

21 Hydrology and flooding – Stage 1

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This chapter provides an assessment of hydrology and potential flooding impacts during Stage 1 and identifies measures to address these impacts. This chapter draws on information in Technical Paper 9 (Hydrology and flooding).

21.1 Secretary’s Environmental Assessment Requirements

The Secretary’s Environmental Assessment Requirements relating to hydrology and flooding, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 21-1.

Table 21-1: Secretary’s Environmental Assessment Requirements – Hydrology and flooding Stage 1

Reference	Secretary’s’ Environmental Assessment Requirement	Where addressed
9. Water – Hydrology and Flooding		
9.1	The existing hydrological regime for any surface and groundwater resource (including mapping, the reliance by users, and for ecological purposes) likely to be impacted, including stream orders.	Section 21.4 Chapter 18 (Groundwater and ground movement – Stage 1) Technical Paper 9 (Hydrology and flooding) and Technical Paper 7 (Hydrogeology)
9.2	Detailed water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration.	Chapter 19 (Soils and surface water quality – Stage 1)
9.3	Requirements for baseline monitoring of hydrological attributes.	Chapter 18 (Groundwater and ground movement – Stage 1)
9.4	The impact on surface and groundwater hydrology in accordance with the current guidelines, including:	Section 21.6 Chapter 18 (Groundwater and ground movement – Stage 1)
	a. natural processes within rivers, wetlands, estuaries, marine waters and floodplains;	
	b. impacts from any permanent and temporary interruption of groundwater flow;	Chapter 18 (Groundwater and ground movement – Stage 1)
	c. stormwater and wastewater management on natural hydrological attributes and the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Section 21.6
9.5	d. water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction.	Chapter 18 (Groundwater and ground movement – Stage 1)
	Flood behaviour for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	Section 21.6
	a. potential flood affectation of other properties, assets and infrastructure;	
	b. consistency (or inconsistency) with applicable Council floodplain risk management plans;	
	c. compatibility with the flood hazard of the land; and	
	d. compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land.	

21.2 Legislative and policy context

The assessment of potential hydrology and flooding impacts of Stage 1 has been conducted in accordance with the requirements of the Floodplain Development Manual (Department of Infrastructure, Planning and Natural Resources, 2005). The Floodplain Development Manual incorporates the NSW Government’s Flood Prone Land Policy. The key objectives of this policy are to identify potential hazards and risks associated with flooding, reduce the impact of flooding and flood liability on owners and occupiers of flood prone property, and to reduce public and private losses resulting from floods. This policy also recognises the benefits of the use, occupation and development of flood prone land.

Most existing flood studies reviewed in this assessment are based on the design rainfall data provided in Australian Rainfall and Runoff 1987. A limited number of the existing studies are more recent and are based on Australian Rainfall and Runoff 2019 design rainfall data, which typically estimates 20 – 30 per cent lower design rainfalls across the Sydney Region compared to Australian Rainfall and Runoff 1987. Potential flood affectation of the Stage 1 construction sites would be lower when modelled using the 2019 data. Consideration of flood affectation and flood impacts during detailed construction planning would use 2019 data.

21.3 Assessment approach

The assessment approach for hydrology and flooding involved:

- Desktop review of publicly available flood study reports from local council(s) and other sources to characterise existing hydrology and flooding conditions at Stage 1 construction sites and the surrounding areas. Characterisation was based on the flood extent for the one per cent annual exceedance probability (AEP) event (a flood event with a one in a hundred per cent chance of occurring in any one year) and probable maximum flood (PMF) event (the largest flood that could conceivably occur at a particular location). The existing flood conditions have been considered with reference to the following:
 - The topography, flow paths and drainage infrastructure in the vicinity of Stage 1 construction sites
 - Flood depths and levels
 - Flood hazard
 - Flood hydraulic categories including floodway and flood storage
 - Flood planning area and flood planning level
- The existing types of flooding affecting Stage 1 construction sites, including:
 - Intense rainfall – due to intense rainfall falling directly onto sites or adjacent to sites during storm events that are not adequately managed by the provided drainage systems
 - Overland flooding – when local catchment runoff exceeds the capacity of existing drainage systems, with excess flows being conveyed on surface flow paths and ponding in low points
 - Mainstream flooding – due to floodwaters in rivers, creeks and canals rising out of the watercourse and inundating the broader floodplain above bank level
 - Coastal inundation – due to elevated ocean levels and storm surges during low pressure weather systems and/or highest astronomical tides (i.e. ‘king tides’)
- Qualitative assessment of the potential hydrology and flooding impacts of Stage 1 for all construction sites (except Clyde stabling and maintenance facility construction site)
- Quantitative assessment of the potential hydrology and flooding impacts of Stage 1 for the Clyde stabling and maintenance facility construction site
- Development of mitigation measures to address potential hydrology and flooding impacts.

21.3.1 Qualitative assessment

Potential hydrology and flooding impacts during Stage 1 were assessed qualitatively for all construction sites, except Clyde stabling and maintenance facility construction site. This level of assessment is appropriate for most construction sites given their low level of flood exposure in addition to the low risk of significant flooding impacts during Stage 1. The qualitative assessment considered the following potential changes:

- Potential increase in flood risk and flood affectation on adjacent properties and assets, and potential impacts to existing emergency management arrangements
- Land use compatibility with respect to flood hazard and floodway/flood storage areas
- Compatibility with relevant council floodplain risk management
- Potential morphologic (increased flow velocity and scour), environmental, social and economic impacts due to changed flood behaviour resulting from Stage 1.

