and flood mitigation strategy, South Sydney LGA
- Floodplain Management Plan, North Wentworthville
- Flood study and floodplain management plan for Murrurundi, Willowtree and Blandford
- Newell Highway flood risk assessment – West Wyalong to Forbes
- Eugowra Floodplain Management Study and Plan
- Austral drainage strategy study for Liverpool City Council
- Gilgandra Floodplain Management Study and Plan
- Armidale Floodplain Management Study and Plan
- Wellington Floodplain Management Study and Plan
- Review of Cabramatta Creek hydrologic and flooding studies
- Flood damages and mitigation options: Lake Burley Griffin

Qualifications

- Ph.D. (Physics of Infiltration and Sub-surface Flow), University of NSW, 1977
- M.Eng.Sci. (Water Engineering), University of NSW, 1970
- National College of Agricultural Engineering (UK) (Hons 1 and Gold Medal), 1966

Awards

- Fulbright Senior Fellowship (US National Soil Erosion Laboratory), 1984
- University of NSW PhD Scholarship, 1970
- Ford Foundation Travel Scholarship (East Africa), 1965

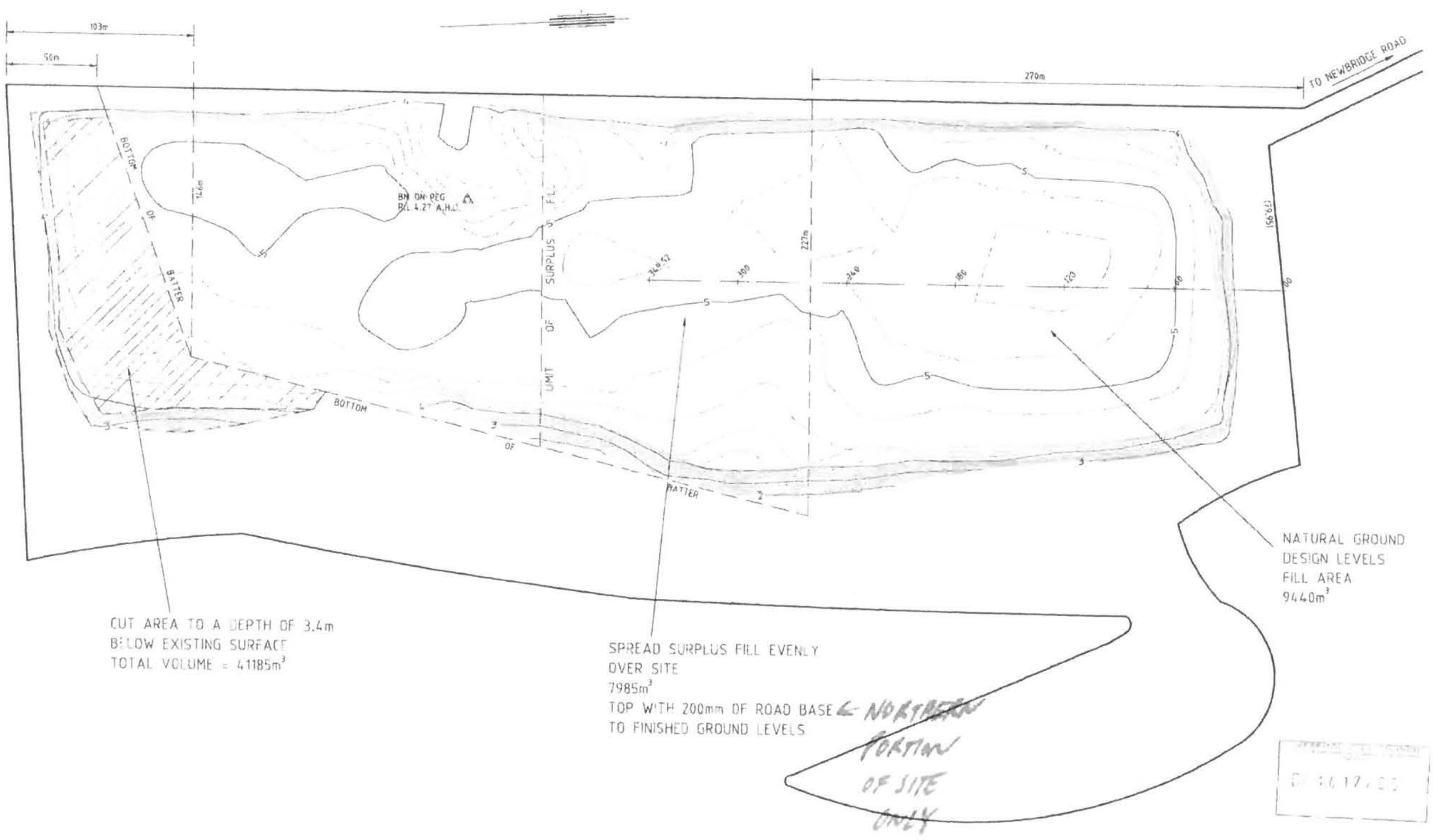
Technical Publications

Two book chapters, 11 monographs and 67 technical papers on aspects of environmental engineering and natural resource management.

Appendix 3

Plans Extracted from DA 1714/05

A2



REV.	AMENDMENT		DATE	CHEC

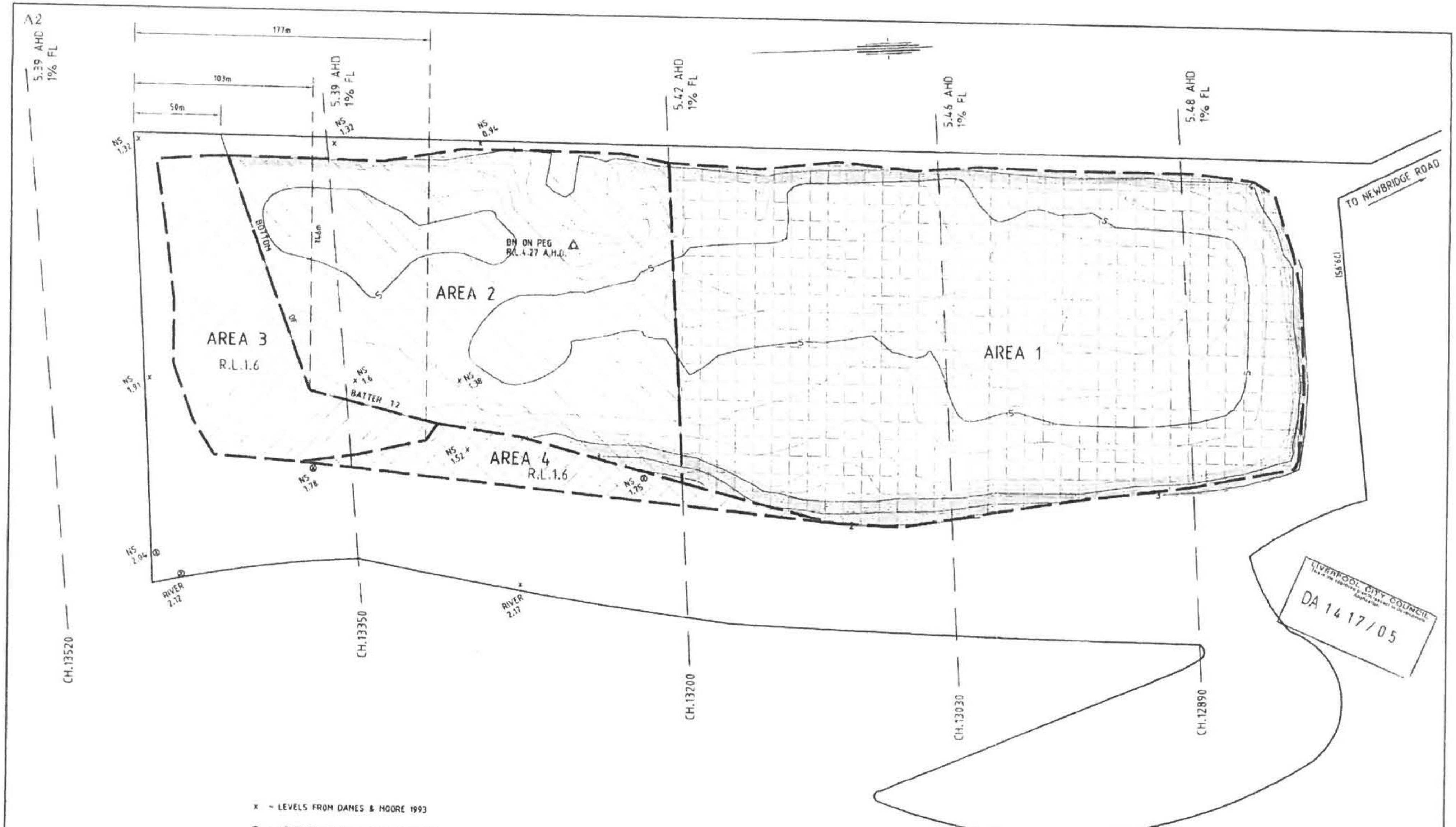
ASHER McNEILL & PARTNERS PTY. LTD.
A.B.N. 91 056 502 955
CONSULTING SURVEYORS
P.O. BOX 1455, PARRAMATTA 2124
TELEPHONE: (02) 9635 5411
FAX: (02) 9635 5237

• PROJECT MANAGEMENT • SUBDIVISION PLANNING
• ROAD & DRAINAGE DESIGN • LAND & ENGINEERING SURVEYS
• STRATA & COMMUNITY TITLE SUBDIVISIONS • PCA SURVEYS

TITLE
DESIGN LEVELS Lot 6
~~LOT 1 D.P.336613~~ DP1065074
NEWBRIDGE ROAD
MOOREBANK

REDUCTION RATIO		DATE	
1:1500		14/3/05	
DRAWING No.		JOB No.	
9226-02		9226	
DATUM A.H.D.	DRAWN BY DB	CHECKED BY	APPROVED BY
SHEET 2	DATE 14/3/05	DATE	DATE

A2



x ~ LEVELS FROM DAMES & MOORE 1993

⊗ ~ ASHER CONSULTING SPOT LEVELS 2003

NS ~ NATURAL SURFACE (PRIOR TO FILLING)

