NSW Department of Education

Sydney West Central Planning Panel Ref: 2017SWC020 DA

City of Parramatta: DA/80/2017

Site Address: Old Kings School Oval,
24 O'Connell Street & 3 Marist Place,
Parramatta NSW 2150

Land Identifier: Lot 6 DP 1182647 & Lot 1 DP1112822

Proposal for Construction of Temporary Demountable School Buildings and Associated Works

Independent Review of Flood Risks

10 April 2017

Bewsher

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A. INTRODUCTION

A1. Background

1. We have been advised that the Department of Education (**Department**) needs to decant 1,000 students from Parramatta Public School to temporary demountable accommodation on the Old Kings School oval (**site**). This is part of the Department's Parramatta strategy which includes the new high rise high school (Arthur Phillip) and the Parramatta Public School.

2. The temporary use of the site will allow construction to commence on the Parramatta Public School. Once construction is completed the students will move back to their new school and the demountables will be removed.

3. A Development Application (**Application**) has been lodged with the City of Parramatta (**City**) and is to be determined by the Sydney West Central Planning Panel (**Panel**).

4. All of the site is flood prone[1] and is comprised entirely of areas within the 'Low', 'Medium' and 'High' Flood Risk Precincts.[2] It is understood that there has been on-going discussions between the Department and the City relating to the appropriateness of the Application given the site's flood risks and the proposed use as a school for young children (Kindergarten to Year 6).

5. There have been a range of reports addressing flood risk which present conflicting opinions about the appropriateness of the development. Consequently the flood risk issues associated with the Application remain in contention.

6. Although the Department has attempted to address the flood risk concerns that had been raised, on 28 March 2017 the City advised that they did not support the Application and considered "*the proposed sensitive land use should not be supported in a flood area. Whilst we acknowledge the detailed work that has gone into mitigation, it does not overcome the in principle concern*".

7. This review was commissioned on 7 April 2017 by the Department. It has been prepared in response to the Department's request for Bewsher to undertake "*an expert and independent review*" of the flood risk issues associated with the Application.

8. The Application is for a temporary use of the site for 12 months. The reviewer understands that should the Application be approved it would likely be a time-limited consent expiring in June 2018. In regard to flood risks this is an important consideration relative to those consents that apply for perpetuity.

[1] i.e. inundated in the probable maximum flood (PMF). The PMF is the most improbable flood that could possibly occur.

[2] As part of the reviewer's experience which is mentioned in paragraph 10, the former Parramatta City Council established a system of flood risk precincts for land use planning and flood risk management across the Parramatta Local Government Area (LGA). The Flood Risk Precincts (**FRP**s) are defined as follows:

- High FRP – land below the 100 year flood that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.
- Medium FRP – land below the 100 year flood that is not subject to a high hydraulic hazard and where there may be some evacuation difficulties.
- Low FRP – land above the 100 year flood up to and including the probable maximum flood.

A2. Experience and Qualifications of Reviewer

9. Bewshers have completed over 20 major Floodplain Risk Management Studies and Plans (**FRMS&P**s) under the NSW Flood Program. This has included work within the majority of NSW's most flood prone valleys including the Georges and the Hawkesbury River systems. The consideration of safety risks associated with evacuation from flood prone lands has been an important consideration in this work.

10. The firm has had a long association with the City (and the former Parramatta City Council) and has completed numerous flood risk assessments and FRMS&Ps within the Parramatta River valley. This included the Upper Parramatta River Catchment FRMS&P in the late 1990s. Our experience with this study is relevant because it provided the basis for the flood planning controls that are currently in place in the City (including those relating to educational establishments).

11. Because of the firms' flood risk management experience over the last two decades the firm has drafted the DCP flood planning controls for over 25 NSW councils.

12. The firm has been engaged by the City (and the former Parramatta City Council) to provide expert flood risk advice on numerous occasions including many appearances as an expert witness in court. The firm has also been engaged by the State Government and the private sector as a flood risk expert.

13. Whilst this review has been commissioned by the Department, it has been carried out independently without favour to either the Department, who is funding this review, or to the City for whom the firm has a long and continuing association in the provision of expert flood risk advice.

14. This review has been undertaken by Drew Bewsher who is a director of the firm. His curriculum vitae are in **Attachment E**.

A3. Documents Examined

15. The documents that have been considered during this review are listed in **Attachment A**.

16. Northrop has provided the bulk of the engineering advice to the Department for this Application including advice on flood risk. The key documents prepared on behalf of the Department that describe the Application and assess the flood risks comprise:

    (a) Northrop's letter to the Department dated 16 March 2017 *Flooding Considerations and Risk Management* (**Northrop's Flood Report**) – refer item A11 in **Attachment A**; and

    (b) Flood Emergency Management Plan (**FEMP**), Issue C, dated 16 March 2017 – refer item A14 in **Attachment A**.

17. The key documents that present the City's flood risk assessment of the Application are:

    (a) *Council Assessment Report* – refer item A20 in **Attachment A**; and

(b) Storm Consulting's emails of 19 and 20 March 2017[3] which related to the Application, and their assessment letter to the City dated 2 March 2017[4] which related to an earlier version of the Application.[5]

18. Comments on flood risk issue associated with the Application were also provided by the Office of Environment and Heritage (OEH). These comments are relevant as OEH are the State Government Agency which provides technical advice on flood risk management practice as set out in the NSW Flood Prone Lands Policy[6] and the NSW Floodplain Development Manual.[7] OEH's comments were set out in their email to the City on 29 March 2017. (A response from the City to these comments was subsequently provided on pages 20 and 21 of the Council Assessment Report).

19. The reviewer understands that the Application before the Panel includes slightly updated architectural plans from those bound into Northrop's Flood Report. These updated plans are those listed in item A19 of **Attachment A** and show the ground floor level of the proposed buildings at 9.55mAHD.

A4. Activities Undertaken during this Review

20. In addition to reviewing the documents listed in **Attachment A** the following activities were also undertaken:

(a) various telephone and email discussions were conducted with the Department;

(b) a site inspection was carried out on Thursday 7 April 2017;

(c) a meeting was held with Northrop's flooding and structural engineers in their Charlestown offices on Friday 8 April 2017. This meeting included a review of the two dimensional flood modelling described by Northrop in their reports of 16 March 2017;

(d) the flood risk issues at the site were assessed based on the reviewer's experience and knowledge of sound flood risk management practice in NSW.

B. FLOOD BEHAVIOUR ON THE SITE

B1. Upper Parramatta River Flood Study

21. For over a decade the best available flood information for this part of the Parramatta River has been provided by flood modelling undertaken by the Upper Parramatta River Catchment Trust (UPRCT) over a decade ago.

[3] Refer items A16 and A17 in **Attachment A**. Note also that following a request from the Department, the City advised that Storm Consulting was the "*Independent Flood Engineer*" and the "*external consultant*" referred to by the City in the Council Assessment Report and various email correspondence.
[4] Refer item A9 in **Attachment A**.
[5] Note that the reviewer has not been provided with a full copy of the earlier Application including earlier versions of any flood risk documentation and earlier versions of the FEMP. It is clear from Storm Consulting's assessment letter that the version of the FEMP that they assessed was Issue B. It is also clear that there were a number of deficiencies present in the documentation which the City raised in their email to JBA on 6 March 2017 (refer item A10 in **Attachment A**).
[6] As set out in Section 1.1 of the NSW Floodplain Development Manual (refer item A1 in **Attachment A**).
[7] Refer item A1 in **Attachment A**.

22. Whilst this modelling had not been formalised through production of a final flood report as would be the normal practice, the modelling has been reviewed by various third parties and utilised in hundreds of flood risk assessments across the City.

23. In the opinion of the reviewer it is appropriate to use this modelling[8] to set flood planning levels (**FPL**s) at the site. This approach is consistent with the *Flood Enquiry Information* issued by the City on 25 November 2016.[9]

24. The key flood levels at the site determined from this modelling are as follows:

    (a) 20 year ARI:[10] 6.6 – 7.0mAHD;

    (b) 100 year ARI: 7.8 – 8.0mAHD; and

    (c) PMF: 12.7 – 13.0mAHD.

25. The UPRCT flood behaviour has been extracted from a one dimensional (**1D**) flood model known as 'MIKE11'. This model was widely used for flood modelling purposes for a number of decades in Australia and overseas. Over the last decade or so, two dimensional (**2D**) modelling is more commonly used as it is better able to simulate flow behaviour of floodplains and other areas where the direction of flow behaviour is not unidirectional.[11]

26. As part of the City's 1D modelling, the extent of the City's floodplains that are 'High Hazard' in a 100 year flood event has been mapped.[12] Based on this mapping, the boundary of the 'Low Hazard' and 'High Hazard' areas across the site were included in the *Flood Enquiry Information* issued by the City to Northrop. This boundary has been reproduced on **Figure 1**.

B2. Additional 2D Modelling Undertaken by Northrop

27. As noted in the FEMP, Northrop undertook 2D flood modelling of the site to provide more detailed information on "*velocity profiles and behaviour at all locations across the site*". This was undertaken using the TUFLOW and XP-STORM flood models.

28. Because only limited details of the modelling were presented in the Northrop reports provided to the City, the reviewer requested further information on the modelling during his visit to their offices on 7 April 2017. The 2D flood modelling was undertaken for both the 100 year and PMF events, with and without the development present on the site.

