CBD AND SOUTH EAST LIGHT RAIL PROJECT

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1A

PART C: REGIONAL ENVIRONMENTAL IMPACT ASSESSMENT

8. Impact assessment approach

Chapter 8 provides an overview of the impact assessment approach undertaken for this Environmental Impact Statement (EIS). This includes explanation of the regional and precinct-based assessment approach, and a summary of the specialist technical assessment methodologies.

8.1 Assessment of regional and local impacts

Considering the nature and location of the Sydney CBD and South East Light Rail Project ('the CSELR proposal' or 'the CSELR'), it would have a range of potential impacts on the environment, including:

- direct local effects, such as noise impacts, changes to access and parking and changes to the visual and social amenity of the local areas through which it would pass
- direct and indirect regional effects, such as transport network changes and wider economic and land use impacts and benefits.

As noted in section 1.8, this EIS takes a regional and local (or precinct-based) approach to assessment of potential environmental impacts. By taking an area-based approach to the impact assessment, the proposal's impacts can be better understood within the local or regional context, as relevant. This impact assessment approach is based on the following rationale:

- The route of the CSELR proposal passes through five local areas (referred to in this EIS as 'precincts'), each of which has a relatively distinctive character.
- Presenting all of the potential local environmental impacts for a precinct in one chapter of the EIS should make it easier and clearer for the local community to understand the impacts and how they interrelate — and therefore to determine how the community might be affected by the proposal.
- The precinct-based assessment approach provides the opportunity to assess and mitigate impacts within each precinct, so that mitigation is applied at the location where it is most relevant/needed.
- Due to its nature and size, the proposal also has the potential for regional level impacts on the environment, including indirect impacts on regional planning and land use, traffic and transport and cumulative impacts. There are also some other environmental impacts (such as water and biodiversity impacts) that are best described on a regional or whole-of-project basis, rather than specific to individual precincts.

Figure 1.5 showed the approximate extent of the five local precincts assessed in Part D of this EIS (Chapters 12 to 16). The boundaries between and surrounding these precincts are deliberately shown as diffuse, as they are only indicative boundaries. In some places the impacts may also cross precinct boundaries, depending on the issue considered. Further details of the precincts are summarised in Table 8.1, along with the relevant chapters these precincts are assessed within. As well as the five precincts, impacts were also assessed on the locality within the vicinity of the proposed Rozelle maintenance depot.

The local impact chapters provide an integrated impact assessment for each precinct and locality, drawing on community concerns raised in consultations, and specialist studies for local traffic and access, heritage, amenity (noise, air, visual impact), socio-economic, property and land use.

Table.8.1 Impact assessment areas for this EIS

AREA	GEOGRAPHIC DESCRIPTION	CHARACTER	RELEVANT EIS CHAPTER(S)
CBD and South East region of Sydney	CBD and/or South East subregions of Sydney.	Ranges from very high density inner city commercial and residential land uses in the CBD, to open parkland and sporting/ entertainment uses in Moore and Centennial parks, to lower density residential and special uses in Randwick, Kensington and Kingsford.	Chapter 9 – Regional planning, transport and socio-economic impacts Chapter 10 – Other regional environmental impacts Chapter 11 – Regional cumulative impacts
City Centre Precinct	From Circular Quay (Alfred Street) to Chalmers Street, north of the intersection with Devonshire Street.	Largely business, commercial and retail and includes some major landmarks (Circular Quay, Queen Victoria Building, Town Hall).	Chapter 12 – Local impacts: City Centre Precinct
Surry Hills Precinct	From Chalmers Street/ Devonshire Street intersection (inclusive) to crossing of South Dowling Street (inclusive).	Inner city residential (medium to high density) with some commercial premises. Some small areas of open space.	Chapter 13 – Local impacts: Surry Hills Precinct
Moore Park Precinct	From immediately east of South Dowling Street crossing to north of Anzac Parade/Alison Road/ Dacey Avenue intersection. Includes northern part of Centennial Park.	Parkland and open space with some commercial and major event uses. Area used for recreational and entertainment purposes. Includes major trip generators such as Entertainment Quarter and sportsgrounds.	Chapter 14 – Local impacts: Moore Park Precinct
Randwick Precinct	East of Anzac Parade/ Alison Road/Dacey Avenue intersection to High Cross Park in Randwick. Includes southern part of Centennial Park.	Suburban residential area (medium, some high density) with commercial premises centred at Randwick shopping zone (Avoca Street). Includes major trip generators such as the University of NSW (UNSW upper campus), the Randwick health precinct and Royal Randwick racecourse.	Chapter 15 – Local impacts: Randwick Precinct
Kensington/ Kingsford Precinct	Anzac Parade/Alison Road/ Dacey Avenue intersection (inclusive) to south of the Nine Ways roundabout in Kingsford.	Suburban residential area (medium density) with commercial premises generally fronting Anzac Parade. Includes major trip generators such as UNSW (lower campus) and the National Institute of Dramatic Art (NIDA).	Chapter 16 – Local impacts: Kensington/ Kingsford Precinct
Rozelle locality	Locality within the vicinity of the proposed Rozelle maintenance depot in the suburb of Lilyfield.	Former goods yard with some residential and commercial/light industrial premises nearby.	Chapter 17 – Local impacts: Rozelle locality

