4. Proposed drainage works

4.1 Sydney Metro design criteria

The design criteria for the project in relation to drainage and flooding was developed as part of the reference design

The reference design on which the impact assessment has been based would be refined during future design stages and the below requirements would be further addressed as necessary at that stage.

Proposed flood immunity criteria for various types of infrastructure are summarised in Table 4-1.

Table 4-1 Minimum flood immunity of metro infrastructure

Infrastructure	Minimum flood immunity	Comment
Above-ground track	1 % AEP climate change event	For mainstream flooding when measured to track formation at the edge of ballast
Above ground rail system facilities	500 mm above the 1 % AEP climate change event	Except where facilities are identified as being critical for emergency management, in which case they must be set at a minimum of the PMF
Above ground stations	1 % AEP climate change event	Subject to site specific flood risk assessment to determine impacts and emergency management in the PMF

Note: A 10 per cent increase in rainfall intensity above the one per cent AEP rainfall intensity has been included to make allowance for the future effects of climate change.

Adopted design criteria for the proposed drainage system are summarised in Table 4-2. Proposed design criteria in relation to flood impacts are provided in Table 4-3.

Table 4-2 Drainage system design criteria

Infrastructure	Design criteria	Comment
Track drainage	Capacity up to 1 % AEP climate change event where subject to overland flooding 2 % AEP + 10 % increase in rainfall intensity elsewhere, except in the Campsie and Marrickville areas, where only 5 % AEP is achievable due to existing track immunity	The existing track immunity is low in these areas due to flooding from the surrounding catchments. Achieving greater flood immunity in these areas has the potential to require major drainage upgrade works, which may alleviate flooding in the rail corridor but exacerbate downstream impacts.
	No net increase in discharge rates to downstream systems for all events up to and including the 1 % AEP event	On site detention to be provided as required.
On-site detention basin spillways	Designed to provide controlled discharge of flows for events up to and including the 1 % AEP climate change event	N/A

Infrastructure	Design criteria	Comment
Stormwater outlets	Prevention of scour up to 2 % AEP + 10 % increase in rainfall intensity	Impacts to be checked for events up to the 1 % AEP climate change event.
Stormwater inlets	Allowance in design for partial blockage	Industry practice to be adopted.
Car park drainage	Applicable council standards Effective drainage to prevent ponding of water	N/A

Table 4-3 Design criteria for flood impacts on adjoining lands

Flooding characteristic	Proposed criteria for flooding on adjoining lands
Duration of flooding	Maximum increase in time of inundation of one hour in a 1 % AEP event.
Maximum increase in flood level at properties where floor levels are already exceeded in a 1 % AEP event	10 mm
Maximum increase in flood level at properties where floor levels are not exceeded in a 1 % AEP event	50 mm
Increase in flood velocities	Identification of measures to be implemented to minimise scour and dissipate energy at locations where flood velocities are predicted to increase.

Note: Of the above criteria, only increases in flood levels and velocities have been modelled at this stage. Floor levels were not available therefore it was not possible to report against these criteria in the EIS.

Where it is not reasonable or feasible to achieve the outcomes in Table 4-3, further analysis would be undertaken at the detailed design stage to determine an acceptable flood impact for individual locations.

Proposed water quality and re-use criteria are provided in Table 4-4 and are based on the *Water Sensitive Urban Design Guideline* (Roads and Maritime Services, 2016). These guidelines were found to be more stringent than the Council guidelines reviewed which included those documented in the former Marrickville Council Development Control Plan 2011 and the Botany Bay and Catchment Water Quality Improvement Plan (Sydney Metropolitan Catchment Management Authority 2011). Relevant Sydney Water standards were also adopted where required.

It is noted that ANZECC guidelines were not adopted for the purposes of this design. However, it is intended that they will be incorporated at a later stage of the project during detailed design.

Table 4-4 Water quality design criteria

Pollutant	Pollutant reduction criteria
Suspended solids	85 % retention of the average annual load (6 months ARI)
Total Phosphorous	65 % retention of the average annual load (6 months ARI)
Total Nitrogen	45 % retention of the average annual load (6 months ARI)
Litter	Retention of litter greater than 50mm for flows up to 25 % of the 63 % AEP (1 year ARI) peak flow

Pollutant	Pollutant reduction criteria
Course sediment	Retention of sediment courser than 0.125 mm for flows up to 25 % of the 63 % AEP (1 year ARI) peak flow
Oil and grease (hydrocarbons)	In areas with concentrated hydrocarbon deposition, no visible oils for flows up to 25 % of the 63 % AEP (1 year ARI) peak flow

4.2 Drainage infrastructure

Major changes to drainage at key locations are discussed below. Numerous other amendments to track drainage and cross drainage are also proposed and are discussed in later sections. In general, changes to existing drainage in the project area would be undertaken to:

- Replace assets in poor condition
- Provide new track drainage to cater to the realigned track
- Provide new track drainage to improve existing capacity issues
- Provide new cross drainage to manage overland flooding issues
- Mitigate increases in flow rates by provision of detention basins

The proposed works include the following:

- Around 14 kilometres of new track drainage
- Six new cross drainage structures to replace assets in poor condition
- Three new cross drainage structures
- Four new detention basins of sizes between 800 cubic metres and 8,000 metres cubed
- Several new inlet structures and open channels to manage runoff from the track formation and upstream areas
- Provision of a number of water quality treatment devices along the corridor to meet water quality objectives

The proposed works are summarised in section 4.2.1 for Marrickville Station, and in section 4.2.2 for stations between Dulwich Hill and Bankstown. The locations of the proposed detention basins are shown in Figure 4-1.

4.2.1 Marrickville Station

To alleviate existing flooding of the rail corridor for events up to the five per cent AEP event, the following is proposed in the vicinity of Marrickville Station to improve collection and conveyance of stormwater runoff.

Drainage to manage stormwater from the north

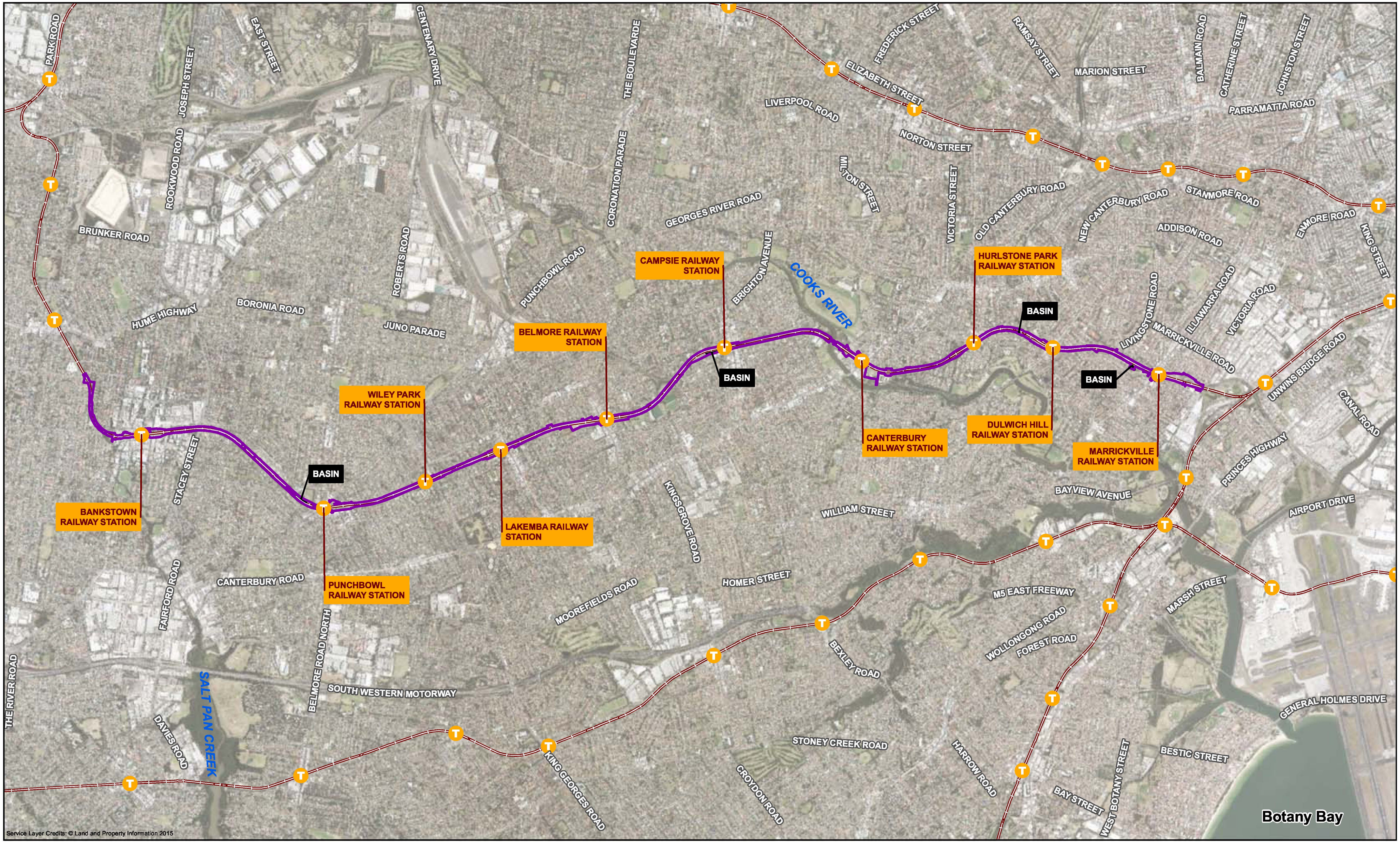
The following is proposed:

- 8,000 metres cubed underground detention basin system in McNeilly Park
- New trafficable grated inlet drains in Hollands Avenue and Livingstone Road
- Trafficable grated inlet drains in Livingstone Road and Marrickville Avenue
- New large diameter (1350 millimetre to 1650 millimetre) buried trunk stormwater system in Livingstone Road and Marrickville Avenue
- Inlet stormwater chamber in Marrickville Avenue adjacent to the rail corridor boundary

The new stormwater system external to the rail corridor would follow an alignment from the Hollands Avenue/ Livingstone Road intersection north of the rail corridor and cross beneath the rail corridor via a large inlet chamber to the north. This stormwater system would continue in an easterly direction, parallel to the cess drainage on the south side of the rail corridor in twin buried pipes placed side by side.

The most southerly of the twin pipe system will be diverted to a new 8,000 metres cubed underground detention system in McNeilly Park on the south side of the rail corridor. This detention basin manages the peak flows and discharges into the existing Malakoff Street stormwater tunnel which passes beneath McNeilly Park.

The remainder of the stormwater system from Livingstone Road continues past the proposed detention basin in McNeilly Park and is conveyed beneath Illawarra Road bridge under existing rail tracks in a large diameter buried pipe system and then diverts to the south beneath the station platform alignment.



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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LEGEND

Project area

Proposed Basin Location

Train station

Railway

GHD

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

Job Number	21-25273
Revision	A
Date	08 Jul 2017

Proposed Basin Locations

Figure 4-1

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy

This system then crosses beneath the existing rail tracks in a northerly direction and discharges into the existing open channel adjacent to Victoria Road. The system then enters the existing closed stormwater system beneath Meeks Road bridge before finally discharging into the Western Channel which outfalls into the Cooks River.

Drainage to manage stormwater from the south

The following is proposed:

- New trafficable drains adjacent to Illawarra Road and parallel to Marrickville Station platforms.
- New drainage culverts to convey flows beneath the Marrickville Station platform.
- A series of new large stormwater drainage pipes in Station Street, conveying flows towards McNeilly Park.

4.2.2 Dulwich Hill to Bankstown

A range of drainage works are proposed in the rail corridor between Dulwich Hill and Bankstown stations. This includes detention basins and upgrades to cross drainage culverts, slotted pipe inter-track drainage, stormwater inlet pits, junction pits, cess drainage, headwalls, and other associated works.

An overview of the proposed drainage works along the alignment from Dulwich Hill to Bankstown is provided in Table 4-5.

Table 4-5 Summary of proposed drainage works from Dulwich Hill to Bankstown

Location*	Summary of existing flooding and drainage issues	Proposed drainage works
Dulwich Hill Station to Canterbury Station	• Surface water flows from north to south beneath rail corridor. • Some locations of overland flooding into the rail corridor when the existing cross drainage capacity is exceeded (refer figures). • Substantial overland flooding east of Canterbury Station (high flood hazard area) due to insufficient track and cross drainage. • Minor overland flooding potential west of Canterbury Station (low flood hazard area).	• Culvert upgrades near Dulwich station. • New track drainage and local drainage upgrades. • 800 m^3 underground detention basin between Dulwich Hill and Hurlstone Park stations to mitigate increases in flow. • Culvert upgrades near Canterbury Station and provision of new 750 mm pipe to Cooks River.