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[8] The 'Draft 8' version of the modelling provides the latest data set applicable to the site.
[9] Refer item A8 in **Attachment A**.
[10] **ARI** = average recurrence interval. The 100 year ARI flood is the flood that would occur or be exceeded on average every 100 years. It has a 1% chance of occurring or being exceeded every year. The terms 1% annual exceedance probability (**AEP**) and 100 year ARI are equivalent.
[11] The City is undertaking 2D flood modelling to replace the existing 1D UPRCT modelling but this new flood modelling is not currently available.
[12] The 'high' and 'low' hazard classifications are described in Appendix L of the NSW Floodplain Development Manual listed in item A1 of **Attachment A**:

- High Hazard – areas where there is a possible danger to personal safety, evacuation by trucks may be difficult, able-bodied adults would have difficulty in wading to safety, and there is potential for significant structural damage to buildings;
- Low Hazard – in these areas, should it be necessary, trucks could evacuate people and their possessions, and able-bodied adults would have little difficulty in wading to safety.

Because the modelling was undertaken in 2D, velocities, depths and impacts[13] were available across the site and were examined by the reviewer.

29. The 2D model was established on a 5m grid and based on estimates of the MIKE11 100 year and PMF flood flows. The 2D model's tailwater condition was set downstream of Lennox Bridge to reproduce the MIKE11 flood level results on the site. Topography used in the model was based on the available ALS data[14] purchased by Northrop from LPI.[15]

30. The review indicated that the modelling did not include allowances for the bridge piers or bridge deck obstructions in the vicinity of the site, and included an incomplete representation of the River's bathymetry. Accordingly the modelling is approximate. However because there has been a quasi-calibration in order to achieve the UPRCT flood levels on the site, the reviewer considers the description of flood velocities on the site in the 2D model will be more accurate than the 1D model.

31. This is particularly in the area immediately downstream of the O'Connell Street Bridge where River flows leave the main channel and travel onto the existing oval. In this area the presence of a band of trees along the northern bank of the River has a significant role in 'shielding' the site from the more active flows within the river channel. Whilst both the 1D and 2D model account for the effects of these trees, in the reviewer's opinion this behaviour will be more accurately simulated in the 2D model.[16]

32. The boundary between low and high hazard conditions which is strongly dependent on these velocity and depth distributions will, in the opinion of the reviewer, be better determined in the 2D model rather than the 2D model.

B3. 100 Year ARI Flood Depths and Hazards on the Site

33. The 100 year ARI depths across the site are shown on **Figure 1**. Because the flood levels in the 2D model have been established to reproduce the 1D model results, the depths determined from both the 1D and 2D models will be the same or very similar.

34. The hazard boundary extracted from the 2D model is also shown on **Figure 1** and is surprisingly similar to the 1D hazard boundary. As would be expected, given the issues raised in paragraph 30, the hazard boundary is closer to the River than predicted by the 1D model.

35. The information in Figure 1 includes an overlay of the proposed building positions and this demonstrates that:

    (a) all the proposed building positions are located clear of the high hazard flood conditions in a 100 year ARI event;[17] and

[13] 'Impact' mapping refers to the difference in flood levels resulting from development. Northrop's 100 year impact map for the Application is provided in **Figure 2** and is discussed in **Section C2.1**.
[14] ALS = airborne laser scanning. ALS survey data is ground level data obtained by an overflying aircraft. It is commonly used for 2D modelling and floodplain mapping.
[15] LPI is the NSW Government's Land and Property Information Service.
[16] This is because in a 1D model, behaviour is only simulated at isolated cross sections (across which the water level is assumed constant) and the 1D model is unable to properly account for variations in the conveyance distribution on adjacent cross sections. In contrast, the 2D model has simulated the conveyance including depths, water level and velocities, on a 5m grid across the entire floodplain.
[17] A consequence of this is that none of the proposed buildings will be on land that is within the 'High' Flood Risk Precinct (refer definitions in footnote 2). All of the proposed buildings will either be on land that is classified as either 'Low' or 'Medium' Flood Risk Precinct.

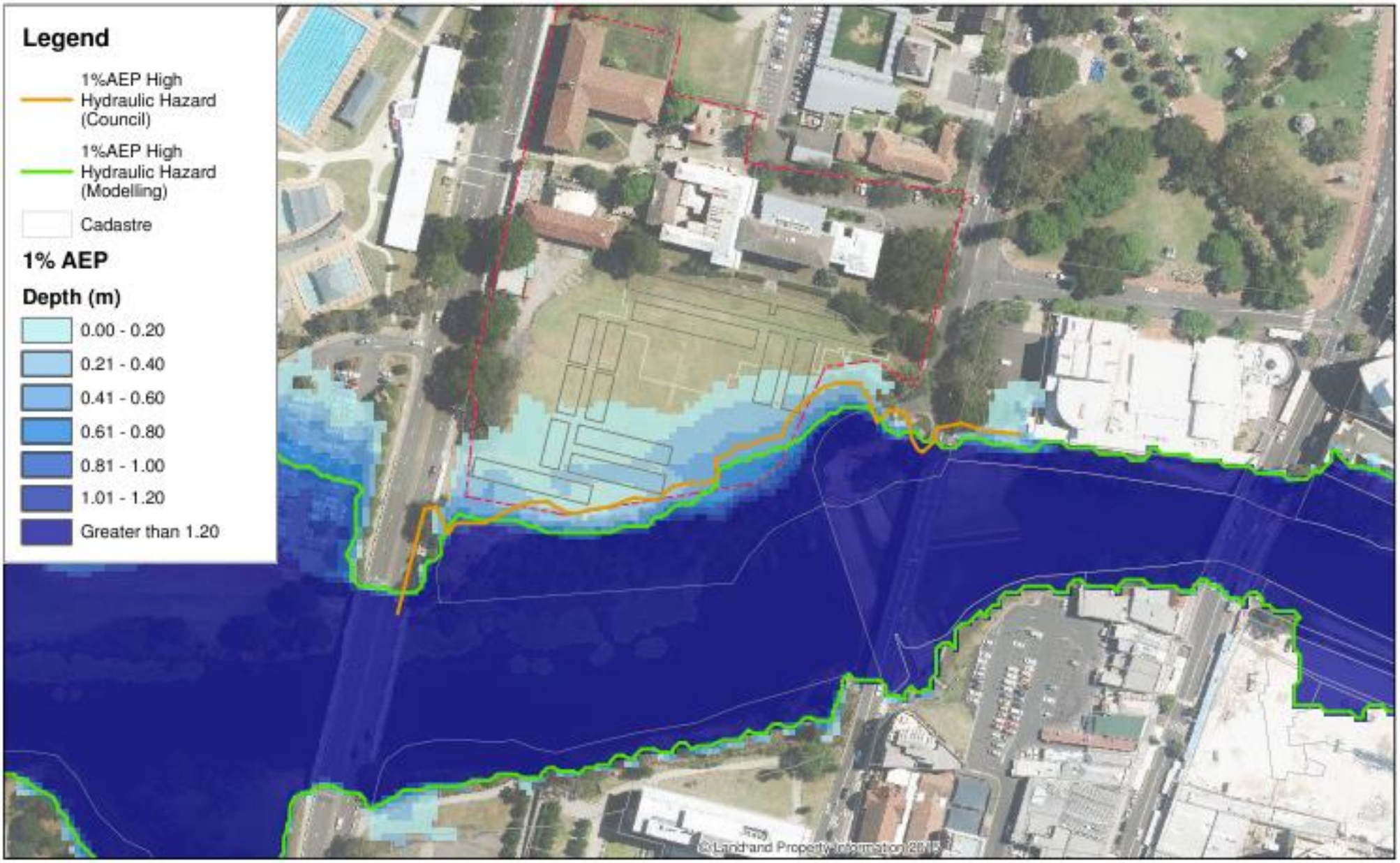

Figure 1: 100 Year ARI Flood Depths and Hazards
(This figure was prepared by Northrop and provided directly to the reviewer. It has been derived from the 2D flood modelling undertaken by Northrop in preparing their Flood Report and FEMP dated 16 March 2017).

(b) about 40% of the buildings are to be located on land that would be inundated in a 100 year ARI event.

36. Flood risk comprises the risk to property and the risk to people. These flood risks are assessed for the Application in **Sections C** and **D** below.

C. ASSESSMENT OF FLOOD RISK TO PROPERTY

37. In accordance with normal practice, the reviewer has assessed the flood risk to property both within and beyond the site.

C1. Flood Risk to Property within the Site

38. As shown on the latest set of plans, the proposed buildings are either one or two storey. The level of the floor of the one storey buildings and the level of the lower storey of the two storey building is 9.55mAHD. This is at least 1.5m above the 100 year flood level.

39. The normal FPL used for most building floors in the City is 0.5m above the 100 year flood level. Consequently the proposed lowest floor levels will be at least 1.0m above this FPL. Based on a preliminary flood frequency estimate carried out by the reviewer, these floors would only be inundated by an event of approximately 1000 years ARI or rarer.

40. In the opinion of the reviewer the proposed minimum floor level of 9.55mAHD provides more than adequately addresses the flood risks to property within the site.

41. It is further noted that no objections to the proposed floor level have been raised by the City or their external flood consultant (in respect of risks to property on the site).

C2. Flood Risk to Property Beyond the Site

42. Risks to property beyond the site can occur via two mechanisms:

(a) obstruction to flood flows across the site causing changes to flood behaviour away from the site including raising flood levels; and

(b) the potential for damage to occur to downstream properties should buildings be washed off the site and form flood debris in an extreme flood.