21.3.2 Quantitative assessment

A quantitative assessment of potential flood impacts was prepared for the Clyde stabling and maintenance facility construction site. The scale of construction works at this site has the potential to result in substantial flooding impacts, and existing flood studies do not provide sufficient information about the current flooding conditions in the locality.

The quantitative flood assessment involved:

- Detailed hydraulic modelling to define baseline flooding conditions
- Detailed hydraulic modelling of potential flooding impacts at the construction site during Stage 1, including a climate change scenario for future projected sea level rise.

21.4 Existing environment

21.4.1 Surface hydrology and drainage infrastructure

Stage 1 would be located within drainage catchments that ultimately drain to Parramatta River and Sydney Harbour. A description of the catchments and watercourses relevant to Stage 1 is provided in Chapter 19 (Soils and surface water quality – Stage 1).

The drainage catchments across Stage 1 are highly urbanised, with large impervious surfaces created by roads, footpaths and buildings. These impervious surfaces are interspersed with pervious surfaces associated with parkland areas and other unsealed surfaces (such as vacant land and landscaped areas). Surface water is generally collected by developed stormwater networks, which consist of road kerb and guttering, lined and unlined drainage channels, and sub-surface pit and pipe networks.

The existing topography and drainage infrastructure relevant to the Stage 1 construction sites is provided in Table 21-2.

Table 21-2: Existing topography and drainage characteristics for the Stage 1 construction sites

Construction site	Existing topography	Drainage characteristics
Westmead metro station	The construction site is located on a hill with Hawkesbury Road to the west acting as a ridge. The land slopes to the south towards Westmead Public School and east towards Domain Creek, which then flows northwards to the Parramatta River. The existing rail line forms a cutting to the north of the construction site. Elevation is around 32 – 37 metres Australian Height Datum (AHD).	No natural overland flow paths affect the construction site. The construction site is adjacent near the top of a stormwater drainage line which flows northwards to Parramatta River.
Parramatta metro station	The construction site is located on a largely flat area with a slight northerly slope towards Parramatta River. Elevation is around nine to 10 metres AHD.	The construction site is located within the Parramatta River floodplain. Stormwater drainage flows to the north of the site, discharging to the Parramatta River.

Construction site	Existing topography	Drainage characteristics
Clyde stabling and maintenance facility	The construction site and surrounding terrain are located on generally flat to undulating terrain. The ground surface is highly modified from previous land use, particularly on Sydney Speedway (located on NSW Government owned land). The construction site is generally three to six metres AHD, with some raised mounds up to 10 metres AHD. The area around the tunnel dive structure includes elevations ranging from five to 15 metres AHD.	The construction site is on the Duck Creek/ A'Becketts Creek floodplain. Drainage on the construction site is generally towards these creeks, although undulations on the current site surface (particularly at the Sydney Speedway site) cause ponding of local runoff and reduce free surface drainage of flows to the creeks. No natural overland flow paths affect the construction site. Existing stormwater drainage arrangements are unknown.
Silverwater services facility	The construction site is located on gently sloping terrain, with land sloping to the north-west towards Duck River. Elevation is around five to 5.3 metres AHD.	The construction site is within the broader Parramatta River floodplain but would only be affected by mainstream flooding in extreme events. Existing stormwater drainage arrangements are unknown but are assumed to be located in Derby Street and Silverwater Road and drain to the north-west to Duck River.
Sydney Olympic Park metro station	The construction site is located on relatively high ground with land generally sloping away from the site in each direction. Elevation is around 16 – 25 metres AHD.	Some localised drainage low points are present within the construction site. The existing stormwater drainage arrangements are unknown. No natural overland flow paths affect the construction site.
North Strathfield metro station	The northern and southern construction sites are located on relatively high ground. The natural catchment boundary is situated 200 metres to the east, with the land sloping towards Powells Creek to the west. Elevation is around 14 – 20 metres AHD.	Stormwater drainage pipelines cross the T9 Northern Line rail corridor and discharge to Powells Creek. There are also drainage channels alongside the rail corridor which intercept surface flows, including overland flows and discharge via pipe drainage to Powells Creek. The rail corridor and Queen Street include features such as kerbs and retaining walls which may act as obstructions to flow and contribute to overland flooding.
Burwood North Station	The northern and southern construction sites are located on a slope, with an easterly decline in topography toward Concord Oval. The northern construction site has an elevation of around 6.5 to 17 metres AHD. The southern construction site has an elevation of around 11.5 to 14 metres AHD.	The construction sites are located adjacent to major overland flow path and St Luke's Park Canal. Existing stormwater drainage flows eastward along Parramatta Road and discharges to St Luke's Park Canal.
Five Dock Station	The western and eastern construction sites are located on a hill and ridge with land sloping to the north to Hen and Chicken Bay. Elevation is around 16.5 – 20 metres AHD.	No natural overland flow paths affect the construction sites. Existing stormwater drainage drains to the north and south away from the sites.
The Bays Station	The construction site is situated on low-lying former docklands and is generally flat land with little to no slope around White Bay. The construction site is generally three to four metres AHD, with some low-lying sections along White Bay (one metre AHD).	Existing drainage arrangements are not fully known. Substantial trunk drainage channel/ culverts and floodways are visible to the north of the construction site, which is presumed to run under Robert Street before discharging to White Bay to the north-east of the construction site. The former White Bay Power Station forms a trapped drainage point to the west of the construction site, which forms part of a major overland flow path that drains an area stretching north-west towards Rozelle. The internal drainage arrangements within the former White Bay Power Station are unknown.