Location*	Summary of existing flooding and drainage issues	Proposed drainage works
Campsie Station	• Surface water flows from south to north beneath rail corridor. • Overflows from local drainage overtop the rail corridor and flow east along rail corridor towards Campsie Station in events greater than the 10 % AEP. • West of Campsie Station is a high flood hazard area. • Overflows from local drainage into rail corridor near Belmore triangle area in events greater than 39 % AEP. • Because of the existing flooding in the rail corridor, and extensive works that would be required outside the project site to alleviate these, it is not considered practical to provide flood immunity in this area up to the 1 % event.	• New inter-track drainage. • New concrete-lined open channel to intercept overland flow from upstream. • 2,500 m^3 detention basin. • Provision of drainage standard and flood immunity to 5 % AEP level only. • New culvert to be provided in Belmore Triangle area to alleviate existing flooding.
Belmore Station	• Surface water flows from south to north beneath rail corridor. • Local drainage capacity constraints outside the rail corridor. • Rail corridor in fill and no predicted overland flow issues within the rail corridor.	• No measures proposed.
Lakemba Station	• Surface water flows from south to north beneath rail corridor. • East of station, risk of flooding in rail corridor for 5 % AEP and greater. • West of station, limited cross drainage capacity however rail corridor is in fill.	• New concrete lined cess drain to be provided. • New track drainage proposed.
Wiley Park Station	• Surface water flows from south to north beneath rail corridor. • Limited cross drainage capacity however rail corridor is mostly in fill.	• New track drainage proposed.
Punchbowl Station	• Surface water flows from south to north beneath rail corridor. • East of the station there are a number of culvert crossings present with varying capacities. • Potential for overflows into the rail corridor. • West of the station drainage modelling indicates overflows into the rail corridor at a number of locations for 1 % AEP climate change event.	• New cess drain and track drainage in this area. • 1,700 m^3 underground detention basin underneath the Up cess area.

Location*	Summary of existing flooding and drainage issues	Proposed drainage works
Bankstown Station	• Rail corridor mostly in fill with limited potential for flooding of tracks except in large (infrequent) events. • An area of medium flood risk hazard to the east of the station.	• New track drainage proposed.

Note: For simplicity, locations are described with reference to the nearest station

4.3 Water quality

Water quality treatment measures have been proposed to satisfy the adopted design criteria outlined in Table 1-3. The proposed measures have been modelled in MUSIC for Punchbowl Station as a test site, and extrapolated for the other stations using the results for Punchbowl as the reference. Punchbowl was adopted as the test site on the basis that it has the largest extent of proposed impervious areas.

The proposed water quality measures are summarised in Table 6-4, and consist of:

- GPTs for the treatment of litter and debris. A total of 12 GPTs (2 each for Lakemba and Wiley Park stations, and 1 each for the remaining stations).
- Rain gardens for the treatment of total phosphorus, total nitrogen and suspended solids. Rain gardens are provided for each of the stations, except for Marrickville, where it is not required.

4.4 Construction

Construction of the project would commence once all necessary approvals are obtained, and the detailed design is complete. Where possible, construction and drainage activities would be planned considering the upcoming weather forecast to minimise the risks of potential heavy rainfall and major surface runoff events.

Although planning of activities in this manner would not prevent construction during periods of potentially heavy rainfall, the risk of having disturbed construction areas or unpreparedness during heavy rainfall periods would be reduced.

4.4.1 Pre-construction works

During the early stages of construction, various preparatory works would be undertaken such as site establishment works and construction access provision. Early stage works would also include:

- Installation of environmental controls, including sediment and erosion controls
- Stormwater drainage channel protection and diversion works
- Any necessary flood mitigation measures to manage overland flows

4.4.2 Construction and maintenance access

Construction access to the rail corridor would be carefully controlled and co-ordinated to minimise disturbance and inconvenience to landholders. Access to the project area would be via existing gates along the rail corridor and from major roads, where possible.

Any new access along the corridor would be formed and stabilised. Where access crosses drainage flow paths, drainage culverts of adequate capacity would be provided across the access track to keep vehicle tyres out of the water whilst facilitating drainage.

4.4.3 Construction compounds and worksites

Construction compounds and worksites would be located both within the rail corridor and in external locations. They would be located:

- At least 50 metres from watercourses or major drainage structures unless a detailed site specific erosion and sediment control plan is implemented.
- Above the five per cent AEP flood level (1 in 20 year ARI flood level) where possible.

Indicative locations for the construction compounds are shown in Figure 4-2. Some of these are within areas identified as existing flood hazard areas. Worksite information and potential construction stage impacts resulting from these are discussed in section 5.2.2. The final construction compound and worksite locations would be selected by the construction contractor and will be included in the Construction Environmental Management Plan (CEMP) or relevant subplan.

4.4.4 Stockpiles

Stockpiles of raw materials or spoil would be located as close as practical to the work area where they are proposed to be used and to permit drainage away from the track to reduce potential flooding impacts.

4.4.5 Surface water flows

A number of proposed improvements to cross corridor drainage would occur as part of the overall construction process. In general, where new cross drainage is proposed, the new infrastructure would be installed first before decommissioning the existing infrastructure. This would minimise the potential for uncontrolled water passage through the site and into adjacent areas.

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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LEGEND

Project area

Compound Locations

Train station

Railway

GHD

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

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Compound Locations
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Figure 4-2

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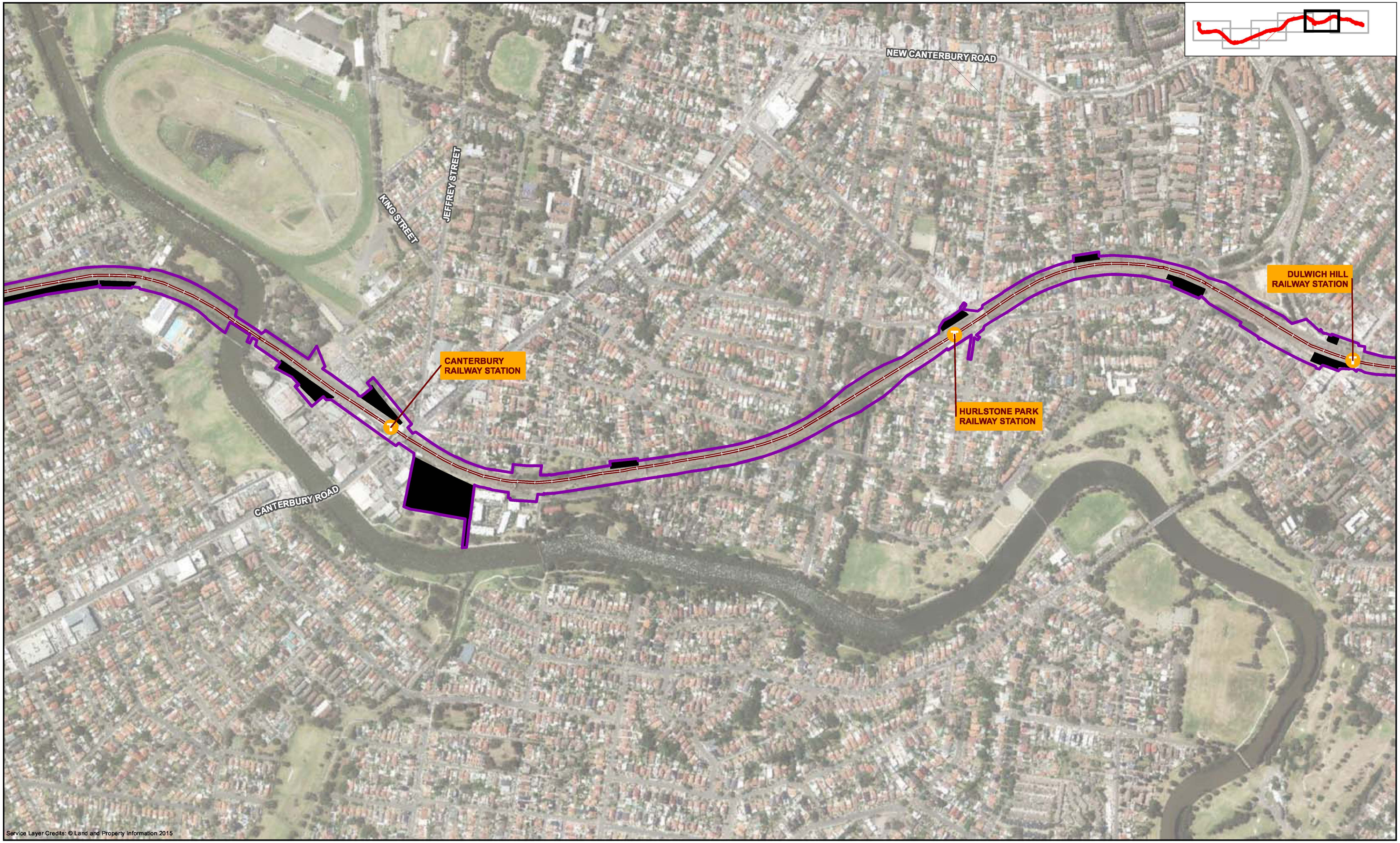
Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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LEGEND

- Project area
- Train station
- Railway
- Compound Locations

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

Job Number	21-25273
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Figure 4-3

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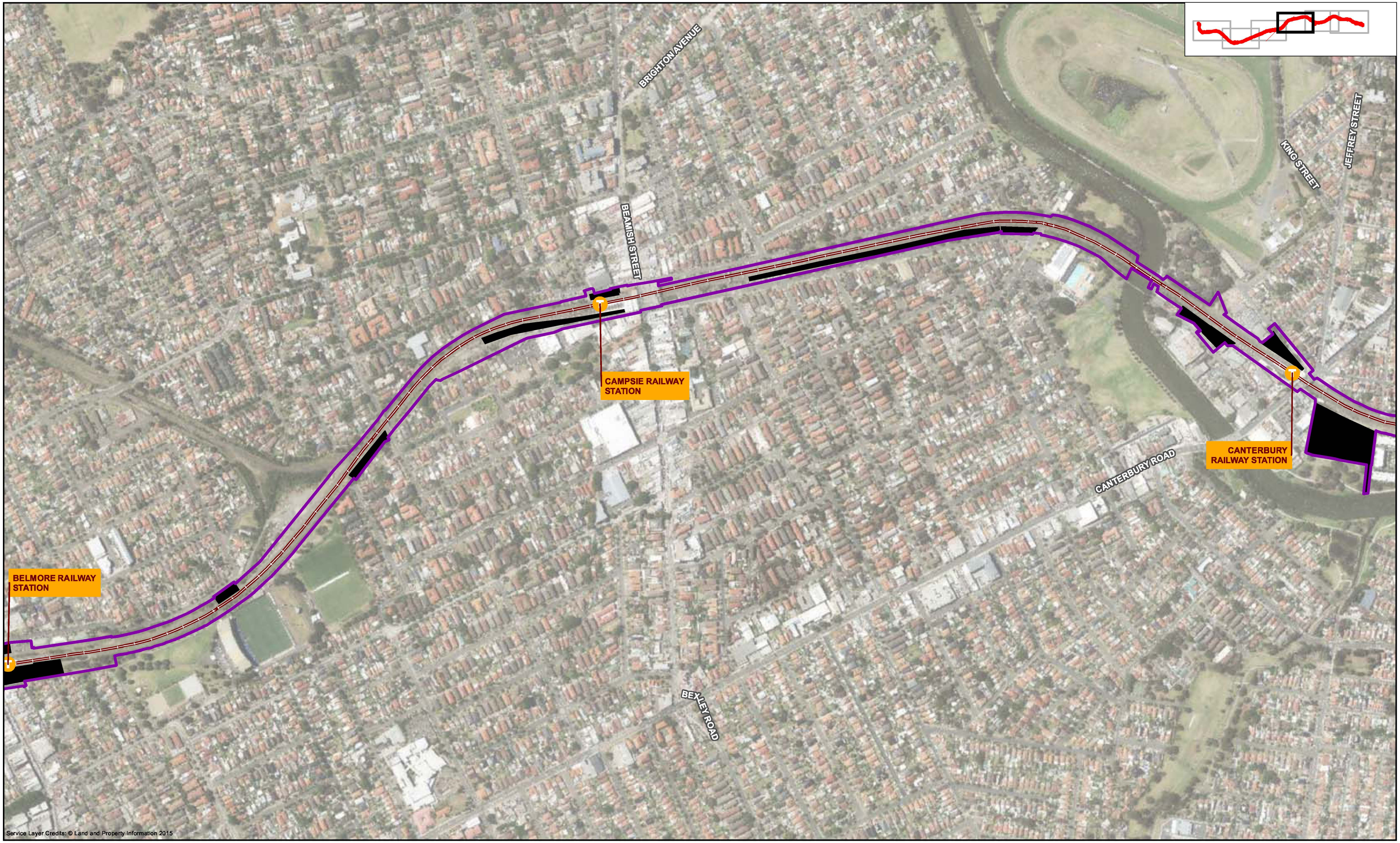

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Map Projection: Transverse Mercator
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LEGEND

- Project area
- Compound Locations
- Train station
- Railway

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

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Compound Locations
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Figure 4-4

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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LEGEND

Project area

Compound Locations

Train station

Railway

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

Job Number 21-25273
Revision A
Date 18 May 2017

Compound Locations
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Figure 4-5

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Map Projection: Transverse Mercator
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LEGEND

Project area

Compound Locations

Train station

Railway

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

Compound Locations
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Job Number	21-25273
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Figure 4-6

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LEGEND

Project area

Train station

Railway

Compound Locations

GHD

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Compound Locations
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Figure 4-7

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5. Construction impacts

5.1 Risk assessment

An assessment of the potential impacts and measures to avoid, mitigate or minimise them during the construction phase is provided in Table 5-1. The risks and impacts listed are discussed in the following sections.

