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APPENDIX P

Stormwater Management Plan

Aurecon

Sydney Football Stadium Redevelopment

Stormwater Management Plan (SWMP)

Lendlease Buildings

Reference: 505100

Revision: E

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Bringing ideas to life

Document control record

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Executive Summary

This report addresses the requirements placed upon the stadium team by the Department of Planning & Environment and details the flooding, water quality, water source and drainage considerations for the site and proposes a design intent that shall be carried through to construction. The design will adhere to the three-tier stormwater management strategies as a minimum:

a. The 100 yr ARI (1% AEP) event peak flow are restricted by means of attenuation measures,
b. 100 yr ARI (1% AEP) event stormwater flows are carried within precinct pipe drainage network without surcharge,
c. Upstream and downstream flood impacts are managed so as not to exacerbate peak flood depth in the 100 yr ARI (1% AEP) event.

The overland flow strategy directs run-off away from the superstructure and directs flow towards Driver Avenue.

The stadium superstructure and habitable substructures have been placed above the 1% AEP flood line throughout the site boundary. A minimum free-board of 500mm above the 1% AEP has been adopted throughout. Surface run-off is directed away from habitable structures should in-ground stormwater infrastructure become blocked, or in the case of more intense rainfall exceeding the limits of the in-ground stormwater system.

Water sensitive urban design (WSUD) principles where appropriate have been incorporated into the design intent with stormwater quality improvement device(s) (SQID's) being adopted elsewhere. The introduction of SQID's has greatly increased the run-off water quality leaving the site. The increased quality of discharge will have positive impacts on the receiving water bodies downstream of the redevelopment due to the significant reduction of pollutants.

The proposed works on the site with respect to stormwater will enhance the quality of run-off and will not contribute or adversely impact flooding within the surrounding environment. It is suitable for the conditions set by the Secretary's Environment Assessment Requirements application number SSD 9835.

This report demonstrates that the proposed Stage 2 development is not inconsistent with the Stage 1 DA (SSD9249).

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1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) for the redevelopment of the Sydney Football Stadium, which is submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The redevelopment is being conducted in stages comprising the following planning applications:

- **Stage 1** – Concept Proposal for the stadium envelope and supporting retail and functional uses as well as development consent for the carrying out of early works, including demolition of the existing facility and associated structures.

- **Stage 2** – detailed design, construction and operation of the stadium and supporting business, retail and functional uses.

Development consent was granted for the Concept Proposal and detailed approval to carry out early works and demolition (SSD 18_9249) by the Minister for Planning on 6 December 2018.

This report relates to the Stage 2 application and considers the detailed design, construction and operation of the new Sydney Football Stadium pursuant to the approved Concept Proposal.

Infrastructure NSW is the proponent of the Stage 2 DA.

1.1 Background

The Sydney Football Stadium (SFS) is a significant component of the sports facilities that comprise the Sydney Cricket and Sports Ground. Completed in 1988, the SFS has hosted numerous sporting events in its 30 years of operation for a number of sporting codes including football (soccer), rugby league and rugby union as well as occasional music concerts.

The NSW Stadia Strategy 2012 provides a vision for the future of stadia within NSW, prioritising investment to achieve the optimal mix of venues to meet community needs and to ensure a vibrant sports and event environment in NSW. A key action of the strategy included development of master plans for Tier 1 stadia and their precincts covering transport, integrated ticketing, spectator experience, facilities for players, media, corporate and restaurant and entertainment provision. SFS is one of three Tier 1 stadia within NSW, the others being Stadium Australia (Olympic Park) and the Sydney Cricket Ground.

In order to qualify for Tier 1 status, a stadium is required to include:

- Seating capacity greater than 40,000;
- Regularly host international sporting events;
- Offer extensive corporate facilities, including suites, open-air corporate boxes and other function/dining facilities; and
- Be the home ground for sporting teams playing in national competitions.

On 6 December 2018, development consent was granted for the Concept Proposal and Early Works/ Demolition stage of the SFS redevelopment (SSD 18_9249). This consent permitted the completion of demolition works on the site and established the planning and development framework through which to assess this subsequent Stage 2 application. Specifically, State Significant Development Consent SSD 18_9249 encompassed:

1. A Concept Proposal for:
    - A maximum building envelope for the stadium with capacity for 45,000 seats (55,000 patrons in concert mode) and 1,500 staff.
    - Urban Design Guidelines and a Design Excellence Strategy to guide the detailed design of the stadium at Stage 2.

- General functional parameters for the design and operation of the new stadium, including:
  - Range of general admission seating, members areas, premium box/terrace, function/lounge and corporate suite options;
  - Administration offices;
  - New roof with 100% drip-line coverage of all permanent seating;
  - Flood lighting, stadium video screens and other ancillary fittings;
  - Food and beverage offerings;
  - Facilities for team, media, administration and amenity such as changing rooms, media rooms and stadium; and
  - Provision for ancillary uses within the stadium and surrounds.
- Principles and strategies for transport and access arrangements.
- Indicative staging of the development.

2. Detailed consent for the following works:
   - The demolition of the existing SFS and ancillary structures, including the existing Sheridan, Roosters, Waratahs and Cricket NSW buildings down to existing slab level.
   - Site and construction management, including use of the existing MP1 car park for construction staging, management and waste processing, and provisions for temporary pedestrian and vehicular access management.
   - The protection and retention of Tree 125 (Moreton Bay Fig adjacent to Moore Park Road) and Tree 231-238 cluster (Hills Weeping Fig and others near Paddington Lane) and all existing street trees located outside of the site boundary, with the removal of all other vegetation within the proposed future building footprint.
   - Works to make the site suitable for the construction of the new stadium (subject to this separate Stage 2 application).

1.2 Site Description

The site is located at 40-44 Driver Avenue, Moore Park within the Sydney Cricket Ground Precinct. It is bound by Moore Park Road to the north, Paddington Lane to the east, the existing SCG stadium to the south and Driver Avenue to the west. The site is located within the City of Sydney local government area.

The site is legally described as Part Lots 1528 and 1530 in Deposited Plan 752011 and Lot 1 in Deposited Plan 205794. The site is Crown Land, with the SCSGT designated as the sole trustee under the *Sydney Cricket and Sports Ground Act 1978*. The site is wholly contained within designated land controlled by the Sydney SCSGT under Schedule 2A of the *Sydney Cricket and Sports Ground Act 1978*.

In a broader context, the site is largely surrounded by Centennial and Moore Parks, the Fox Studios and Entertainment Quarter precincts and the residential suburb of Paddington. Located approximately 3km from the Sydney CBD and approximately 2km from Central Station, the site is connected to Sydney's transport network through existing bus routes and will benefit from a dedicated stop on the soon to be completed Sydney CBD and South East Light Rail.

The locational context of the Site is shown in Figure 1, and existing site features are shown in Figure 2.

Figure 1: Site Location - SCGT Precinct

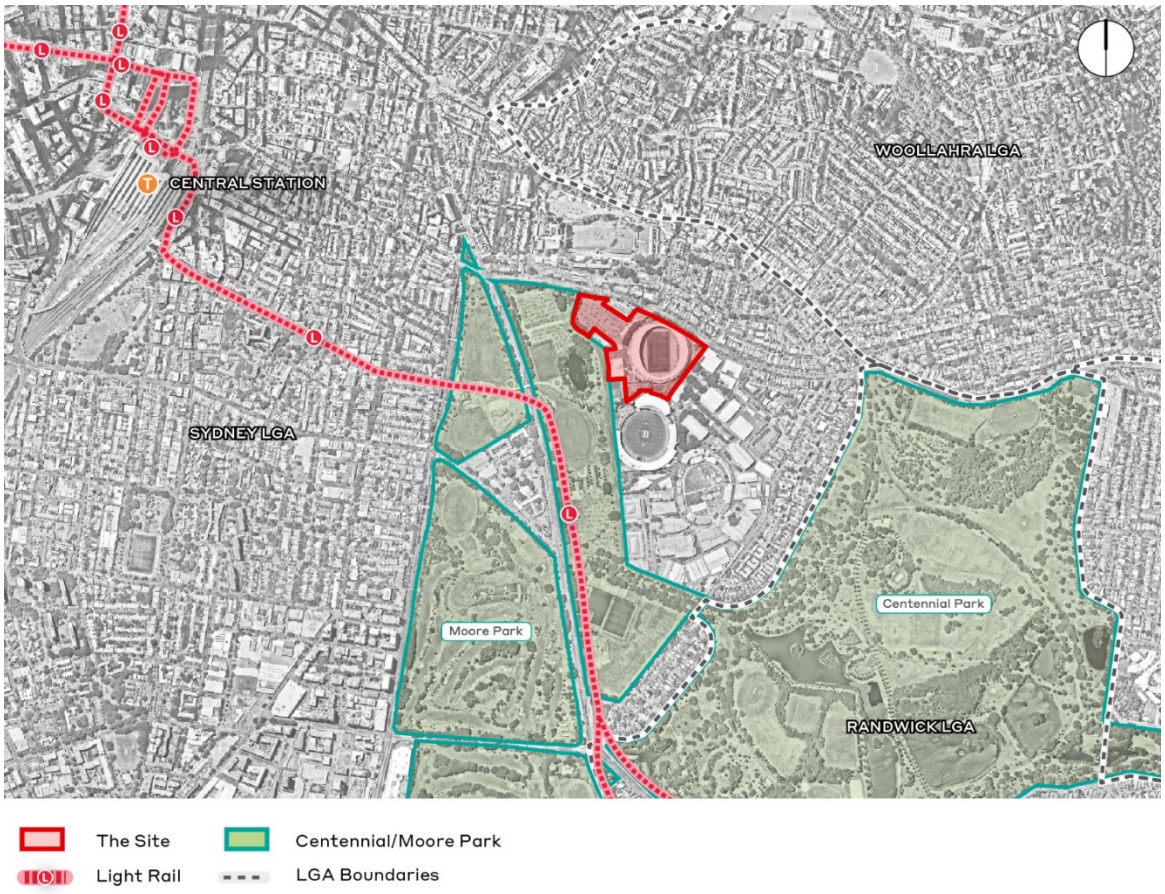
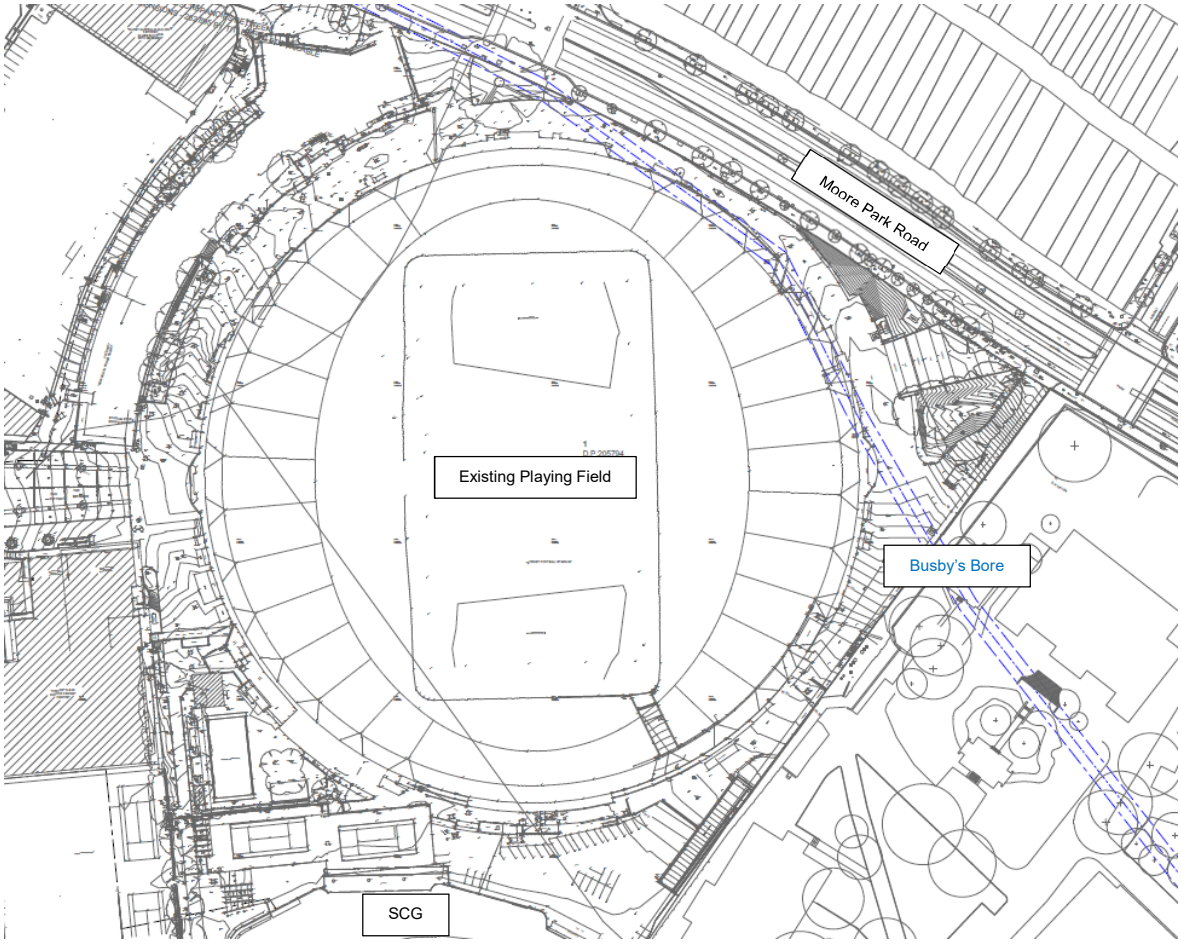