0 15 30 60 90 150m

1 : 1500

ASHER McNEILL & PARTNERS PTY. LTD.
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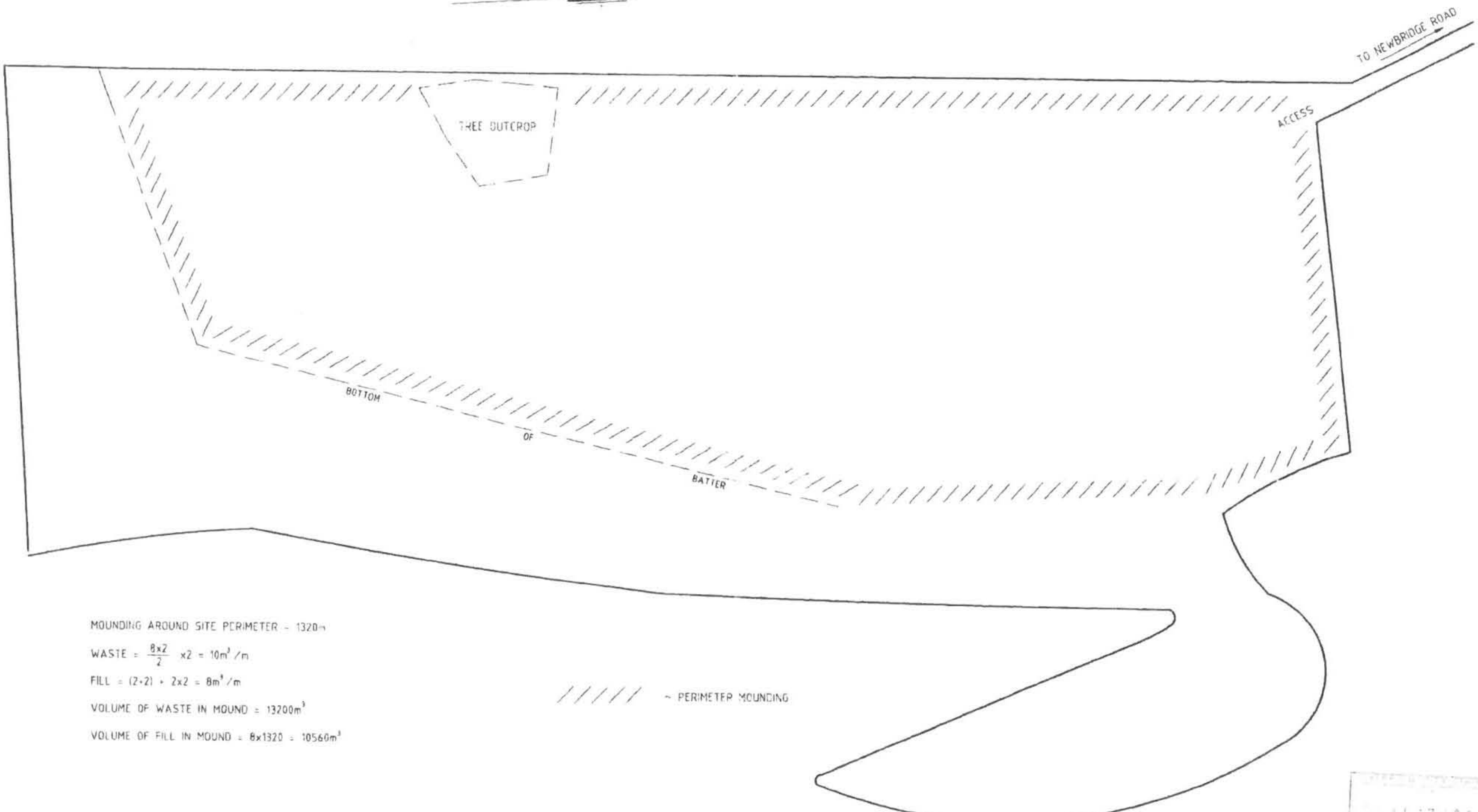
- PROJECT MANAGEMENT - SUBDIVISION PLANNING
- ROAD & DRAINAGE DESIGN - LAND & ENGINEERING SURVEYS
- STRATA & COMMUNITY TITLE SUBDIVISIONS - PCA SURVEYS

TITLE:
FLOOD LEVELS
LOT 1 D.P.336613
NEWBRIDGE ROAD
MOOREBANK

REV.	AMENDMENT	DATE	CHEC.
B	AMENDED	22.8.05	
A	AMENDED	21.7.05	

REDUCTION RATIO: 1:1500		DATE: 18/5/05	
DRAWING No.: 9226flood01		JOB No.: 9226	
DATUM: A.H.D.	DRAWN BY: DB	CHECKED BY:	APPROVED BY:
SHEET:	DATE: 18/5/05	DATE:	DATE:

A2



MOUNDING AROUND SITE PERIMETER = 1320m

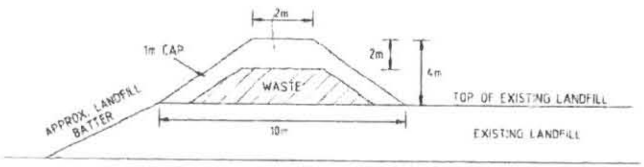
WASTE = $\frac{8 \times 2}{2} \times 2 = 10m^3/m$

FILL = $(2 \cdot 2) + 2 \times 2 = 8m^3/m$

VOLUME OF WASTE IN MOUND = $13200m^3$

VOLUME OF FILL IN MOUND = $8 \times 1320 = 10560m^3$

/ / / / / ~ PERIMETER MOUNDING



PERIMETER MOUND SECTION

NOT TO SCALE

ASHER McNEILL & PARTNERS PTY. LTD.
A.B.N. 91 056 502 955
CONSULTING SURVEYORS
P.O. BOX 1455, PARRAMATTA 2124
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- PROJECT MANAGEMENT - SUBDIVISION PLANNING
- ROAD & DRAINAGE DESIGN - LAND & ENGINEERING SURVEYS
- STRATA & COMMUNITY TITLE SUBDIVISIONS - PCA SURVEYS

TITLE:
PERIMETER MOUNDING LOT6
~~LOT 1 D.P.336613~~ DP1065574
NEWBRIDGE ROAD
MOOREBANK

REV.	AMENDMENT	DATE	CHEC.

REDUCTION RATIO: 1:1500		DATE: 14/3/05		
DRAWING No. 9226-03		JOB No. 9226		
DATUM: A.H.D.	DRAWN BY: DB	CHECKED BY:	APPROVED BY:	
SHEET: 3	DATE: 14/3/05	DATE:	DATE:	

Appendix 4

Moorebank Recyclers – Flood Impact Assessment (2016)

Level 2, 160 Clarence Street
Sydney, NSW, 2000

Tel: (02) 9299 2855
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Email: wma@wmawater.com.au
Web: www.wmawater.com.au

MOOREBANK RECYCLERS FLOOD IMPACT ASSESSMENT

FINAL REPORT

AUGUST 2016

Project Moorebank Recyclers Flood Impact Assessment	**Project Number** **116061**
Client Moorebank Recyclers Pty Ltd	**Client's Representative** Mark McDonald
Authors Catherine Goonan	**Prepared by**
Date 17 August 2016	**Verified by**

Revision	Description	Distribution	Date
3			
2			
1	Final Report	Mark McDonald	Aug 2016

MOOREBANK RECYCLERS FLOOD IMPACT ASSESSMENT

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1. INTRODUCTION

Moorebank Recyclers Pty Ltd propose to develop a materials recycling facility on the western floodplain of the Georges River immediately downstream of Newbridge Road, Moorebank. The site location is shown in Figure 1.

WMAwater has primarily been engaged by Advisian to carry out flood impact assessment work for various potential earthworks at the subject site. Additionally WMAwater has been asked to provide information relevant to Item 98 Point d) of the Land and Environment Court Amended Statement of Facts and Contentions (SOFAC), 29 July 2016. With respect to the SOFAC, WMAwater have specifically been asked to provide information in regard to flood level sensitivity to sea level rise and to provide further background on the modelling tools used in flood modelling work. Broadly WMAwater's report is ancillary to the report provided by Dr Steve Perrens (Perrens, 2016).

1.1. WMAwater's Qualifications

WMAwater are a specialist water engineering consultancy with over thirty years' experience in flood investigations, and have completed numerous Flood Studies and Floodplain Management Studies throughout NSW. As a result we have developed a high level of in-house expertise in hydrologic and hydraulic modelling as well as considerable experience in floodplain management and mitigation modelling.

Steve Gray, the author of this report, has twenty years' experience in the industry, post graduate qualifications in 2D modelling and has previously worked on various matters before the Land and Environment Court. A copy of his CV is attached in Appendix C.

2. BACKGROUND

2.1. Existing Flood Regime at Subject Site

The subject site is entirely flooded by the 1% AEP from the Georges River and the corresponding flood extent for the existing case is shown in Figure 1 The 1% AEP peak flood level reaches 5.50 mAHD around the study site. The site lies within the Liverpool City Council (LCC) LGA.

2.2. Models Utilised in the Assessment

2.2.1. Hydrology

The hydrograph for the 1% AEP Georges River flood event was obtained from the 1999 Georges River Model Study (Bewsher, 1999) and is applied approximately 3 km upstream of the site.

2.2.2. Hydraulic Models

Impact Assessment

The model used for impact assessment is a TUFLOW model. This model has been developed based on the existing SOBEK model that has been used for previous work on the site (and other proximate sites which have also been before LCC for assessment). Appendix B presents further information in regard to the model utilised for the impact assessment work.

Sea Level Rise Assessment

The model used to examine the subject site's sensitivity to sea level rise predictions is the 1999 Mike11 model developed by Bewsher on behalf of LCC (Bewsher, 1999). Appendix B presents further information in regard to the model utilised for the sea level rise sensitivity work.

3. METHODOLOGY

3.1. Development Impacts

A 2D flood model has been used to quantify the flood impact of the proposed earthworks. This model is further described in Appendix B. Flood impacts are calculated by subtracting base case results from the "proposed development" scenario and the difference is presented as an impact map.

The base case adopted for this analysis includes the detailed drawings of ground level contours from "Earthworks Approval Plan #1' - a plan prepared by Asher McNeil in 2005 (Drawing 9226-02).

The flood impact assessment consists of three scenarios listed in Table 1. The proposed site plan with area zones is shown in Figure 1.