Table 5-1 Potential construction risks and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Hydrologic		
Impact on surface water flow in watercourses	• Changed surface flow paths across the rail corridor.	• Minimise regrading of terrain along the rail corridor. • Install appropriately sized culvert and bridge structures along the corridor.
Hydraulic issues		
Impact of raising the rail formation on flows	• Increased upstream flooding depths and extents • Increased upstream flood durations • Increased impacts on buildings • Increased impacts on adjacent infrastructure (e.g. road closures) • Additional impacts downstream of structures	• Install drainage works prior to or concurrent with rail formation construction to minimise potential adverse impacts.
Impact of conveying additional flows downstream by increasing cross drainage capacity	• Increased downstream flooding depths and extents • Increased downstream flood durations • Increased downstream impacts on buildings • Increased impacts on adjacent infrastructure (e.g. road closures)	• Provide detention basin to manage flows to existing council system. • Locate spoil mounds where they do not impact flow paths and patterns.
Working in the floodplain or flood prone areas	• Impact to construction workers working on flood prone land	• Locate construction compounds outside flooded areas, where practicable. • Prepare wet weather working and construction flood management plans.
Water quality issues		
Impact of construction activities mobilising sediment	• Pollution of receiving drainage networks and watercourses	• Locate construction compounds outside flooded areas. • Prepare wet weather working and construction flood management plans.

5.1.1 Impact of surface flow paths across the rail corridor

Surface flow paths across the rail corridor have the potential to:

- Impact on the flood immunity of the track, where the track passes through existing overland flow paths. Increases in the duration of inundation, flood levels, and flood extents may impact on the safety and operations of the metro line where design criteria and thresholds are exceeded.
- Result in changes in flow patterns, which may lead to undesired downstream flood impacts.

It is noted that the project would be designed such that rail formation overflow would not occur, except at a limited number of locations for events up to one % AEP (or five per cent AEP at Marrickville and Campsie) event, and in order to meet the flood immunity criteria.

5.1.2 Impact of raising formation levels in the project area

Raising the rail formation level could create several potential impacts:

- Increase the upstream flood level and flood extent as a result of the increased head required to pass the flow through replacement structures. Increasing the size of the replacement culverts, or providing a greater number of culverts, could reduce this impact but it would increase the potential impacts downstream of the rail corridor.
- Under existing conditions, many areas of the rail corridor overtop in relatively small design rainfall events. Raising the formation level would reduce the extent and frequency of any overtopping which could redirect flow paths or cause increases in the duration and depth of upstream flooding.

5.1.3 Impact of flow increases downstream

Where culvert capacity is to be augmented, there is potential for:

- Increasing flow depths, durations and hazard downstream of the culverts.
- Increasing load on the downstream drainage networks, some of which may be in poor condition.

5.2 Flooding and drainage outcomes

The following potential impacts on stormwater quantity and flooding are expected. A soil and water management plan (SWMP) would be required for the project area generally, with site-specific plans required at construction compounds and major worksites to manage and reduce the risk of flooding and drainage impacts associated with the works.

5.2.1 Works in the floodplain

Predicted flood extent information is available in parts of the corridor in the Marrickville and Bankstown areas. A number of work sites in these areas (refer Figure 4.2) are indicated to be partially within the floodplain including:

- The Marrickville Station construction compound, which is within the 63 per cent AEP flood extent. The compound to the east of the station is also situated near a high hazard area for the one per cent AEP event.
- The Victoria Road construction compound, also located near Marrickville Station, and also within the 63 per cent AEP flood extent. The Victoria Road compound on the southern side of the rail corridor is also situated near a high hazard area for the one per cent AEP event.

- The Campsie Station compound to the west of the station, which is situated near a high hazard area for the one per cent AEP event.
- The Canterbury Station construction compound to the east of the station, which is situated near a high hazard area for the one per cent AEP event.

Obstruction of flow paths due to the presence of construction works has the potential to:

- Redistribute flood flows and impact downstream development.
- Mobilise construction equipment or debris and cause downstream safety or water quality impacts.

The proposed location of the Marrickville and Victoria Road construction compounds within the 63 per cent AEP flood extent means that there is a 63 per cent chance that these compounds would be flooded in any year.

Due to the generally small sizes of these construction compounds, relative to the size of the floodplain, it is considered that any associated impacts are likely to be minimal.

Options to relocate these compounds or careful planning of compound layouts and management and planning of construction activities, would be considered during detailed design, if necessary, to minimise potential adverse impacts. Further review of construction compound locations beyond the Marrickville area would also be undertaken during detailed design stage to confirm that these are located above the five per cent AEP design flood event level (refer also to Section 7.1).

5.2.2 Potential for detrimental increases in the flood affectation of other properties, assets and infrastructure

During construction, there may be a need to temporarily disconnect or divert existing stormwater drainage pipes, which could result in localised modifications to existing flooding patterns, flow volumes, and velocities.

Temporary diversions would be required to transfer runoff around construction work sites. This may involve excavations and embankments, which would alter localised flow patterns. These changes would be temporary and limited to the construction phase. The landform would be restored as near as practicable to the pre-works condition following construction.

Construction would result in a small increase in impervious areas, which would have the potential to increase the volume of water flowing to watercourses. However, the change in impervious area would be negligible compared to the overall catchment area.

Temporary changes to the stormwater drainage system during construction would be subject to further design and analysis to confirm the potential impacts and to identify any required mitigation. Any flood impacts during construction are expected to be localised and relatively minor, and would be managed by implementing the measures provided in section 1. This would include, wherever possible, implementation of replacement drainage in advance of any disconnections or diversions (refer to section 7.1).

The locations of work areas and compounds within designated flood hazard areas would not result in flood affectation of other properties, assets and infrastructure (refer explanation below).

5.2.3 Consistency with Council floodplain risk management plans

Relevant plans are described in section 1. The *Salt Pan Creek Catchments Floodplain Risk Management Study and Plan* proposes drainage modifications near Wattle Street in Bankstown, which is close to the project area. Construction of the project would not prevent or compromise these proposed works. Construction works are therefore considered to be consistent with Council's floodplain risk management plans.

5.2.4 Compatibility with the flood hazard of the land

Some construction activities, work sites and compounds would be located in areas where there is an existing flood hazard. However, due to the generally small sizes of compounds and work sites relative to the size of the floodplain, minimal impacts on flood hazard would result. The layout of construction work sites and compounds would be undertaken with consideration of overland flow paths and avoid flood liable land where practicable. The location of work sites and compounds would be reviewed during construction planning to avoid, where possible, high hazard areas. Following completion of construction, no further impacts would occur.

5.2.5 Compatibility with the hydraulic functions of flow conveyance in floodways and storage areas of the land

Some areas of construction are located in areas with overland flow paths that may constitute floodways. Obstruction of flow paths and floodways due to the presence of construction works and equipment has the potential to redistribute flood flows and impact downstream properties, and/or mobilise construction equipment or debris, which could result in downstream safety or water quality impacts.

Careful review of the proposed layout of construction compounds, including siting of buildings and plant, would be undertaken where these are located within or partially within flood liable land. However, given their small size relative to the overall floodplain area, minimal impacts are expected. Following completion of construction, no further impacts would occur.

Some modifications to flood storage areas, including at McNeilly Park, are proposed. Construction flood management planning would incorporate measures to maintain the storage function of those areas in a flood event (refer also to Section 7.1).

5.2.6 Downstream velocity and scour potential

There is the potential for temporary drainage works to impact overland flow paths during construction. This could divert or concentrate flows, potentially resulting in the scouring of downstream areas, particularly where soil has been exposed during construction.

Soil and water management measures would be implemented in accordance with *the Blue Book* and *Managing Urban Stormwater: Soils and Construction, Volume 2A* (DECC, 2008), to minimise any potential impacts resulting from runoff and flooding during construction.

5.2.7 Impacts on existing emergency management arrangements

Preliminary consultation was undertaken with the NSW SES and local councils regarding existing flood evacuation routes and the potential impacts of the project. A number of roads providing access to the project area around Marrickville are subject to flooding under existing conditions (described in section 3.6.4).

With the implementation of mitigation measures provided in section 4, no impacts on existing emergency management arrangements are expected during construction. Ongoing liaison would be undertaken with relevant stakeholders during detailed design and the construction period.

5.2.8 Social and economic costs to the community

Although there would be temporary changes during construction, including installation of drainage and culvert works, there is not expected to be any social and economic costs to the community as a result of these works.

5.3 Surface water quality outcomes

The following potential impacts on stormwater quantity and flooding are expected:

- Increased erosion and sedimentation from a range of construction activities resulting in an increase in sedimentation in downstream waterways from runoff.
- Contamination of the waterways from chemical or hydrocarbon spills.

As for flooding and drainage, a SWMP would be prepared and implemented and include measures to manage and reduce the risk of water quality impacts associated with the works.

5.3.1 Erosion and sedimentation

Soil is the most likely potential contaminant that can impact water quality during the construction phase if runoff is allowed to mobilise exposed underlying soils. This can result in increased erosion and sedimentation, which is influenced by the severity of a storm event and the slope and footprint of the disturbed area.

Ground disturbance works affects all construction sites in one form or another and poses the greatest risk where they occur near waterways and steep slopes such as the existing railway embankments.

The earthworks and construction of the above ground components of the project would require the removal of existing vegetation and structures in some locations, thereby disturbing and exposing the soils. The earthworks and the movement of construction vehicles within the project area could increase erosion and sediment deposition in the waterways, particularly in proximity to inlets to the existing railway drainage or Council stormwater drainage network.

There is also the potential for the disturbance of sediments during excavation works to amend utilities including changes and additions to the existing stormwater drainage networks.

The location of existing surface water quality treatment devices in the Salt Pan Creek and Cooks River catchments downstream of the project area has not been confirmed but it is likely that devices such GPTs and bioretention basins are present. Devices such as GPTs largely treat gross pollutants such as rubbish and leaf litter and would provide very limited treatment of sediments that may be generated by the construction works. In excessive amounts, increased sediments from construction works have the potential to cause siltation of these devices, thus requiring additional maintenance. Bioretention devices or basins also retain sediments but excessive sediment loads have the potential to reduce their effectiveness.

As the construction programme will run over several years, the probability of a rainfall event occurring in excess of the minor drainage capacity is likely and appropriate flow or temporary diversion measures would be necessary. There is potential for large quantities of sediments to be directed into the stormwater network potentially resulting in siltation and blockage.

5.3.2 Potential for spills/ leaks

The release of potentially harmful chemicals and other substances in the environment may occur accidentally during construction due to spills, as a result of equipment refuelling, malfunction and maintenance, via treatment and curing processes for concrete, as a result of inappropriate storage, handling and use of the substances or from the disturbance and inappropriate handling of contaminated soils. This has the potential to impact on water quality in receiving waters downstream of the project. These contaminants could include acids and chemicals from washing processes, construction fuels, oils, lubricants, hydraulic fluids and other chemicals. Water quality and associated ecological impacts could result if these contaminants end up in the waterways and ultimately Botany Bay downstream of the works areas.

In accordance with the *Chemical Storage and Spill Response Guidelines* (Transport for NSW), spill kits would be provided at each compound and at worksites to cater for contingency events. Storage of hazardous goods, maintenance activities and refuelling activities would only be undertaken in bunded areas and away from waterways, including flood prone locations (refer also to Section 7.1.3). These locations would be identified in the soil and water management plan.

5.3.3 Demolition and construction works

There are key activities and areas within the project area that have the potential to result in downstream water quality impacts. Examples of sources of pollutants that could affect water quality from these works are as follows:

- Asbestos and other building materials
- Contaminated soils including fertilisers and pesticides
- Heavy metals
- Chemicals including hydrocarbons and fluids associated with demolition and construction processes and machinery
- Dust and airborne pollutants

Typical impacts on the waterways would be through mobilised dust, litter and other building materials being deposited or picked up by surface water runoff, waterways or stormwater management infrastructure thereby degrading the quality of the receiving environment. The transportation of building waste from the demolition and construction sites could potentially impact the quality of the waterways through inappropriate storage locations or accidental spills/material drops. Some materials that are typically found in building demolition, such as chemicals, can be easily transported from the demolition sites through off site stormwater runoff. These pollutants can be ingested by aquatic fauna and result in dead or sick marine life.