43. These two mechanisms for the Application to cause off-site impacts are discussed in **Sections C2.1** and **C2.2** below.

C2.1 *Alterations to Flood Levels and Flood Behaviour Off-Site*

44. In preparing their advice on this issue within their Flood Report, Northrop conducted 2D modelling to investigate the potential for the proposed buildings to obstruct and alter flood behaviour.

45. **Figure 2** maps the change in flood levels derived from the 2D model, with and without the Application, assuming the proposed buildings provide complete blockage of flood flows.

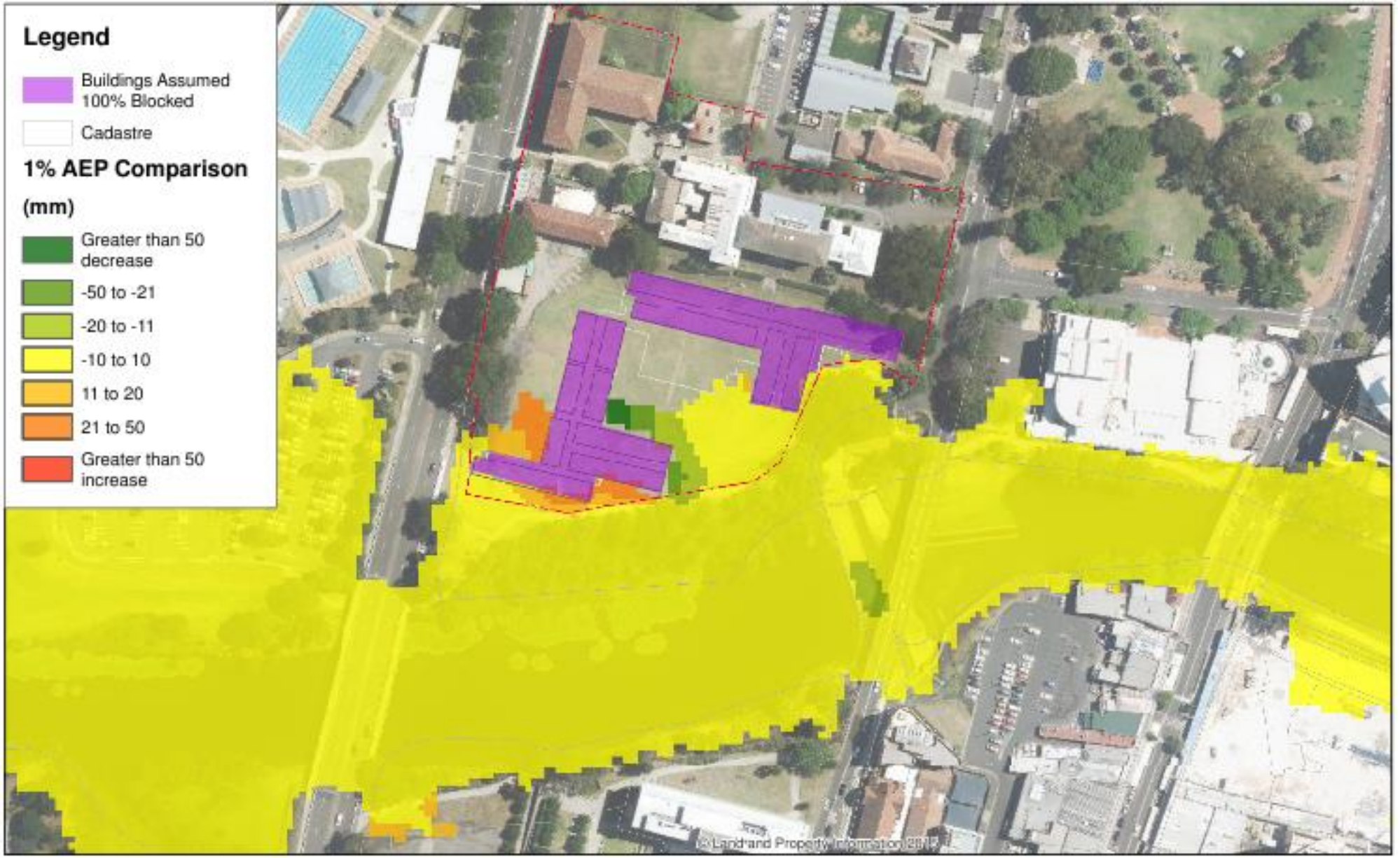

Figure 2: 100 Year ARI Flood Impacts
(i.e. increase in flood levels assuming full blockage of flood flows by the buildings)
(This figure was prepared by Northrop and provided directly to the reviewer. It has been derived from the 2D flood modelling undertaken by Northrop in preparing their Flood Report and FEMP dated 16 March 2017).

46. The impact mapping in **Figure 2** indicates the Application will generally not increase flood levels beyond the site by more than 10mm in the 100 year ARI flood event.[18] In the opinion of the reviewer this demonstrates that the Application will not have any significant impact on flood behaviour to third parties. It also demonstrates that the buildings are not located within a floodway for this event.

47. Further, because the buildings are to be constructed to allow flow under their floors, the actual impacts of the Application will be somewhat less that those shown in **Figure 2**.[19]

48. The reviewer notes that Storm Consulting, in their role as the City's Independent Flood Engineer, has not raised any concerns relating to the potential for Application to adversely alter flood behaviour off-site.

C2.2 *Potential for Buildings to be Washed Downstream an Extreme Flood*

49. When assessing any development in a floodplain it is important to consider the potential for any of the proposed buildings to wash off the site. In respect of this Application it is especially important because:

    (a) the PMF flood levels are about 5m higher than the 100 year flood levels and water levels in a very extreme flood could be above the ceilings and roofs of the ground floor building. This considerable depth of flood waters, the associated increased buoyancy, together with the potential for upstream flood debris to impact on the buildings, mean the structural stability of the buildings is reduced compared with more typical floodplain developments;

    (b) the school buildings are demountables; and

    (c) due to other environmental constraints on the site, the reviewer understands there is to be no excavation of the surface of the oval. This includes the placement of underground anchors to restrain the buildings. (Consequently the stability of the buildings is restrained by their mass, including the mass of the foundation slab, and frictional resistance against sliding).

50. Whilst these concerns are recognised, in the opinion of the reviewer they can be overcome by proper structural engineering design. The structural analyses prepared by Northrop demonstrate that a practical solution ensuring the stability of the buildings can be achieved.[20]

51. In the experience of the reviewer, it would be normal practice for the stability of the buildings to be certified by a structural engineer, and for the consent authority to rely on

[18] Note the modelling shows all upstream areas have no increases in water levels that exceed 10mm. However **Figure 2** shows there is an area on the southern bank of the river downstream of the O'Connell Street bridge where the increases are 10-20mm. Examination of the model output shows the typical water level increase in this area is about 10.5mm with a maximum increase in one isolated model cell of 13.5mm. It is likely that the increase shown in this area is due to a model perturbation (which is common in 2D models) and is not representative of a sustained increase in water levels and is within the modelling accuracy in this area. In any event the increase is very small (and would be much less in the proposed building configuration where water flows under the buildings).

[19] The reviewer notes that the undercroft areas of the buildings are to be screened to prevent entry by school children and there will be potential for these screens to partially block with debris carried by flood waters during a flood. Whilst the reviewer notes that Northrop have proposed measures to mitigate against blockage (by allowing collapse of the screens in large floods), even without these mitigation measures, it would be normal flood modelling practice to assume 50% blockage (not the 100% blockage allowed in **Figure 2**). This 50% blockage assumption is consistent with the latest recommendations of the current revisions to Australian Rainfall and Runoff (refer item A6 in **Attachment A**).

[20] Further in the reviewer's opinion, satisfaction of structural stability concerns for new development in floodplains can be addressed in a routine manner as the water loads are normally comparable to wind loads.

this certification. Accordingly if the Panel is of a mind to approve the Application, the reviewer recommends such structural certification be carried out as a condition of consent prior to issuance of the Construction Certificate.

52. The reviewer's opinion that the structural stability of the buildings can be ensured subject to structural certification also appears consistent with Storm Consulting's advice to the City in their assessment of the structural adequacy of the latest Application.[21] In this advice Storm Consulting stated that "*Northrop's letter appears to address both my concerns*" and "*third party structural certification*" should be conditioned.

53. Storm Consulting's advice also noted that in relation to the flood velocities used in the structural stability calculations "*There should also be more confidence around the flood modelling to confirm these velocity figures so I believe a third party review would be appropriate*". The reviewer considers that his review of the Northrop modelling has been sufficient for this purpose but in any event, this could also be part of the recommended structural certification that the reviewer has recommended in paragraph 51 above.

D. ASSESSMENT OF FLOOD RISK TO PEOPLE

54. Consideration of the flood safety risks to school children, staff and other users of the site are of prime importance in this Application.

55. Whilst the proposed use of the site for 1000 school children (from Kindergarten to Year 6) would be under constant supervision by teachers, given the young age of the children, the site may also be used for other activities outside normal school hours where less supervision occurs.

56. Having regard to these school and other uses of the site, Northrop has prepared a revised Flood Emergency Management Plan (FEMP) being Issue C and dated 16 March 2017.[22]

57. A previous FEMP was assessed by Council and Storm Consulting and a detailed list of concerns and deficiencies were identified and conveyed by the City to the Department via an email to JBA on 6 March 2017.[23] Whilst the reviewer has not examined the earlier FEMP which was the subject of the City's email, the reviewer concurs with the City that many of the matters raised in their email are important considerations that need to be addressed in the final FEMP for the site.