8.2 Environmental risk analysis

Environmental risk analysis is used to identify potentially significant environmental effects associated with development projects. Evaluating a project's construction and operating characteristics, and the baseline environment, helps in deriving potential issues and further impact assessment needs. For the CSELR proposal, environmental risk analysis was used to define key and non-key environmental, social and economic issues for assessment as part of the EIS. It also helped to define mitigation measures for the proposal to assist in mitigating potential risks.

A preliminary environmental risk analysis was undertaken for the purposes of scoping the EIS and preliminary environmental assessment as part of the CSELR State significant infrastructure (SSI) application and supporting document (Transport for NSW 2013d). This analysis was updated with technical specialist input, once the EIS specialist studies had commenced. The analysis was further updated once the EIS studies were mostly complete and mitigation measures had been partially defined. Finally, a residual risk analysis was completed to confirm potential residual impacts after application of proposed mitigation measures.

Key findings are summarised in Chapter 18 — Environmental management and mitigation.

8.3 Director General's requirements

The Director General's requirements (DGRs) for the CSELR proposal issued by the Department of Planning and Infrastructure (DP&I) on 5 August 2013 (refer to Appendix A) were reviewed in detail to confirm the impact assessment approach and the scope of key and non-key issues for assessment in this EIS.

8.4 Identifying community and stakeholder issues

As described in Chapter 2, extensive community and stakeholder consultation was undertaken to identify issues for assessment in the EIS, as well as issues that needed to be addressed in the design and/or mitigation measures.

8.5 Technical impact assessment approaches

Due to the precinct-based approach to this EIS, detailed methodologies for the various specialist technical assessments are not provided within each impact assessment section for each precinct. A summary of the various technical impact assessment approaches is included in Table 8.2 below (including a cross-reference to where further details are provided).

Detailed methodologies and technical impact assessment approaches for each of the environmental issues associated with this EIS are provided in the supporting technical specialist papers provided as Volumes 2 to 6.

Table 8.2 Summary of technical impact assessment approaches

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Traffic, transport and accessibility	A Transport Operations Report was prepared to document the operational traffic, transport and access impacts and mitigation for the proposal, including: • traffic and transport integration • access to key light rail stops and interchanges (considering customer access by bus, private vehicle, foot, bicycle, heavy rail, and ferry) • traffic once the CSELR proposal is in operation • pedestrian, cyclist and traffic and transport safety • the integration of traffic and light rail within the road environment • a two-tiered modelling approach comprising: – Tier 1 modelling - localised intersection models with a combination of LinSig, SIDRA and VISSIM modelling to validate the proposed traffic management changes for intersections directly along the corridor – Tier 2 modelling – area-wide network modelling for dynamic simulation of regional route diversions, as well as micro-simulation modelling of smaller pockets of the network • a parking and access assessment, including an assessment of: – existing parking supply – impact of the CSELR on parking supply – existing parking demand, occupancy and utilisation – impact of the CSELR on parking demand – management of parking demand and supply in the south-eastern precincts – mitigation of direct impacts on loading and other kerbside uses in the CBD • special events analysis, to assess the compatibility of light rail with special events (such as street parades, major sporting and cultural events) along the proposal corridor.	Both regional (network) and precinct-based	For operational impacts refer Technical Paper 1 – *Transport Operations Report* in Volume 2 For construction impacts refer to Technical Paper 2 – *Construction Traffic and Transport Management Plan* in Volume 2