Working near watercourses or in low-lying areas introduces increased risks of contaminants being washed into the receiving stormwater network. Activities and areas which present a higher risk of impacting on the receiving waters would be outlined in the soil and water management plan, along with specific controls to reduce the risk of these impacts occurring.

5.4 Cumulative impacts

5.4.1 Council drainage works

The Salt Pan Creek Catchment Floodplain Risk Management Study and Plan proposes drainage modifications near Wattle Street in Bankstown, including formalising the overland flow path from Wattle Street to an existing rail culvert, modifications to fencing and upgrading of drainage on the upstream side of the rail corridor. Construction of Sydney Metro would not prevent the drainage upgrades by Canterbury- Bankstown Council though timing of construction would potentially need to be coordinated with the council.

5.4.2 Chatswood to Sydenham project

Construction works for the Marrickville tunnel dive structure associated with the Chatswood to Sydenham component of Sydney Metro would occur within the vicinity of the project area and is likely to be sensitive to potential cumulative impacts.

Planning, consultation and coordination work will be undertaken to ensure the planning, staging and implementation of the proposed works for both projects. In particular, the construction works would be staged to avoid or minimise the obstruction of any overland flow paths and extent of flow diversions required. Construction design criteria adopted for the project include the following:

- Increases in flood levels during events up to and including the one per cent AEP event would be minimised, particularly within private properties.
- Any increase in flow velocity for events up to and including the one per cent AEP event would not lead to scour and erosion.
- Dedicated evacuation routes would not be adversely impacted in flood events up to and including the PMF event.

On the basis of the above measures being adopted, it is not expected that there would be any significant cumulative impacts with this project.

Interface meetings between the two design teams are being undertaken and would continue during detailed design and construction to ensure that the proposed works for the two projects are well-coordinated and in order that potential cumulative impacts are minimised.

5.4.3 WestConnex

It is understood that WestConnex will drain primarily to Wolli Creek in this area, and then to the Cooks River downstream of the project. The construction impacts of the Sydenham to Bankstown project and of the WestConnex project are expected to be relatively localised and, as they are located remote from each other, the WestConnex project has a low probability to interact and impact on the water quality and flooding aspects of the Sydenham to Bankstown project during construction.

6. Operational impacts

6.1 Risk assessment

An assessment of the potential flooding risks, and measures to avoid, mitigate or minimise them during operation is provided in Table 6-1. The risks and impacts listed are discussed in the following sections.

Table 6-1 Potential impacts and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Hydrologic		
Impact on surface flow in watercourse and flows in channels / drainage structures	• Modified surface flow volume or rate downstream of the rail corridor.	• Avoid installation of culverts that create localised surface water ponding. • Provide detention basins prior to discharge to existing drainage network where an increase in drainage capacity is proposed.
	• Changed surface flow paths across rail corridor.	• Minimise regrading of terrain along the rail corridor. • Install appropriately sized culvert along the rail corridor.
Hydraulic issues		
Impact of raising the rail formation on flows	• Increased upstream flooding depths, extents and hazard. • Increased upstream flood durations. • Increased upstream impacts on buildings. • Increased impacts on adjacent infrastructure (e.g. road closures). • Additional impacts downstream of structures.	• Provide additional inlet capacity on upstream side and drainage capacity to convey flows into Eastern Channel.
Impact of providing increased culvert / drainage capacity	• Increased downstream flooding depths, extents and hazard. • Increased downstream flood durations and reduced emergency access. • Increased downstream impacts on buildings. • Increased impacts on adjacent infrastructure (e.g. road closures). • Increased downstream velocities and scour potential.	• Provide detention basins prior to connection to existing external drainage systems. • Do not reduce watercourse flow areas. • Locate spoil mounds where they do not impact flow paths and patterns. • Increase capacity of Eastern Channel (bank raising) at key location. • Local scour protection works in unlined channels.
Impact of filling / works in flood storage areas	• Increases in flood levels, or hazard. • Changes in flow paths.	• Avoid building in flood storage areas • Provide additional capacity / mitigation if required.

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Flood warning and emergency management issues	• All the above items resulting in changes to duration and nature of flooding have the potential to impact flood warning and emergency evacuation.	• Implement flood warning and awareness plans.
Water quality issues		
Minor increase in hard standing areas	• Increases in pollutant generation.	• Install water quality treatment devices.
Increased flow velocities (refer hydraulic issues above)	• Increased sediment mobilisation.	• Install scour protection and control.

6.1.1 Impact of modified surface flow volume or rate downstream of the rail corridor

During operation, ongoing modification to flow volumes and rates downstream of the rail corridor could occur as a result of changes to the flow rate and/or duration of flow through culverts that are constructed for the project. This could create additional erosion either upstream or downstream of the culverts or increased local flood potential where flow conditions are modified significantly (see also below in section 6.1.2).

6.1.2 Impact of raising project area levels

Raising ground levels for the rail formation would prevent flows from overtopping the rail corridor. This could have upstream effects including:

- Increased flood depths, duration of flooding and flood hazard upstream of the culverts with potential impacts to properties and road access.
- Reducing the uncontrolled flow of water over the rail formation.

6.1.3 Impact of providing increased drainage capacity / culvert area

Increased culvert and drainage capacity would allow greater flows through the project area to the downstream areas with potential impacts including:

- Increasing flow depths, durations and hazard downstream of the culverts.
- Increased load on the downstream drainage networks, some of which may be in poor condition.
- Altered flow paths downstream where the capacity of the drainage into which the upgraded culverts are connected is overwhelmed.

6.1.4 Impact of development in flood storage areas

The location of works within areas currently acting to store floodwaters could:

- Decrease flood depths and hazard or alter overland flow paths if flood storage areas are increased.
- Increase flood depths and hazard or alter overland flow paths if flood storage areas are decreased.

6.1.5 Impact of increases in impervious areas

Increases in impervious areas could result in increased generation of surface runoff, litter and other pollutants being conveyed to receiving watercourses.

6.2 Hydrologic and hydraulic modelling results

The most flood affected parts of both the project area and surrounding study area are located in the vicinity of Marrickville Station. The key outcomes in relation to flooding in Marrickville, and between Dulwich Hill to Bankstown, are summarised in Table 6-2 and the following sections.

6.2.1 Marrickville

The key hydrologic and hydraulic outcomes in relation to flooding in the Marrickville area are summarised in Table 6-2. Mapping of the expected change in flood level, velocity and flood hazard compared to existing conditions is provided in Figure 6-1 to Figure 6-6.

Table 6-2 Design performance against flooding criteria in Marrickville

Key criteria	Marrickville	Adjacent lands	Public roads
Maximum increase in time of inundation of one hour in a 1 % AEP event	Achieved	1) No increase in flooding in the majority of the study area for 1 % AEP climate change event. 2) Reduction in flood level of up to 300mm along rail corridor west of station and between 50-150mm further to the west for 1 % AEP climate change event. 3) Reduction in flood level of between 50-100mm east of station for 1 % AEP climate change event. 4) Where there is increases in flood level, increase is 50mm or less for events up to the 1 % AEP climate change event. 5) Floor level survey and detailed analysis required to assess above-floor impacts at +- 10 mm level	1) Reduction in flood level of between 150-200mm in vicinity of Byrnes Street, O'Hara Street, and Cavey Street. 2) Reduction in flood level of between 50-100mm at southern end of Carrington Road and Richardsons Crescent, including Mackey Park and Carrington Road Industrial Park. 3) Where there is increase in flood level, increase is 50mm or less for events up to 1 % AEP climate change event.
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a 1 % AEP event	Floor level survey not available. Any potential flooding above-floor will be assessed during detailed design.		
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a 1 % AEP event	Achieved		
Increase in flood velocities - identification of mitigation measures	Many locations benefit from flood velocity decrease. Selected locations of velocity increase are generally <0.25m/s for all flood events with further development of mitigation measures to be undertaken during the next stage of design		

As shown in Figure 6.1 to Figure 6.6, the proposed drainage works outlined in section 4.2.1 would be effective at mitigating potential increases in flood level, velocity and flood hazard for the full range of flood events from the 63 per cent AEP event to the PMF event such that there would be little adverse impacts to the surrounding community.

No increase in flooding is expected in the majority of the study area for the one per cent AEP climate change event. Most of the modelled area would benefit from a reduction in flood levels of between five to 300 millimetres over the full range of flood events up to the PMF. This includes areas immediately east and west of Marrickville Station along the rail corridor, the vicinity of Byrnes Street, O'Hara Street, Cavey Street, the southern end of Carrington Road/ Richardsons Road, Mackey Park and the Carrington Road Industrial Park.

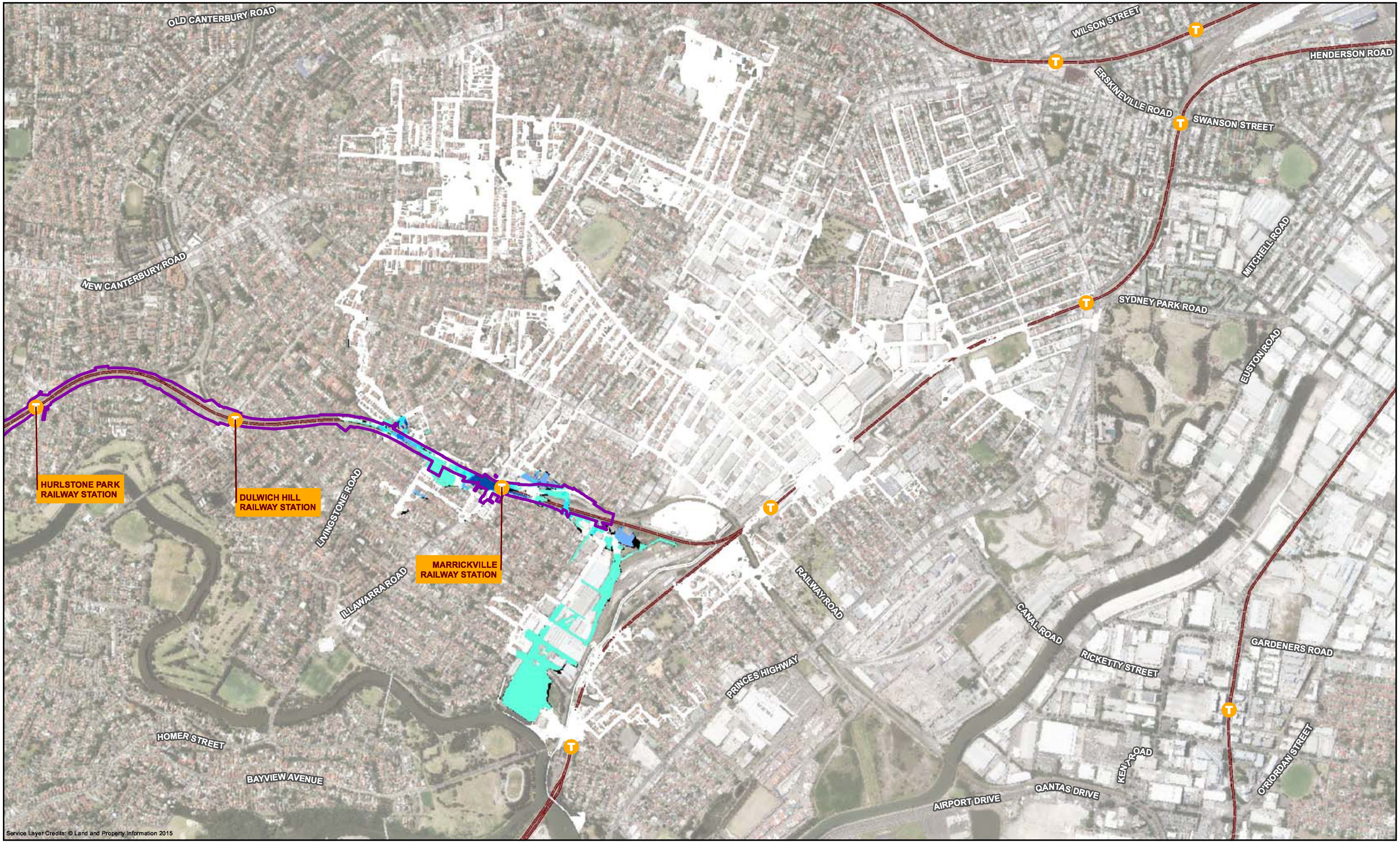
Where increases in flood levels are observed, they would be generally less than the 50 mm design criteria over the full range of flood events. The only exception is a short stretch of road along Junction Street, between Schwebel Street and Ruby Street, where increases of up to 100 mm are predicted for the 39 per cent AEP event. However, this impact is limited to the road only, and no private property would be affected.

Similarly, changes in velocities are estimated to be generally less than 0.25 metres per second at all locations for the full range of flood events. As in the case of flood levels, much of the study area would benefit from a net reduction in velocities as a result of the project.

As a result, no substantial changes in existing flood hazard are predicted with the proposed works in place.