D1. Provision of Additional Access to Higher Ground North of the Site

58. The site has ready access to high ground at the rear (i.e. to the north) via egress to O'Connell Street and Marist Place. In the opinion of the reviewer, this significantly reduces the flood safety risks at the site.

59. The safety could be further improved if formal access during flood emergencies was provided directly from the proposed lowest flood level of 9.55mAHD, into the old school site at the rear through to Marist Place, without descending below 9.55mAHD. Discussions between the reviewer and the Department have confirmed this could be provided without difficulty. **Figure 3** shows a location for the proposed egress route.[24]

[21] Refer emails listed in item A17 of **Attachment A**.
[22] Refer item A14 in **Attachment A**.
[23] Refer item A10 in **Attachment A**.
[24] It would appear most practical to provide this additional access via an elevated timber walkway. Northrop confirmed by email to the reviewer on 10 April 2017 that the egress route shown on **Figure 3** was available via an

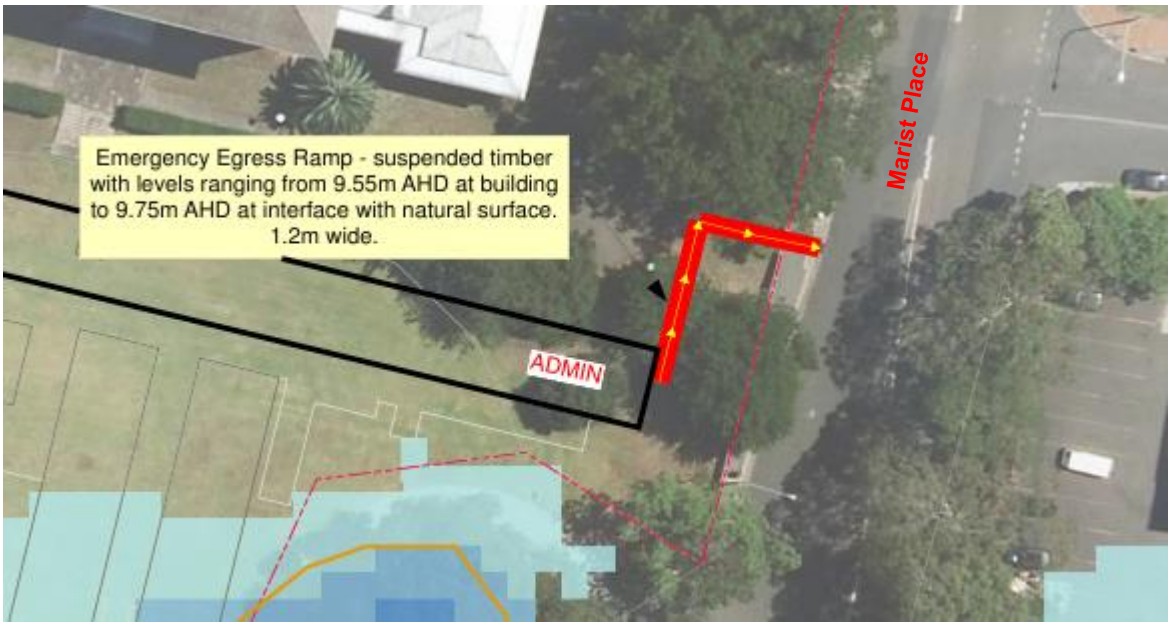

Figure 3: Recommended Additional Egress Route at North-East Corner of Site
(This figure was prepared by Northrop using the same base as **Figure 1** and provides a constantly rising egress route from the lower floor of the proposed buildings).

60. This additional access is not intended to supersede the arrangements in the FEMP. Rather it would provide a further margin of safety should for whatever reason one of more persons not evacuate the site before flood waters rose and cut the proposed pedestrian egress routes described in the FEMP. In such a situation any trapped person could go up into the buildings and exit onto Marist Place via a pedestrian accessway that was horizontal or rising.

61. Whilst the reviewer does not consider this additional egress route to be essential, given that it can be readily achieved and will provide an additional factor of safety, he recommends that it be implemented as a condition of consent.[25]

D2. Review of the FEMP

62. It is normal practice for flood emergency management plans to be prepared in draft at the development application stage and then finalised as a condition of consent prior to issuance of the Occupation Certificate once further details of the likely occupancy are known. This provides an opportunity for the FEMP to be updated with relevant information (e.g. phone numbers of relevant staff).

63. Whilst the FEMP (Issue C) which has been developed is quite comprehensive, various matters (including some raised by the City) remain outstanding. The reviewer has also

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exit from the north-eastern corner of the proposed administration building. The route would be fenced and subject to further discussions within the Department, may only be available during a flood emergency or might also be available on a more frequent basis. The egress route would be constantly rising and comprise a 1.2m wide suspended timber walkway with levels ranging from 9.55m AHD at the building to 9.75m AHD at the interface with the natural surface (and thence onto the Marist Place footpath from where land above the PMF is available to the north adjacent to St Patricks Cathedral).

[25] In the absence of this egress route being provided, a person who became trapped could take shelter on the ground floor of the building and wait until flood waters subsided. If flood water rose above the floor level of 9.55mAHD, shelter would be available on the second storey where the floor level is 12.76mAHD. If a PMF occurred, which is an extremely remote event with an ARI of approximately 100,000 years, water would inundate this upper floor to a depth of approximately 0.2m which is low hazard and whilst it would not be comfortable, would be 'survivable' if the trapped persons remained calm and waited out the event (which would likely be less than one hour).

made his own assessment of the FEMP and noted some improvements that could be made.

64. Within **Attachment B** the reviewer has listed all the improvements to the FEMP that he considers need to be made. These improvements also include for the suggested additional high level access discussed in **Section D1** above.

65. In the opinion of the reviewer, all these changes could be made to the FEMP via conditions of consent. The revised FEMP should then be certified by an appropriately qualified flood emergency management specialist prior to issue of the Occupation Certificate.[26]

66. The reviewer notes that Storm Consulting also recommended to the City that they "*may also want to consider obtaining some evidence that the FRP is being implemented. This could be done by either audit or submission of regular reports from the school. Checklists should be created as evidence for all the inspections, monitoring checks and flood drills undertaken. These checklists can either be submitted directly to council or audited by a third party who then reports to Council. … I suggest it would be worthwhile conditioning the above aspects.*"[27] The reviewer concurs with this recommendation from Storm Consulting.

67. In the opinion of the reviewer, subject to the implementation of the recommendations listed above, the flood risks to life associated with the Application are acceptable and are consistent with good flood risk management practice.

E. RESPONSE TO ISSUES RAISED BY THE CITY

68. The reviewer has assessed the consistency of the Application with the City's DCP objectives and Clause 6.3 of the LEP. This assessment is provided in **Attachment D**.

69. The reviewer has also prepared a detailed response to various flood risk issues raised by the City in the Council Assessment Report. This response is tabulated in **Attachment C**.

70. Additional comments from the reviewer on the key flood risk concerns raised by the City are provided in the **Sections E1** to E3 below.

E1. Is the Proposed Land Use Appropriate in a Flood Area?

71. The City has advised that "*the proposed sensitive land use should not be supported in a flood area"*.

72. Under the City's flood controls listed in Part 2 of the DCP, "*educational establishments*" are classified as "*Sensitive Uses and Facilities*".[28] The prescriptive controls in the DCP's floodplain matrix presented in Table 2.7 of the DCP specify that such uses are "*Unsuitable Land Uses*" in any area of the floodplain (i.e. below the PMF).

73. In the reviewer's opinion, the reason for designating these as unsuitable land uses arose because school facilities in new areas are regularly used as evacuation centres.[29] Accordingly the developers of the matrix considered it appropriate to exclude new schools

[26] There are a handful of such specialists in Sydney, some of whom regularly undertake work for Council.
[27] Refer email to the City from Storm Consulting listed in item A16 of **Attachment A.**
[28] Refer Table 2.6 of the DCP listed in item A3 of **Attachment A**.
[29] The reviewer notes that the definition of "*Sensitive Uses and Facilities*" in Table 2.6 of the DCP includes "*buildings which may provide an important contribution to the notification and evacuation of the community during flood events*".

from the floodplain. The reviewer supports this position within the prescriptive controls of the DCP.

74. Nevertheless given that this is an existing school site and is proposed only for temporary use of one year, it is not appropriate to apply the matrix controls.

75. As noted in **Attachment D** the Application satisfies the DCP's objectives for floodplain development.

E2. Reliance on a FEMP is Contrary to the Floodplain Development Manual

76. The reviewer agrees with the City that the NSW Floodplain Development Manual (**Manual**) states that FEMPs should not be used as the basis for development consents.[30] The reviewer agrees with this requirement and considers it a component of good floodplain development practice.

77. However the current Application is not proposing reliance on the FEMP as a basis for the consent. The Application will have access to high ground where occupants can take shelter. The FEMP enhances and facilitates this egress. Without the FEMP this access to high ground would still be available.

78. The Manual and the SES recommend implementation of FEMPs because they reduce flood risks. The development of a FEMP for this Application is fully in accordance with the requirements of the Manual, the SES' guidelines and good floodplain management practice. The development of a FEMP is also consistent with the City's own policies (refer DCP Design Principle P.6 listed in **Table D3** within **Attachment D**). This states that "*New developments must provide an evacuation plan …*".