21.4.2 Flooding

Due to the highly urbanised drainage catchments surrounding the Stage 1 construction sites, flooding behaviour is expected to be largely controlled by the capacity of stormwater drainage systems and roadways that form overland flow paths. Existing flood behaviour at the construction sites has been investigated to varying degrees in previous flood studies including:

- Parramatta River Flood Study – Draft (Cardno, 2019)
- Parramatta Light Rail Flooding Technical Paper (Arup, 2017)
- Duck River and Duck Creek Flood Study Review (WMAwater, 2015a)
- Concord West Precinct Master Plan Flood Study (Jacobs, 2015)
- WestConnex M4 East EIS Appendix Q – Surface Water: Flooding and Drainage (Lyll & Associates, 2015)
- Exile Bay, St Luke’s and William Street Flood Study (WMAwater, 2017)
- Leichhardt Floodplain Risk Management Study and Plan (Cardno, 2017)
- Leichhardt Flood Study (Cardno, 2014)
- Hawthorne Canal Flood Study (WMAwater, 2015b)
- Dobroyd Canal Flood Study (WMAwater, 2014).

Based on the above studies, the existing flood behaviour around the Stage 1 construction sites is described in Table 21-3. Maps showing flood extents/depths and flooding hazard for the one per cent AEP flood and PMF (where identified from previous flood studies) are included in Technical Paper 9 – Hydrology and flooding.

Table 21-3: Existing flood behaviour for Stage 1 construction sites

Construction site	Existing flood behaviour
Westmead metro station	<ul style="list-style-type: none">• The construction site and immediate surrounds are outside of flooding extents, flood hazard, floodway and flood storage areas in the one per cent AEP event and PMF event• There are no overland flooding, mainstream flooding or coastal inundation risks relevant to the construction site and immediate surrounds.
Parramatta metro station	<ul style="list-style-type: none">• The construction site and immediate site surrounds are affected by overland flooding and mainstream flooding, with flood depths of about 0.15 metres in the one per cent AEP event and about one metre in the PMF event• The construction site and immediate surrounds are outside of high flood hazard, floodway and flood storage areas• There are no coastal inundation risks relevant to the construction site and immediate surrounds.
Clyde stabling and maintenance facility	<ul style="list-style-type: none">• The construction site and immediate surrounds are affected by overland flooding and mainstream flooding. About one quarter of the site is flood-affected in the one per cent AEP event to depths of up to 2.4 metres. Most of the site is flood-affected in the PMF event to depths of about four metres• The construction site and immediate surrounds contain areas of high flood hazard, but is expected to be outside floodway and flood storage areas based on the terrain and flood behaviour• There are no coastal inundation risks relevant to the construction site and immediate surrounds.
Silverwater services facility	<ul style="list-style-type: none">• The construction site and immediate surrounds are affected by overland flooding and mainstream flooding. The construction site would not be affected in the one per cent AEP event, but would be flood-affected in the PMF event to depths of about 0.7 metres• The construction site and immediate surrounds are located in floodway and flood storage areas. It is unclear if the site is located within a flood hazard area• There are no coastal inundation risks relevant to the construction site and immediate surrounds.

Construction site	Existing flood behaviour
Sydney Olympic Park metro station	<ul style="list-style-type: none">• One per cent AEP and PMF flood depths, flood hazards, floodway and flood storage areas for the construction site and immediate surrounds could not be determined from the available flood studies and reporting. The construction site appears to be outside the nearest floodplain and is expected to be outside of high hazard, floodway and flood storage areas• There are no overland flooding, mainstream flooding or coastal inundation risks relevant to the construction site and immediate surrounds.
North Strathfield metro station	<ul style="list-style-type: none">• There is minor overland flooding potential across the construction site from Queen Street of up to 0.1 metres during the one per cent AEP event (low hazard area) and 0.3 metres during the PMF event (predominantly low hazard area)• There is major overland flooding potential across the northern portion of the construction site of up to one metre during the PMF event (high hazard area)• The construction site and immediate surrounds are not located in floodway or flood storage areas• There are no mainstream flooding or coastal inundation risks relevant to the construction site and immediate surrounds.
Burwood North Station	<ul style="list-style-type: none">• There is minor overland flooding potential across the northern construction site. Flood depths could not be determined from the available flood studies and reporting• There is minor overland flooding potential across the southern construction site of up to 0.2 metres during the one per cent AEP event and up to 0.3 metres during the PMF event. Flooding is expected to be contained within the roadway, with a small area of ponding within the construction site• The northern and southern construction sites and immediate surrounds are outside of high flood hazard, floodway and flood storage areas• There is no mainstream flooding or coastal inundation risks relevant to the construction sites and immediate surrounds.
Five Dock Station	<ul style="list-style-type: none">• One per cent AEP and PMF flood depths, flood hazards, floodway and flood storage areas for the western and eastern construction sites and immediate surrounds could not be determined from the available flood studies and reporting.• There is minor overland flooding potential across the construction site during the one per cent AEP event and PMF event, which is expected to be contained within the roadway• The construction sites and immediate surrounds are expected to be located outside of high flood hazard, floodway and flood storage areas• There are no mainstream flooding or coastal inundation risks relevant to the construction sites and immediate surrounds.
The Bays Station	<ul style="list-style-type: none">• There is major overland flooding potential across the construction site of up to one metre during the one per cent AEP event. Overland flooding of up to one metre would affect most of the construction site during the PMF event• There is coastal inundation potential across low-lying portions of the construction site during the one per cent AEP event• Parts of the construction site are located within high flood hazard, floodway and flood storage areas• There are no mainstream flooding risks relevant to the construction site and immediate surrounds.