Table 1 Proposed Development Scenarios

Scenario	Development Description
A	Area 1: bounded by mounds (East, West and North), with access ramps to connect to Brickmakers Drive Areas 2, 3 & 4: At existing level
B	Area 1: bounded by mounds (East, West and North), with access ramps to connect to Brickmakers Drive Area 2: at existing level Area 3 & Area 4: excavated to 1.6 m AHD
C	Area 1: bounded by mounds (East, West and North), with access ramps to connect to Brickmakers Drive Areas 2, 3 & 4: Protected from 1% AEP flood either by raising (filling) to 10 m AHD

3.2. Sea Level Rise

Whilst the localised 2D model was used to assess flood impacts for the site, this model was not suitable for examining the site's sensitivity to sea level rise. The deficiency in this case with the localised 2D model is that it extends only 2 kilometres downstream of the M5 instead of to Botany Bay as is required.

A model with a domain which included the subject site and the downstream Botany Bay was required for the assessment. The only model that currently exists which is suitable is the 1999 Mike11 model as referred to in Section 1.2.2 and further described in Appendix B. The Mike11 model (Bewsher, 1999) was used to investigate the site's sensitivity to sea level rise. For testing purposes a sea level rise value of 0.41 m was used.

4. RESULTS

4.1. Development Scenarios

4.1.1. Scenario A

Figure 3 shows peak flood impacts for the 1% AEP event from the proposed development with the mound being built around "Area 1" (Scenario A). All the impacts in the vicinity of the site are within the standard applied tolerance of 0.01 m. "Area 1" is no longer flooded due to the high mound.

4.1.2. Scenario B

Figure 4 shows peak flood impacts for the 1% AEP event from the proposed development with the mound being built around "Area 1", and "Area 3" and "Area 4" being excavated to 1.6 m AHD (Scenario B). The impacts are almost identical to those of Scenario A.

4.1.3. Scenario C

Figure 5 shows peak flood impacts for the 1% AEP event from the proposed development with the mound being built around "Area 1", and "Area 2", "Area 3" and "Area 4" being raised above the peak flood level of the 1% AEP event. The modelled impacts are almost identical to those of Scenario A.

The proposed ramp is no longer flooded in all three proposed scenarios due to the raised elevation. All the impacts in the vicinity of the ramp are negligible.

4.2. Sea Level Rise and Climate Change

The sea level rise runs indicated a peak flood level that was 0.05 m higher at the subject site than for the standard 1% AEP design run (see Figure 6). This indicates that the subject site is relatively insensitive to sea level rise and certainly it is anticipated that this negligible change to design flood levels would not affect the flood impact of proposed works.

4.3. Design Flood Events Assessed

This investigation has assessed the impacts of development and climate change scenarios for the 1% AEP design flood event, as this is the standard compliance event as per Council's DCP and as is consistent with standard practice and the NSW Floodplain Development Manual (NSW Gov., 2005).

5. CONCLUSION

WMAwater has completed a flood impact assessment for proposed development scenarios at the Moorebank Recyclers site. The impact has been assessed for the Georges River 1% AEP event.

The Georges River 1% AEP event will have a peak flood level of approximately 5.50 m AHD around the subject site. The impact of the proposed works on this flood level (which is used to inform floor levels of adjoining developments) is nil. These proposed works assessed for flood impact herein then do not impact on design flood levels. An assessment of sea level rise due to climate change was also conducted, and results showed that the site's distance from Botany Bay meant on-site flood levels were increased by 0.05 m given an increase in sea level of 0.41 m.

6. REFERENCES

NSW Government, **Floodplain Development Manual,** 2005

Bewsher Consulting Pty Ltd, **Georges River Model Study,**1999

Department of Environment, Climate Change and Water NSW, **NSW Sea Level Rise Policy Statement**,2009

Public Works Department, **Georges River Flood Study,** 1991

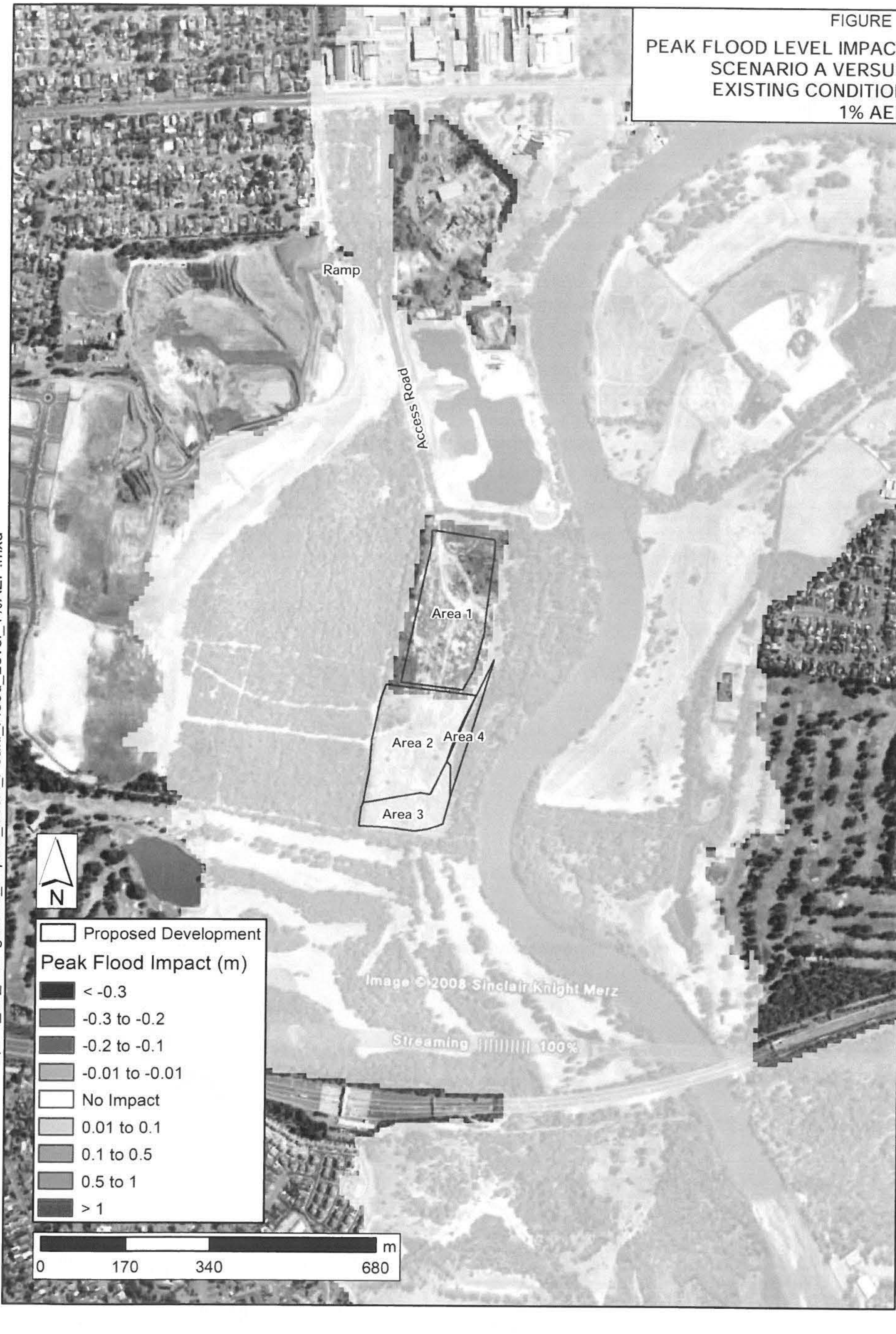
Perrens,S (Advisian) **Materials Recycling Facility, Moorebank**, 2016

Land and Environment Court of NSW, **Statement of Facts and Contentions (SOFAC)**, Case Number 2016/157848 (Formerly 2015/10898), 29 July 2016.

Figures

J:\Jobs\113041-01\ArcGIS\ArcMap\Figure01_Proposed_Plan.mxd


FIGURE 2
PEAK FLOOD LEVELS
GEORGES RIVER FLOW - 1% AEP
EXISTING CONDITION
5.5
5.6
5.4
5.3
5.2
Image © 2008 Sinclair Knight Merz
Site
Contours
Value
High : 6
Low : 5
N
m
0
170
340
680
J:\Jobs\113041-01\ArcGIS\ArcMap\Figure02_Levels_1%AEP_GeorgesRiver.mxd



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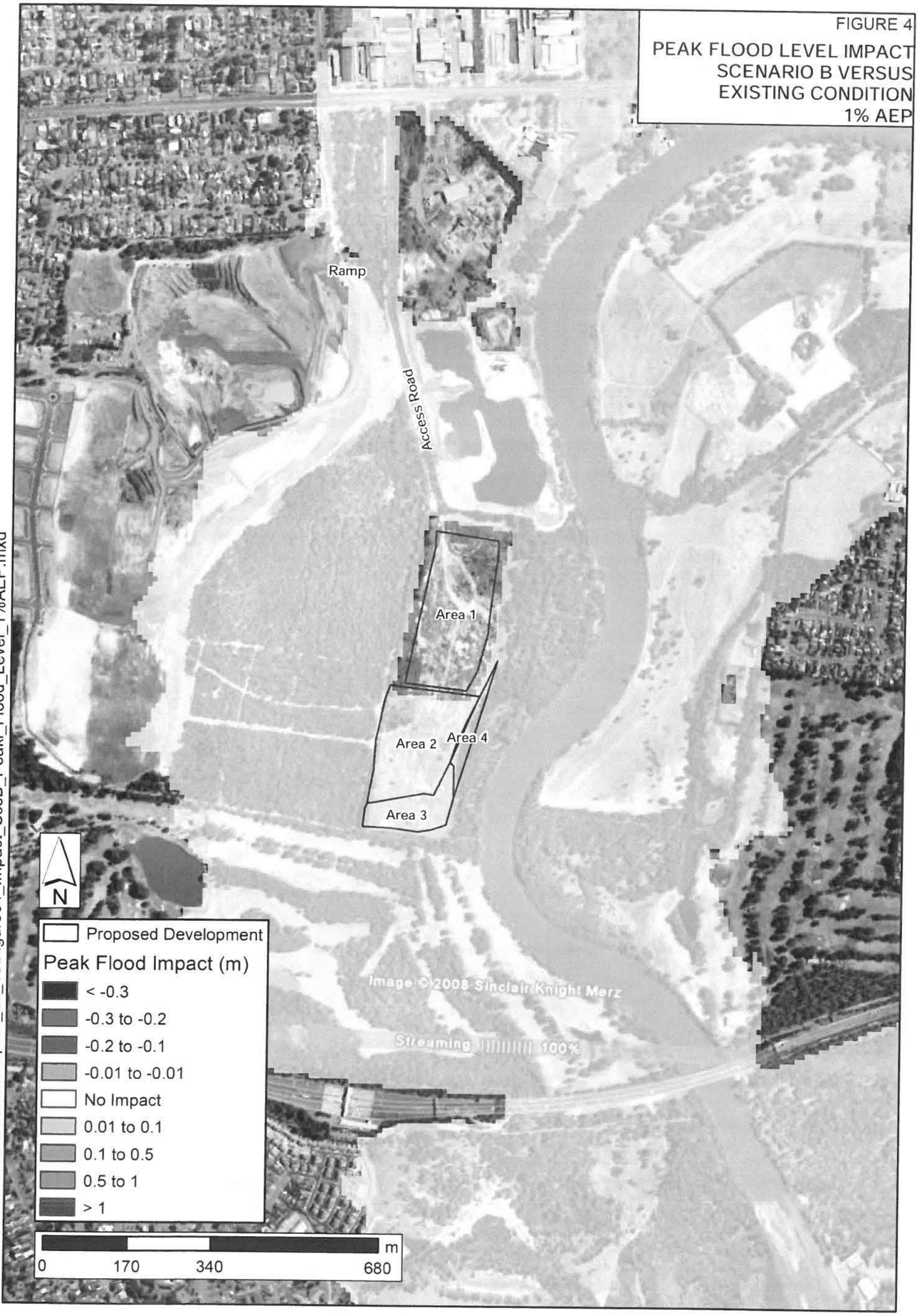