Figure 2: Existing Site Feature - SCGT Precinct



1.3 Purpose of this Stormwater Management Plan

Aurecon Australia Pty Ltd has been commissioned by Lendlease to prepare a Stormwater Management Plan (SWMP) in support of the Stage 2 Development Application (SSD9835). This report presents the stormwater strategy for the project. The report will also discuss the impact of potential pluvial flooding within the precinct from the wider Centennial Park regional catchment and the potential impacts the new development may have on adjacent properties.

The report responds to the States Secretary's Environmental Assessment Requirements (SEARS) *Section 4.12(8) of the Environmental Planning and Assessment Act Schedule 2 of the Environmental Planning and Assessment Regulation 2000*.

The following conditions set out in the SEARs are discussed within the report;

- SEAR's 26 – Drainage,
- SEAR's 27 – Water and Natural Resources (items related to stormwater management only),
- SEAR's 28 – Flooding,

This report incorporates the best practice policies and standards of local councils such as City of Sydney Engineering Guidelines and the Floodplain Development Manual for the management of flood liable land, 2005.

Table 1 – Conditions of Consent

Requirement	Where Addressed
B15 - Prior to the lodgement of the future development application Sydney Water must be consulted to determine the location of the stormwater assets and in the preparation of the stormwater plans and flood reports, plans for relocating Sydney Water assets and the protection of relevant assets.	A Section 73 Application (anticipated requirements) has been submitted on the 4th of March 2019. Sydney Water are currently reviewing the development requirements prior to the issue of the Notice of Requirements. A Stormwater Adjustment Application has been submitted to Sydney Water on the 15th of January 2019. Discussions with Sydney Water will continue under these processes.
C35- The future development application must be accompanied by a Stormwater Management Plan detailing an assessment of any flood risk on site, the future buildings and the users including the patrons and staff. The stormwater management plans and associated reports must comply with any relevant provisions of the NSW Floodplain Development Manual 2005. The plans for stormwater and drainage infrastructure, and details must demonstrate that water sensitive urban design measures have been incorporated into the future development. Evidence of consultation with Sydney Water required by Schedule 2, condition B15, and Council in preparing the stormwater management plans must be submitted as part of the future development application.	Refer to section 2.0 Flood Analysis. Refer to Appendix F for consultation with City of Sydney. A Section 73 Application (anticipated requirements) has been submitted on the 4th of March 2019. Sydney Water are currently reviewing the development requirements prior to the issue of the Notice of Requirements. A Stormwater Adjustment Application has been submitted to Sydney Water on the 15th of January 2019. Discussions with Sydney Water will continue under these processes.
C36- The future development application must include: a) a 2D Flood Model using Council's flood model for this catchment to address whether the asset causes flooding; and	Refer to section 2.0 – Flood Analysis and 3.4 Stadium Stormwater Discharge Results Refer to Appendix F for consultation with City of Sydney.

b) a detailed hydraulic design to address whether the design performs with no surcharges. Evidence of consultation with Sydney Water required by Schedule 2, condition B15, and Council in preparing the flood management plans must be submitted as part of the future development application.	A Section 73 Application (anticipated requirements) has been submitted on the 4th of March 2019. Sydney Water are currently reviewing the development requirements prior to the issue of the Notice of Requirements. A Stormwater Adjustment Application has been submitted to Sydney Water on the 15th of January 2019. Discussions with Sydney Water will continue under these processes.

Table 2 – Mitigation Measures SSD9249

Requirement	Where Addressed
CP-SF1- A detailed Stormwater and Flooding Assessment is to be prepared and submitted with the Stage 2 Development Application taking into account the detailed design to the stadium and public domain, and outlining measures for rainwater capture and reuse within the site, piped and overland flow, on-site stormwater detention, water sensitive urban design, and include modelling of water quality and quantity for discharges from the site. Details of impacts upon local stormwater infrastructure and local flood conditions is to be included in the assessment.	Refer to section 2.0, Flood Analysis, 3.2.2 for Water Quality and 3.4 Stadium Stormwater Discharge Results Refer to section 3.6 regarding rainwater capture and reuse.
CP-SF2- The Stage 2 Development Application is to contain details of water quality assessment and modelling undertaken to demonstrate that pollutant reduction targets are achieved.	Refer to section3.2.2 for Water Quality
CP-SF3- Targets for rainwater capture and re-use identified in the ESD Strategy prepared by Aurecon (May 2018) are to be adopted for the detailed design and identified in the Stage 2 Development Application.	Refer to section 3.6 regarding rainwater capture and reuse.

Table 3 – Secretary's Environmental Assessment Requirements (SEAR's)

Requirement	Where Addressed
Drainage Detail measures to minimise construction and operational water quality impacts on surface waters and groundwater including Kippax Lake and Moore Park. Stormwater plans detailing the methods of drainage without impacting on the downstream properties. Relevant Policies and Guidelines:	Refer to section 3.4 Stadium Stormwater Discharge Results

• Guidelines for development adjoining land and water managed by DECCW (OEH, 2013).	
Flooding Identify flood risk on-site (detailing the most recent flood studies for the project area) and consideration of any relevant provisions of the NSW Floodplain Development Manual (2005), including the potential effects of climate change, sea level rise and an increase in rainfall intensity. If there is a material flood risk, include design solutions for mitigation. Relevant Polices and Guidelines: • City of Sydney Interim Floodplain Management Policy; and • Centennial Park Floodplain Risk Management Plan	Refer to section 2.0 Flood Analysis and Appendix A for Flood Risk profile.

On-Site Detention Requirement

This report discusses the merit of On-Site Detention (OSD) and its use in restricting flow from the site entering receiving infrastructure. Downstream receiving infrastructure includes the Driver Avenue (via existing OSD) and Fox Studio box culverts (via SCG basement), refer to figure 5 for discharge locations. Both assets (Driver Avenue and Fox Studio culverts) are maintained and owned by Sydney Water.

2 Basis of Design – Flooding Analysis

As detailed in the infrastructure NSW (iNSW) Sydney Football Stadium Redevelopment Civil Engineering report, lodged with Stage 1 DA, there are various upgrades proposed for the site, the following of which are key for the hydraulic behaviour (stormwater drainage and overland flow flooding), these include:

- Upgrade of the Sydney Football Stadium itself, including an increased roof area;
- Regrading of the concourse areas around the proposed new stadium;
- Introduction of various (retaining) walls along select alignments within concourse areas;
- Building footprints (existing Rugby League and Rugby Union) within the Moore Park carpark area to the west of the proposed new stadium;
- Redirected and resized stormwater drainage lines; and
- The introduction of additional and augmentation of existing onsite stormwater detention tanks (OSD).

2.1 Purpose of Assessing Flood Risk

The purpose of the stormwater management component of the proposed design plan is to assess the proposed SFS redesign and reconstruction from a stormwater and flooding perspective. This assessment is to determine compliance against relevant local and state government requirements, as set out in SEAR's, Stage 1 conditions and mitigation measures and listed in Section 2.2 covering compliance standards.

2.2 On-Site Stormwater Strategy Objectives & Compliance Standards

A number of compliance standards have been identified in relation to local and state government requirements together with industry best practice. Additionally, flooding conditions have been specified under the Secretary's Environment Assessment Requirement (SEARs) document with reference to Section 4.12 (8) of the Environmental Planning and Assessment Act and Schedule 2 of the Environmental and Assessment Regulation, 2000.

These conditions state that the proposed development is to give due consideration to the relevant content of the following studies and best practice guidelines:

- Floodplain Development Manual for the management of flood liable land,
- City of Sydney Interim Floodplain Management Policy; and
- Centennial Park Floodplain Risk Management Plan.