21.5 Avoidance and minimisation of impacts

Potential flooding impacts have been minimised through the selection of Stage 1 construction sites to avoid existing flood prone land where possible.

The design of the Clyde stabling and maintenance facility site considered the results of initial modelling of existing flood conditions at and near the site. Refinements were made to the design to ensure adequate flood immunity and minimise offsite flooding impacts. These included:

- Refinements to the design of the proposed structures over A'Becketts Creek and Duck Creek
- Modifications to the channels of A'Becketts Creek and Duck Creek
- Provision of an open channel and structure to carry PMF flood flows from the western side of James Ruse Drive to the eastern side of the future stabling and maintenance facility.

Further design refinement at the Clyde stabling and maintenance facility site would occur during detailed design with the aim of further reducing potential offsite flooding impacts related to Stage 1.

21.6 Potential impacts

21.6.1 Potential impacts on flood behaviour during Stage 1

Stage 1 construction works and infrastructure has the potential to impact existing flooding behaviour through disruption of existing conditions (such as drainage systems and/or overland flow paths). In addition, flooding events during construction could impact areas within and near the Stage 1 construction sites, including the potential inundation of construction sites.

Potential flood-related impacts during construction may include:

- Interruption of overland flowpaths by installation of temporary construction site infrastructure (i.e. noise barriers, acoustic sheds, retaining walls) and/or modifications to landforms (i.e. placement of fill materials, stockpiles)
- An increase in runoff volumes following rainfall events due to an increase in impervious surfaces (i.e. construction sites)
- The interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent areas
- Blocking of drainage networks through increased sedimentation of surface water
- Flow of water into station excavations, services facility shafts and tunnel portals.

A summary of the potential flooding impacts at Stage 1 construction sites is provided in Table 21-4 with detailed information provided in Technical Paper 9 (Hydrology and flooding). Key areas of potential flooding risk include the Parramatta metro station, Clyde stabling and maintenance facility, Silverwater services facility and The Bays Station construction sites. Flooding impacts are expected to be minor to negligible at all other Stage 1 construction sites.

Flooding risks at Clyde stabling and maintenance facility are discussed in further detail in the following section.

Table 21-4: Potential flooding impacts for Stage 1

Construction site	Potential flooding impacts
Westmead metro station	<ul style="list-style-type: none">• Impacts to existing flooding behaviour at the construction site and immediate surrounds are unlikely.
Parramatta metro station	<ul style="list-style-type: none">• Potential inundation of the construction site and ingress of floodwaters into station excavations during the PMF event• Potential minor to moderate localised flooding impacts to Horwood Place between Macquarie Street and George Street and the Macquarie Lane access to Smith Street from the obstruction of existing flow paths through the construction site.
Silverwater services facility	<ul style="list-style-type: none">• Potential ingress of floodwaters into the shaft during the PMF event• Potential flooding impacts to Derby Street from the obstruction of parts of the existing flow paths through the construction site.
Sydney Olympic Park metro station	<ul style="list-style-type: none">• Impacts to flooding at the construction site and immediate surrounds are unlikely.

Construction site	Potential flooding impacts
North Strathfield metro station	<ul style="list-style-type: none">• Potential inundation of the construction site from existing flow paths on Queen Street and ingress of floodwaters into station excavation during the PMF event• Potential flooding impacts to Queen Street, including ponding, from the obstruction of existing flow paths through the construction site. Flow paths may be obstructed by construction site hoardings.
Burwood North Station	<ul style="list-style-type: none">• Impacts to existing flooding behaviour at the northern and southern construction sites and immediate surrounds are unlikely.
Five Dock Station	<ul style="list-style-type: none">• Impacts to existing flooding behaviour at the western and eastern construction sites and immediate surrounds are unlikely.
The Bays Station	<ul style="list-style-type: none">• Potential inundation of the construction site and ingress of floodwaters into the station excavation during the one per cent AEP event and the PMF event• Potential flooding impacts to Robert Street and surrounding areas from the obstruction of existing flow paths through the construction site. Flow paths may be obstructed by site filling works to raise and regrade the construction site.

Clyde stabling and maintenance facility

As discussed in sections 21.3.2 and 21.4.2, Stage 1 works for the Clyde stabling and maintenance facility has the potential to result in flooding impacts. The potential flooding impacts at the Clyde stabling and maintenance facility are provided in Table 21-5.

Overall, the potential flooding risks are expected to be minor in all flooding events. Where there are increases in flooding risks, impacts would be managed in accordance with the mitigation measures in Section 21.7.2. Design refinement would also be considered at detailed design stage to mitigate potential impacts where feasible and reasonable.