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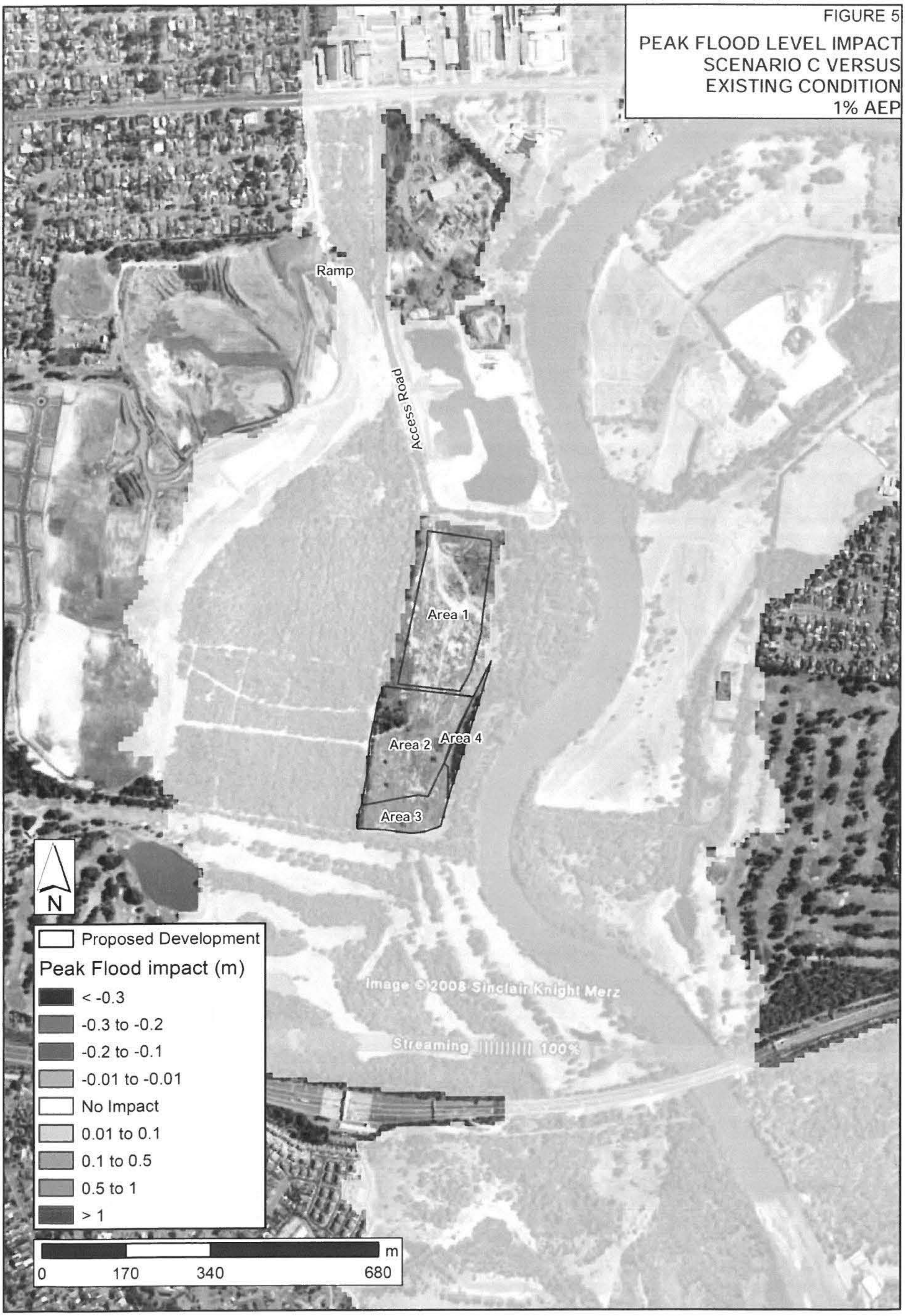

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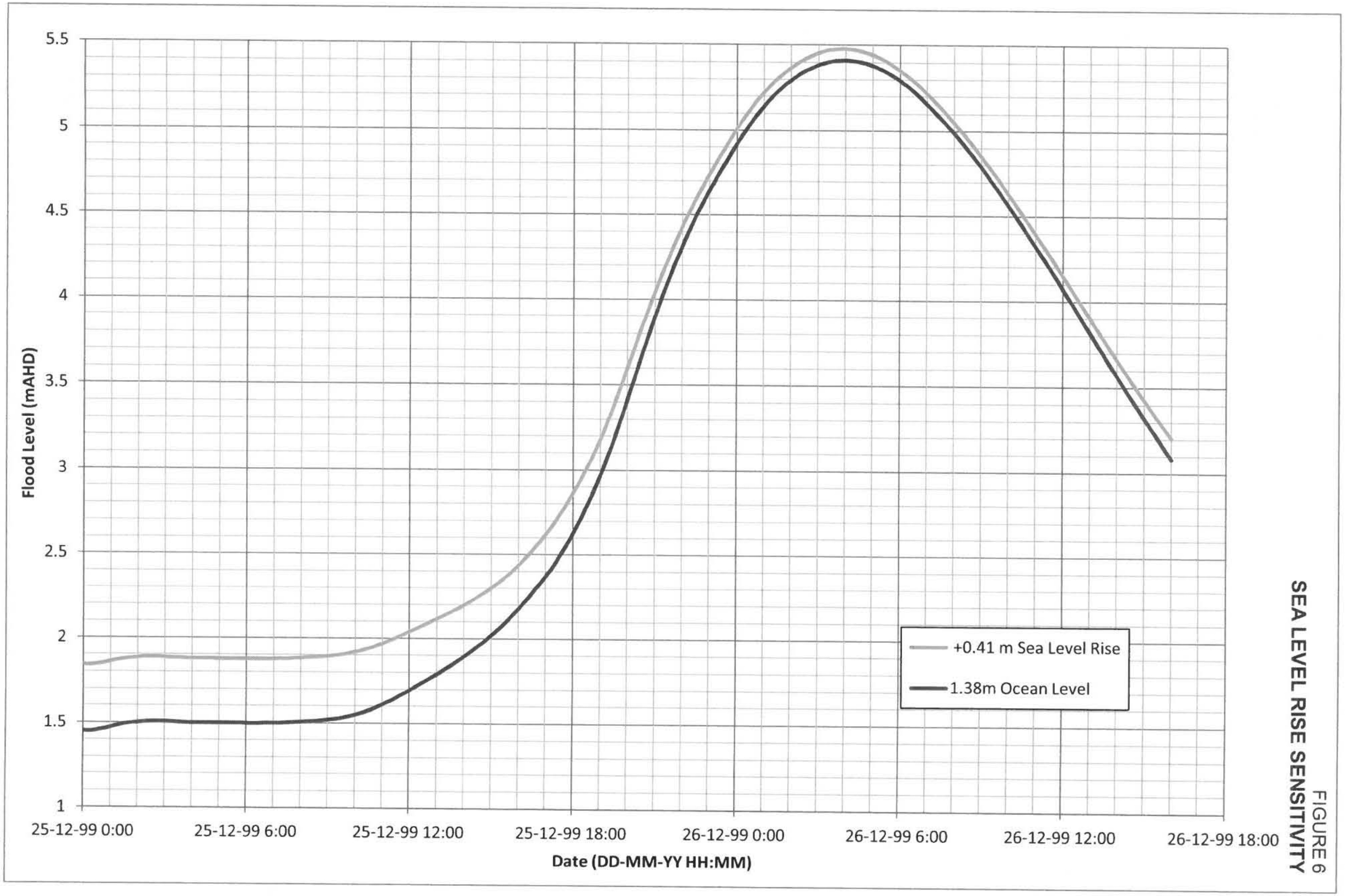


FIGURE 6
SEA LEVEL RISE SENSITIVITY

Appendix A

APPENDIX A. GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils
Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.

Annual Exceedance Probability (AEP)
The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).

Australian Height Datum (AHD)
A common national surface level datum approximately corresponding to mean sea level.

Average Annual Damage (AAD)
Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.

Average Recurrence Interval (ARI)
The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

caravan and moveable home parks
Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.

catchment
The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

consent authority
The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.

development
Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act).

infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development.

new development: refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

	redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	

The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.

floodplain Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.

floodplain risk management options The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.

floodplain risk management plan A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.

flood plan (local) A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.

flood planning area The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.