For the purpose of this investigation, the measure of compliance has been addressed in terms of "adverse flooding impacts", which are those instances where outcomes are observed that do not comply with the standards listed above.

2.3 Existing Flood Studies and Scope of this Assessment

The hydrology and hydraulics for drainage and overland flow flooding for the Centennial Park area has previously been extensively modelled by both:

- The City of Sydney, to represent flood risk onsite under existing conditions; and
- ARUP, which included option assessment and modelling to attempt to achieve a "no worsening" configuration for the stadium reconstruction/reference design.

Detail covering the basis for setup and key assumptions associated with the existing case and ARUP proposed case hydrology and hydraulic models are given in their respective accompanying reports from both the City of Sydney and ARUP as listed below:

- The Centennial Park Flood Study Final Report, WMA Water, 2016; and
- The Sydney Football Stadium Redevelopment Civil Engineering Reference Design Report, ARUP 2018.

These studies have been used as the basis for the investigations described herein. This is where the following investigations and presentation of results have been prepared:

- Review of the hydraulic modelling and options testing completed by ARUP for comparison with the proposed reference design (as presented in civil drawings) and suitability for re-use to test for adverse flooding impacts.
- Update and re-run of the proposed case design run model to reflect the proposed reference design, as presented in the civil design drawings; and
- Review for residual food risk and any adverse impacts of the proposed design compared to the existing case scenario, where the hydraulic model has had to be updated and re-run to match the reference design civil drawings.

2.4 Site Conditions Topography and Drainage

A detailed description of the site topography and existing drainage infrastructure is included in the Centennial Park Flood Study Final Report, WMA Water, 2016; and the Sydney Football Stadium Redevelopment Civil Engineering Reference Design Report.

2.5 Site Flooding and Drainage - Flood Risk Management

2.5.1 Existing Conditions and Flood Sensitive Locations

Extensive reporting and mapping has been completed to describe modelling for the existing case scenario and existing flood sensitive locations around Centennial Park in referenced existing reports. The key locations of interest for the purpose of this assessment have been extracted and summarised below.

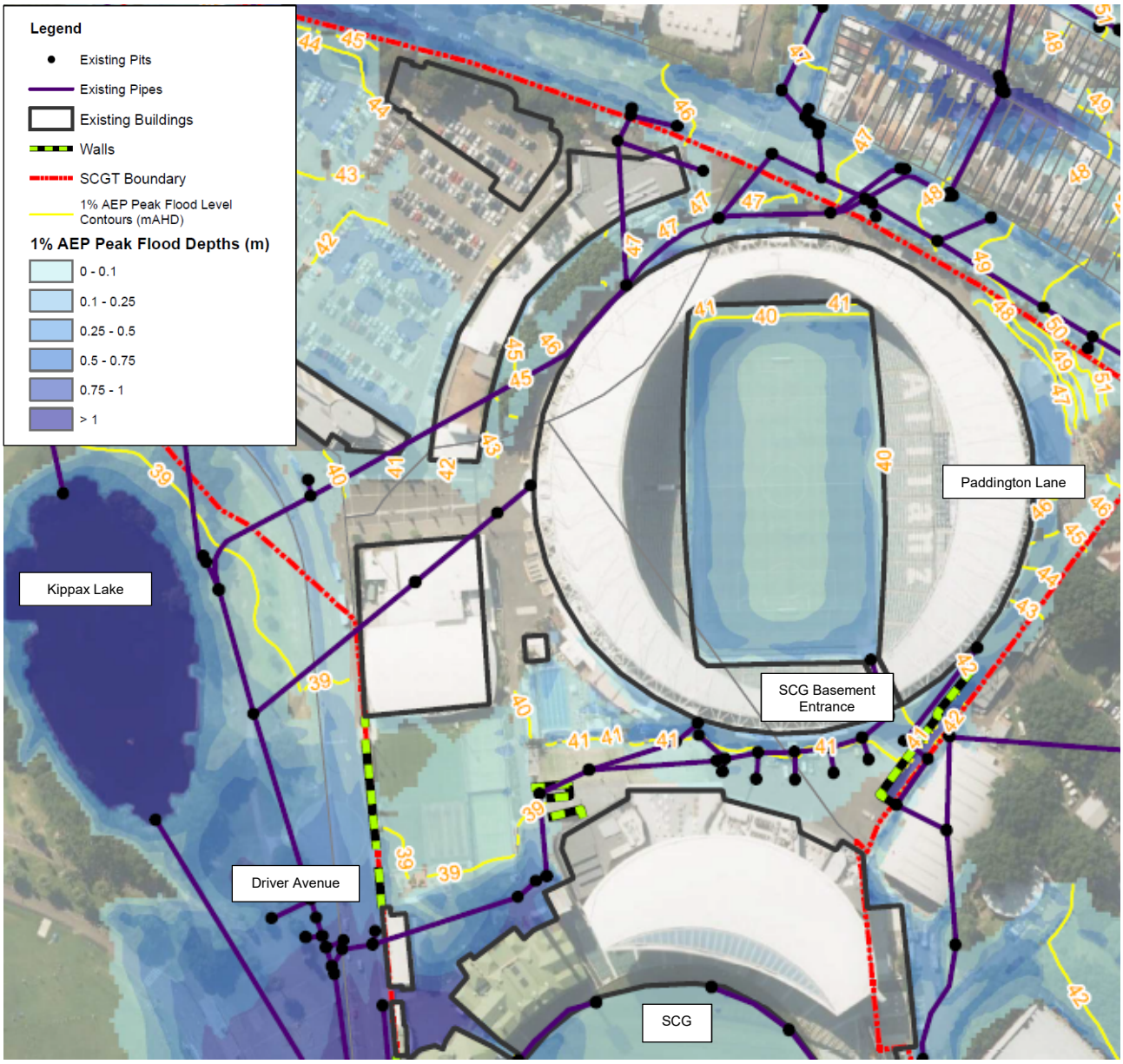
Paddington Lane Inundation

Paddington Lane, runs off Moore Park Road in a southerly direction and consists of a long ramp providing access to the basement of the Sydney Cricket Ground. Overland flow originating from the north east along Moore Park road runs deep enough in the 1% AEP 60minute storm to exceed the crest level of the gutter at the entrance to Paddington Lane, and overland flows run down the ramp towards the stadium basement. Similarly, further to the west along Moore Park Road, access stairs to the stadium also overtop from overland flow along Moore Park Road.

Ponding and Flood Hazard at SCG Entrance adjacent Kippax Lake

Significant overland flow originating from Moore Park Road and running around the Sydney Football Stadium, flowing in a south westerly direction towards Kippax Lake, accumulates at a low point along Driver Avenue in front of the entrance to the Sydney Cricket Ground. In the 1% AEP event, inundation becomes deep enough to create an area of significant flood hazard. Accumulation of flows in this area and around Kippax Lake, demonstrates a lack sufficient stormwater drainage capacity to convey flows away from the area in the 1% AEP 60min storm event. Namely through the Sydney Water Main running south underneath Driver Avenue past the Sydney Cricket Ground.

Figure 3: Existing Site Conditions – Reference Design – 1% AEP



2.5.2 Proposed Conditions and Proposed Mitigation

As a part of the proposed redevelopment, changes to the grading and configuration of the plaza areas surrounding the proposed new football stadium and the Sydney Cricket ground. Additionally, onsite stormwater detention tanks have been proposed to manage the redirection of overland flow where adverse impacts would otherwise be created, as a result of the reconfiguration of the concourse areas. The proposed changes have been outlined in the preliminary civil design drawings in the Sydney Football Stadium Redevelopment Civil Engineering Reference Design Report.

The key features/changes with significance to management of drainage and overland flow flooding are as follows:

Regrading of Stadium Concourse Areas

Regrading of stadium plaza areas have been proposed with intent to drain the direction of overland flow to areas where it can be intercepted by stormwater pits and the drainage network into proposed detention features or away from known flood sensitive locations. The proposed regrading predominantly consists of the following:

Directing overland flow originating from the north east along Moore Park Road past the entrance to Paddington Lane and around the north-western extents of the footprint of the proposed stadium and south along the western plaza area towards Driver Avenue and Kippax Lake.

Introduction of Retaining Walls/Flow Barriers

Introduction of retaining walls along the southern edge of Moore Park Road and around the western edge of the northwest plaza between the proposed stadium and the Moore Park carpark. These walls are to complement and enhance the redirection of overland flow as intended with the regarding of plaza areas described above.

Upgrade of the Local Stormwater Drainage Network

Redirection of stormwater drainage networks around the proposed stadium footprint and resizing and redirection of various existing stormwater drainage lines.

Upgrade of Existing Onsite Detention (OSD)

Capture excess overland flow and additional stadium roof area runoff in a system of onsite detention tanks (OSD), draining to either of two discharge locations at the Sydney Water main under Driver Avenue to the west and the Sydney Water main draining under Fox Studios. The intent is to mitigate the potential for introducing flows to the downstream stormwater drainage network to push it further beyond capacity.

2.6 Comparison of Predevelopment and Proposed Development Hydraulic Models

The following is a summary of comparisons between hydraulic models, firstly where updating from existing case scenario (predevelopment) and secondly proposed development case scenario.

The predevelopment and proposed development site hardstand differs somewhat, most notably the coverage of the proposed roof structure. This roof structure now provides additional coverage with the drip line covering all seating stands.

2.6.1 Predevelopment (EXG06) vs Proposed **Stage 2** DA Development (DES12) Comparison

The predevelopment hydraulic model from City of Sydney is identified as run name “EXG06”. The updated hydraulic model used for the presentation of results in the Sydney Football Stadium Redevelopment Civil Engineering Reference Design, is identified as proposed design run “DES17” (Proposed Stage 2 DA Development).