Table 21-5: Potential flooding impacts for Stage 1 – Clyde stabling and maintenance facility

Potential impact	Description
Change in peak flooding levels	<ul style="list-style-type: none">• Potential reduction in peak flood levels on the Duck Creek and A'Becketts Creek floodplains of up to 0.1 metres during the five per cent and one per cent AEP events (upstream of the Clyde stabling and maintenance facility)• Potential increase in peak flood levels in and adjacent to Duck Creek and Duck River of up to 0.08 metres during the five per cent and one per cent AEP events (downstream of the Clyde stabling and maintenance facility)• Potential increase in peak flood levels in the PMF event (upstream and downstream of the Clyde stabling and maintenance facility):<ul style="list-style-type: none">• Up to 0.07 metres in the A'Becketts Creek floodplain• Up to 0.15 metres in the Duck Creek floodplain upstream of the culvert crossing• Up to 0.06 metres in Duck Creek downstream of the culvert crossing• Up to 0.1 metres in the Duck River floodplain (upstream of the M4 Motorway)• Up to 0.2 metres on the south-western section of Rosehill Gardens racecourse grounds.
Change in flood extent	<ul style="list-style-type: none">• Potential minimal increases in the flood extent for all events up to the PMF• Potential maximum increases in the PMF extent of around 10 metres and typical increases of less than five metres.
Change in flood hazard	<ul style="list-style-type: none">• Potential minor increases in high flood hazard extent in the five per cent and one per cent AEP and PMF events (refer to Figure 21-1 to Figure 21-3)• Some potential reductions in the high hazard extent in the five per cent and one per cent AEP events (refer to Figure 21-1 and Figure 21-2).
Change in duration of inundation	<ul style="list-style-type: none">• No significant increases in the duration of inundation.

Potential impact	Description
Property impacts	<ul style="list-style-type: none">• Potential minor increases in flood levels of 0.01 to 0.02 metres at industrial properties adjacent to Duck River in Auburn in the five per cent and one per cent AEP events (refer to Figure 21-4)• Potential increases in flood levels of 0.08 metres at commercial and industrial properties near the Duck Creek and Duck River confluence in the five per cent and one per cent AEP events• No newly-affected properties in the one per cent AEP event• Potential for seven newly-affected properties in the PMF event.
Critical infrastructure impacts	<ul style="list-style-type: none">• No significant impacts to critical infrastructure.
Climate change impacts	<ul style="list-style-type: none">• No increase in the flood protection level required to account for the effects of climate change on flooding.



Figure 21-1: Potential change in flood hazard at the Clyde stabling and maintenance facility construction site – five per cent AEP event