Flood Planning Levels (FPLs) FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.

flood proofing A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.

flood prone land Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.

flood readiness Flood readiness is an ability to react within the effective warning time.

flood risk Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.

existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.

future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.

continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

flood storage areas Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood

	storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:
	$ the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
	
	$ water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or

- $ major overland flow paths through developed areas outside of defined drainage reserves; and/or
- $ the potential to affect a number of buildings along the major flow path.

mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State=s rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to Awater level@. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Appendix B

APPENDIX B. Hydraulic Model Details

Various hydraulic models have been developed for the Georges River over time. These range in time for the 1980's until 2015 and span physical models, 1D models all the way through to detailed 2D models.

Official models developed as part of studies carried out by Councils under the NSW FRMP include the Georges River physical model (Dept. Public Works, 1991) and the 1999 Mike11 model (Bewsher, 1999). These models have been calibrated and verified to perform to a standard and can be considered to define "official" design flood levels for the Georges River.

Other models have been developed by numerous parties in order to carry out flood impact assessments for various proposed works. WMAwater have built two such models and these are described herein.

The following text describes the various models developed for the Georges River and provides background on the models used in the flood assessment and other flood related modelling work carried out for the subject site.

B.1. Georges River Physical Model

B.1.1. Background

The 1991 Georges River Flood Study (Dept. Public Works, 1991) used a physical model to establish flood levels of the Georges River floodplain from Liverpool to Picnic Point. A scaled floodplain model was constructed from concrete within an enclosed building at University of New South Wales Water Research Laboratory (WRL).

A hydrologic (WBNM) model was used to provide model inflows in the vicinity of the study area. Materials of different roughness were placed on the physical model to simulate patches of dense scrub or mangroves. Gravel was used to simulate ground irregularities. The physical model was calibrated to the April 1988 flood by changing the in bank and overbank roughness. The calibrated model water levels were roughly within 0.1 m of the observed water levels for the April 1988 flood which was approximately a 5% AEP (20 year ARI) event.

B.1.2. Review

Physical models are still in use today, however they are more commonly used on much smaller river systems. Due to the physical size of the model and the cost to maintain it, it was dismantled in 1993. The size of the river system modelled meant that large scaling factors were used. Such large scaling factors reduce the accuracy of results, and in this case the level of accuracy is in the order of ±0.1 m (Dept. Public Works, 1991).

The calibration process typically applied in physical models whereby the surface is roughened with a variety of different materials does not equate easily to a Manning's "n" number, and therefore makes comparison with other computer model studies difficult. Physical models of this scale also have limitations in accurately recording model results. For example, 1 mm within the Georges River physical model equates to 70 mm at full scale. This type of physical model typically generates surface turbulence that is much larger than 1 mm making it impossible to assess or reproduce changes in flood level of less than 0.1m.

As previously discussed, the physical model achieved a good calibration to the April 1988 event. The calibrated model was then used to determine flood behaviour for the 1% AEP (1 in 100 Year) event.

B.2. MIKE-11 Model

B.2.1. Background

The 1999 Georges River Model Study (Bewsher, 1999) established a one-dimensional (1D) hydraulic (MIKE-11) numerical model to predict flows and flood levels between Bunburry Curran Creek and Botany Bay. MIKE-11 is a 1D unsteady state finite difference model suitable for areas with channel networks and control structures. The objective of the model study was to establish a numerical model to replicate levels from the Georges River physical model, rather than to recalibrate to observed data from historical flood events. The verification of the Mike11 result is presented in Figure B1.

The model inflows for the major tributaries were adopted from the 1991 Georges River Flood Study and associated physical model. Cross-section data was taken from 1:4000 orthophotos for overbank areas with in-channel data obtained from hydrosurvey, cross-sections were placed approximately every 100 m along the channel. The model was calibrated to the physical model (rather than observed peak flood level data) by varying the Manning's "n" roughness values for the overbank and inbank areas. However, the Manning's "n" values adopted for final calibration are not published in the study. In the vicinity of the proposed development site, the MIKE-11 model flood levels are generally within 0.15 m of the physical model results for the 1% AEP (1 in 100 Year) design flood.

B.2.2. Review

The MIKE-11 model has several limitations in the area of interest, due mainly to the assumptions inherent for 1D modelling approaches. The channel and overbank areas are represented as one channel, limiting the definition and directions of overbank flow, as well as velocity and hazard classifications. A single velocity value is averaged across the entire cross-section ignoring the interactions between overbank and channel flow that would occur in complex real systems.

The single branch definition of a river with cross-sections every 100 m is likely to underestimate storage potential in overbank areas and is likely to overestimate the contribution to flow conveyance. In studies of similar areas (i.e. low-lying rivers below tidal limits with large areas of overbank flow) current industry practice is to use a two-dimensional (2D) hydraulic model. Unlike 1D models, 2D models can represent spatial variations in flow behaviour (i.e. levels and velocities) across the floodplain. These types of models can therefore account for the complex interactions between overbank and channel flow during a flood. Nevertheless the 1D model spans the upper reaches of the Georges River to Botany Bay in the downstream and hence provides a unique overview of Georges River Flooding behaviour.

B.3. Comparison of Modelling Approaches

Physical, one-dimensional (MIKE-11) and two-dimensional computational hydraulic models are quite varied approaches and hence comparison between model results is difficult. However both physical and 2D hydraulic models implicitly represent floodplain storage in a more accurate manner than is possible with a 1D MIKE-11 model.

In the current MIKE-11 model, there is typically no definition between channel, flood storage and flood fringe areas. Hence the effects of different development scenarios on the edge of the floodplain cannot be properly evaluated. By contrast the channel and overbank within a 2D hydraulic model are represented by a regular grid of ground elevations, allowing a better assessment of the distribution of flows, water levels and velocities across the floodplain. A 2D hydraulic model can also represent floodways in the overbank areas having higher velocities than surrounding areas.

B.3.1. Site Specific Modelling

For a more detailed assessment of flows, peak flood levels and velocities across the study area, a 2D hydrodynamic (SOBEK) model was established. The model extends from upstream of Newbridge Road to immediately upstream of the East Hills footbridge and railway line. SOBEK is a finite difference numerical model for the solution of the depth averaged shallow water flow equations in 2D. The model extent is shown in Figure B2.

A digital elevation model (DEM) was generated from ALS of the study area with a 10 m grid cell resolution. Airborne Laser Scanning (ALS) data of the site was obtained from AAMHATCH to define the ground surface elevations (refer to Figure A1). The LCC government area portion of the data was collected on 18th February 2005, with the Bankstown Council portion on 21st May 2003. The ALS raw data was collected at an average point density 1.3 m^2 for this reason it was provided on a 2 m regular grid. The raw data has a vertical accuracy ±0.15 m for 1 standard deviation on clear hard ground, a standard for this type of data. In comparison orthophoto map contours have an accuracy in the order of ±2 m. The DEM is shown in Figure B2.

Boundary conditions for the SOBEK model were obtained from the MIKE-11 model result files provided by council. The upstream and downstream river boundaries were located in areas where flow was mostly restricted to the river channel and a sufficient distance from the study area not to influence model results. A flow hydrograph was applied at the upstream boundary and a stage-discharge relationship was applied at the downstream river boundary. The Manning's "n" roughness values were based on established ranges for different land use types and floodplain areas. The adopted roughness values are shown in Table B1 and mapped in Figure B3.

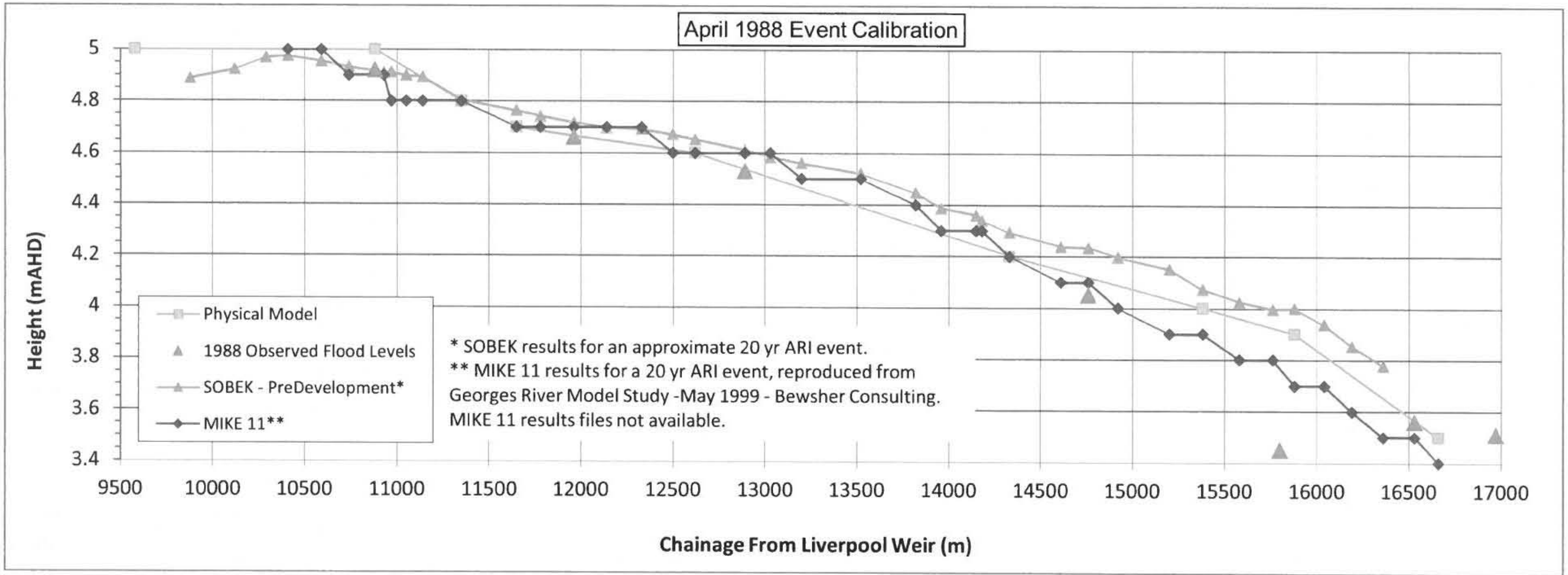
Table B 1 Manning's "n" Values for SOBEK Model

Area	Manning's "n" Roughness Values
Main River Channel	0.03 – 0.05
Open Space/Bare Earth	0.04
Partially Cleared Vegetation	0.05
Developed/Residential/Native Vegetation	0.06

The SOBEK model was calibrated against the 1% AEP (1 in 100 Year) event physical model and MIKE-11 results. The April 1988 flood event (approximately a 1 in 20 year event) was used for validation of the SOBEK model. A comparison of peak flood level profiles produced by the SOBEK, MIKE-11 and physical model along the Georges River is shown in Figure B1. The SOBEK model produced flood levels similar to the Georges River physical model.