Key updates from the Predevelopment to Proposed Stage 2 DA Development hydraulic models with regards to hydraulic performance of the stormwater system include:

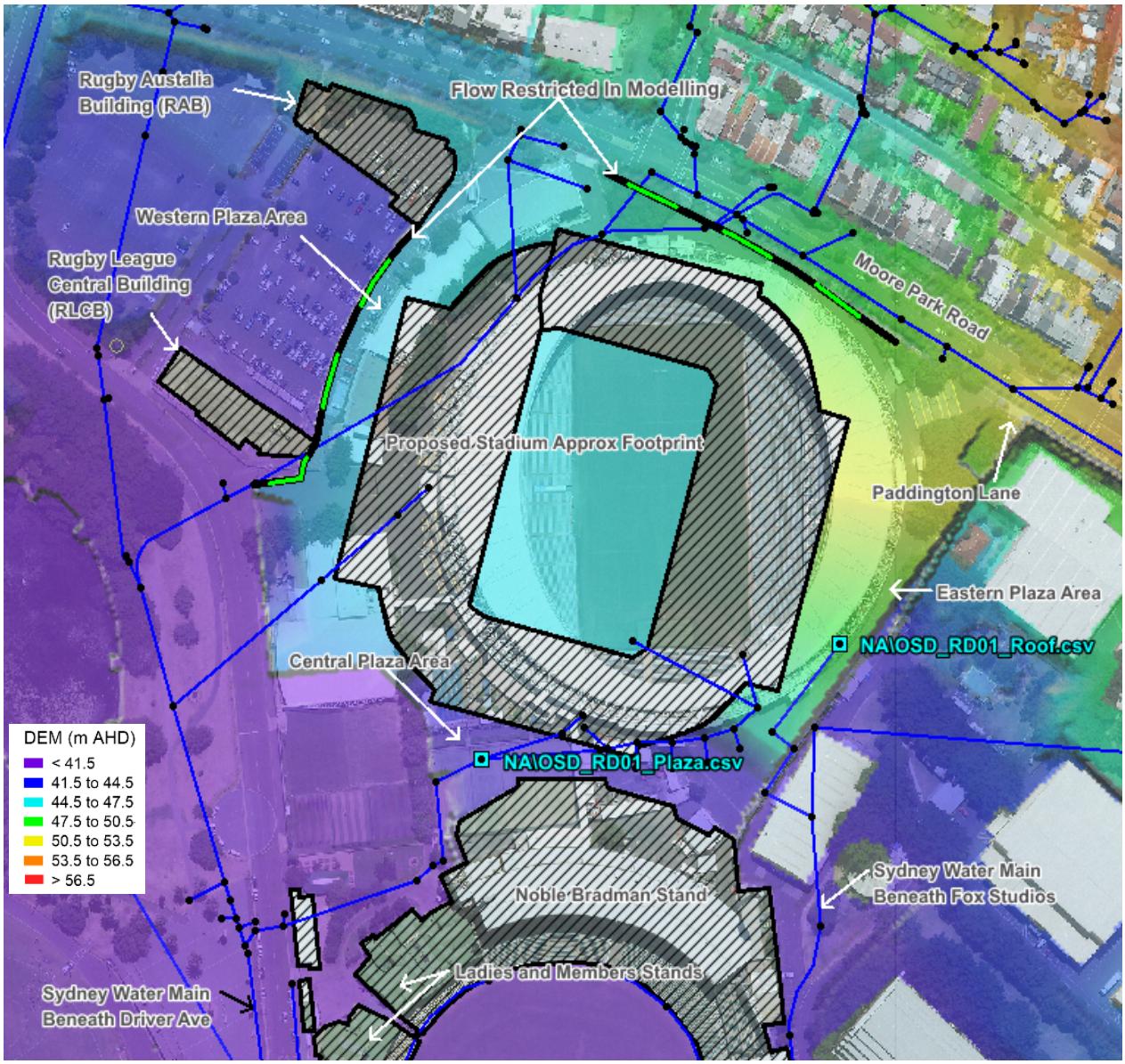
- regrading of plaza areas;
- additional On-Site Detention (OSD) storages, the proposed new roof for the new football stadium positioned in the eastern plaza and
- an increase in size to the existing OSD tank in the central plaza adjacent to the north of the Bradman/Noble Stand of the Sydney Cricket Ground from 750m^3 to 3000m^3.
- Updates with site specific topographic survey level information,
- Inclusion of as-built information for the Noble, Bradman and Messenger Stands, including finished surface levels, on-site detention (OSD) tank and associated drainage modifications,
- Addition of walls and other barriers to flow including using site and aerial photography,
- Inclusion of the Australian Rugby Union and UTS building,
- Inclusion of Rugby League Central building,

- Inclusion of SCG and existing Allianz Stadium as-built drainage information,
- Refinements to in-ground drainage using Sydney Water record drawings,
- Refinement to in-ground drainage of Sydney Water asset to diverted,
- Inclusion of the pipe outlets for Kippax Lake connecting to the Sydney Water trunk along Driver Avenue,
- Creation of flow path to allow likely inundation of the SCG and SFS pitches,
- Refinements of the building footprints to match existing conditions,
- Refinements to catchments based on built environment features and existing drainage networks.

The above refinements and modifications are supported by Stage 1 DA site observations from a ground truthing exercise undertaken to verify site falls and barriers/obstructions to flow.

Refer to Figure 4 below.

Figure 4: Hydraulic Model Layout - Proposed Case Scenario DES17



**DEM – Digital Elevation Model*

2.6.2 Proposed Stage 2 DA Development OSD

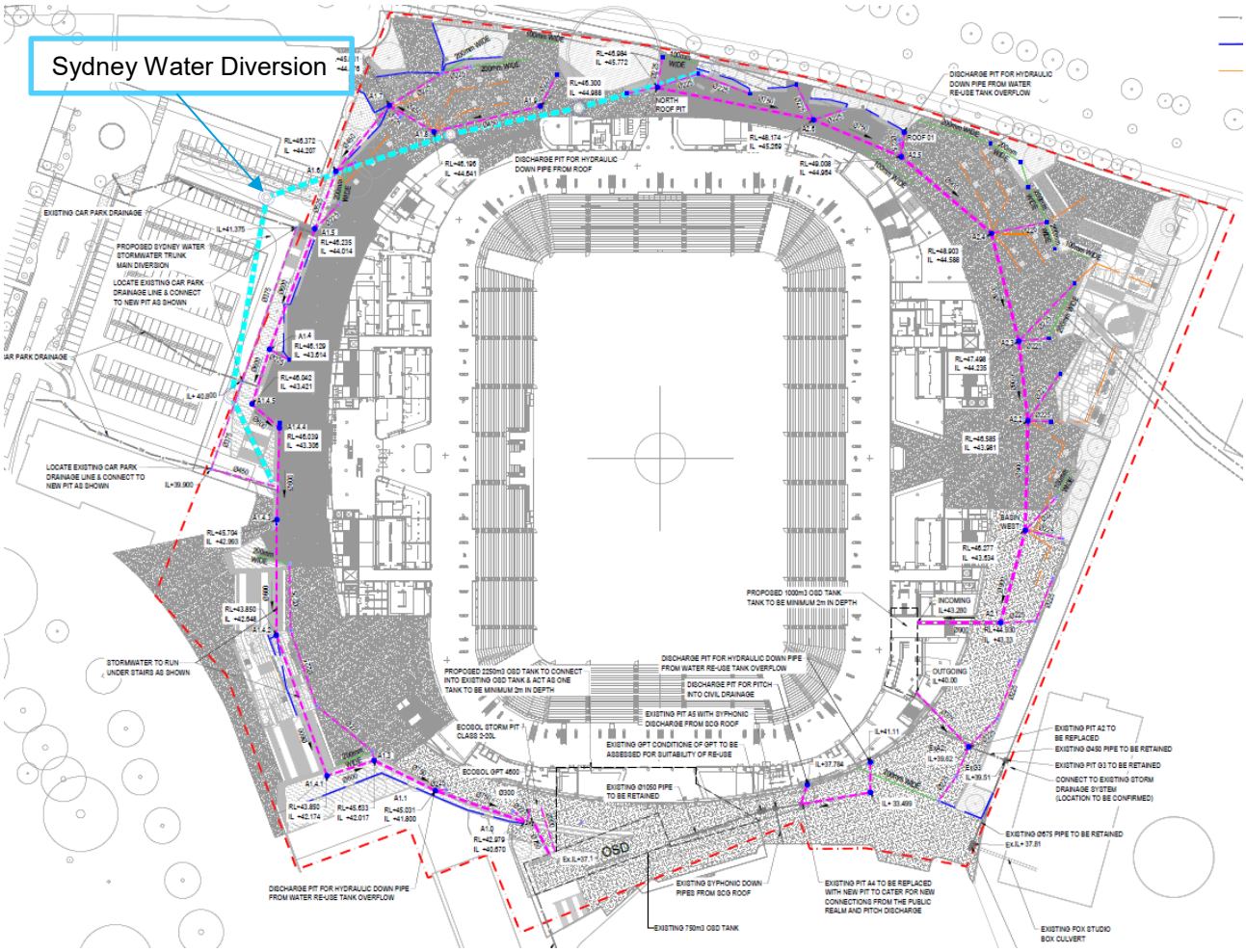
For the purpose of analysis, additional OSD has been evaluated. This evaluation is discussed in detail in section 3.3 of this report. A summary table below demonstrates the key OSD volume changes.

Table 4 - OSD Tank Sizes for Predevelopment vs Proposed Stage 2 DA Development

Model Design Run Existing Case (EXG06)				**Stage 2 DA Design (DES17)**			
Name	Basin Size	Capture Area	Discharge Line	Name	Basin Size	Capture Area	Discharge Line
"**Existing OSD**" Central Plaza (adjacent the Bradman/ Noble Stand)	750m^3	Pitch area + central plaza area	Sydney Water Main under Driver Avenue to the west	**"OSD_RD_01_Plaza"** Central Plaza (adjacent the Bradman/ Noble Stand)	3000m^3	Western roof area + pitch area + central plaza area: 30,050 m^2	Sydney Water Main under Driver Avenue to the west
N/A	N/A	N/A	N/A	**"OSD_RD_01_Roof"** Eastern Plaza (adjacent the eastern stand of new stadium)	1000m^3	Eastern roof area + eastern plaza area: 17,230m^2	Sydney Water Main under Fox Studios to the south east

Proposed changes to the existing site stormwater drainage network, as seen in Figure 5, specifically the diversion of the Sydney Water main around the western edge of the new proposed stadium footprint has been incorporated into the Stage 2 DA Design model (DES17) for completeness. For this study, the detention storages (and associated additional drainage lines e.g. Sydney Water Diversion) have been updated for the proposed design case scenarios and all other existing case stormwater drainage lines (external to the site) remain unchanged to the adopted model with the exception of the Sydney Water Trunk Main diversion that is being relocated on the site under MOD 2 to SSD DA 9249.