E3. Will Approval of the Application Increase Flood Risks on the Site?

79. Flood risks exist on any land within the floodplain up to the PMF. Therefore any development in the floodplain up to the PMF is exposed to some flood risk. Because the site lies within the floodplain, any development of the land must be exposed to a flood risk. The key issue is not whether there will be an increase in flood risk; the key issue is whether the flood risk is appropriate given the proposed land use.

80. This is made clear by the guidelines within the Floodplain Development Manual and the Government's Flood Prone Land Policy which "*promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable*" (underlining added by reviewer).

81. Further in this way " *... the policy avoids the unnecessary sterilisation of flood prone land*" whilst ensuring "*that flood prone land is not the subject of uncontrolled development inconsistent with its exposure to flooding*"

82. In summary, it is the opinion of the reviewer that the Application (with the recommendations included within this report) is appropriate having regard to good floodplain management practice. The reviewer considers that the flood risks to which users of the site will be exposed are not significant and are acceptable.

[30] These statements were introduced into the Manual at the request of the SES after approvals were granted to developments in the 1990s which had severe flood evacuation constraints from which it was impossible to safely evacuate, without implementing emergency management procedures which the SES considered were unlikely to be followed given the passage of time and a loss of flood awareness.

F. SUMMARY AND CONCLUSIONS OF THIS REVIEW

83. This review was commissioned by the Department and evaluates the flood risks of a proposed temporary school on the oval of the old Kings School. The Department is seeking a time-limited consent for the school expiring in June 2018. The school will accommodate 1000 children from Kindergarten to Year 6.

84. Whilst the review was commissioned by the Department it has been carried out independent of all parties involved noting that the reviewer has a long standing relationship with the City and is currently engaged by them to provide flood risk advice in other areas of the City.

Documents and Assessments Reviewed

85. The review has considered flood risk documents and assessments carried out by:

    (a) Northrop – the Department's flooding and structural engineers for this project;

    (b) the City – who have their own in house engineering and strategic planning expertise;

    (c) Storm Consulting – who are stormwater engineers engaged by the City to provide independent flood risk advice; and

    (d) OEH – who are the State agency which administers the NSW Flood Program and provides advice on implementation of the NSW Flood Prone Land Policy and the NSW Floodplain Development Manual.

86. The reviewer is aware that there have been small changes to the Application and some more significant changes to the FEMP over the last month or so. The reviewer also understands the Department has agreed to incorporate an additional rising pedestrian access from the lower story buildings to Marist Place (as discussed in **Section D1** above).

87. This review is based on the latest plans listed in item A19 of **Attachment A** and includes the additional rising access. None of the assessments referred to in paragraphs 85(a) to 85(d) will have considered the proposed rising access. Further some of Storm Consulting's and the City's comments appear to have been based on earlier information and therefore their comments have not always been directly applicable to the current Application.

Key Flood Characteristics and Considerations

88. Key flood issues which influence consideration of flood risks at the site are as follows:

    (a) schools and educational establishments are normally regarded as 'sensitive uses and facilities' and warrant special attention when located in floodplains;

    (b) the flood range at the site is large with approximately a 5m rise between the 100 year ARI flood level (about 7.9mAHD) and the PMF (about 13mAHD);

    (c) the typical time to rise of the Parramatta River is about nine hours, although shorter times to rise can and do occur;

    (d) no formal flood level warnings are issued by the Bureau of Meteorology for the Parramatta River but generalised flood warnings are issued for this River given the very large number of people who live in its Catchment. The Bureau also issues

Flood Watches and Severe Weather Warnings. It is inconceivable that flood waters could rise to a level to significantly inundate most of the oval without many hours' notice being available;

(e) schools have emergency procedures to manage a range of threats. A proposed FEMP has been prepared to be incorporated into the school's management system. The reviewer recommends further improvements be made to the FEMP prior to occupation of the site. (These improvements could be conditioned if the Panel was of a mind to approve the Application);

(f) the floor levels of the lower storey buildings will be about 1.5m above the 100 year flood and would only be inundated in a 1000 year event. The upper storey floors would only be inundated in an event rarer than a 50,000 year flood. (The occurrence of such an extreme event over the 12 month tenure of the site is very remote);

(g) the proposed school buildings will be located on areas that are only partly inundated in a 100 year event, and none of the buildings will be located in an area classified as 'high hazard' under the NSW Floodplain Development Manual.

The Flood Emergency Management Plan (FEMP)

89. The FEMP provides a procedure for all school children, teachers and other occupants to leave the site ahead of imminent flooding. In most flood events, a decision will be made to close the school on the previous day and therefore evacuation will not be necessary.

90. Nevertheless in the event that this closure does not occur and flood waters begin to rise significantly whilst the site is occupied, the reviewer is satisfied that evacuation of the site could be completed within 30 minutes and that there will be sufficient notice of rising flood waters to allow this evacuation to occur.

91. Two further layers of redundancy exist should, for whatever reason, some people remain on site when flood waters have cut the egress routes nominated in the FEMP. These redundancies are:

(a) a rising pedestrian egress route from the lower storey through the rear of the site and onto Marist Place (refer paragraph 86 above); and

(b) the opportunity for trapped persons to shelter in the upper storey buildings which cover a large area. This is the 'option of last resort'. The depth of inundation in a PMF would only be 0.1-0.2m over the floor which represents low hazard conditions in such an event. Whilst it would not be comfortable, it would be survivable.

Impacts on Flood Behaviour and Structural Stability of Buildings

92. Concerns have been raised that Northrop have undertaken insufficient analyses to properly assess the velocities of flood waters around the buildings and the impact of the buildings on flood flows. The reviewer's investigations and discussions with Northrop have identified that 2D flood modelling had been undertaken which provided the basis of the analyses in Northrop's documentation. Nevertheless their documentation of this modelling was very limited and this may have led to concerns being raised by the City and Storm Consulting.

93. After examining Northrop's 2D modelling the reviewer considers:

(a) the proposed buildings, even if assumed to contain fully blocked undercrofts, will not raise flood levels off-site to any significant extent (i.e. generally less than 10mm in a 100 year flood event). The buildings will therefore not alter flood behaviour off the site;

(b) the 2D velocities in the vicinity of the buildings have been assessed by Northrop and used by their structural engineers to ensure the stability of the proposed buildings even in a PMF event. Structural stability assessments are routinely undertaken for floodplain developments and, in the opinion of the reviewer, the calculations which have already been submitted are sufficient for a consent authority to be satisfied that the buildings can be designed so that they will not wash away, even in the most extreme flood event. As noted in this review report, and in accordance with normal practice, the reviewer also recommends that structural engineering certification of the final design be prepared at CC stage.

Outcome of this Review

94. In the opinion of the reviewer, the flood risks to people and property associated with the Application are small and acceptable.

95. Having regard to good floodplain management practice, there are no flood risk reasons why the development should not be approved.

96. If the Panel is of a mind to approve the Application, he recommends that the matters listed in paragraphs 51, 61, 65 and 66 be addressed by normal conditions of consent.

…….

Signed: Drew Bewsher

Date: 10 April 2017

ATTACHMENT A

Documents Considered During This Review

KEY DOCUMENTS CONSIDERED DURING THIS REVIEW

A1. *NSW Floodplain Development Manual*. 2005.

A2. *Parramatta Floodplain Risk Management Policy*. City of Parramatta. Version 2. Commenced: 26/06/06. Last adopted/approved: 27/10/14

A3. *Parramatta Development Control Plan 2011*.

A4. *Managing the floodplain: a guide to best practice in flood risk management in Australia.* Handbook 7. Australian Emergency Management Handbook Series. Australian Emergency Management Institute. Australian Government Attorney-General's Department. 2013.

A5. *New South Wales State Flood Plan.* A Sub Plan of the State Emergency Management Plan (EMPLAN). March 2015 v1.0.

A6. *Project 11. Australian Rainfall And Runoff. Blockage Guidelines For Culverts And Small Bridges*. Engineers Australia. February 2015.

A7. *Parramatta Local Environmental Plan 2011*. Current version for 23 September 2016.

A8. *Flood Enquiry Information Issued - 25 November 2016*. Issued by the City of Parramatta. This was included with Attachment 2 of Northrop's letter referred to in item A11 below.

A9. *RE: Old Kings School: DA/80/2017: Assessment of Flood Risk to proposed buildings*. Storm Consulting's letter to City of Parramatta. 2 March 2017.

A10. Email from the City to JBA sent 9:44am 6 March 2017. This email outlined the City's "*outstanding concerns*" relating to flood risk and was prepared after the City had "*received a formal response from an external engineer … along with our internal engineer*". This was a comprehensive list of issues and deficiencies in the material that had been provided at that time. It appears that this email prompted the revisions to the documentation and the Application that were subsequently provided by the Department and which are listed in items A11 to A14 below.

A11. *Re: Demountables for Temporary O'Connell Street Primary School, 24 O'Connell Street Parramatta – Flooding Considerations and Risk Management*. Northrop letter to Department of Education. 16 March 2017.

A12. *Re: Temporary O'Connell St Primary School, O'Connell St, Parramatta – Structural Provisions for Flooding*. Northrop letter to Department of Education. 16 March 2017.

A13. Architectural drawings of proposed development. These were bound into Attachment 1 of Northrop's letter referred to in item A11 above.