For ease of use in the current assessment the SOBEK model was recreated as a TUFLOW model. The same bathymetry, roughness values and overall discretisation were used. A run was made to confirm that the TUFLOW model results, in the 1% AEP event, were an approximate match for those produced by the SOBEK model. These results are shown in Figure B4 and Figure B5.

The TUFLOW model produces levels which approximately match the SOBEK model for the subject site. SOBEK model results continue to be used to set design flood levels for the subject site. However the TUFLOW model is utilised for the assessment of the various earthworks scenarios described in Section 3.



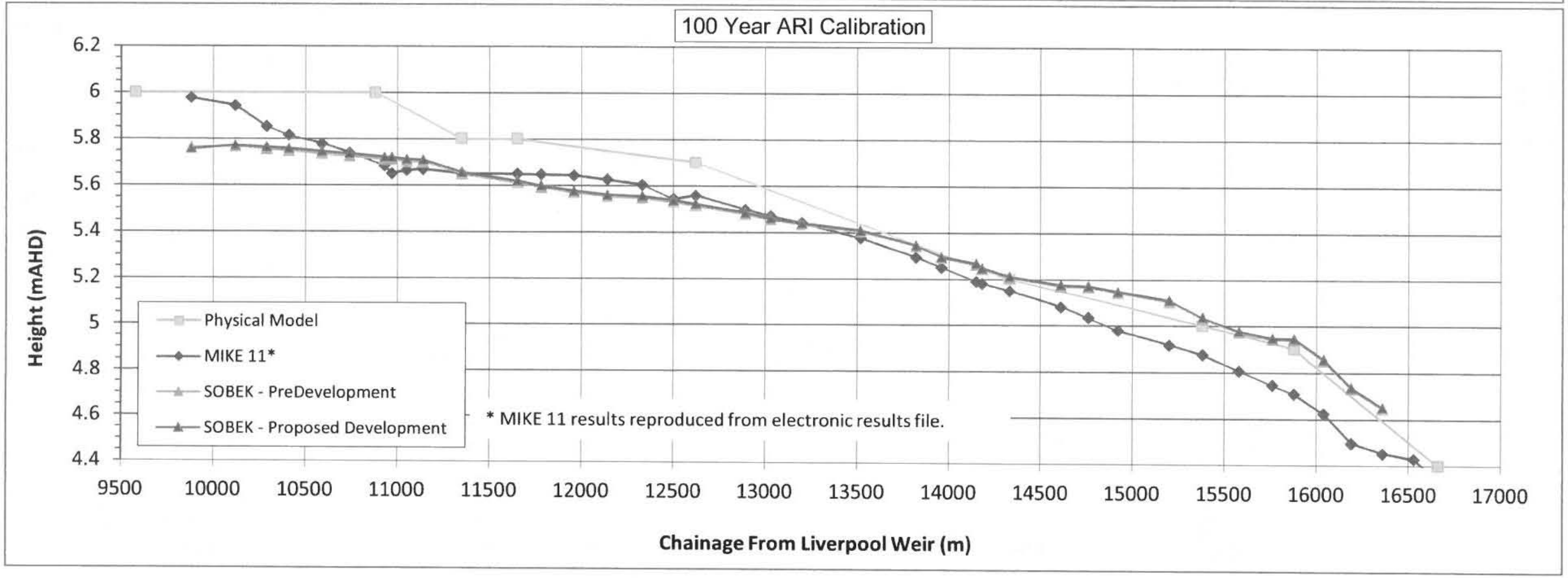


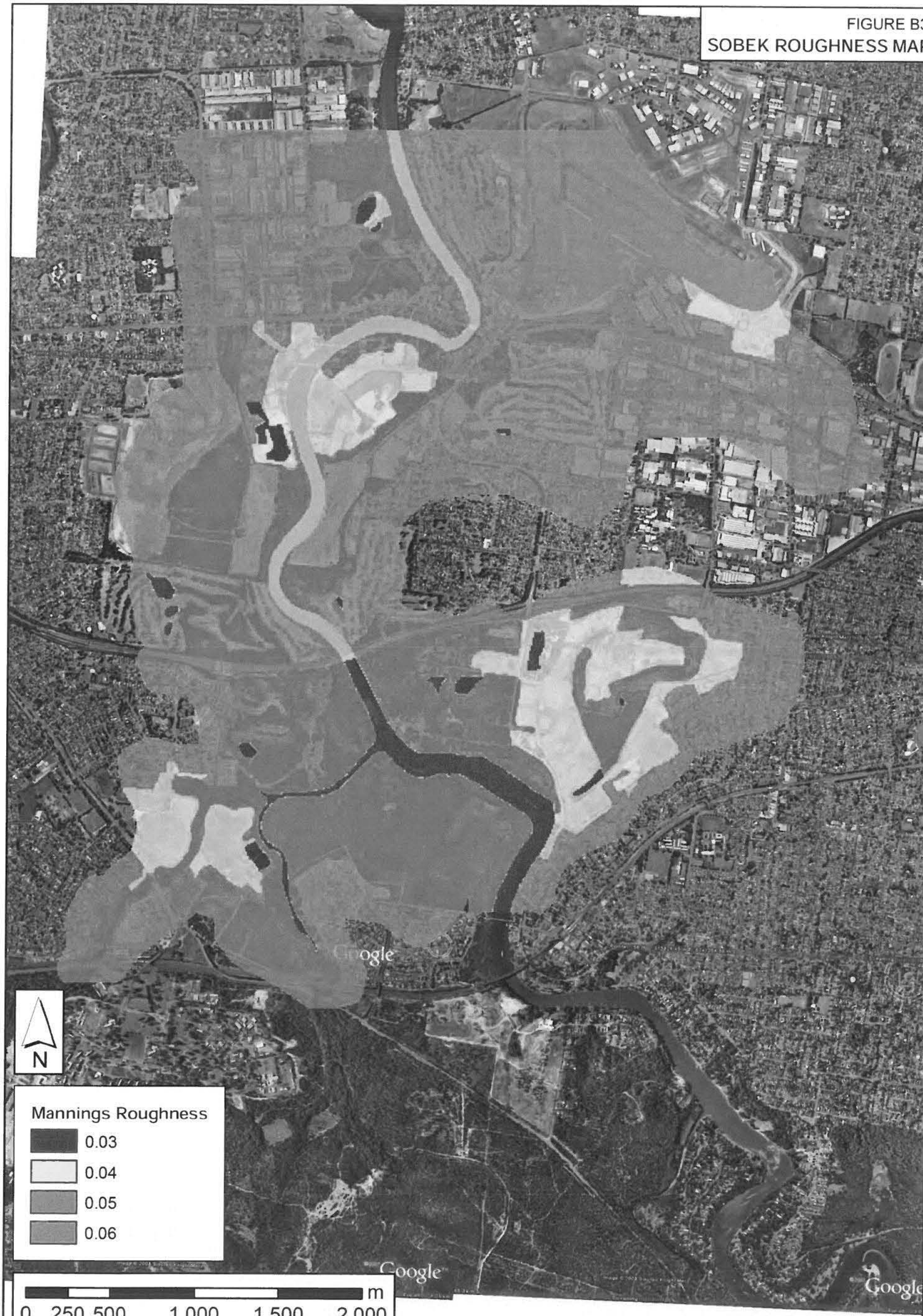
FIGURE B1
MODEL VERIFICATION PROFILES

SOBEK MODEL LAYOUT

J:\Jobs\27069\Arcview\Maps\ReportFigures\Figure2_StudyArea_SOBEKModelLayout.mxd

FIGURE B3

SOBEK ROUGHNESS MAP



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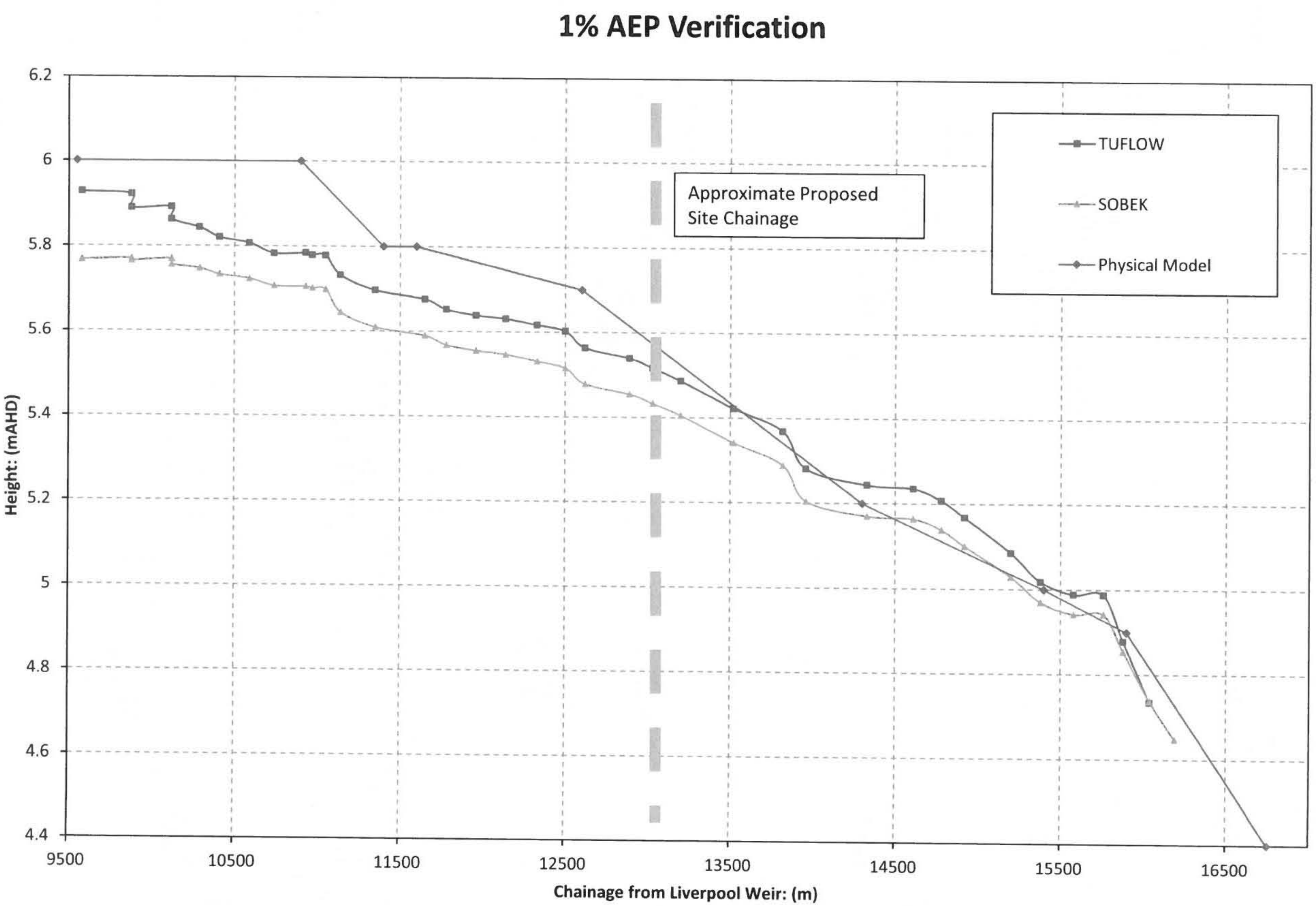