Existing culverts within the Marrickville area include culverts no. 1 to 4 as listed in Appendix C. The post-development hydraulic results for the culverts indicate that culvert no. 3 would experience a slight increase in exit velocity for the one per cent AEP event. However, this post-development exit velocity is estimated to be only of the order of 2 metres per second, which is well within the limiting velocities for grass. On this basis, it is considered that this increase in velocity would not represent a substantial change in terms of scour and erosion potential.

Further design development would be undertaken to confirm the drainage details in the Marrickville area during detailed design.



Paper Size A3

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

Project area

Train station

Railway

Change in Flood Level (m)

<-0.3m	-0.15m - -0.1m	+0.1m - +0.15m	+0.4m - +0.5m	Was wet now dry
-0.3m - -0.2m	-0.1m - -0.05m	+0.15m - +0.2m	> 0.5m	Was dry now wet
-0.2m - -0.15m	-0.05m - +0.05m	+0.2m - +0.3m		
	+0.05m - +0.1m	+0.3m - +0.4m		

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

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1% AEP +10% flood level change

Figure 6-1

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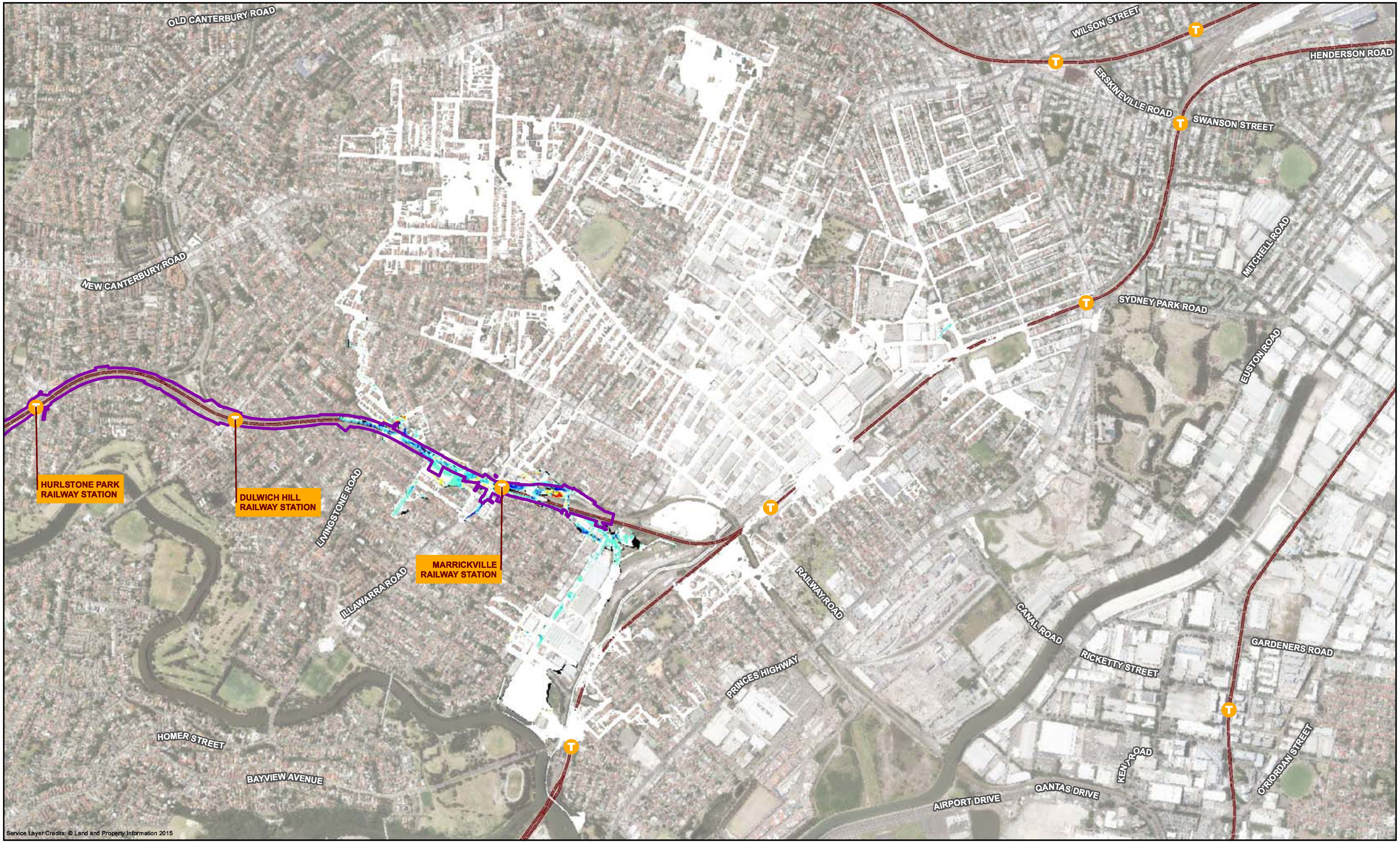
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy



Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project area
- Train station
- Railway

Change in Flood Velocity (m/s)

- Greater than -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5
- Was wet now dry
- Was dry now wet

GHD

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

Job Number	21-25273
Revision	A
Date	06 Jul 2017

1% AEP +10% velocity change

Figure 6-2

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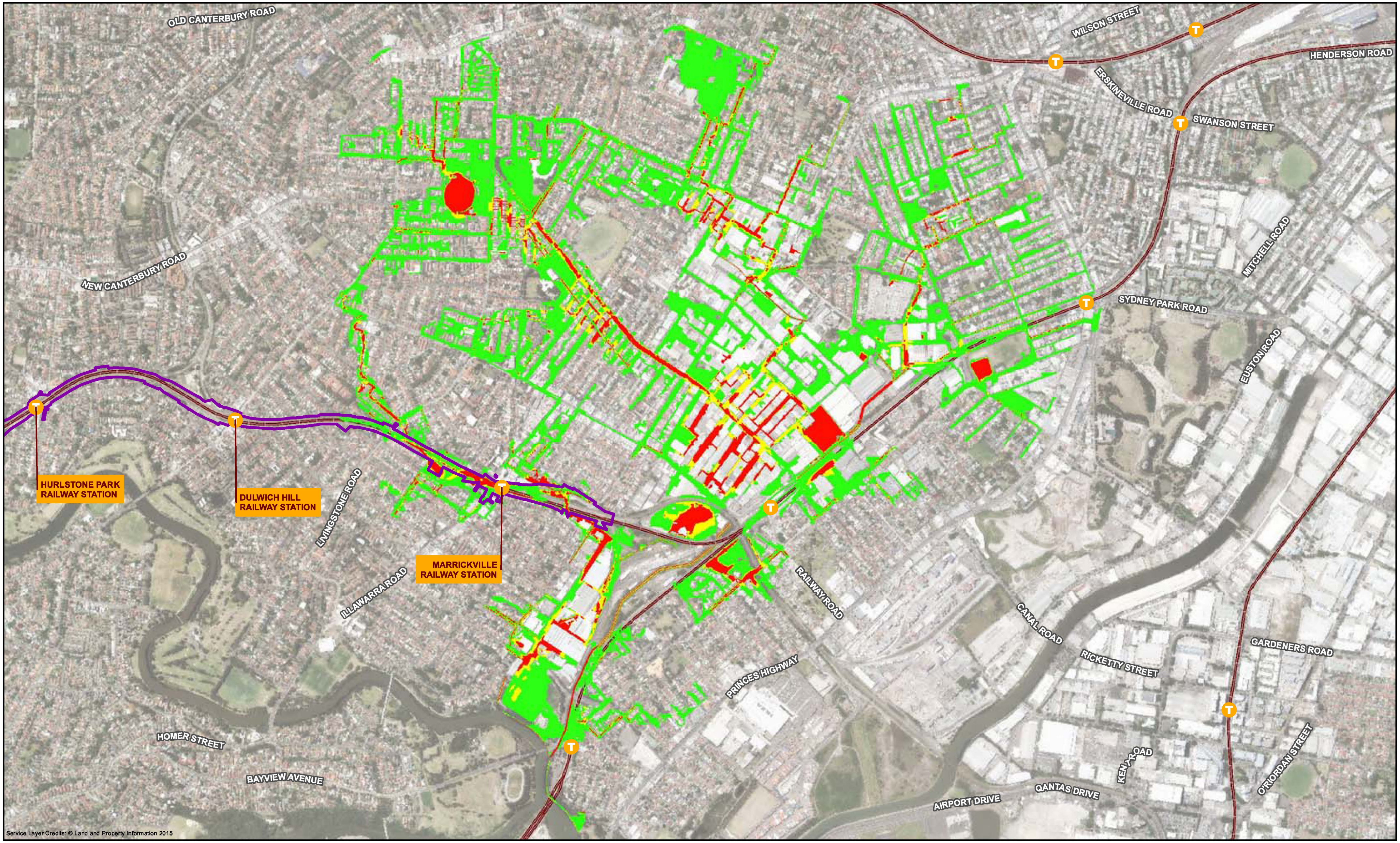
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy



Paper Size A3

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project area
- Train station
- Railway

Provisional Hazard Category

- 1 - Low Hazard
- 2 - Transitional Hazard
- 3 - High Hazard

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Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

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Revision	A
Date	22 May 2017

Post-developed 1% AEP + 10% climate change provisional flood hazard

Figure 6-3

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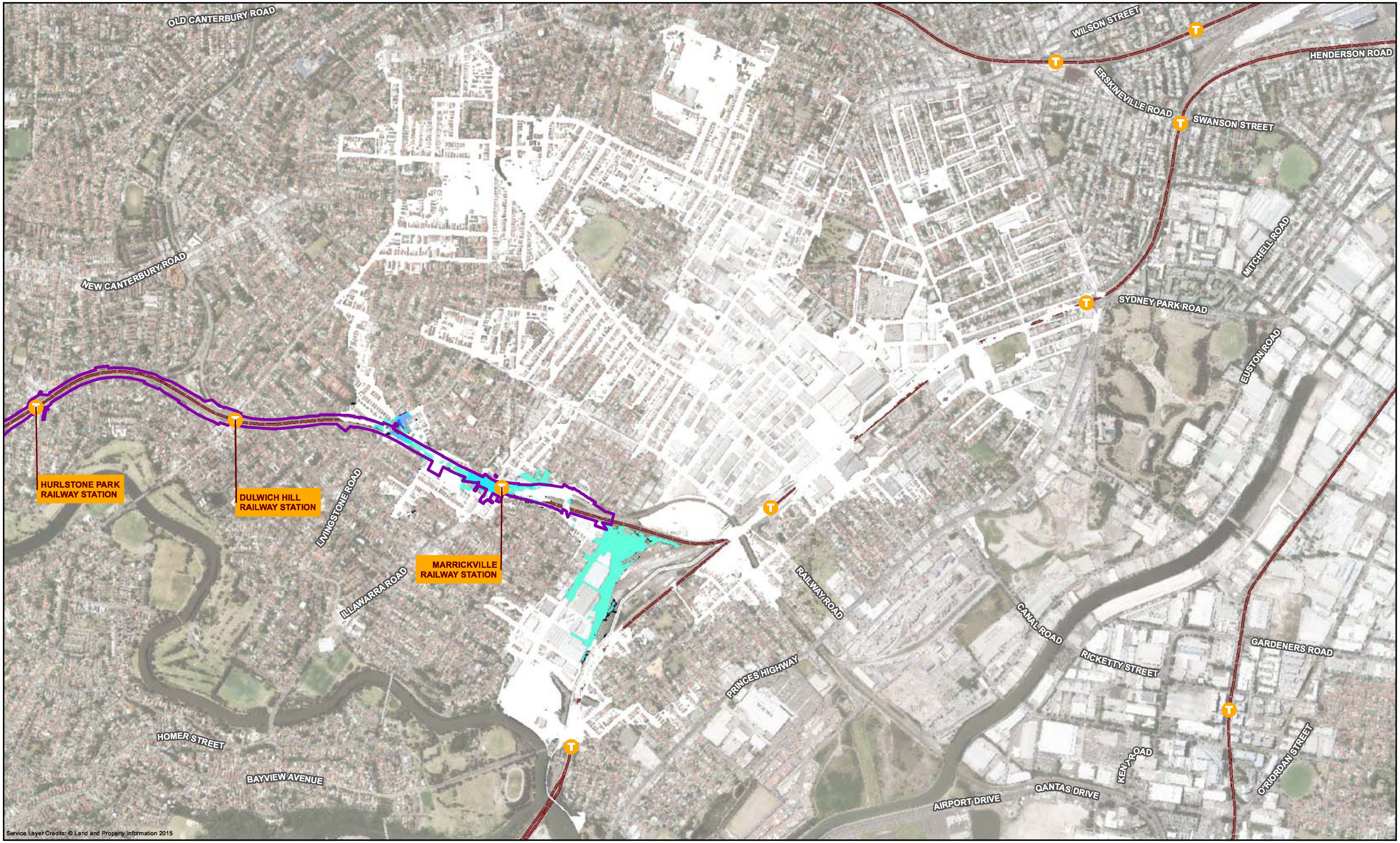
Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy