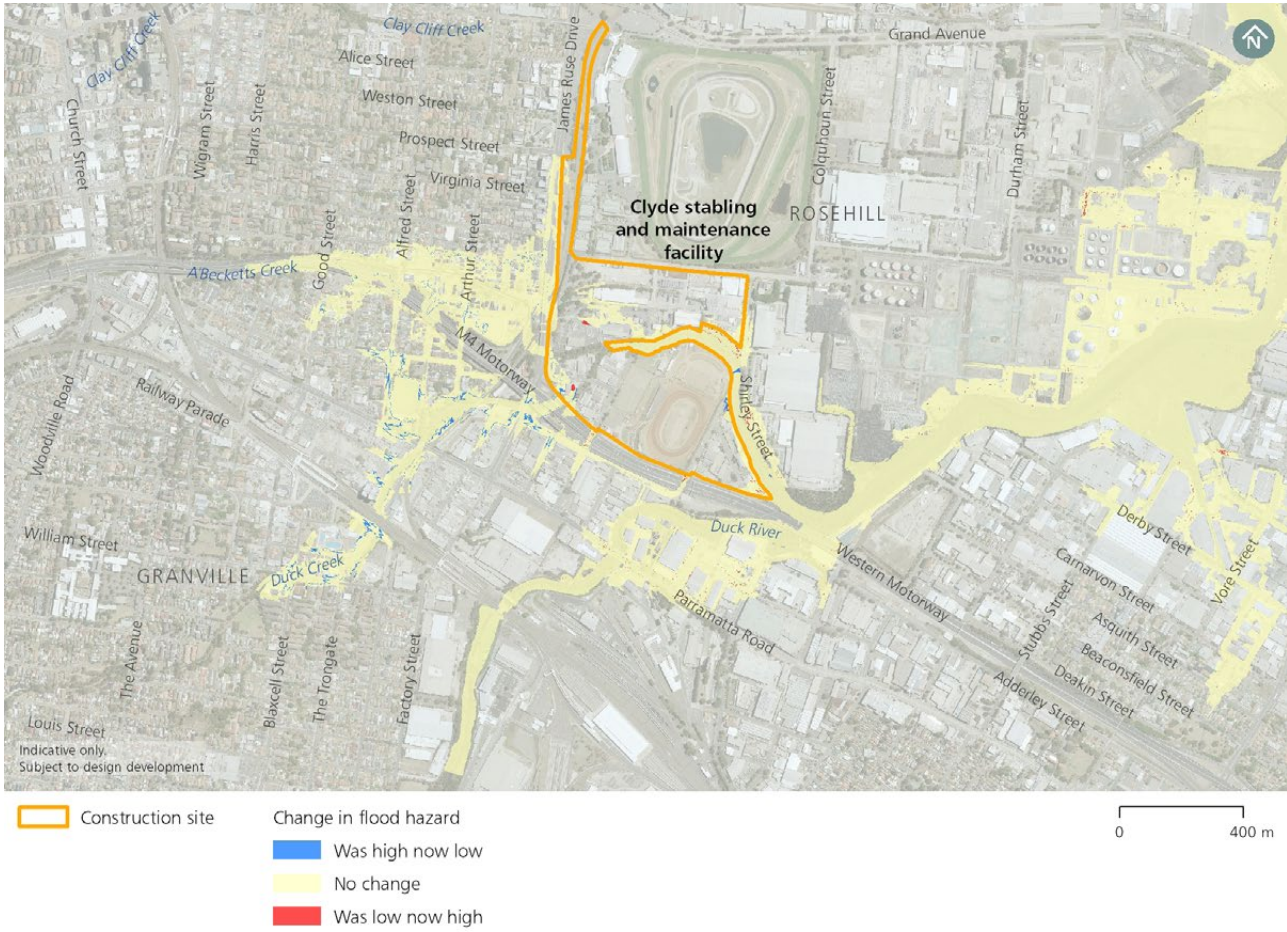


Figure 21-2: Potential change in flood hazard at the Clyde stabling and maintenance facility construction site – one per cent AEP event



Figure 21-3: Potential change in flood hazard at the Clyde stabling and maintenance facility construction site – PMF event

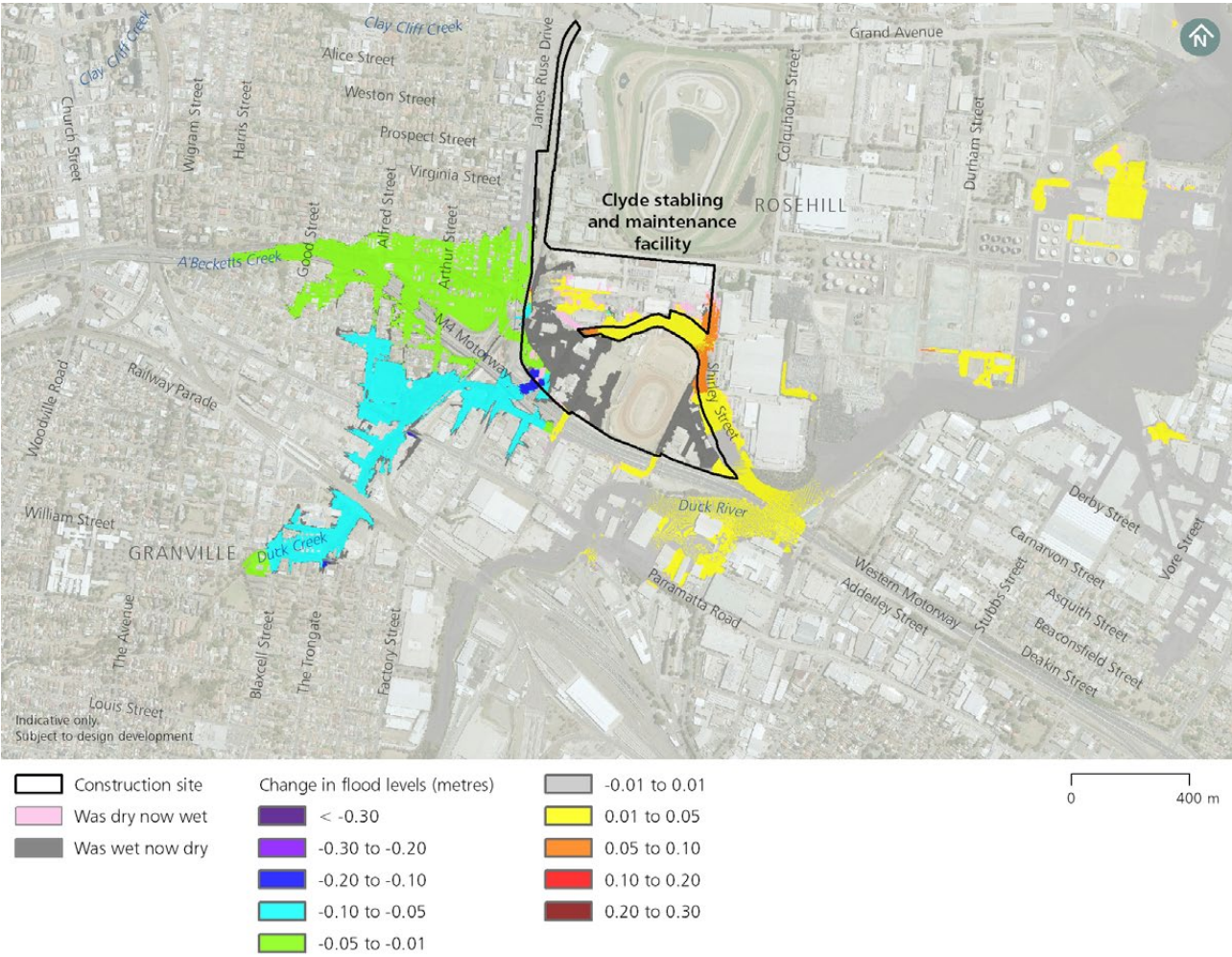


Figure 21-4: Potential change in flood levels at Clyde stabling and maintenance facility construction site – one per cent AEP event

21.6.2 Compatibility of construction sites with flood conditions

All Stage 1 construction sites were assessed as compatible with flood conditions due to construction sites either not being flood prone, or having a low risk or existing low hazard exposure and as mitigation measures can readily be provided to manage flood risks. The compatibility of construction sites to the existing flood conditions was determined based on the exposure of the site to existing high hazard or high risk flooding, potential impacts on flooding behaviour on surrounding properties, potential impact of flooding on the construction sites and the ability to provide effective mitigation measures to any existing conditions or potential impacts.