A14. *Flood Emergency Management Plan for Temporary O'Connell Street Primary School at 24 O'Connell St, Parramatta*. Revision C. This was included with Attachment 3 of Northrop's letter referred to in item A11 above.

A15. Various email correspondence between Northrop and the Department of Education relating to emergency management planning and WH&S procedures within the Department. January – March 2017.

A16. Email from Storm Consulting to the City relating to the "*revised flood report and revised flood response plan*". Sent 10:36am 19 March 2017. (This email was sent after the City forwarded the documents listed above in A11 to A14 to Storm for comment. The City also sent Storm a copy of an email dated 17 March 2017 from Northrop explaining the changes they had made to these documents).

A17. Two emails from Storm Consulting to the City relating to "*structural elements*", "*structural certification*" and "*evidence that the FRP is being implemented*". Sent 10:48am 19 March 2017 and at 10:55am on 20 March 2017. (This email was sent after the City forwarded the documents listed above in A11 to A14 to Storm for comment. The City also sent Storm a copy of an email dated 17 March 2017 from Northrop explaining the changes they had made to these documents).

A18. *Old Kings School - OEH comments on flood risk*. Email from Gus Pelosi, A/Senior Team Leader – Water Floodplains & Coast, NSW Office of Environment and Heritage to Myfanwy McNally, Manager City Significant Development, City of Parramatta. 29 March 2017.

A19. Architectural Plans of the Application emailed to the reviewer by the Department on 6 April 2017. (Filename *Attachment_plans_2017SWC020.pdf*).

A20. *Council Assessment Report.* Prepared by the City of Parramatta for the Sydney West Central Planning Panel. Panel Ref: 2017SWC020 DA. Undated.

ATTACHMENT B

Recommended Improvements to Northrop's Flood Emergency Management Plan (FEMP)

General Comments

B1. The FEMP should be updated, finalised and certified prior to issuance of an Occupation Certificate. The certification should be provided by an experienced flood emergency management specialist. This should include a review of all proposed signage and arrangements for the publication, distribution and implementation of the FEMP procedures.

B2. Prior to finalisation of the FEMP, a flood frequency analysis should be undertaken to confirm the proposed DipStik alert level of 5mAHD. This analysis should be undertaken for the Parramatta River at Parramatta Hospital (Marsden Weir) (AWRC gauge number 213004) noting that previously the UPRCT developed a reliable high flow rating curve for this site and flood frequency assessment at the 213004 gauge to calibrate its model. The purpose of this analysis will be to confirm whether the trigger can be set lower than 5mAHD whilst avoiding unnecessary activations.

B3. The FEMP is to be modified to include the option for egress though the old school site to Marist Place as discussed in **Section D1,** only in the circumstance when the primary egress routes nominated in the FEMP are no longer available due to rising flood waters.

B4. As recommended by Storm Consulting in their email listed in item A17 of **Attachment A**, procedures for auditing or submission of regular reports from the school on the FEMP implementation should be prepared. Checklists should be created as evidence for all the inspections, monitoring checks and flood drills undertaken. These checklists could either be submitted directly to the City or audited by a third party and then reported to the City.

Specific Comments

B5. p.8 – flood behaviour needs to discuss rate of rise and include hydrographs;

B6. p.11 & 19 – further attention to be given to the training and implementation of Wardens for before or after school care to ensure that persons occupying the buildings during these occasions are fully compliant with the FEMP requirements. This should include for all potential persons on site such as contractors, canteen staff, teacher assistants, parent helpers, SRE teachers, etc;

B7. p.12 – consideration should be given to locating younger children (e.g. kindergarten) on the least flood-prone land with closest access to the egress routes and the COLA.;

B8. p.12 – written confirmation should be provided of the availability and capacity of St Patrick's cathedral to accommodate 1000 children plus staff;

B9. p.15 – brochure to be prepared and sent to all parents providing information about flood risks on the site and the proposed actions during a flood emergency;

B10. p.16 – monitoring should occur at 8am and 4pm and more frequently should concerns arise over approaching bad weather;

B11. p.17 – triggers to be expanded to include for the issuance, by the Bureau of Meteorology, of a Generalised Flood Warning or a Flood Watch, or other advices issued by the SES or the Department;

B12. p.18 – refuge needs to be ready even if Flood Watch issued;

B13. p.22 – should also be revised if official FWS developed;

B14. P.26 – the response summary is to be expanded and finalised.

ATTACHMENT C

Review of Flood Risk Components of 'Council Assessment Report' (undated)

Table C1: Response to Council Assessment Report

Assessment Comment by the City	Response by Bewsher
Page 18, Paragraph 3: "*The covered outdoor learning area (COLA) would be at 8m AHD and as such would not meet the freeboard*".	The COLA is an outdoor area protected by a roof. It has a concrete floor and no walls. It is not a habitable area (based on the definitions in the Floodplain Development Manual). It does not require a FPL or a freeboard.
Page 18, Paragraph 4: "*The Probable Maximum Flood (PMF) is approx. 13m AHD (4m to 5m above ground level). The proposed first floor level is 12.9m AHD and as such would not provide refuge in place for the PMF*".	The City has calculated the depth of inundation to be 0.1m in a PMF. (The reviewer has calculated a depth of 0.2m). Given that the ARI of a PMF is approximately 100,000 years, it could serve as a refuge. This would be an 'option of last resort' should, for whatever reason, a person fails to evacuate and becomes trapped.
Page 18, Paragraph 5: "*.. predictions of the geographic extent of flood risk are subject to inherent inaccuracies as a result of technical limits. Given the flatness of the site, small increases in flood level would result in large expansion of the extent of high flood hazard across the site. There is a high sensitivity to rainfall at this site as evidence by the difference between the 1% AEP level of approx. 7.9m AHD and the PMF level of approx. 13m AHD*".	All hydrological calculations are subject to some uncertainties. The reviewer agrees with the City that that the flood range between the 100 year ARI event and the PMF is large (i.e. approx 5m) and this places additional flood risk considerations on the site. However the proposed floor levels are well above the normal FPLs and there is a rising egress route available for evacuation. There are adequate margins of safety and redundancies to safely cope with any variations in the predicted flood behaviour that could likely occur.
Page 18, Paragraph 7: "*The proposed use is classified as a 'sensitive use and facility'. Such uses are not considered to be appropriate even in low hazard flood areas. The DCP sets no distinction between permanent and temporary uses.* ".	Refer to **Section E1** for the reviewer's response on the classification of the land use as a *"sensitive use and facility"*. Whilst the DCP has not specifically referred to "*temporary uses*" the duration of a consent is a very pertinent consideration and clearly influences flood risk assessments. Therefore although not mentioned specifically, because the duration of a consent influences flood risks, it is a relevant consideration in determining compliance with the objectives of the DCP.
Page 18, Paragraph 8: "*Council's DCP states that new development should not result in any increased risk to human life. While the proposal has gone some way to reduce the risk to human life, the fact that some risk will always remain is considered to be contrary to the principle. As such the proposal is inconsistent with the DCP* ".	Refer comments in **Section E3**.
Page 18, Paragraph 9: "*The applicant has outlined, and Council officers agree, that it is not appropriate to attempt refuge in place in the event of severe weather* ".	Whilst the reviewer agrees that taking refuge on-site is not the primary means of managing flood risks, the availability of a refuge as an 'option of last resort' is a further mitigating factor in reducing the site's flood risks.
Page 19, Paragraph 2: "*Council officers worked with the applicant to optimise the evacuation plan. However, the NSW Government's Floodplain Development Manual is explicit in denouncing the reliance on evacuation plans* ".	The reviewer does not agree. Refer comments in **Section E2**.
Page 19, Paragraph 3: "*Further, given the high number and young age of the students, it is considered that the chance that inappropriate decisions are made and that the flood evacuation management plan is not adequately adhered to are high. Further, while the proposed buildings are raised, the flood evacuation route requires that students descend back to ground level, increasing the risk during evacuation.* ".	Because these children are so young, they will be under the full-time control and supervision of their teachers. This assists in ensuring all children can respond to the FEMP actions when directed to do so by their teachers. With regard to the City's comments about students descending back to ground level, the reviewer agrees. Nevertheless given the good visual clues of advancing flood waters and the early evacuation trigger of 5m, this is not considered to be problematic. In the remote circumstances that the route back to ground level was blocked by flood waters, a higher alternative egress route which does not involve descent, will be available (refer **Section D1**).
Page 19, Paragraph 4: "*As such the only safeguard that remains is the imperative to cancel school if high rains are predicted.*	There a range of circumstances that could trigger evacuation or closure of the school, not only a rainfall forecast on the previous day (e.g. triggering of the

Assessment Comment by the City	Response by Bewsher
Given the inherent uncertainty in meteorology this is not considered to be sufficient basis for fully mitigating the risk to human life ".	DipStik gauge, visual notification of rising flood waters, a generalised flood warning, and/or advice from emergency service personnel). In addition, as recommended in this review, the issuance of a Flood Watch by the Bureau of Meteorology should also be used as a trigger to close the school.
Page 20, Paragraphs 3 and 4: "*The primary risk to property resulting from the development would be one or more of the demountable units becoming unmoored and travelling down river. The applicant has submitted a statement by qualified structural engineers that the proposed buildings would be able to withstand the estimated flood velocities and associated debris impacts. However, Council's engineer and the external engineer hired to review the proposal have questioned the assumptions used in determining the flow velocities used to make these calculations.* *It is unlikely that the proposed structures would withstand significant floods between the 1:100 and the PMF (fast moving water 5m to 6m above ground level). In such an event the demountable buildings would be destroyed on site and/or washed into the river causing additional risk to human life and property downstream* ".	The reviewer disagrees with the City's assessment. Refer comments in **Section C2.2**.
Page 20, Paragraphs 6 and 7: "*The demountable buildings have been designed to allow up to 1:100 flood waters to flow through the cavities under the buildings. However, large objects such as trees, vegetation, and vehicles, could back up against the building support legs, diverting the flow of flood waters. However, the entire ground floor of the building would be submerged at the PMF flood and as such would divert floodwaters. From this diversion, flood flow patterns will change and flood levels will be raised in adjoining land.* *Council's Engineering is of the opinion that the buildings would block and disrupt the existing flood flows and flood levels on site, in the river, and on adjoining land, to an unacceptable degree* ".	The reviewer disagrees with the City's assessment. Refer comments in **Section C2.1**.