Paper Size A3

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

Project area

Train station

Railway

Change in Flood Level (m)

<-0.3m	-0.15m - -0.1m	+0.1m - +0.15m	+0.4m - +0.5m	Was wet now dry
-0.3m - -0.2m	-0.1m - -0.05m	+0.15m - +0.2m	> 0.5m	Was dry now wet
-0.2m - -0.15m	-0.05m - +0.05m	+0.2m - +0.3m		
	+0.05m - +0.1m	+0.3m - +0.4m		

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PMF level change

Figure 6-4

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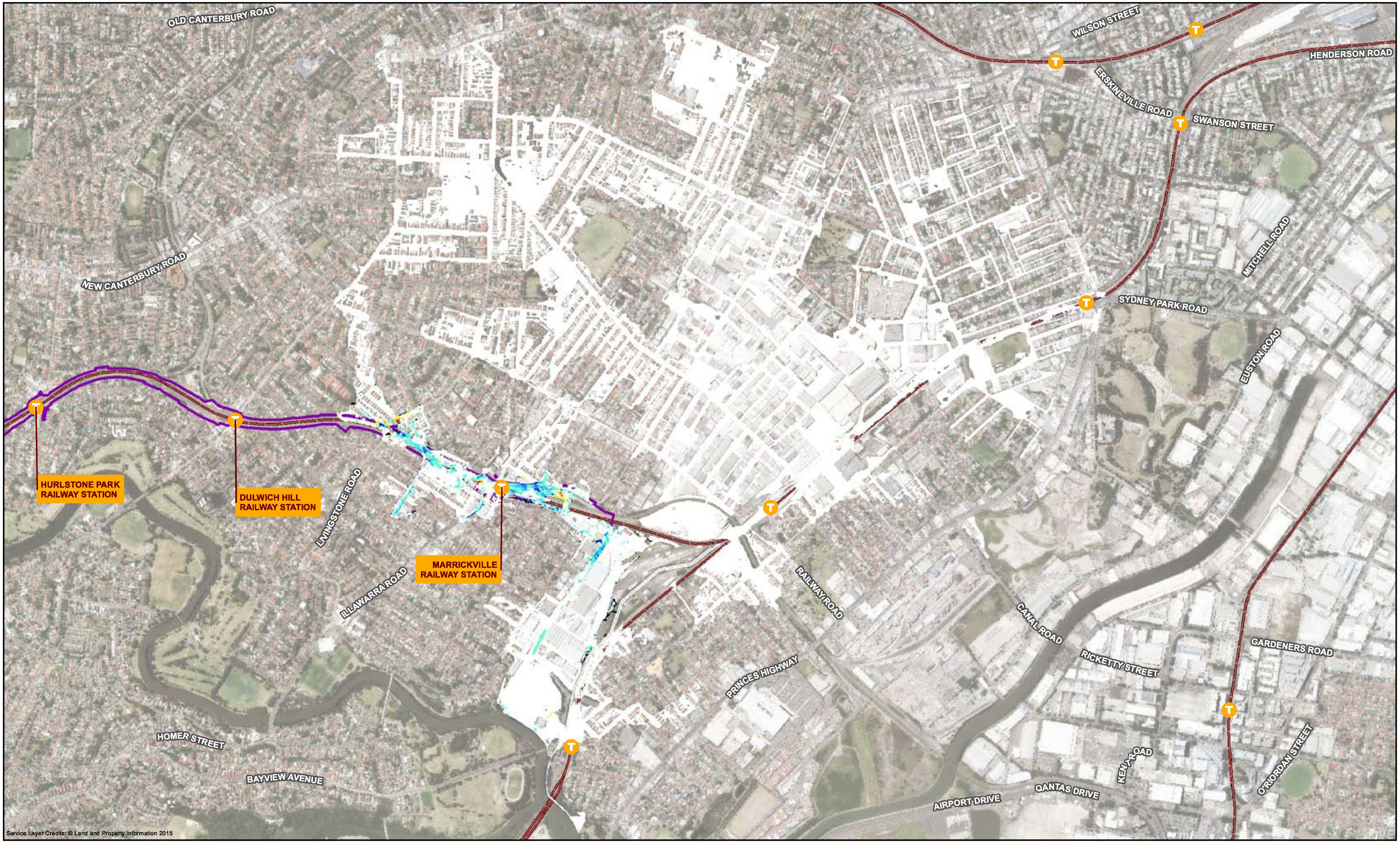
Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy



Paper Size A3

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project area
- Train station
- Railway

Change in Flood Velocity (m/s)

- Greater than -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5
- Was wet now dry
- Was dry now wet

GHD

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Surface Water Assessment

Job Number	21-25273
Revision	A
Date	22 May 2017

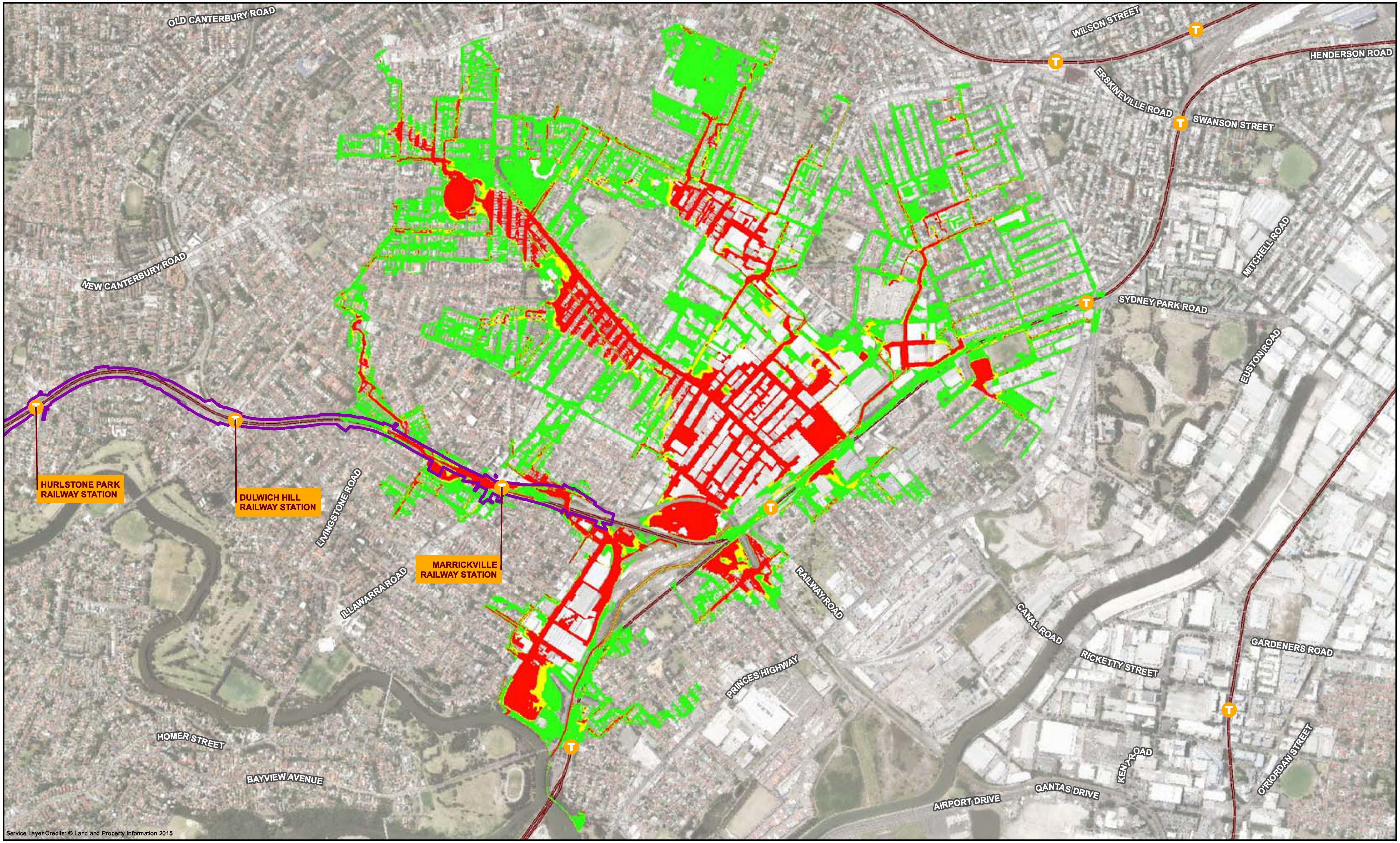
PMF velocity change

Figure 6-5

G:\21\25273\GIS\Maps\Deliverables\SurfaceWaterSMA.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy



Paper Size A3

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project area
- Train station
- Railway

Provisional Hazard Category

- 1 - Low Hazard
- 2 - Transitional Hazard
- 3 - High Hazard

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

Job Number	21-25273
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Date	22 May 2017

Post developed PMF provisional flood hazard

Figure 6-6

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy

6.2.2 Dulwich Hill to Bankstown

The drainage measures outlined in section 4 include the provision of upgraded drainage infrastructure and detention basins to mitigate increases in flows to the receiving stormwater drainage network. The conclusion of the design work and modelling completed is that these measures would generally be effective at limiting downstream impacts.

In general, it was identified that peak flow rates from cross drainage structures would increase where no detention basins are proposed. It was also identified that the overall peak flow rates in the drainage systems would not increase due to differences in the timing of peak flows between the rail culverts and the wider drainage network.

Existing culverts between Dulwich Hill and Bankstown stations include culverts no. 5 to 36, as listed in Appendix C. However, of these culverts, only culverts no. 5 and 12 were identified to result in an increase in velocity with the proposed works in place. Post-development velocities for both culverts were of the order of 2 metres per second, however being less than the adopted limiting criteria of 2.5 metres per second, were not considered to be of concern.

It is noted that a number of the culverts have velocities well in excess of 2.5 metres per second under existing conditions. This includes culvert nos. 9, 13, 16, 17, 18, 24, 25, 26, 27, and 28 (refer Table 3-2 and Appendix C). At some of these locations, the velocities are up to 6 metres per second. The hydraulic results indicate that the project will not change the existing velocities at these culverts. However, in order to minimise the likelihood of scour and erosion occurring at these outlets, scour protection measures would need to be considered.

Flood modelling at the Cooks River at Canterbury Station was not undertaken as part of this project. Based on the draft *Canterbury LGA Overland Flow Study for Cooks River Catchments* (Cardno, 2015), flooding is identified to occur along the rail corridor at Canterbury Road, with flood depths of up to two metres for the five per cent AEP, one per cent AEP and PMF events. The corresponding flow velocities are estimated to be of the order of 0.2 to 0.5 metres per second. The potential impact of this project on the existing flood behaviour at Canterbury is not known however further analysis and design would be undertaken to confirm the details of design mitigation measures during detailed design.

6.3 Flooding and drainage outcomes

6.3.1 Potential for detrimental increases in the flood affectation of other properties, assets and infrastructure

As noted in section 6.2, the most flood affected parts of both the project area and surrounding study area are located in the vicinity of Marrickville Station. The key outcomes in relation to flooding in Marrickville are summarised in Table 6-2 and Figure 6-1 to Figure 6-6.

At other locations along the corridor between Marrickville and Bankstown stations, more limited modelling was undertaken to confirm that the introduction of the proposed infrastructure would not result in downstream impacts.

The conclusion of the assessment is that the proposed drainage measures would generally be effective at limiting downstream impacts. While detailed assessment of flooding at Canterbury Station was not undertaken, based on the *Draft Overland Flow Study Canterbury LGA Cooks River Catchments* (Cardno, 2016), flooding was found to occur along the rail corridor at Canterbury Road, with flood depths of up to two metres for the five per cent AEP, one per cent AEP, and PMF events.

In general, it was identified that peak flow rates from cross drainage structures would increase where no detention basins are currently proposed. It was also identified that the overall peak flow rates in the drainage systems would not increase, due to differences in the timing of peak flows between the rail culverts and the wider drainage network.

Further analysis and design would confirm the required design mitigation measures and impacts at lower risk locations.

6.3.2 Consistency with applicable Council floodplain risk management plans

As noted in section 6.2, drainage works associated with the project are compatible with local floodplain risk management plans, and would result in generally a reduction of existing flood extent and depth.

6.3.3 Compatibility with the flood hazard of the land

Results of flood modelling indicate that the project would not result in a change to existing flood hazard in or surrounding the rail corridor.

6.3.4 Compatibility with the hydraulic functions of flow conveyance in floodways and storage areas of the land

Drainage works have been designed to mitigate potential adverse impacts on more minor floodways (such as roads) in events up to the PMF.

Detention capacity in McNeilly Park (and at other locations) would be increased to cater for additional flows. Therefore, the project is considered compatible with the floodway and flood storage functions of the floodplain.

6.3.5 Downstream velocity and scour potential

At Marrickville, changes in velocities are estimated to be generally less than 0.25 metres per second at all locations for the full range of flood events. As in the case of flood levels, many of the areas would benefit from a net reduction in velocities as a result of the project.