21.6.3 Potential downstream velocity and scour impacts

Mitigation measures would manage potential increases in flow velocity and scour potential that may occur where Stage 1 construction works could alter flood flow patterns and significantly divert or concentrate flood flows. As most construction sites are not located within or adjacent to major overland or mainstream flow paths, there is a low potential to impact downstream velocity and scour.

Flow velocities are expected to potentially increase at the Clyde stabling and maintenance facility by about 18 per cent from 0.8 metres per second to over 0.9 metres per second during the one per cent AEP event. This is due to the proposed culvert crossings of A'Becketts Creek and Duck Creek and formalisation of sections of these creek channels. In addition, there is potential for localised scouring of bed material at the transition from hard drainage structures to the natural or unlined channel surfaces. These impacts would be managed in accordance with mitigation measures outlined in Section 21.7.

21.6.4 Floodplain risk management

A review of publicly available floodplain risk management plans did not identify any conflicts or inconsistencies with proposed floodplain risk management measures.

The Leichhardt Floodplain Risk Management Study (Cardno, 2017) identifies proposed flood modification works which would involve duplication of existing drainage running under Robert Street that discharges to White Bay. Inner West Council would be consulted prior to construction so that construction work at The Bays Station construction site is coordinated with these proposed flood modification works.

21.6.5 Potential impacts to emergency management arrangements for flooding

As identified in Section 21.6.1, the construction sites at Parramatta metro station, Clyde stabling and maintenance facility and The Bays Station are at potential risk of flooding during construction. The potential impacts to emergency management arrangements are summarised in Table 21-6.

Mitigation measures would manage any potential increases in flood depths affecting emergency management routes and sensitive properties in the vicinity of these sites. The mitigation measures outlined in Section 21.7 includes consultation with NSW State Emergency Service and relevant local councils prior to construction.

Table 21-6: Potential impacts to emergency management arrangements

Construction site	Identified emergency management routes, facilities and sensitive properties	Potential impacts
Parramatta metro station	<ul style="list-style-type: none">Emergency management routes:<ul style="list-style-type: none">Macquarie StreetChurch StreetGeorge StreetSmith StreetSensitive properties:<ul style="list-style-type: none">Arthur Phillip High SchoolYMCA Child Care Services (Smith Street)Reggio Emilia Child Care (George Street).	<ul style="list-style-type: none">One per cent AEP flood event: potential impacts to emergency access routes, emergency facilities and sensitive properties are unlikelyPMF event: potential impacts to emergency arrangements are unlikely as substantial flooding depths and high hazard is already present in the existing environment case.
Clyde stabling and maintenance facility	<ul style="list-style-type: none">Emergency management routes:<ul style="list-style-type: none">James Ruse DriveM4 MotorwayParramatta RoadSensitive properties:<ul style="list-style-type: none">Rosehill Public School and PreschoolFun2learn Early Learning CentreKinderooLittle Angels KindergartenRosehill Montessori Kindergarten.	<ul style="list-style-type: none">One per cent AEP flood event: potential impacts to emergency access routes, emergency facilities and sensitive properties are not expectedPMF event: potential impacts to emergency arrangements are unlikely as substantial flooding depths and high hazard is already present in the existing environment case. Parts of the Kinderoo property would potentially be affected by the PMF event with increases in flood depths of up to 0.02 metres.
The Bays Station	<ul style="list-style-type: none">Emergency management routes:<ul style="list-style-type: none">Robert StreetMullens StreetVictoria Road.	<ul style="list-style-type: none">Potential increase in flood depths in Robert Street east of Mullens Street without appropriate mitigation measures.

21.6.6 Potential social and economic costs from flooding impacts

Given the generally low flood affectation of construction sites and expected low impact on flood behaviour on surrounding properties and infrastructure, the potential social and economic costs from flooding impacts are considered low. Based on the assessment of potential flooding impacts in Section 21.6.1, the potential flooding impacts of Stage 1 are generally expected to be minor or negligible for most construction sites. Potential flooding impacts at Parramatta metro station, Clyde stabling and maintenance facility and The Bays Station construction sites would be managed through the mitigation measures outlined in Section 21.7.

21.6.7 Cumulative impacts

Potential cumulative impacts were considered for assessment based on the likely interactions of Stage 1 with other projects and plans that met the adopted screening criteria. The approach to assessment and the other projects considered are described further in Appendix G (Cumulative impacts assessment methodology).

There is potential for cumulative impacts to occur at the following Stage 1 construction sites:

- Parramatta metro station
- Clyde stabling and maintenance facility.

Parramatta metro station

The Parramatta metro station construction site has the potential for cumulative impacts with the following projects and plans:

- Parramatta Light Rail Stage 1
- Draft Camellia Town Centre Master Plan.

Flood impact modelling carried out for Parramatta Light Rail Stage 1 indicates that in the one per cent AEP flood event, peak flood levels in the immediate vicinity of the Parramatta metro station construction site would reduce due to proposed light rail track drainage and changes to the ground surface elevations. There would not be increased flood-affectation of the Stage 1 construction site due to Parramatta Light Rail Stage 1, therefore cumulative impacts are unlikely.

The draft Camellia Town Centre site is substantially affected by the PMF event and future development associated with the draft Master Plan is expected to have potential impacts on flood behaviour. Flood modelling carried out for the Clyde stabling and maintenance facility indicates the PMF levels at the Parramatta metro station construction site may increase by up to about 0.5 metres if Stage 1 construction coincides with or follows development included in the draft Master Plan. Future modelling is recommended during detailed construction planning of Stage 1 to confirm the impacts at the Parramatta metro station construction site as further information regarding the draft Master Plan becomes available.