ATTACHMENT D

Review of the Application's Compliance with:

- **Clause 6.3 of the LEP;**
- **DCP Objectives (Part 2 of DCP); and**
- **DCP Design Principles (Part 2 of DCP)**

Table D1: Assessment of Application against the Clause 6.3 of the LEP

Clause 6.3	Evaluation of Application Against Clause
(1) The objectives of this clause are as follows: (a) to minimise the flood risk to life and property associated with the use of land, (b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change, (c) to avoid significant adverse impacts on flood behaviour and the environment.	(a) as discussed in **Sections C** and **D**, the Application minimises the flood risk to life and property; (b) none of the buildings occur within a high hazard area. The Application is consistent with the site's hazard. Climate change is not relevant as the use is temporary for 12 months until June 2018; (c) as discussed in **Section C2.1** there will be no adverse flood impacts on flood behaviour and the environment.
(2) This clause applies to land at or below the flood planning level.	Noted
(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development: (a) is compatible with the flood hazard of the land, and (b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and (c) incorporates appropriate measures to manage risk to life from flood, and (d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and (e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.	(a) the information that has been reviewed demonstrates that the Application is compatible with the flood hazard of the site; (b) as discussed in **Section C2.1** the Application will not significantly adversely affect flood behaviour off the site; (c) appropriate measures to manage flood risk to property and flood risk to life are included in the Application and have been discussed in **Sections C** and **D;** (d) the Application does not significantly alter flood behaviour and involves no works near the river banks and therefore is unlikely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses; (e) because the flood risk to life and property are satisfactorily managed, the Application is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.
(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government, unless it is otherwise defined in this clause.	Noted.
(5) In this clause: *flood planning level* means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.	Noted.

Consequently the Application complies with Clause 6.3 of the Parramatta LEP 2011.

Table D2: Assessment of Application against the DCP Objectives

DCP Objective	Evaluation of Application Against Objective
O.1 To ensure the proponents of development and the community in general are aware of the potential flood hazard and consequent risk and liability associated with the use and development of flood liable land.	Will be achieved through implementation of the FEMP.
O.2 To manage flood liable land in an economically, environmentally and socially sustainable manner.	The reviewer understands this objective is achieved and has been separately addressed by others.
O.3 To ensure that developments with high sensitivity to flood risk (e.g. critical public utilities) are sited and designed to provide reliable access and minimise risk from flooding.	Reliable access in the DCP means "*the ability for people to safely evacuate an area subject to imminent flooding, having regard to the depth and velocity of flood waters, the suitability of the evacuation route, and without a need to travel through areas where water depths increase*". Reliable access is available for this site.
O.4 To allow development with a lower sensitivity to the flood hazard to be located within the floodplain, subject to appropriate design and siting controls and provided that the potential consequences that could still arise from flooding remain acceptable.	Refer **Section D**. Implementation of the Application will result in an acceptable flood risk at the site.
O.5 To prevent any intensification of the development and use of High Flood Risk Precinct or floodways, and wherever appropriate and feasible, allow for their conversion to natural waterway corridors.	The Application does not propose development within the High Flood Risk Precinct or within a floodway.
O.6 To ensure that the proposed development does not expose existing development to increased risks associated with flooding.	This objective will be achieved as discussed in **Sections C, D** and **E3**.
O.7 To ensure building design and location address flood hazard and do not result in adverse flood impact and unreasonable impacts upon the amenity or ecology of an area.	The buildings are not located in a high hazard area and have been designed so that they will not wash away in the most extreme flood event that could possibly occur. Within regard to amenity and ecology impacts, the reviewer understands these objectives are achieved and have been separately addressed by others.
O.8 To minimise the risk to life by ensuring the provision of appropriate access from areas affected by flooding up to extreme events.	As discussed in **Section D**, risk to life is minimised and appropriate egress from the site is available in extreme flood events.
O.9 To minimise the damage to property, including motor vehicles, arising from flooding.	This objective is achieved as discussed in **Section C**. The objective relating to motor vehicles is not applicable as no on-site parking is proposed.
O.10 To incorporate the principles of Ecologically Sustainable Development (ESD).	The reviewer understands this objective is achieved and has been separately addressed by others.

Consequently the Application complies with the DCP's Objectives relating to flooding.

Table D3: Assessment of Application against the DCP Design Principles

DCP Design Principles	Evaluation of Application Against DCP Design Principle
P.1 New development should not result in any increased risk to human life.	Refer comments in **Section E3**. There will be unacceptable increase in risk to human life.
P.2 The additional economic and social costs which may arise from damage to property from flooding should not be greater than that which can reasonably be managed by the property owner, property occupants and general community.	This is achieved as the proposed floor levels will be well above the normal FPLs. Consequently the chance of inundation above floor level is much rarer than for other floodplain developments in the City.
P.3 New development should only be permitted where effective warning time and reliable access is available for the evacuation of an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy where in existence.	Reliable access and effective warning time are available. (Refer also to response to Objective O.3 in **Table D2**).
P.4 Development should not adversely increase the potential flood affectation on other development or properties, either individually or in combination with similar developments(s) that are likely to occur within the same catchment.	Refer **Section C2**. There will be no adverse flood impacts on adjacent land.
P.5 New developments must make allowances for motor vehicles to be relocated to an area with substantially less risk from flooding, within an effective warning time.	Not applicable. No on-site parking is proposed as part of the Application.
P.6 New developments must provide an evacuation plan detailing procedures that would be in place for an emergency (such as warning systems, signage or evacuation drills).	This is achieved via the FEMP.
P.7 Flood mitigation measures associated with new developments should not result in significant impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (e.g. by unsympathetic house raising) or by being incompatible with the streetscape or character of the locality (including heritage).	The reviewer understands this principle has been incorporated within the design and has been separately addressed by others.
P.8 Proposals for raising structures must provide a report from a suitably qualified engineer demonstrating that the raised structure will not be at risk of failure from the forces of floodwaters.	Refer Northrop's structural stability analyses in item A12 of **Attachment A**.
P.9 Development is to be compatible with any relevant Floodplain Risk Management Plan, Flood Studies, or Sub-Catchment Management Plan.	The Application is consistent with the City's Floodplain Risk Management Plan and the Flood Study for the area.
P.10 Development must not divert flood waters, nor interfere with floodwater storage or the natural function of waterways.	The Application will not have adverse flood impacts as discussed in **Section C2.1**.
P.11 Filling of land up to 1:100 Average Recurrence Interval (ARI) (or flood storage area if determined) is not permitted. Filling of and above 1:100 ARI up to the Probable Maximum Flood (PMF) (or in flood fringe) must not adversely impact upon flood behaviour.	Not applicable. No filling of any significance is proposed.
P.12 New development must consider the impact of flooding resulting from local overland flooding whether it is a result of Local Drainage or Major Drainage.	This will be addressed at Construction Certificate stage as part of the design of the stormwater system.
P.13 Where hydraulic flood modelling is required, flow hazard categories should be identified and adequately addressed in the design of the development.	This has been considered in the design and is discussed in **Sections B2** and **B3**.
P.14 Council strongly discourages basement car parks on properties within the floodplain. Where site conditions require a basement car park on a property within the floodplain, development applications must provide a detailed hydraulic flood study and design demonstrating that the proposed basement car park has been protected from all flooding up to and including the PMF event. An adequate emergency response and evacuation plan must also be provided where basement car parks are proposed in the floodplain.	Not applicable as basement car parking is not proposed.

Consequently the Application complies with the DCP's Design Principles relating to flooding.