Modelling of existing conditions indicates that approximately 10 of the existing culverts have exit velocities greater than 2.5 metres per second, which is the velocity above which scour and erosion could occur. While an increase in velocities is predicted to occur at two culverts, following implementation of the project, the level of increase is small, and the velocity would be less that the design limit.

Appropriate methods of scour protection at identified locations would be identified during detailed design.

6.3.6 Impacts of flooding on existing emergency management arrangements

Preliminary consultation was undertaken with NSW SES regarding existing flood evacuation routes and the potential impacts of the project. Roads identified to be flooded under existing conditions (refer section 3.6) which would provide access to the project area around Marrickville are also expected to be flooded once the project is operational. However, modelling results indicate no level changes are expected for storms up to and including the PMF (refer Table 6-3).

Table 6-3 Changes in emergency access route flooding during PMF event

Street	Flood level / extent of change
Marrickville Road	Negligible change in flood level
Illawarra Road	Negligible change in flood level
Schwebel Street	Negligible change in flood level
Arthur Street	Negligible change in flood level

Flood emergency management is incorporated in the design criteria for station infrastructure. Flood emergency management procedures would be incorporated in Sydney Metro's operational emergency management plans. Consideration would need to be given to flood warning and emergency management under extreme flood conditions (refer section 1).

6.3.7 Surface water flows

The proposed structures under the rail formation in some locations include increases in proposed cross drainage capacity to prevent flooding in the rail corridor.

The increased flow velocities through the culverts would potentially increase erosion immediately downstream of the culverts. The effect of this would be dependent upon site-specific soil conditions and terrain along the entire length of the rail corridor. Further design development would include consideration of potential scour and detention basins where feasible.

6.3.8 Social and economic consequences

Transport for NSW has undertaken a systematic and scientific assessment of the existing and post-development flooding situation in the project area using widely accepted design criteria utilised on other major infrastructure projects. This has included a desktop review of existing floodplain management studies by the relevant councils and consultation with the Canterbury-Bankstown and Inner West councils as well as emergency services agencies.

The above analysis indicates that there are limited adverse effects resulting from the project and an improvement in many aspects relative to existing conditions under a range of potential flood events. The impacts identified are primarily increases in velocity at a limited number of locations and in one location, an impact in flood depth (on a public road). It is considered therefore that the economic and social consequences of the proposed development are negligible.

6.4 Surface water quality outcomes

The potential operational impacts of the project include changes in the hydrologic regime leading to increased erosion and sedimentation and pollutant generation from the rail infrastructure.

Minor increases in impervious surface areas associated with the works would have the potential to result in adverse impacts on the hydrological regime in terms of increased runoff volumes and peak flows. This could lead to a range of impacts associated with increased erosion and sedimentation as well as introduction of additional quantities of other pollutants.

Discussion of the potential operational risks and impacts on water quality associated with the operation of the project is provided in the following sections.

6.4.1 Stormwater runoff

Contamination of the waterways can be caused through stormwater runoff containing typical pollutants such as oils and greases, petrochemicals and heavy metals as a result of rolling stock operations and wear. The contamination of waterways by the aforementioned pollutants can result in habitat degradation and negatively impact on the health of aquatic flora and fauna species. However by and large, the project is within the existing footprint of an existing operating railway and the potential for increase in contamination levels from these types of pollutants is expected to be very small relative to the existing situation.

As outlined in section 4.3, water quality treatment measures would be included in station precincts as a combination of GPTs and rain gardens. Table 6-4 provides details of the proposed water quality treatment measures by location, including indicative sizing.

It is noted that the proposed station impervious areas are very small relative to the total catchment area for each station ranging from only 0.02 to 1.56 per cent of their respective catchment areas. Consequently, there is very little influence on overall catchment water quality.

Table 6-4 Proposed water quality treatment measures

Location	Total station impervious area (ha)	Total catchment area (ha)	% station impervious area[2]	Rain garden area (m^2)	Number of GPTs
Marrickville	0.23	68	0.34	-3	1
Dulwich Hill	0.45	42	1.07	55	1
Hurlstone Park	0.10	41	0.24	15	1
Canterbury	0.23	1150	0.02	30	1
Campsie	0.61	39	1.56	75	1
Belmore	0.39	100	0.39	50	1
Lakemba	0.34	69	0.49	45	2
Wiley Park	0.16	118	0.14	20	2
Punchbowl	0.73	118	0.62	90	1
Bankstown	0.55	127	0.43	70	1

Note: 1: Hardstand area within station precinct under proposed development conditions
2: Station precinct hardstand area as a %age of catchment area
3: Marrickville Station precinct has a net reduction in impervious area of about 700 m^2 after development, and hence no raingarden is proposed.

As outlined in section 2.3.2, preliminary MUSIC modelling has been undertaken and results indicated that the proposed measures would be effective at reducing pollutant loads to the targets identified in Table 1-3 at a downstream location however:

- Treatment is not proposed within the rail corridor itself.
- The targets may not be met at each discharge point location, but would be exceeded at other locations, resulting in a net result of meeting the proposed targets within the overall catchment.

The project design team will also investigate spill containment as part of the water quality treatment train to mitigate potential spills of hazardous materials, though no specific measures were incorporated into the reference design.

Water quality outcomes been assessed against the project water quality criteria. The intention is that assessment against ANZECC guidelines would be undertaken during the detailed design.

Provision of the proposed water quality treatment measures is expected to contribute to improved water quality overall against the existing conditions, though further analysis would be required at detailed design stage to confirm this. Implementation of effective water quality treatment measures for the project would mean no adverse impacts in meeting the water quality objectives for the catchments over time.

6.4.2 Potential for spills/ leaks

The potential impacts on water quality from the operation of the rail corridor would be related to the spill of vehicle oils, lubricants, hydraulics fluids and other accidental spills including chemicals in transit through leakage.

Any such spill has the potential to pollute the downstream waterways and therefore cause detrimental effects for the riparian Botany Bay receiving environments.

As above however, the project footprint is similar to the existing condition and therefore the potential extent of any increased spills or leaks is expected to be small relative to the existing situation. There is opportunity to incorporate some spill containment capability within the water quality treatment train and this would be reviewed during design development for feasibility to incorporate into the design.

6.4.3 Erosion and sedimentation

Once the construction of a project is completed, there is a subsequent period where recently disturbed soils are susceptible to scour and erosion from stormwater runoff.

The modification of overland flow paths can cause an increase in scour of surface soil, banks or bed material and resultant sedimentation in downstream waterways. This is expected to be relevant predominantly in the vicinity of Marrickville. The potential impacts would occur in the event that appropriate reestablishment of embankments was not undertaken and poor stabilisation resulted in additional soils being mobilised and affecting water quality.

With the projected small increase in impervious area as a result of the project, there would be a comparable increase in stormwater runoff which can scour surface soil and increase sediment loading in downstream waterways.

The potential for sediment transport is influenced by factors such as severity of storm events, the slope and scale of the disturbed area and the quality of revegetation. As the disturbance area and change in impervious areas are in this case small relative to the catchment as a whole, the potential impacts would be expected to be limited in nature and less than the construction phase.

6.5 Cumulative impacts

6.5.1 Council drainage works

As noted previously, various drainage works are proposed by the Inner West and Canterbury-Bankstown councils to rectify existing flood conditions. The design has been prepared in consideration of these where details are available. Ongoing consultation with these councils during detailed design development would be undertaken to confirm the program of proposed works, where they interact with the Council’s drainage network’s and including any future mitigation works. Further hydraulic modelling to assess combined operational stage impacts may also be required, although given the way the project has been developed by reference to each Council’s studies and works programs, it is expected that an overall improvement would result.

6.5.2 Chatswood to Sydenham project

The project adjoins the Chatswood to Sydenham component of Sydney Metro which was assessed as part of the Chatswood to Sydenham Environmental Impact Statement and subsequent modifications.

Interface and coordination meetings are being undertaken to ensure that there are no conflicts in scheduling and that potential cumulative impacts can be avoided.

Additional measures would also be reviewed during detailed design as part of that project, with the aim of further reducing flood levels in existing areas which currently flood, including any private property areas.

6.5.3 WestConnex

The WestConnex project will discharge predominantly to Wolli Creek and the Cooks River at a location downstream of the Sydenham to Bankstown project. The WestConnex project has the potential to impact on flow behaviour and proposed works in the vicinity of the Marrickville dive structure area, part of the Chatswood to Sydenham project, which is remote from the project area and therefore no cumulative impacts are expected.

6.5.4 Sydenham to Bankstown Urban Renewal Corridor

The Department of Planning and Environment are currently preparing an urban renewal plan for the Sydenham to Bankstown corridor to provide greater housing choice, more jobs and improve parks and open space. A number of different building types are being considered with medium/ high rise and high-rise buildings up to 25 stories being proposed within 400 metres of railway stations. It is assumed that all future building development would be designed in accordance with relevant Council standards and guidelines and would be subject to the DA approval process.

Considering that the proposed development corridor area is already highly urbanised, it is expected that redevelopment of the corridor would not have any significant impact in terms of increased runoff and flow velocities. On this basis, no adverse cumulative impacts are expected.

7. Recommended mitigation measures

7.1 Construction

7.1.1 Flooding and drainage

Construction phase mitigation measures would generally include:

- Temporary drainage or drainage diversions to be installed as necessary so that stormwater drainage function is not impeded during construction of new stormwater drainage lines and connections to existing stormwater network.
- Installation of on-site detention measures.

Careful review of the proposed layout of construction compounds including siting of buildings and plant would be undertaken where these are located within or partially within flood liable land and a review undertaken to locate compounds above the 5% AEP event where practical. Management procedures would be put in place to address wet weather and flooding. This would include:

- Appropriate controls to cease work in flood prone areas when a severe weather warning is issued, as once the onset of a large rainfall event occurs, the onset of flooding would be quick, as noted earlier in this report.
- Flood management plan to be incorporated into construction planning documentation during the construction of works at McNeilly Park, including appropriate controls during wet weather or forecasts of heavy rainfall.
- Identification of measures to, where feasible and reasonable, not worsen existing flooding characteristics up to and including the one per cent AEP event in the vicinity of the project. Not worsen is defined as:
  - a maximum increase flood levels of 50 millimetre in a one per cent AEP flood event
  - a maximum increase in time of inundation of one hour in a one per cent AEP flood event
  - no increase in the potential for soil erosion and scouring from any increase in flow velocity in a one per cent AEP flood event.

7.1.2 Flood event monitoring

It would be impractical to monitor the flood impacts during an individual flood event. Therefore, should a flood event occur during the construction phase, the following would be undertaken to verify the design performance and impact predictions, or to refine the design should there be a significant difference between the actual and predicted flood impacts and behaviour:

- The construction area would be inspected for damage and any required maintenance completed.
- The presence of any culvert blockages in the construction area, if present, would be recorded and cleaning undertaken as required.
- Where there is a significant variance between the predicted flood levels and the observed levels on the recently constructed stage of the works, council and local residents would be consulted to improve the understanding of the local flow and flooding behaviour.
- Any areas, and extent, of any erosion downstream of culverts would be recorded to compare to predicted values for the recently constructed stage of the works.

- The locations of any rail overtopping or damage would be recorded together with any maintenance required and form of works.
- Decisions would be made on the need to refine the design of works yet to be installed and the need to undertake required mitigation measures.
- The form and location of any implemented mitigation measures would be recorded.

7.1.3 Surface water quality

As a general guiding principle for major civil design and construction works, water quality mitigation and management measures should be implemented in accordance with the relevant requirements of:

- The Blue Book
- Managing Urban Stormwater Soils and Construction Volume 2A (DECC, 2008)
- The ANZECC guidelines
- the *Australian Guidelines for Water Quality Monitoring and Reporting* (NWQMS, 2000)
- *Australian Runoff Quality – A Guide to Water Sensitive Urban Design* (Engineers Australia, 2006)
- Other water quality criteria and guidelines identified in this report

A series of SWMPs would be prepared as part of the suite of overall CEMPs. The SWMPs would define the control and mitigation of potential surface water quality impacts during construction. The SWMP would be developed to incorporate the most appropriate or 'best practice' controls and measures in accordance with the Blue Book. The SWMP would be staged to suit the changing needs as the works progress. Due consideration would also be given to the extent of works and situation relative to the sensitivity of the surrounding environment in relation to the construction activity.

Both the CEMP and SWMP would typically include strategies such as:

- Bunding of storage areas containing hazardous goods and undertaking of refuelling activities in bunded areas
- Creation of exclusion zones to limit disturbance
- Construction staging
- Specific activity procedures for vegetation clearing and access road creation
- Diversion of run-off from upslope areas around works areas
- Surface controls to promote soil stability
- Limit run-off lengths and reduced run-off velocities within the work sites
- Installation of devices to capture and retain sediment on-site and measures to re-establish a stable groundcover as soon as practicable following the completion of construction

With appropriate strategies in place, the risk of sedimentation of the local watercourses in the vicinity of the works location would be substantially reduced.