Clyde stabling and maintenance facility

The Clyde stabling and maintenance facility construction site has the potential for cumulative impacts with the draft Camellia Town Centre Master Plan. Flood modelling carried out for the Clyde stabling and maintenance facility indicates the future development associated with the draft Master Plan is not likely to impact on the Clyde stabling and maintenance facility construction site. However, future modelling is recommended during detailed construction planning of Stage 1 to confirm the impacts at the Clyde stabling and maintenance facility construction site as further information regarding the draft Master Plan become available.

21.7 Management and mitigation measures

21.7.1 Approach to management and mitigation

Stage 1 hydrology and flooding impacts would be managed in accordance with the Construction Environmental Management Framework. In relation to hydrology and flooding, the Construction Environmental Management Framework identifies that Stormwater and Flooding Management Plans would be prepared where required. These plans would identify the appropriate design standard for flood mitigation based on the duration of construction, proposed works and flood risks.

More details of the Construction Environmental Management Framework are provided in Chapter 27 (Synthesis of the Environmental Impact Statement) and Appendix D.

21.7.2 Mitigation measures

The mitigation measures that would be implemented to address potential hydrology and flooding impacts are described in Table 21-7.

Table 21-7: Mitigation measures – Hydrology and flooding Stage 1

Reference	Impact/issue	Mitigation measure	Applicable location(s) ¹
HF1	Flooding behaviour impacts	Detailed construction planning would consider flood risk at construction sites. This would include: <ul style="list-style-type: none">• Identification of measures to not worsen flood impacts on the community and on other property and infrastructure during construction up to and including the one per cent AEP flood event• Provide flood-proofing to excavations at risk of flooding or coastal inundation during construction, where feasible and reasonable, such as raised entry into shafts and/or pump-out facilities to minimise ingress of floodwaters into shafts and the dive structure• Review of site layout and staging of construction works to avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required. This includes design of site hoardings to minimise disruption to flow paths (if possible). Not worsen is defined as: <ul style="list-style-type: none">• A maximum increase in flood levels of 50mm in a one per cent AEP flood event• A maximum increase in time of inundation on one hour in a one per cent AEP flood event• No increase in potential soil erosion and scouring from any increase in flow velocity in a one per cent AEP flood event.	PMS, CSMF, SSF, NSMS, TBS
HF2	Flooding behaviour impacts	On-site stormwater detention would be provided for the Clyde stabling and maintenance facility to manage peak site runoff rates and volumes due to increased imperviousness of the site.	CSMF
HF3	Flooding behaviour impacts	Further design refinement at the Clyde stabling and maintenance facility construction site would occur during detailed design to mitigate the identified potential impacts including: <ul style="list-style-type: none">• The increases in flood levels of up to 0.08 metres in Duck Creek and adjacent properties in the one per cent AEP flood event• Increases in flow velocities and the potential increased risk of scour at the proposed creek crossings and in the downstream channels• The potential flooding impacts from filled features including the road overbridge approach.	CSMF
HF4	Flooding behaviour impacts	Drainage at construction sites would be designed, where feasible and reasonable, to mitigate potential alterations to local runoff conditions due to construction sites.	All
HF5	Flooding behaviour impacts	Detailed construction planning for The Bays Station construction would aim to minimise changes to existing levels in relation to potential impacts on flood behaviour, along the north-western side of site adjacent to low-lying property, to minimise reduction in floodplain storage.	TBS
HF6	Flood protection	Consultation would occur with the proponent of the Camellia Town Centre redevelopment to understand potential flood impacts from the redevelopment on Stage 1 and to identify any additional flood protection (if required).	PMS
HF7	Flooding emergency management	Construction planning regarding flooding matters would be carried out in consultation with the NSW State Emergency Service and the relevant local council.	PMS, CSMF, TBS

Reference	Impact/issue	Mitigation measure	Applicable location(s) ¹
HF8	Impacts to flood mitigation works	Detailed construction planning for The Bays Station construction site would aim to avoid conflicts with the potential construction of flood mitigation works in Robert Street, in consultation with Inner West Council.	TBS

Note 1: WMS: Westmead metro station; PMS: Parramatta metro station; CSMF: Clyde stabling and maintenance facility; SSF: Silverwater services facility; SOPMS: Sydney Olympic Park metro station; NSMS: North Strathfield metro station; BNS: Burwood North Station; FDS: Five Dock Station; TBS: The Bays Station; Metro rail tunnels: Metro rail tunnels not related to other sites (eg tunnel boring machine works); PSR: Power supply routes.

21.7.3 Interactions between mitigation measures

Mitigation measures in other chapters that are relevant to the management of potential hydrology and flooding impacts include:

- Chapter 18 (Groundwater and ground movement – Stage 1), specifically measures which address impacts to groundwater levels
- Chapter 19 (Soils and surface water quality – Stage 1), specifically measures which address the management of surface water in accordance with the Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) and Volume 2 (Department of Environment and Climate Change, 2008), and confirmation of local stormwater system capacity.

These measures would work collectively to minimise the potential hydrology and flooding impacts of Stage 1.

There are no mitigation measures identified in the assessment of other environmental aspects that are likely to affect the assessment of hydrology and flooding.