ATTACHMENT E

Review of Flood Risk Advice from OEH to the City on 4 April 2017 and the City's Response

Table E1: Bewsher's Reply to OEH's Advice and the City's Response

OEH's Advice	The City's Response	Bewsher's Reply
The NSW Government's Flood Prone Land Policy promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable. The merit approach is based on a risk analysis of identifying risks, estimating their likelihood and evaluating potential consequences.	This report outlines a merit based approach to the assessment of the application. Council has followed the NSW Flood Prone Land Policy carefully. This includes considering the social and economic parameters and sustainability of the proposed development.	The City has undertaken its own merit assessment and believes the Application should not be approved. However in carrying out its assessment it has come to various conclusions about aspects of the proposed development which, as discussed in this report, are not accurate (in the opinion of the reviewer). Once these inaccuracies are resolved, the City may come to a different conclusion about the merit assessment.
The NSW Government's 2005 Flood Development Manual does not mention that schools or other sensitive uses should have a higher flood planning level, only that flood evacuation be considered.	This is not relevant as a higher flood planning level has not been sought. The Floodplain Development Manual specifically advises that an evacuation plan does not mitigate flood hazard and risks and should not be the basis for determining a Development Consent.	The reviewer agrees with OEH that there is no specific reference in the Manual to schools having higher FPLs. However existing best practice typically locates schools outside the PMF because these facilities often serve as evacuation centres for the local community. Nevertheless as discussed in **Section E1**, this is not a relevant consideration in the circumstances of the Application because only a 12 month temporary use is proposed and there is no intention for the proposed school to serve as an evacuation centre. In response to the City, the reviewer notes that the Manual, the SES (and the City's DCP) encourage use of FEMPs as a means of reducing site flood risks. As discussed in **Section E2** the Application is not relying on the proposed FEMP as the basis of the consent sought by the Department.
The Department of Education is placing school children in an area of flood risk but is managing that risk through raised floor levels and flood evacuation.	Council's assessment incorporates all aspects of risk management and has found that the Department of Education is intending to place school children at risk in the floodway of Parramatta River and such risks cannot be adequately managed.	The available evidence provided to the reviewer is that the proposed buildings are not located within a floodway. With the provision of the additional site egress discussed in **Section D1** (which neither OEH nor the City would have been aware of when making their comments) there will be rising egress available which further reduces the site's flood risks.
A temporary school which will be in place for 1 to 2 years has a lower flood risk that a permanent school building and Council as the consent authority may apply a different standard of flood planning level.	Council has assessed the risk level and finds that a 1% per annum risk of total inundation of the school site is unacceptable.	The temporary nature of the proposed use must mitigate the flood risks. This does not appear to have been properly considered by the City.
In a major flood the buildings would be damaged and should be tied down to the piers to avoid floating away in a flood.	In a major flood, the piers, foundations and classrooms, and the underlying topsoil would all likely be washed away. Due to archaeological restrictions no foundations or ground anchors are permitted.	The City is correct in that the Application will not utilise foundations or ground anchors. The stability of the proposed buildings will be certified by a structural engineer. Such proposed certification was proposed by Council's independent flood engineer as a means of addressing this concern. There are no technical reasons to believe that the stability of the

OEH's Advice	The City's Response	Bewsher's Reply
		proposed buildings cannot be achieved in even the most extreme flood event. (Refer further comments in **Section C2.2**).
As the flooding is mainstream Parramatta River flooding there would be some flood warning to allow evacuation to occur.	Council has not yet found a satisfactory way to achieve flood warning for any occupants of the entire Parramatta River floodplain.	The City's comments are not appropriate to this Application. There is no need to warn "*any occupants of the entire Parramatta River floodplain*" only those at this site. Being a school it has management systems in place which enable it to respond to flood threats in a more organised manner than many other types of floodplain developments. In the opinion of the reviewer there is ample flood warning time available for the 15-30 minutes required to assemble school students and staff and evacuate the site.
Typically schools are better placed than other uses to have the staff and systems in place to manage safe evacuation.	This comment does not withstand examination. There will be about 1000 school children on site.	The reviewer disagrees with the City's comments. (Refer previous reply immediately above).
There is adjacent rising evacuation to a PMF refuge.	The route proposed to higher ground is complicated and unclear. It places less mobile or disabled children (and staff) at greater risk. In any case, the Floodplain Development manual specifically notes that an evacuation plan does not mitigate against a hazardous situation and should not be the basis for determining a consent.	Having a rising evacuation route is an important factor in mitigating flood risks. The reviewer disputes that the egress route is "*complicated and unclear*". In any event the proposal for the additional egress route described in **Section D1** will further reduce any residual safety risks and provide an extra margin of safety.
Many existing schools in Sydney are located below the 100 year flood extent and over 30% of Sydney would be inundated in a PMF flood event. The additional flood risk from this proposal to that across greater Sydney is minor.	Council is obliged to assess cumulative impacts. Lack of planning for flooding in the past is not a justification for continuing to ignore this risk now. This DA is being assessed on its merits and as required by State Policy.	The reviewer agrees with the City's comments about the lack of past planning providing a justification for the current Application. The Application should be assessed on its merits. As concluded by this review, the Application's flood risks to life and property are small and acceptable.
I accept that all development in the floodplain involves some risk but the flood risks at the Old Kings School can be managed.	It is Council's view that the risks to which school children and staff would be exposed in this proposal are unacceptable and unmanageable in real world conditions.	There is a fundamental difference of opinion between the City and OEH over the acceptability of the flood risks associated with this Application. The reviewer does not endorse the approach taken by the City and considers it to be overly risk-averse and inconsistent with sound floodplain management practice across NSW. Given the important role that OEH staff take in managing the State's Flood Program and the technical advice they provide to Council's in implementing the principles in the Floodplain Development Manual, the reviewer considers OEH's advice in this situation should not be discounted.

ATTACHMENT F

Curriculum Vitae of Drew Bewsher

Drew BEWSHER

QUALIFICATIONS

Bachelor of Engineering (Hons), University of Tasmania, 1975.
Master of Science in Civil Engineering, California Institute of Technology USA, 1977

AFFILIATIONS AND AWARDS:

Fellow, Institution of Engineers, Australia.
Member, College of Civil Engineers, Institution of Engineers, Australia.
Chartered Professional Engineer, NPER-3 Registration
Registered Professional Engineer of Queensland
Awards by Floodplain Management Australia:

- 2016 Australian Flood Risk Manager of the Year (Allan Ezzy Award)
- 2013 Harold Sternbeck Medal

FIELDS OF SPECIAL COMPETENCE

Over thirty five years' experience in water related projects in Australia, America and South East Asia. This work has included floodplain management studies, river hydraulics and flood studies, computer modelling, hydrological studies, irrigation and salinity modelling, urban drainage investigation and design, water quality investigations, dam break studies, environmental planning and environmental impact assessment, construction supervision and the project management and economic evaluation of water resources projects. He has also provided expert testimony in legal proceedings related to flooding and drainage matters in the Supreme Court, District Court, and Land and Environment Court, and other tribunals in NSW, Victoria and Queensland.

EXPERIENCE

1986 to date | Bewsher Consulting Pty Ltd

Principal responsible for a number of projects including:

Floodplain Risk Management Studies and Plans for approximately 30 NSW councils including those for the Hawkesbury, Double Bay, Eastwood, Nundle, Woolomin, Macquarie Park, Georges River, Mullet/Brooks Creek, Fairy/Cabbage Creek, Bowral, Coffs Creek, Camden Haven, Upper Parramatta River, Grafton, Lower Clarence River, Salt Pan Creek, Lower Georges River, Ballina and Tweed (BMT-WBM projects), Gwawley Bay, Prospect Creek, Billabong Creek, Berrima, Towradgi Creek, Haslams Creek, Mudgee, North Wentworthville, Carlingford, Brickfield Creek, Cabramatta Creek, Boundary Creek, Eastern Creek, Narrabri, Scone, Molong and the Paterson River.

Independent technical audits and expert advice associated with flood risk management, hydrologic modelling and water resources issues in Australia. This has included advice to the Queensland Floods Commission of Inquiry, expert hydrological review of major highway projects, expert technical support to the Snowy Water Inquiry and numerous Government projects relating to water efficiency savings throughout the Murray-Darling Basin including Menindee Lakes, technical auditor of the Murray-Darling Basin Commission 'Cap' models comprising 24 valley models developed by four states and the ACT, expert advice on various projects related to the Murray-Darling Basin Salinity

Management Strategy, expert review of IQQM models and environmental flow objectives for the NSW government, expert independent assessment of hydrological components of major infrastructure projects and EISs (e.g. Tillegra and Traveston Crossing Dam projects), together with numerous reviews carried out for the private sector.

Flood risk assessment and computer modelling of flood behaviour for over 500 projects in urban and rural areas of Australia. This has included assessment of risks to life and property from flooding, simulation of flow behaviour using one and two dimensional models, stormwater and urban drainage assessments, and consideration of a range of related environmental, riparian corridor and water quality issues.

Expert testimony in excess of 60 court proceedings relating to development applications, valuation of flood prone land, personal injury claims and other issues relating to flooding, hydrology and stormwater drainage issues in NSW, Queensland and Victoria.

Policy formulation for floodplain development. This has included the preparation of over 25 Development Control Plans for local councils in NSW to ensure new developments meet best practice standards for floodplain management. The scope of these policies has also addressed flood prone caravan parks, on-site stormwater detention and a range of broader stormwater management issues.

Design and management of flooding and drainage infrastructure projects. These projects comprise detention basins, major trunk stormwater systems, creek rehabilitation, and the civil works associated with numerous floodplain and stormwater projects.

1980 to 1986 | Sinclair Knight & Partners Pty Ltd, Australia

Specialist Water Engineer working on numerous development, government aid, mining and World Bank projects in NSW, Malaysia, and the islands of Sumatra and Java in Indonesia.

1978 to1980 | River Murray Commission, Australia

Investigation Engineer responsible for modelling of water resources of the Murray-Darling Basin, assisting the Executive Engineer with river operations and various investigations into the water resources of basin, and the preparation of water accounting procedures.

1977 | Camp, Dresser & McKee, USA

Engineering investigations of flood behaviour and river hydraulics in the Los Angeles Basin.

PAPERS

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