Figure 5: Proposed Stage 2 – Civil Stormwater Layout Plan



2.7 Flood Risk - Proposed Stage 2 DA Development – (model run "DES17")

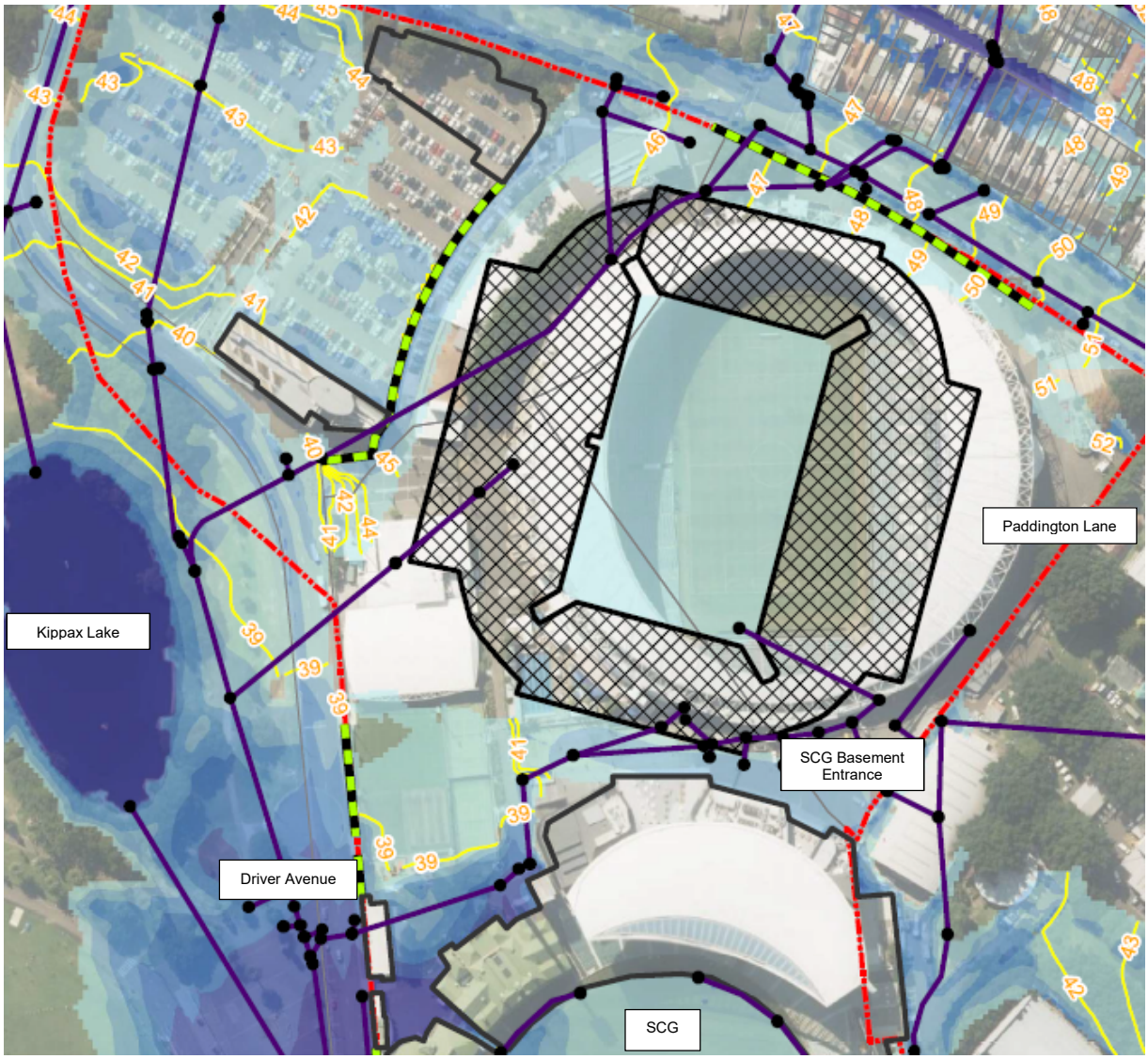
For the review of the residual flood risk associated with the reference design proposed as part of the Stage 1 DA for the Sydney Football Stadium Redevelopment (SFSR), the hydraulic model was adopted and re-run for the existing and proposed Stage 2 design cases. The Stage 1 hydraulic modelling was run in TUFLOW software model version 2012-05-AC-iDP-w64. For ease of extraction and comparison of results the model was run with the updated version of TUFLOW hydraulic modelling software version 2018-03-AC-iSP-w64. Results were compared, between each version of the software and any changes to results did not significantly change the estimation of the hydraulic behaviour of the study area or pose any significant change to alter the findings or recommendations of this investigation.

The following is a summary of a review of the results from the proposed Stage 2 DA case scenario (model run DES17).

2.7.1 Paddington Lane Inundation

Regrading of the northern most entrances to the stadium concourse is proposed as part of the design. The regrading will direct overland flows originating from the eastern upstream end of Moore Park Road back onto the road rather than the stadium concourse. Regrading along the road at the entrance to Paddington Lane will also prevent run-off entering the lane. This regrading will prevent floodwaters in the 1%AEP 60min storm from entering the existing SCG stadium basement.

Figure 6: Proposed Development Scenario - Reference Design – 1%AEP Without Mitigation



2.7.2 Flood Levels at Driver Avenue Adjacent Kippax Lake

Regrading of the stadium concourse areas has encouraged overland flows around the north western side of the proposed stadium and down the proposed stairs onto Driver Avenue and Kippax Lake. The increase of flows has been partially offset by the increase in size (750m^3 to 3000m^3) of the introduced detention tank under the central concourse adjacent the Noble Bradman Stand. Regrading has created no significant increases to flood levels on Driver Avenue at the bottom of the proposed concourse stairs. The increase in levels on Driver Avenue have been restricted to between 10mm and 50mm and they are fully contained within the SCGT precinct. Given the regional catchment size of the Centennial Park flood model, the minor afflux levels along Driver Avenue are within regional modelling sensitivities. The standing flood levels along Driver Avenue are largely unchanged and are consistent with the predevelopment SFS site. Refer to Appendix A for scenario mapping and further information on the pre and post-development flood conditions.

2.7.3 Ponding and Flood Hazard at Driver Avenue Adjacent SCG Entrance

The Stage 2 DA model run continues to show ponding occurring at the low spot at the entrance to the Sydney Cricket Ground on Driver Avenue. This ponding is consistent with the extent of potential flooding with the former SFS site, which reaches depths deep enough to represent significant flood hazard in the 1%AEP 60min storm event. This ponding is not a significant increase over existing flood ponding levels and flood hazard ratings at the location are unchanged. These minor afflux levels are manageable and again subject to sensitivities within the regional Centennial Flood model.

For Afflux, Water Surface Level, Velocity, Depth and Hazard mapping for the Stage 2 DA (DES17) proposed case scenario hydraulic model run in Appendix A – Proposed Stage 2 DA Design Case Scenario Mapping.

2.8 Conclusion of Flooding Assessment Findings

As per the scope of this assessment the key findings are as below:

Review of the Hydraulic Modelling and Options Testing Completed

A revised version of the proposed Stage 2 DA case scenario model was developed and re-run hydraulic parameters that represent the proposed reference design (DES17) with an update to existing site conditions inclusive of the Sydney Water Diversion.

Proposed Stage 2 DA Design Case Scenario

The updated hydraulic model (DES17) was re-run with the latest version of hydraulic software modelling package TUFLOW and compared outputs to the existing predevelopment case scenario hydraulic characteristics of the area.

The detention tank storage sizes tested in the proposed case scenario were:

- A 1,000m^3 storage (“OSD_RD01_Roof”) situated in the eastern plaza to capture roof run off from the proposed new stadium. The tank connects to drainage to the Sydney Water main underneath the Fox Studios to the south east; and
- An increase in size to the existing detention storage tank in the central plaza area adjacent to the Noble Bradman Stand of the SCG (“OSD_RD01_Plaza”), increased from 750m^3 to 3,000m^3. This tank connects to the Sydney Water main underneath the Driver Avenue to the south west.

Comparison of peak flood levels, depths and hazards found:

- No significant increase to peak flood depths for the SCGT precinct for the 1% AEP, 60min local design storm event.
- Some localised flood level increases inside the SCGT precinct were observed, which were:
    - Confined to the stadium concourse area around the outside of the northern side of the new grandstand along the southern side of Moore Park Road, with increases between 10mm and 50mm;

    - Confined in the central concourse area between the SCG and the new proposed stadium, with some ponding to create increases up to 100mm (due to changes in proposed site regrading); and
    - At the bottom of the proposed new steps from the stadium west onto Driver Avenue, were increase of between 10mm to 50mm on the road itself. Whilst this increase contributes to inundation of the road, it does not extend to increase impact on private properties.
- Hazards identified in the predevelopment, due to ponding (approx. 1.2m to 1.3m depth) at a low point on Driver Avenue in from of the SCG entrance, is predominantly unchanged.

The proposed Stage 2 DA design run, has also shown the prevention of flow from entering the basement of existing SCG stadium, via the regrading of the concourse area and entrance to Paddington Lane off Moore Park Road.

Overall, testing of the proposed reference design arrangement with additional detention to offset the changes to the site as a result of the football stadium redevelopment, has not demonstrated significant additional flood risks to the SCGT precinct and very minimal changes to the existing case hydraulic behaviour of the area. There has been no worsening to the upstream and downstream catchments or adjacent properties.

2.9 References

Modelling references include;

- Sydney Football Stadium Redevelopment Civil Engineering Reference Design Report, ARUP 2018
- Floodplain Development Manual for the management of flood liable land (2005),
- City of Sydney Interim Floodplain Management Policy,
- Centennial Park Floodplain Risk Management Plan,
- Sydney Football Stadium (SFS) Project Brief (2018),
- Planning Secretary's Environmental Assessment Requirements (SEAR's),

3 Stadium Site Stormwater Drainage

3.1 Existing Stormwater Drainage

There are existing Sydney Water trunk stormwater mains, running through and surrounding the site. These include major culverts located below Driver Avenue and a separate system which drains through Fox Studios.