FIGURE B4
MODEL VERIFICATION PROFILES

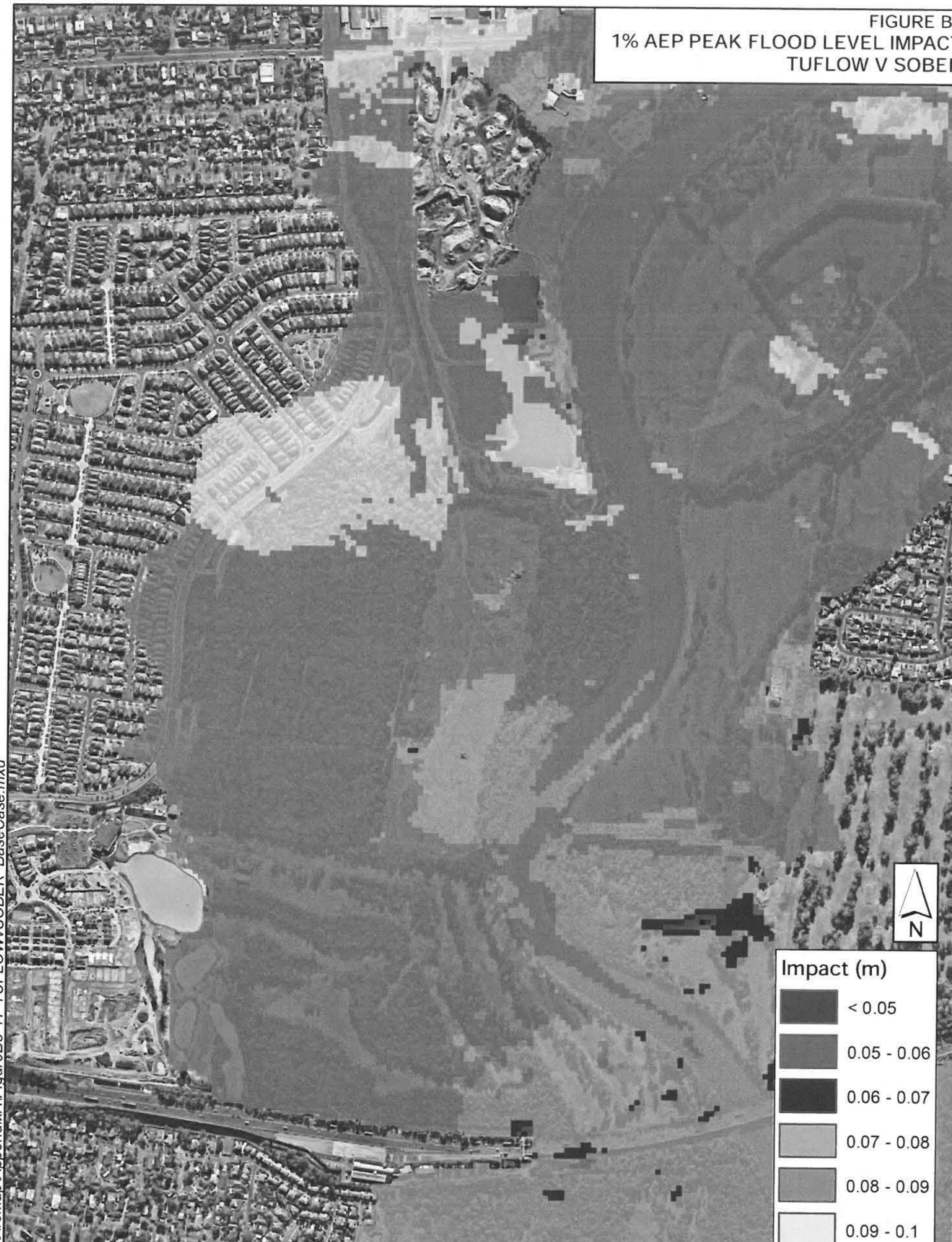
FIGURE B5
1% AEP PEAK FLOOD LEVEL IMPACT
TUFLOW V SOBEK
N
Impact (m)
< 0.05
0.05 - 0.06
0.06 - 0.07
0.07 - 0.08
0.08 - 0.09
0.09 - 0.1
0.1 - 0.11
0.11 - 0.12
0
0.25
0.5
0.75
1
Km
J:\Jobs\116061\ArcGIS\ArcMap\AppendixA\FigureB5_H_TUFLOWvSOBEK_BaseCase.mxd

Appendix C

Stephen GRAY

POSITION: Director

DATE OF BIRTH: 13 July 1974

NATIONALITY: Australian

PROFESSION: Water Resources Engineer

QUALIFICATIONS:

- Bachelor of Engineering (Res. Eng)
  University of New England, 1997
- Master of Engineering (Research)
  University of Technology Sydney, 2009

SPECIAL FIELDS OF COMPETENCE

- ***Hydrology (Flow Estimation)***
- ***Coupled 1D/2D Hydraulic Modelling***
- ***GIS Integration in Hydrology/Hydraulics***

PROFESSIONAL EXPERIENCE

WMAwater
Director

- Exile Bay and Powell's Creek Flood Studies
- Culcairn, Holbrook and Henty Flood and FRMS&P Studies
- Rushcutters Bay, Centennial Park and Woolloomooloo Flood and FRMS&P Studies
- Gundagai Flood Study
- Currambene and Moona Moona Creeks FRMS&P
- Milperra Riverside Development Modelling
- CBD and Darling Harbour FRMS&P
- L&E Court – Ashfield Council
- North Sydney Overland Flow Flood Study
- Detailed Model Review – Wagga Wagga
- Lockhart and The Rock – Flood and FRMS&P Studies
- Blackwattle Bay and Johnstons Creek FRMS&P
- Medowie FRMS&P
- Harold Park Flooding, Stormwater and WSUD Review
- Commission into Brisbane River Floods of January 2011
- SES – Griffith 2012 Flood Review
- Griffith CBD FRMS&P
- Griffith CBD Flood Study
- Dobroyd Canal Flood Study
- Hawthorne Canal Flood Study
- Astrolabe Park Flood Impact Study and Design Project
- Middle Bays Floodplain Risk Management Study and Plan
- Woolaware Bay Flood Study
- Eastern Creek Hydrological Assessment – RAFTS Model Build
- Parken Pregan Road Improvement Impact Assessment
- SES - Murrumbidgee River December 2010 Flood Data Collection
- Wagga LGA Murrumbidgee River 2D Modelling
- Griffith Aerodrome Floodplain Risk Management Study and Plan
- RTA Narara to Lisarow Flood Impact Analysis and Review of Modelling
- Wagga Wagga Caravan Park Flood Impact Assessment
- Marrickville Valley Flood Study
- Jugiong Floodplain Risk Management Study and Plan
- Oura to Braehour Flood Mapping, WWCC
- Holbrook Road Development Impact Assessment – Wagga
- ANU Flood Study – ACT
- Flower Power Flood Impact Study and Floodplain Management Advice
- Medowie Drainage Study
- Upper South Creek Flood Study
- Wagga Wagga Major Overland Flow Study
- Box Hill Impact Assessment, LPMA – Sydney
- L&E Court - Timbumburi Creek Flood Study
- Boral Moorebank Impact Assessment and Floodplain Management Advice
- Murray Area 2D Modelling Review
- Hay Overland Flow Study
- Cotter MIKE She Post Bushfire Yield Review
- Young Street Residential Development – Surface Water Study
- Wagga Wagga 1D to 2D Model Conversion Project
- Griffith Airport Overland Flow Study
- Sandy Beach Development Proposal Environmental Assessment – Review of findings

DHI Malaysia SDN. BHD, KL
Water Resources Manager

- Melaka 3D Thermal Plume Modelling
- Bintang 2D Water Quality Modelling
- ECOLAB Training Thailand
- Penang ISMP
- Sg Muar Flood Mitigation Study
- Parit Buntar and Bagan Serai Drainage Masterplan Study
- Sg Perai Masterplan Study
- Sg Johor/Tebrau/Skudai Conceptual Flood Mitigation Study
- CPG Brunei Drainage Study
- Penang Bridge Widening Survey Study
- PTP Dredging Impact Assessment
- Lido Boulevard Reclamation Works Impact Assessment

- Yemen Port Wave Modelling
- South China Sea Wave Modelling

Trainer for:
- Reservoir Sedimentation Issues
- Dam Break Modelling in Mike Flood
- M21C/M21/M11/MIKE Flood/MIKE BASIN