Construction-related risks, such as earthworks, spills, and location of stockpiles and equipment, are fairly common for projects of this size and type, and would be managed in accordance with Transport for NSW or other guidelines and standards. Typical mitigation measures that would be considered and implemented where relevant include:

- Minimising disturbed areas and revegetating them as soon as practical as the works progress
- Installation of appropriate erosion control measures such as silt fencing, straw bales, check dams, temporary ground stabilisation, diversion berms or site regrading
- Diverting clean water runoff away from the works or disturbed areas wherever possible
- Installation of new temporary sediment basins as appropriate
- Providing bunded areas for storage of hazardous materials such as oils, chemicals and refuelling areas
- Protection measures where work platforms or access tracks are required in the vicinity of waterways

Management of construction work sites proposed in the flood zone would be undertaken to avoid mobilisation of sediments or other contaminants due to overland flooding (refer the following section).

7.1.4 Residual impacts

It is expected that with the appropriate mitigation measures in place, including review of the location of construction worksites and compounds relative to the floodplain, the residual potential construction impacts would be successfully managed using similar approaches to other measures employed for major infrastructure projects in Sydney.

7.2 Operation

7.2.1 Flooding and drainage

A number of drainage and flooding measures have been incorporated into the project to avoid adverse impacts on flooding outcomes in the project area and downstream. The measures are predicted to be effective in key locations for events up to and including the one per cent AEP climate change event.

The residual risks remaining would be addressed through either further design development and/or specific mitigation measures outlined below.

Further design development

The following areas were identified as requiring further analysis and attention during future design development:

- Inner West Council has requested opportunities for discharge of more flow into the Malakoff Tunnel during minor flood events to be reviewed
- Review of proposed drainage measures and conflicts with other proposed services which may result in a need for proposed drainage modifications and an increased detention basin capacity in one location
- Detailed flow calculations for smaller catchments that have not been included in the analysis to confirm drainage implications
- Confirmation of various drainage assumptions based on more detailed asset surveys

Further sensitivity analyses would be undertaken by the design team during the next stage of design development to assess the impacts of 20 per cent and 30 per cent increases in design rainfall intensity and of sea level rise, for locations potentially affected.

The drainage works would be designed in accordance with relevant design criteria and guidelines as the design progresses to ensure that identified issues are appropriately addressed.

7.2.2 Flood event monitoring

The project is designed largely to meet the flood immunity criteria of remaining flood free in events up to and including the one per cent AEP climate change event. At some locations, it is not expected to be practical to achieve flood immunity in excess of the five per cent AEP event. Flooding of the Sydney Metro tracks would therefore be expected to be a rare occurrence. However, if the rail corridor is closed due to flooding, as soon as practical after the track is considered to be safe:

- The track would be inspected and the flood levels along the length of the rail corridor would be recorded for verification against the predicted flood levels.
- The presence of any culvert blockages would be recorded.
- Where there is a significant variance between the predicted flood levels and the observed levels, consultation with nearby property owners would be undertaken to improve the understanding of the local flow and flooding behaviour.
- Any areas, and extent, of any erosion downstream of culverts would be recorded to compare to predicted values.
- The locations of any rail overtopping or damage would be recorded together with any maintenance required and form of works.
- Decisions would be made on the need to refine the design of works yet to be installed and the need to undertake required mitigation measures.
- The form and location of any implemented mitigation measures would be recorded.

Flood emergency management

The analysis undertaken by the design team has identified local flood evacuation routes which are compromised under existing conditions. However, no additional routes are affected under post-development conditions for both the one per cent AEP and PMF events, and changes in flood levels from the project are expected to be negligible.

Development of a flood warning and evacuation plan for the project would be undertaken in consultation with stakeholders including Inner West Council and the NSW SES. Such a review may also include a wider review of local flood emergency planning as well as impacts of nearby development including the WestConnex project.

Scour and velocity

A more detailed analysis including consideration of impacts to the Cooks River would need to be undertaken for a full range of flood events to confirm impacts to the Cooks River and any required mitigation measures.

7.2.3 Surface water quality

The intent of the project design with regard to water quality would be to target the minimisation of impacts on the receiving systems and implementation of the design criteria.

The preliminary modelling indicated that water quality could be managed to meet the design criteria for the project, though comparison against ANZECC guidelines was not carried out. Further design development is required to confirm treatment types and locations as well as implementation of any spill containment measures.

A water quality monitoring program would be developed to monitor water quality outcomes against the water quality objectives for the Cooks River and Salt Pan Creek. The surface water quality monitoring program would monitor key parameters, including nutrients, coliforms, sediments, hydrocarbons and heavy metals. It is expected that this would be undertaken on a monthly basis over a two year period.

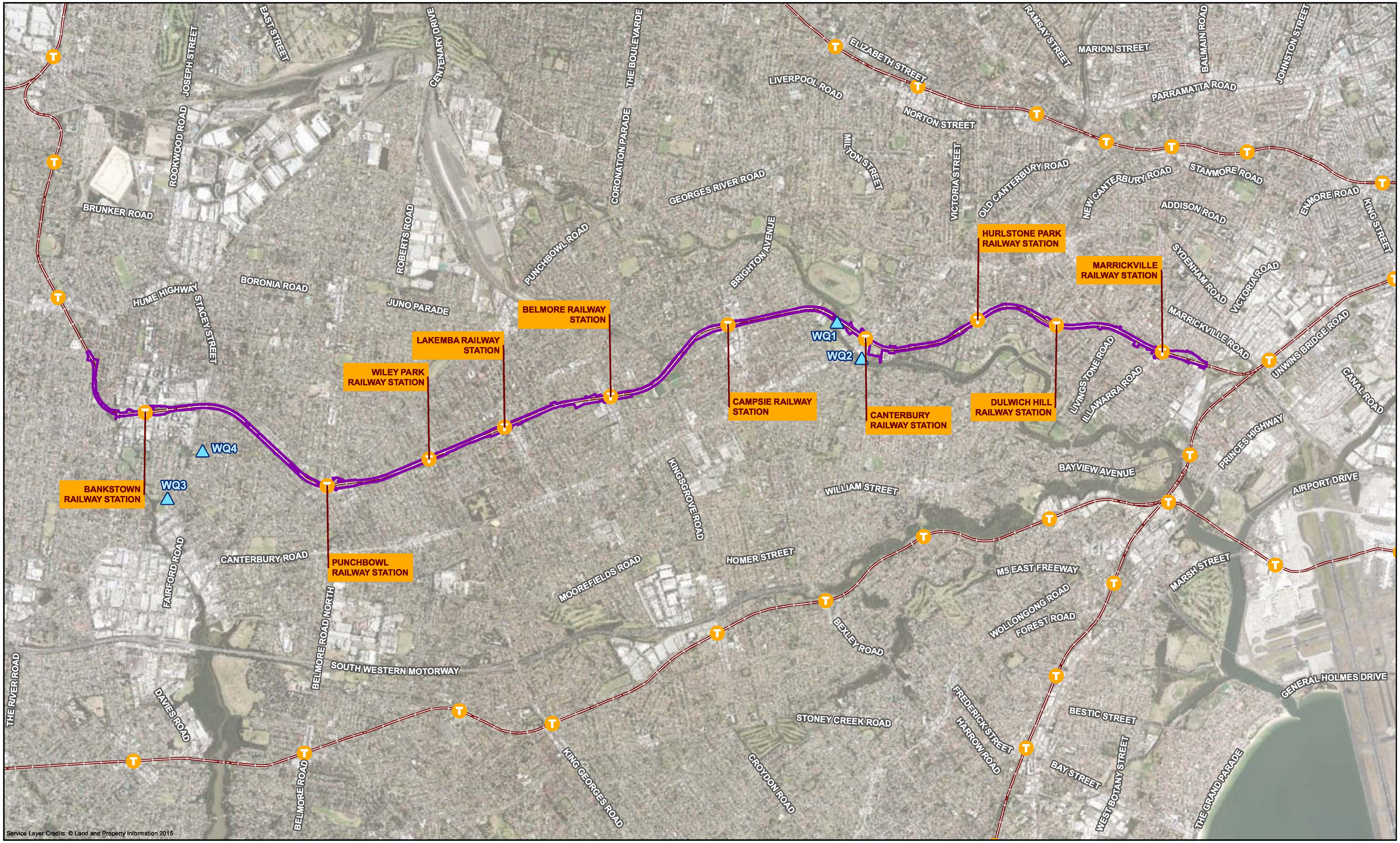
Possible indicative locations of water quality sampling points are provided in Figure 7-1. Final locations would be selected based on:

- The detailed drainage design
- Review of accessibility to sampling points
- Selection, where possible, of upstream and downstream sampling points limiting inflows from sources other than the rail corridor

Due to the extensive surface water drainage network in and surrounding the project area, as well as the linear nature of the rail corridor, identification of sampling points which effectively isolate the influence of the rail corridor may not be possible and locations should be further considered as the design develops.

7.2.4 Residual impacts

Residual impacts of the project would include increases in flood level in rare to extreme flood events of greater than the one per cent AEP climate change event. This would include impacts to surrounding properties including increased flood depth, potential flood damages during a flood event and emergency access during times of flooding.



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Map Projection: Transverse Mercator
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LEGEND

- Project area
- Train station
- Railway
- Indicative Water Quality Montoring Locations

GHD

Transport for NSW
Sydney Metro - Sydenham to Bankstown upgrade
Surface Water Assessment

Indicative Water Quality Monitoring Locations

Job Number	21-25273
Revision	A
Date	08 Jul 2017

Figure 7-1

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Aerial imagery - sixmaps 2016, General topo - NSW LPI DTDB 2012. Created by:afoddy

8. Conclusion

A surface water and flooding assessment was carried out for the project.

The assessment drew on the following sources of information including:

- A desktop review of available drainage, flooding and water quality information
- Site inspections
- Analysis undertaken by the designer
- Various reference design documentation

The project area is located in a highly urbanised environment that has been substantially altered from its natural state and water quality is typical of that for urban catchments in Sydney.

Under existing conditions, the project area is subject to local flooding varying in severity due to insufficient capacity in the surrounding drainage network during large storm events and also due to insufficient drainage within the rail corridor in places. More extensive flooding currently occurs in Marrickville.

Key construction stage impacts include:

- The potential for increased sediment being discharged to downstream systems as a result of construction activities
- Flooding and overland flow issues caused by the presence of construction worksites and compounds on flood liable land

Construction impacts would be managed through implementation of SWMPs in accordance with the Blue Book and detailed planning and management of construction sites to avoid impacting overland flow paths without appropriate mitigation.

Drainage works are proposed as a component of other nearby projects and there would be a low risk of cumulative construction stage flooding and water quality impacts. Coordination with other works is proposed in order to mitigate cumulative construction impacts.

Key residual construction stage impacts include flooding to construction worksites and compounds during construction, with associated potential downstream impacts.

In the operational stage, drainage measures incorporated into the design are predicted to provide effective mitigation of major flood impacts for events up to and including the one per cent AEP climate change event.

A flood warning and evacuation plan would be developed for emergency management of flooding up to the PMF.

Water quality impacts would be managed through implementation of water sensitive urban design measures. A water quality monitoring program would be developed to monitor water quality outcomes against long term water quality objectives.

Potential for cumulative operational impacts of Council drainage upgrade works and the project exists, however the design has been developed with consideration of known proposed measures to avoid impacts. There are opportunities for combined improvement to existing drainage issues in the project area and surrounds.

The potential for cumulative impacts with other projects, including the Chatswood to Sydenham project, WestConnex and the Sydenham to Bankstown Urban Renewal Corridor projects were identified and considered to be low.

In terms of residual operation impacts, negligible increases to flood depths along key access routes are predicted in both the one per cent AEP and PMF events, though some of these areas are already predicted to be substantially flooded under existing conditions.

The drainage design is at a reference stage and refinement of the drainage details would occur as part of the design development process. Further consideration of proposed changes against the design criteria would be undertaken at all stages to ensure that flooding, drainage and water quality impacts for a range of flood events would be managed. Further assessment of climate change impacts, including consideration of 20 per cent and 30 per cent increases in peak rainfall intensity as well as further consideration of sea level rise would also be undertaken.

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Appendices

Appendix A – Photographs

Figure A.1 Cooks River near Hurlstone Park

Figure A.2 Rail bridge over Cooks River

Figure A.3 Cooks River near rail crossing (looking upstream)

Figure A.4 Upper reaches of Salt Pan Creek

Figure A.5 Tidal reaches of Salt Pan Creek near Riverwood

Figure A.6 Wetland area near Riverwood

Figure A.7 Western Channel south east of Marrickville Station on Myrtle Street

Figure A.8 Culvert under rail corridor near Belmore Sportsground

Figure A.9 Rail culvert structure west of Lakemba Station

Figure A.10 One of the culvert structures passing beneath the rail corridor at Wiley Park Station

Figure A.11 Upper reaches of Coxs Creek

Figure A.12 Confluence of Coxs Creek and Cooks River near South Strathfield