Figure 6 shows a number of pipes entering the site along its northern edge, near the intersection of Moore Park Road and Oatley Road, crossing the site to Driver Avenue as follows:

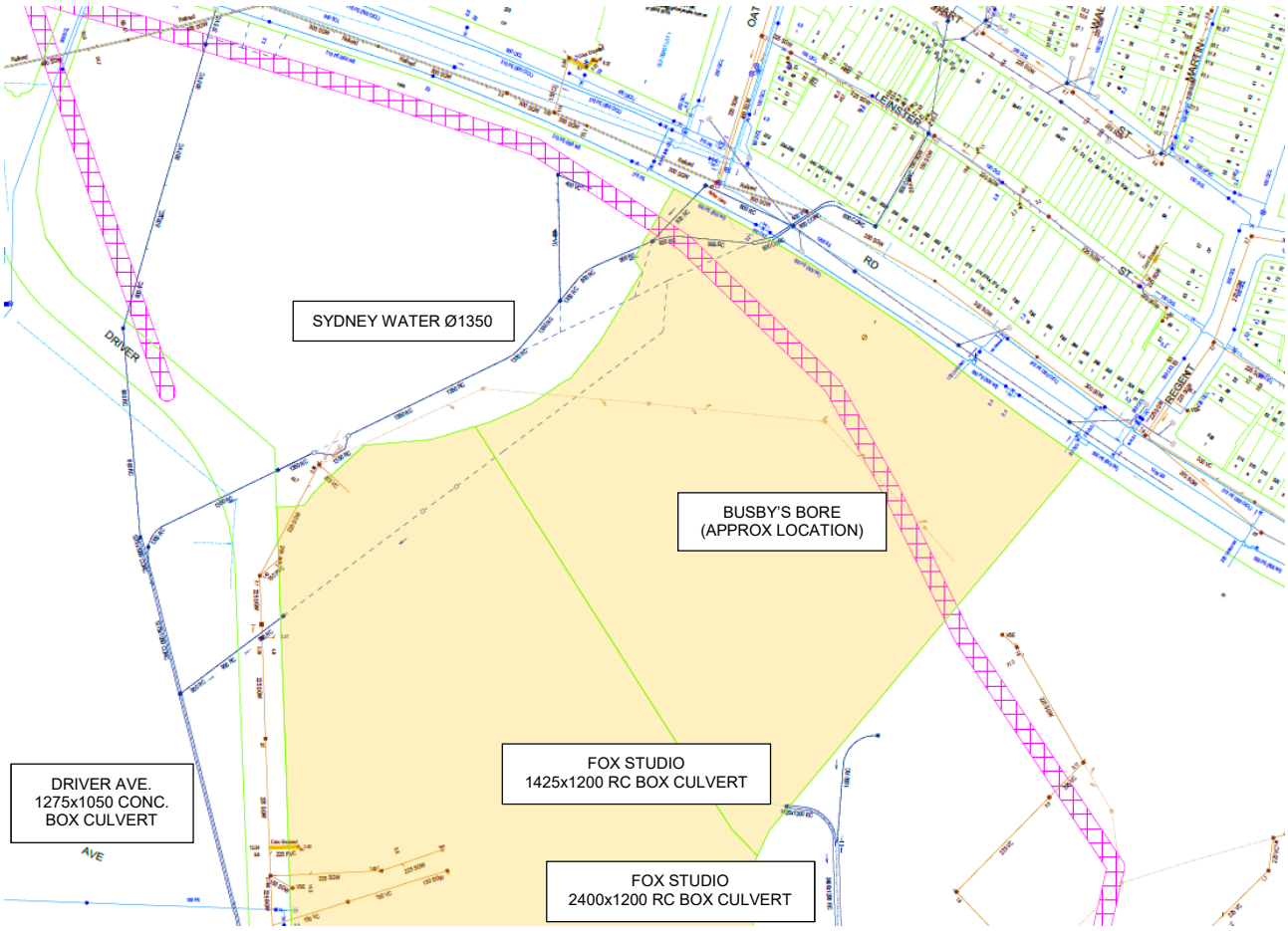
- Parallel Ø600 and Ø400 pipe join and run into a Ø900 just inside the site boundary, east of Oatley Road, running to the south-west,
- A Ø600 enters the site from the Oatley Road intersection and joins the Ø900 approximately 30m inside the boundary,
- A Ø450 runs south under the Sheridan building and joins the Ø900 which has increased to Ø1350,
- The Ø1350 continues across the site, around the NRL headquarters and under Driver Avenue,
- The Ø1350 joins a 1275x1050 box culvert which runs south along Driver Avenue to Lang Road,
- An additional Ø900 runs from the western side of the SFS to the box culvert west of Driver Avenue.

In addition to this network, there is a separate culvert that runs from the south-east corner of the site, through Fox Studios and the EQ to Centennial Park, discharging in Busby's Pond.

- 1425x1200 box culvert exiting the site east of the SCG basement access at the bottom of the basements access dive structure,
- Ø1050 from within Fox studios joins the culvert above, and the size increases to 2400x1200.

Currently the site discharges to both the Driver Avenue and the Fox Studios trunk mains, though the area discharging flow to Fox Studios was reduced following the Noble-Bradman Stand upgrade.

Figure 7: Existing Sydney Water Network Map Adjoining the Site



3.2 Key Design Objectives

The key on-site stormwater design objectives are;

- Minimise the post-development volume and rate of stormwater runoff to equal or less than pre-development,
- No increase in flood risk to upstream or downstream properties (addressed in section 2),
- Provide guidance to the Architect regarding finished levels so that a minimum flooding freeboard of 500mm is maintained throughout,
- Minimise disturbance to existing drainage system,
- Utilise distributed stormwater control and treatment measures,
- Utilise Water Sensitive Urban Design (WSUD) and Stormwater Quality Improvement Devices (SQID's) measures,
- Stormwater infrastructure to visually integrate with the landscape,
- Provision of flood evacuation routes from the Stadium and Stadium Precinct,
- The effects of Climate Change due to the change in temporal patterns (intense rainfall more often),
- Controlled discharge into the existing Sydney Water assets on Driven Avenue and Fox Studios so as not to compromise downstream conveyance capacities. No surcharge within the on-site drainage system,

3.2.1 Stormwater Quality Objectives

Water quality considerations are required by several project stakeholders as follows:

- Sydney Water have technical requirements for water quality which applies to developments discharging stormwater to their infrastructure.
- City of Sydney Council's Development Control Plan (DCP) includes requirements for water quality for new developments within their LGA.
- SC&SGT have selected sustainable certification tool Leadership in Energy and Environmental Design (LEED) for this project which includes water quality requirements.

Whilst each set of requirements are diverse, there is concurrence in the collective intent. Broadly, the objectives seek to achieve appropriate management of both the quality and the quantity of water discharged from the proposed development. Supplementary objectives include;

- Treatment and control measures implemented and used during construction and operation of the stadium,
- Minimise erosion and sedimentation, nutrient and seed dispersal due to stormwater discharge,
- Ensure no adverse environmental impacts,

The stormwater treatment system MUSIC is used to model the required pollution reduction loads presented here in Table 5,

Table 5 - Stormwater Treatment Targets for Development

Pollutant	Performance Target Reduction Loads
Gross Pollutants (GP)	reduce the baseline annual pollutant load for litter and vegetation larger than 5mm by 90%
Total Suspended Solids (TSS)	reduce the baseline annual pollutant load for total suspended solids by 85%
Total Phosphorus (TP)	reduce the baseline annual pollutant load for total phosphorous by 65%
Total Nitrogen (TN)	reduce the baseline annual pollutant load for total nitrogen by 45%

3.2.2 Stormwater Quality Results

Input parameters for source and treatment nodes have been obtained from Sydney Catchment Authority MUSIC modelling manual (NSW Govt, 2012) as well as the NSW MUSIC modelling guidelines (BMT WBM, 2010).

The source nodes in the MUSIC model have been configured based on the DRAINS catchment nodes for the post-development scenarios.

- Music version 6.3 has been used.

The treatment nodes incorporated into this model include a number of rainwater reuse tanks for stormwater harvesting of the proposed stadium roof, gross pollutant traps, filters and litter baskets to achieve the treatment quality results. Please refer to figure 6 for treatment train and table 3 for quality results.

Figure 8: MUSIC Treatment Train

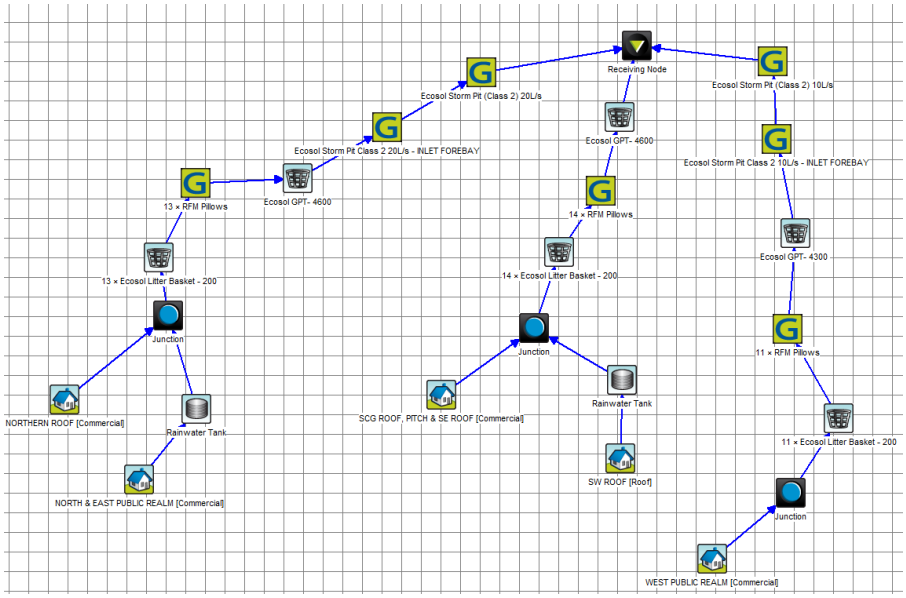


Table 6 - Post Development Stormwater Run-Off Quality Results

Pollutant	Estimated Annual Reduction Efficiencies (%)	Pollutant Reduction Targets (%)
Gross Pollutants (GP)	100	90
Total Suspended Solids (TSS)	86.2	85
Total Phosphorus (TP)	65.2	65
Total Nitrogen (TN)	48.3	45

As presented in Table 8, the stormwater quality management objectives can be achieved for TP, TN and GP through a combined use of stormwater quality improvement devices (SQID's) and integrated water cycle management (IWCM) philosophy utilising the maximum volume of non-potable water supplies for reuse.