DHI Australia PTY LTD
Senior Engineer
Flooding and Floodplain Management
- Thurgoona Dam Break Study
- Tanoui NZ MIKE Flood Modelling
- Chowilla Velocity Impact Analysis
- Chowilla Water Use Analysis
- Wyong Economic Zone Hydrologic and Hydraulic Study
- Haslams Ck Tooheys Site MIKE Flood Investigation
- Thurgoona and Airport Flood Study
- Bungambrawatha Dam Break Study
- MIKE Flood Model Review – Greater Wellington Regional Council
- Bankstown Airport MIKE Flood Impact Study
- Chowilla Wetlands 2D Modelling Project
- MIKE Flood Development – Denmark
- Phulbari Open Cut Coal Mines Levee Design – Bangladesh
- East Lavington Drainage Study
- Benalla Model Conversion – MIKE21/MIKE11
- ACT Yield Modelling – MIKESHE/MIKE11
- Poulton Park 2D Drainage Study
- Huon valley Dam Break
- Iberia Street 2D Drainage Study
- Elanora 2D Drainage Study
- SMEC Laos 2D/1D Flood Diversion Project
- Bulimba Creek 2D Preliminary Flood Study
- Buttonderry Creek Development Impact Study
- Hume Dam Catchment Hydrology
- Tenterfield Flood Study
- Orange Flood Study
- RTA Tamworth Road Works
- Brisbane City Council Sewer Study
- Townsville Flood Study

Training Carried Out
- Software Support
- MIKE Product Training – Gui and Partners Sdn Bhd Training
- Papakura Council SHE/MIKE STORM Training
- MIKE Flood Advanced Training – Auckland NZ
- MIKE21 Training – Auckland NZ
- Greater Wellington Regional Council – MIKE21/Mike11 Training
- University of Canberra CRC for Freshwater Ecology – MIKE21/MIKE11 Training
- HydroTasmania MIKE21/MIKE11
- MIKE FLOOD (2D/1D) Training Course

ERM Australia PTY LTD
Senior Engineer
- Canungra Army Base Re-development Water Strategy Study
- Parramatta Rail Link Soil and Water Sub-plans
- Hoxton Park Flood Impact Assessment
- Rolleston Coal Mine Environmental Impact Assessment
- Rhodes Peninsula Soil Rehabilitation Project EIS
- AUSTEEL Steel Mill and Harbour Facilities EIS

WBM Oceanics Australia
Water Resources Engineer
- Hexham Swamp Tide Gate Re-Opening Impact Analysis
- East Hills Flood Mitigation Work Analysis
- Singleton Stormwater Management Plan and Infrastructure Design Report
- Cudgera Creek, Yelgun NSW
- Riverlink Canal Estate Development Impact Study
- Steel St, Newcastle NSW
- Cottage Creek Flood Study
- Ulmarra Floodplain Management Study, Ulmarra NSW
- Newcastle Flood Data Collection Study

Ecowise Environmental LTD
Water Resources Engineer
- Flood Inundation Mapping, Benalla VIC
- ACT Flood Plan
- Flood Forecasting Operations
- Flood Study for the Ginninderra Catchment, ACT

Water Resource Related Civil Works
- Installation of Discharge Monitoring Sites, Dampier WA
- Design of Sedimentation Ponds and Pipe Network, Dampier WA

Water Yield Analysis
- Preliminary Water Balance Investigation, Tuggeranong
- Water Supply Study for ACTEW

Water Quality Modelling
- Proposed Lake Jerrambombera Aquatic Facility
- GIS Land Capability Mapping and CMSS Modelling

Dam Break Modelling
- Kenyir Dam Break Assessment
- Thurgoona Dam Break Study
- Bungambrawatha Dam Break Study
- Huon Valley Dam Break Modelling
- Hume Dam Hydrology and Failures Scenarios

PUBLICATIONS

2011 Gray, S.D, Ball, J.E. and M.K. Babister (2011). The Direct Rainfall Method – A Critical Discussion of Current Practice. Proceedings 51st Floodplain Management Association Floodplain Managers Conference Tamworth , February 2011.

2010 Gray, S.D and Ball, J.E. (2010). Coupled One and Two Dimensional Modelling in Urban Catchments – Reducing Uncertainty in Flood Estimation. Proceedings 32nd Hydrology and Water Resources Symposium, December 2009

1997 Beavis, S. G., A. J. Jakeman, L. Zhang and S. D. Gray (1997). Erosional History of Selected Upland Subcatchments in the Liverpool Plains, New South Wales. Proceedings International Congress on Modelling and Simulation, MODSIM97, University of Tasmania, 8-11 December 1997. A. D. McDonald. (Eds). Vol. 1 pp. 277

Appendix 5

Georges River Water Quality Data

Summary Water Quality Statistics - Georges River

Site Locations
Garrison Point: 150.97411, -33.90975
Rabaul Road: 150.97430, -33.91568
Deepwater: 150.97459, -33.95189

Analyte	Units	Statistic	Garrison Pt 2004-2006	Rabaul Rd 1997-2002	Deepwater 1997-1999	ANZECC Default Trigger Values	ANZECC Source
pH	pH unit	*Count*	*22*	*58*	*19*	7.0-8.5	Table 3.3.2
		Mean	7.39	7.18	7.57		
		20%ile	7.21	6.73	7.15		
		80%ile	7.56	7.46	7.68		
Conductivity	µS/cm	*Count*	*17*	*55*	*20*	N/A	
		Mean	13,285	11,151	21,885		
		20%ile	4,325	2,460	7,160		
		80%ile	20,772	17,920	32,740		
Total P	mg/L	*Count*	*22*	*61*	*25*	0.03	Table 3.3.2 Physical and chemical stressors (south-east Australia), Estuaries
		Mean	0.08	0.09	0.09		
		20%ile	0.04	0.04	0.05		
		80%ile	0.12	0.12	0.11		
TKN	mg/L	*Count*	*22*	*60*	*24*	N/A	
		Mean	0.59	0.55	0.74		
		20%ile	0.44	0.30	0.40		
		80%ile	0.70	0.80	1.04		
Nitrogen (N)	mg/L	*Count*	*22*	*61*	*25*	0.30	Table 3.3.2
		Mean	0.82	0.30	0.30		
		20%ile	0.55	0.07	0.07		
		80%ile	1.18	0.46	0.54		
DO (%)	%	*Count*	*22*	*57*	*19*	80-110	Table 3.3.2
		Mean	90	90	88		
		20%ile	81	67	65		
		80%ile	98	100	101		
DO	mg/L	*Count*	*22*	*58*	*19*	N/A	
		Mean	8.2	7.2	7.6		
		20%ile	7.0	6.7	4.8		
		80%ile	9.6	7.5	9.7		
ORP	mV?	*Count*	*22*	*59*	*20*	N/A	Table 3.3.2
		Mean	283	152	74		
		20%ile	234	56	41		
		80%ile	326	220	99		
Turbidity	NTU	*Count*	*22*	*57*	*18*	0.5-10	Table 3.3.3 Turbidity (south-east Australia) Estuaries
		Mean	28	27	80		
		20%ile	0	2	11		
		80%ile	44	30	79		
Suspended Solids	mg/L	*Count*	*22*	*60*	*24*	N/A	
		Mean	32	16	17		
		20%ile	13	7	8		
		80%ile	41	20	23		
Chl a	µg/L	*Count*	*22*	*59*	*24*	N/A	
		Mean	4.8	5.1	4.1		
		20%ile	2.2	2.2	2.3		
		80%ile	5.6	6.3	4.9		
Faecal coliforms	CFU/100mL	*Count*	*22*	*60*	*24*	1000.00	5.2.3.1 Secondary recreational contact
		Mean	4,530	3,602	2,028		
		20%ile	54	20	5		
		80%ile	4,240	626	980		

Appendix 6

Water Quality Data for Fairfield Sustainable Resource Centre

Water Quality Sampling: Sustainable Resource Centre, Wetherill Park

			ANZECC Default Trigger Values for Ecosystem Protection		ANZECC Trigger Values for 80% Species Protection				
	Units	LOR	Lowland Rivers	Estuaries	Freshwater	Marine	North Dam	North Dam	North Dam
Sample Date							11-Dec-15	11-Dec-15	10-Aug-16
Physical Charcteristics									
pH Value		0.01	6.5 - 8.0	7.0 - 8.5			8.1	7.9	9.1
Electrical Conductivity @ 25°C	µS/cm	1	125 - 2,200	-			1,020	481	680
Suspended Solids (SS)	mg/L	5					72	142	6
Total Dissolved Solids	mg/L								430
Turbidity	NTU		6 - 50	0.5 - 10[1]					6.3
Anions and Cations									
Sulfate (as SO4)	mg/L	1					30	27	
Chloride	mg/L	1					221	70	
Calcium	mg/L	1					27	29	
Magnesium	mg/L	1					20	10	
Sodium	mg/L	1					140	46	
Potassium	mg/L	1					7	3	
Fluoride	mg/L	0.1					0.8	0.2	
Nitrogen, Phosphorus and Carbon									
Ammonia as N	mg/L	0.01	0.02	0.015	2.3	1.7	3.09	0.17	
Nitrite as N	mg/L	0.01					<0.01	<0.01	
Nitrate as N	mg/L	0.01			170	ID[2]	0.03	0.08	
Nitrite + Nitrate as N	mg/L	0.01	0.04	0.015			0.03	0.08	
Total Nitrogen	mg/L		0.5	0.3			3.12	0.25	1.8
Total Phosphorus	mg/L		0.05	0.03					0.05
Total Organic Carbon	mg/L	1					17	16	
Metals									
Arsenic	mg/L	0.001			0.36	ID[2]	0.002	0.002	0.002
Cadmium	mg/L	0.0001			0.0008	0.036	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001			0.040	0.085	0.001	<0.001	0.033
Copper	mg/L	0.001			0.0025	0.008	0.002	0.003	0.007
Iron	mg/L	0.05			ID[2]	ID[2]	0.5	0.87	
Lead	mg/L	0.001			0.0095	0.012	<0.001	<0.001	<0.001
Manganese	mg/L	0.001			3.6	ID[2]	0.226	0.37	
Mercury	mg/L	0.0001			0.0054	0.0014	<0.0001	<0.0001	<0.0005
Nickle	mg/L	0.001			0.017	0.560	0.002	0.002	0.001
Zinc	mg/L	0.005			0.031	0.043	<0.005	<0.005	<0.001
Hydrocarbons									
Oil & Grease	mg/L						8	9	
TRHC6 - C9	µg/L								<10
TRHC6 - C10	µg/L								<10
TRHC10 - C14	µg/L						<50	<50	<50
TRHC15 - C28	µg/L						<100	<100	<100
TRHC29 - C36	µg/L						<50	<50	<100

1 Estuaries and Marine

2 ID = Insufficient data to derive a reliable trigger value