Proposed SQID devices include but are not limited to,

- Litter Basket(s),
- GPT(s),
- Filtration Unit(s)

3.2.3 Water Sources Objectives

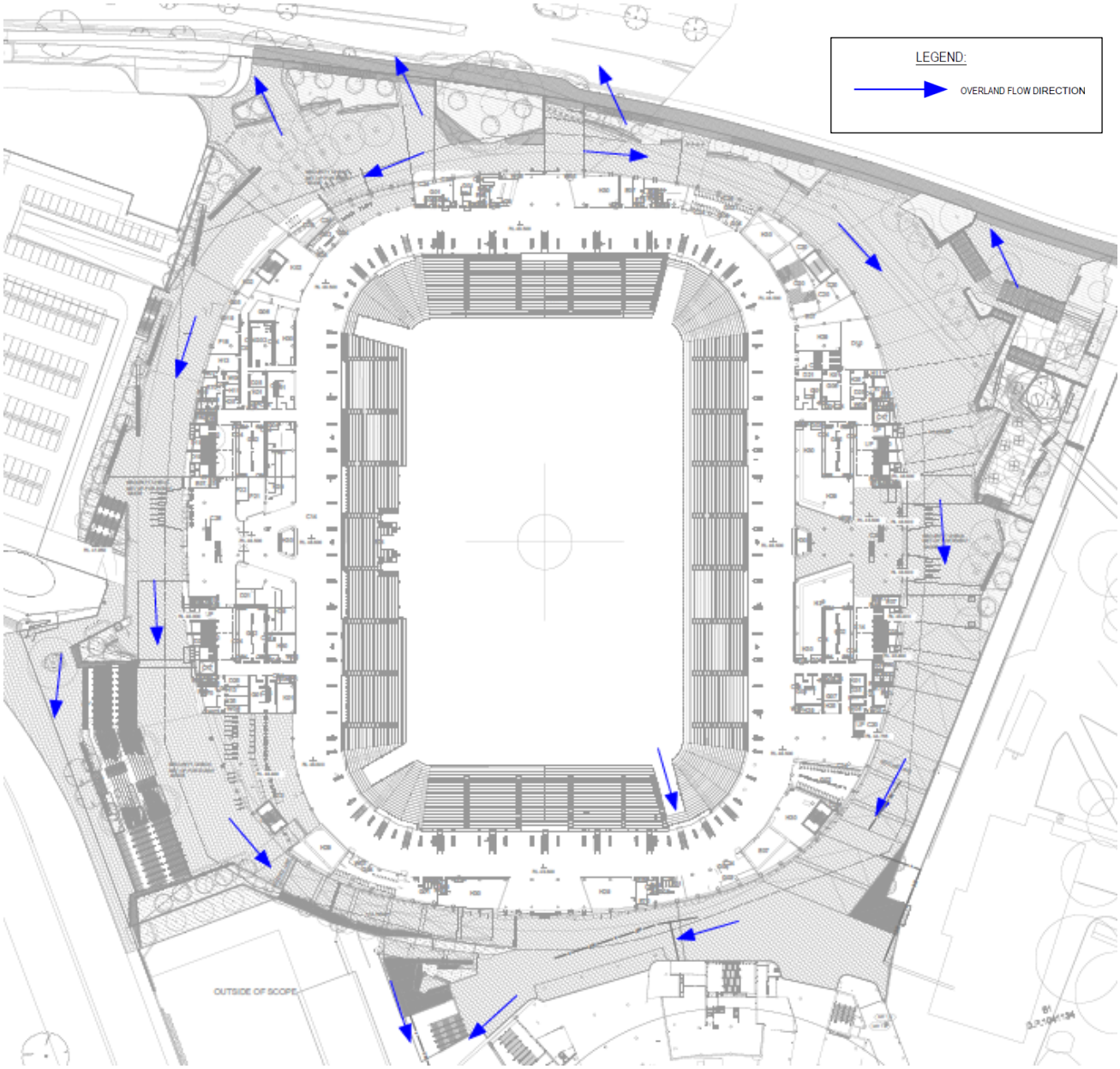
Both the future SFS and the SCG extract bore water from the subsurface aquifer to irrigate the playing fields. The water sources objectives are;

- Where practically possible, allow infiltration of rainfall run-off through passive irrigation means, via planting, tree pits and soft-scaping,
- Promote the beneficial use and reuse (also refer to Hydraulic documentation for the re-use for roof water for the flushing of toilets) of water resources,
- Reduce erosion and transported sediment within the site.

3.3 On-Site Overland Flow

Following the natural topography of the existing site, the proposed overland flow strategy is consistent with the pre-development site directing surface flow around the site from the high point adjacent to Moore Park Road to the lowest point along Driver Avenue in line with the SCG. The overland flow purposely directs flow away from structures and building entry points. The following figure demonstrates the controlled flow directions. Within the site, the overland flow has a low hazard rating together with a low velocity (refer to appendix A). The in-ground drainage will contain the 1% AEP further limiting the impact of overland flow within the site boundary.

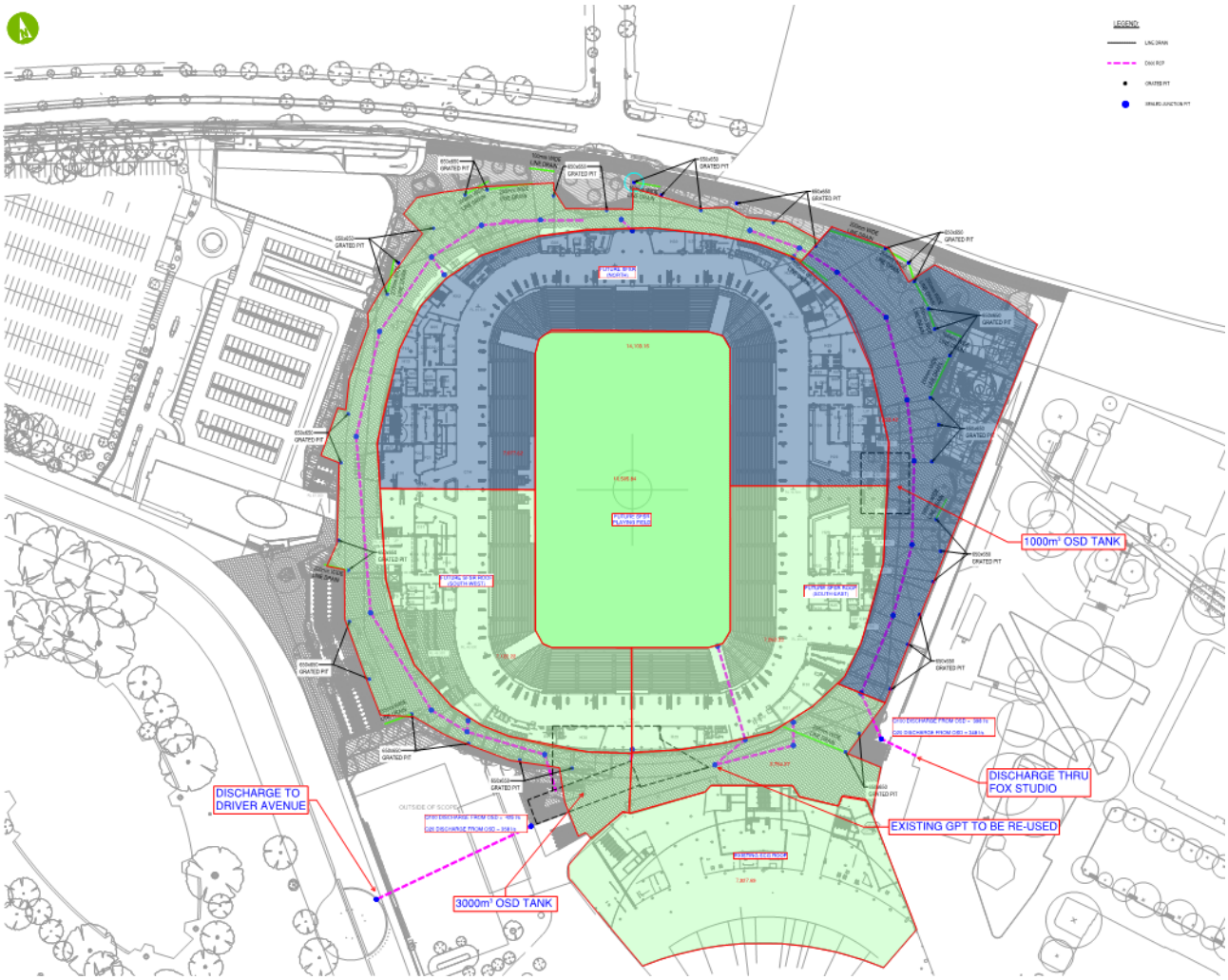
Figure 9: On-Site Overland Flow



3.4 On-Site Detention (OSD)

This section discusses the merit of providing OSD for the development site. The singular purpose of the OSD is to detain and control the peak run-off from the site prior to discharge to receiving infrastructure. There are two primary discharge points from the development site, through Driver Avenue and Fox Studios. Both discharge points connect into the Sydney Water culvert systems prior to discharging into their ultimate receiving water bodies, Botany Dams (Driver Avenue) and Busby's Pond (Fox Studio).

Figure 10: Stadium Catchment Plan



Retention and discharge from the site will be at the discretion of local authorities including City of Sydney and Sydney Water. Presently, the policy of these authorities is to detain run-off from upper catchment sites and allow discharge in a controlled manner with the quality of the discharge not having an adverse impact on the surrounding waterway environment or drainage infrastructure systems.
For analysis, the provision of two large capacity OSD's has been adopted. OSD A, located to the south-west has a storage volume of 3,000m^3 (inclusive of the existing 750m^3 OSD serving Nobel Bradman) and OSD B located to the east of the site with a storage volume of 1000m^3. During detailed design some refinement of the volumes may be revisited.

3.5 Stadium Stormwater Discharge Results

For stormwater modelling purposes, Australian Rainfall & Runoff (AR&R) 2016 rainfall intensity values have been adopted.

There are two primary discharge points, one to Driver Avenue via the existing OSD A and a second via the Fox Studio culvert via OSD B. The resulting flows from each discharge is presented table 3.

Both discharges have restricted flow capacities, flow going to Driver Avenue should not exceed 448 l/s, and flow entering the Fox Studio culvert should not exceed 408 l/s. Both constrained flow rates were achieved given the current site layout and roof flow discharge aided by the use of OSD. Both permissible discharges adhere to City of Sydney's Section 3 DCP Drainage and Stormwater Management guidelines where connecting to existing stormwater infrastructure should not exceed 10% of the receiving assets flow capacity.

Table 7 - Stormwater Discharge from the Site (DRAINS Out-Put)

Design Storm Event * Project Brief F6.4.4 (a)	Driver Avenue Discharge * Discharge from existing augmented OSD A	Fox Studio Discharge * Discharge from internal pit (site) leading to Fox Studio box culvert via OSD B
1in2yr ARI Event	270 l/s	239 l/s
1in5yr ARI Event	327 l/s	265 l/s
1in10yr ARI Event	359 l/s	327 l/s
1in20yr ARI Event	375 l/s	361 l/s
1in50yr ARI Event	407 l/s	375 l/s
1in100yr ARI Event	425 l/s	398 l/s

The discharge results shown on table 7 demonstrate the controlled discharge flow from the site to both the southern Driver Avenue and eastern Fox Studio Sydney Water box culverts satisfies the key objectives set out by this report.

The in-ground drainage system has found that surcharging from at grade pits does not occur as the hydraulic grade line has remained below the design surface throughout (refer to figure 11 for example). Surcharging has been prevented by utilising correctly sized pipework with adequate conveyance capacity and the use of OSD to detain the peak run-off mainly from the stadium roof catchments.

Figure 11: DRAINs Hydraulic Model Output

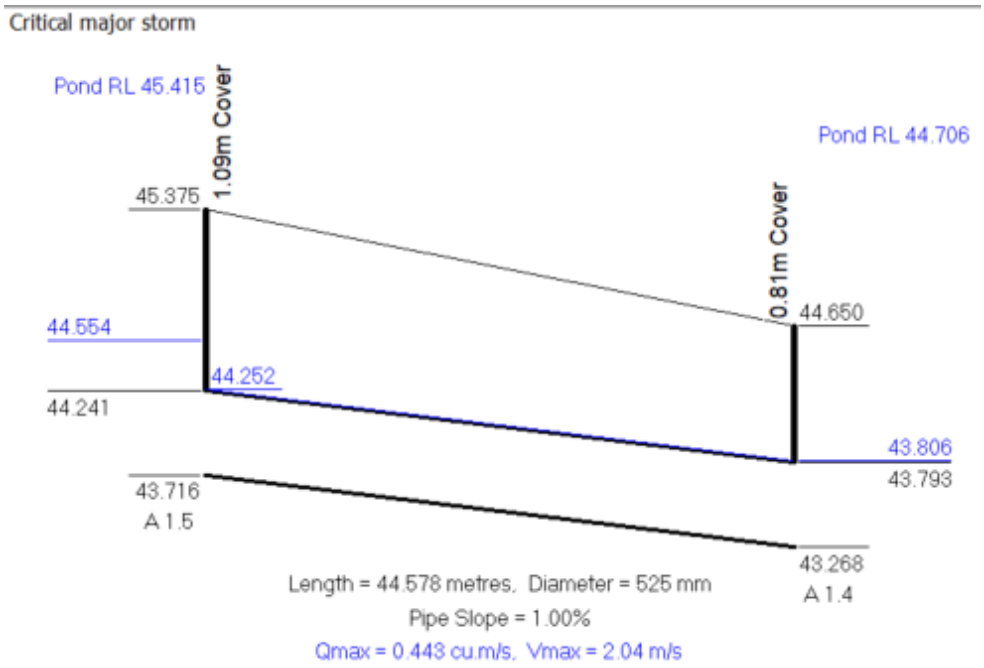
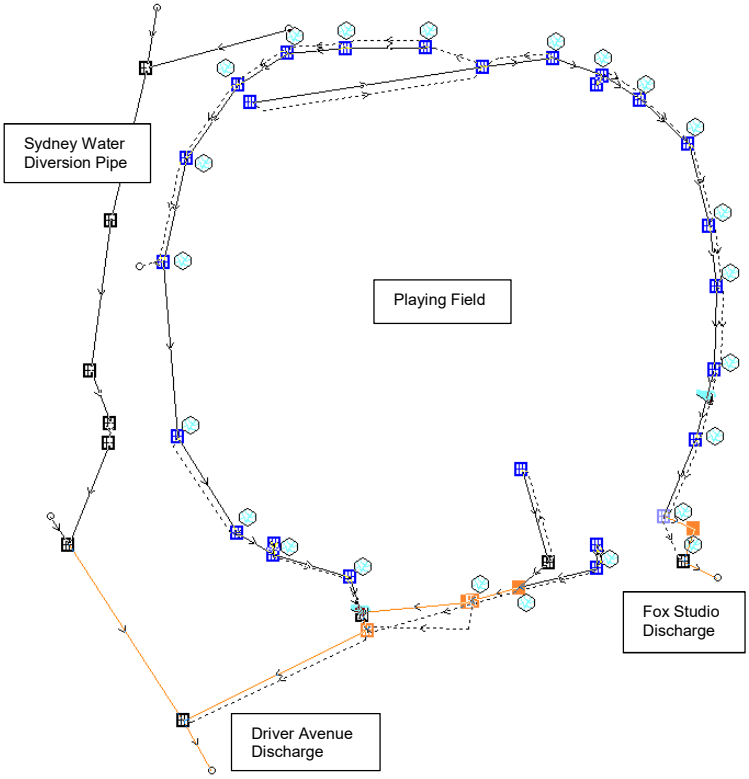


Figure 12: Schematic DRAINs Hydraulic Model Layout



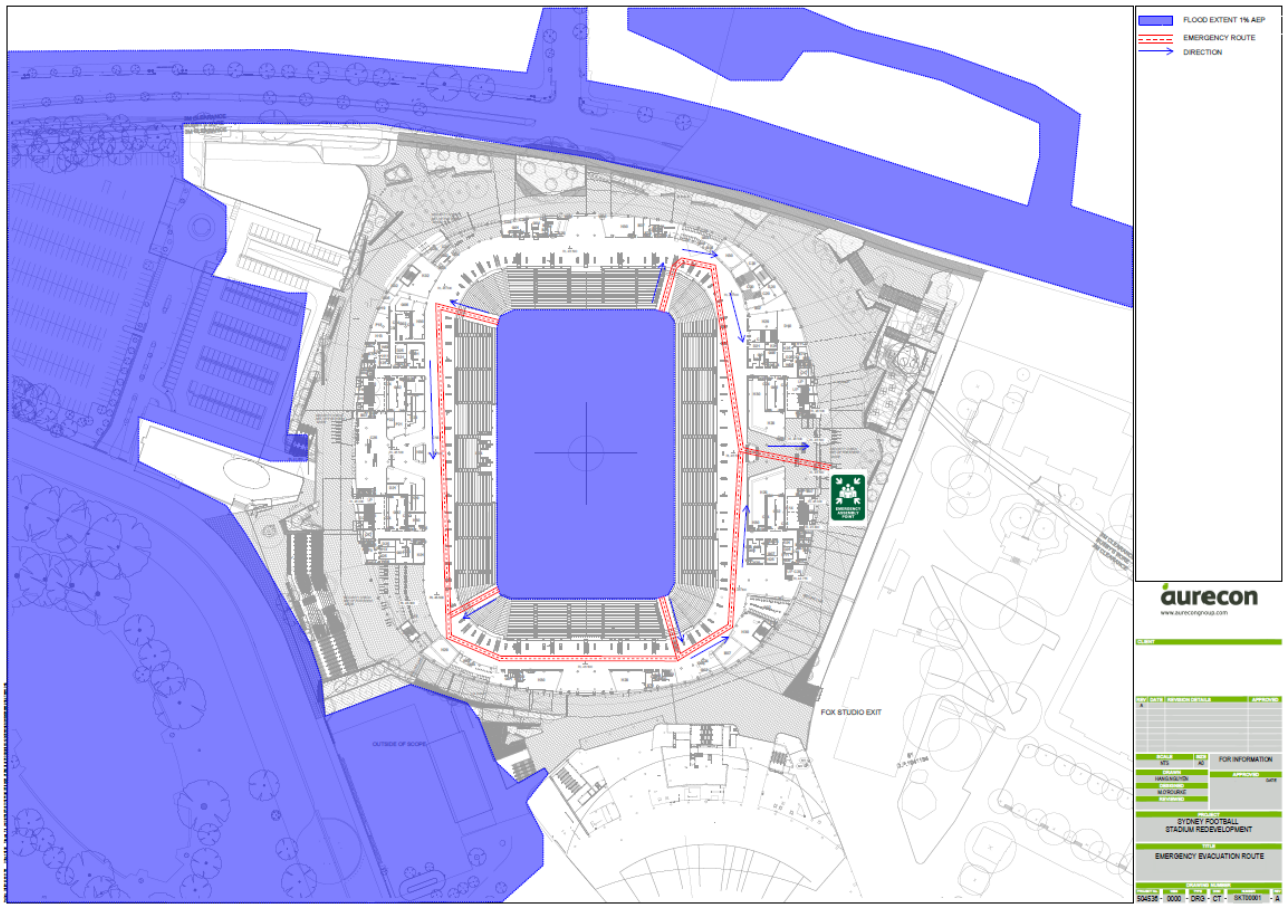
3.6 Rainwater Capture and Reuse

A rainwater harvesting system will be installed within the new stadium. Two 150kl tanks will be installed within the basement at the northern and southern ends. These tanks will capture water from the roof and this water will primarily be used for toilet flushing within the stadium. Any overflow from these tanks once full will be diverted to the proposed OSD tanks.

3.7 Emergency Evacuation Plan

Presented below is the emergency exit plan during peak flood events showing escape routing via Fox Studios.

Figure 13: Stadium Emergency Exit Plan



3.8 Climate Change

Projections for NSW is for longer periods of drier conditions with further predictions for increases in seasonal higher intensity rainfall events (source CSIRO). Three prime aspects associated with climate change include, increased/decrease in rainfall intensities, frequency of large rainfall events and the rise in sea level.

During detailed on-site drainage modelling, scenarios were run to simulate high intensity storms together with greater frequency. During this sensitivity analysis, the run-off from the site was stored and discharged in a controlled manner ensuring adequate capacity within the OSD tanks for the subsequent storm.

There is no tidal effect that influences the Project Site and the conveyance culverts immediately downstream of the site. Should higher intensity rainfall events occur in greater frequency, the project site as presented in Section 2 shows that inundation does not occur at post-development.

Should future flow rate volumes exceed todays proposed stormwater pipes capacity, the overland flow strategy allows for controlled flow/velocities around the site with an emergency exit plan shown in figure 11.

3.9 Sediment & Erosion Control

Erosion and sediment controls are to be provided during the construction phase in accordance with applicable guidelines (e.g. Landcom Blue Book) and as shown in Appendix B. The general approach is intended to confine all ground level soil disturbance between Moore Park Road site boundary and the Driver Avenue, so that no sediment will be transferred to the adjacent streets or introduced into the existing

stormwater drainage lines. During earthworks, suitable temporary sediment basins within the demolished site areas will be provided to capture all runoff from disturbed areas. Additional measures such as sediment fences surrounding disturbed areas, sand bags around existing pit inlets and a truck shaker grid at the point of access to the work area.

3.10 Conclusion

The site has been studied under the following high-level headings with their accompanying conclusion;

Flooding

The pre-development site flood condition is principally unchanged in the post-development Stage 2 condition with no significant afflux, flood hazard rating or flood velocity. Additional OSD has been introduced onto the site to capture and detain the peak run-off flow generated from the site.

Stormwater

The stormwater network nominated for the Stage 2 site contains the 1% AEP within the network with no surcharge occurring within the site. Peak run-off from the site is controlled so that discharge is or less than 10% of their receiving capacity.

Rainfall Run-Off Water Quality

The post-development site meets the City of Sydney water treatment targets for gross pollutants, suspended solids, total phosphorus and total nitrogen.

In addition, adherence to the Stage 1 condition has been consist with no significant changes being made to the site during Stage 2.

Appendix A – Proposed Stage 2 DA Design Case Scenario Mapping