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Traffic, transport and accessibility	A Construction Traffic and Transport Management Plan was prepared to document construction impacts of the proposal at both the regional network and precinct level. This included: • detailed modelling of the impact of the construction scenario on the wider network during the AM peak (6–10 am) and PM peak (3–7 pm) time period, using a traffic forecast year of 2016 • assessment of network level construction impacts and mitigation measures – which aim to minimise any reduction in network performance and journey times for all road users, including travel demand management measures, to ensure demand is better matched to the temporarily reduced network capacity • assessment of precinct level construction impacts and mitigation measures which address the day-to-day activities undertaken on and around the corridor, including local traffic, pedestrian, cycle and emergency vehicle access. The construction and operational assessments included traffic management changes as a direct consequence of the CSELR and their impacts, including any potential impacts to surrounding precincts. For context, the traffic modelling also included assumptions regarding potential changes to buses in the CBD and South East that were assumed to be proposed as part of the NSW Government's (2013b) draft *Sydney City Centre Access Strategy* (SCCAS) and *Sydney's Bus Future* plan (under development). Notwithstanding this, the focus of this EIS is on impacts of the CSELR and not the wider bus network changes.	Both regional (network) and precinct-based	For operational impacts refer Technical Paper 1 – T*ransport Operations Report* in Volume 2 For construction impacts refer to Technical Paper 2 – *Construction Traffic and Transport Management Plan* in Volume 2
Property and land use	A review of existing land use was undertaken using information including: • existing geographic information system (GIS) land use data/mapping • aerial photography (2011) • relevant background studies • ground-truthing of existing land use along the CSELR alignment during a site visit undertaken on 3 July 2013. Background studies were also reviewed to identify potential future developments including: • zoning information from the City of Sydney and Randwick local environmental plans • outcomes of consultation with major landholders regarding their plans for future development (e.g. at Royal Randwick racecourse) • a search of the DP&I's major projects database (undertaken on 25 July 2013) • high level planning strategies for the subregion including the *Draft Metropolitan Strategy for Sydney 2031* (NSW Government 2013a), and the Sydney City, East and Inner West draft subregional strategies • local planning strategies • other available master plans. Potential impacts of the proposal on land use were identified with consideration of the following issues: • direct impacts on land uses within the proposal boundary or areas of proposed acquisition • indirect positive and negative impacts on land uses, including potential land use integration issues, impacts on land use amenity including impacts on adjacent land uses, potential opportunities and/or benefits for urban renewal/development.	Both regional and precinct-based	No technical paper

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Economic impacts	The economic assessment included: • a review of relevant available research and background information • a profile of existing geographic areas and businesses that may be influenced by the proposal • a 'snapshot' survey of 100 businesses located along the route alignment • discussions with the City of Sydney and Randwick City Councils • demographic analysis • a review of issues and comments raised through the consultation and communications programmes undertaken to date • a scope of the likely changes/impacts that may occur as a result of the proposal • research of studies and literature establishing impacts of similar projects and issues • analysis of potential negative and positive impacts, and direct and indirect impacts during construction and operational stages in light of government objectives and strategies • the identification of plans and strategies for monitoring and managing the impacts during both construction and operational stages.	Both regional and precinct-based	Refer section 1 of Technical Paper 4 – *Economic Impact Assessment* in Volume 3
Social impacts	A social impact assessment (SIA) was undertaken to identify and evaluate key social issues that could potentially arise during the construction and operation of the proposal. The SIA drew upon various specialist studies including the economic impact, property and land use, traffic, noise, air quality, visual and other assessments to provide an integrated approach. This assessment followed the standard procedure for SIA, including (in this order): • scoping of impact issues and identification of affected communities and stakeholders • profiling of the affected areas using both quantitative demographic data and qualitative information about the affected communities • assessment of potential impacts, both positive and negative, using information from stakeholders and the community, as well as through comparison with similar projects • developing impact management recommendations for minimising or mitigating negative impacts and enhancing project benefits.	Both regional and precinct-based	Refer section 1 of Technical Paper 3 – *Social Impact Assessment* in Volume 3

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Built and non-Indigenous heritage	A built and non-Indigenous heritage assessment was prepared using the following general methodology: • review of statutory heritage lists, including the State Heritage Register, heritage schedules on local and regional environmental plans, state agency Section 170 heritage and conservation registers, the National Heritage List and the Commonwealth Heritage List • review of relevant heritage reports, archaeological zoning plans and archaeological assessments previously prepared for relevant items and areas along the route, as available • site inspections of the CSELR alignment to inspect listed heritage items and potential archaeological sites • desktop research and historical research to inform the impact assessment, including review of relevant conservation management plans and plans of management • consultation with heritage advisors at local councils and state agencies regarding items on their heritage registers, where required • assessments of heritage significance based on the NSW Heritage Council's guideline *Assessing Heritage Significance* from the *NSW Heritage Manual* • assessments of historical archaeological potential • assessments of heritage impact based on the NSW Heritage Council's guideline *Statements of Heritage Impact* (2002) from the *NSW Heritage Manual* • recommendations in regard to management and mitigation of impacts • development of a Heritage Interpretation Strategy.	Both regional and precinct-based	Refer section 1 of Technical Paper 5 – *Heritage Impact Assessment* in Volume 5 Also refer Technical Paper 6 – *Heritage Interpretation Strategy*
Landscape and visual impact assessment	A precinct-based landscape and visual impact assessment was prepared, through: • review of the relevant planning framework, including relevant policies, master plans and strategies for each precinct • assessment of visual impacts based on the level of visual modification created by the proposal and the sensitivity of the viewers • assessment of night-time visual impacts drawing guidance from the Institution of Lighting Engineers (UK) *Guidance for the reduction of obtrusive light* (2005) • landscape character assessment considering the sensitivity of the landscape (ranging from neighbourhood and local to Regional, State and National sensitivities), the magnitude of change proposed and assessment of overall impact on the landscape character of each precinct • assignment of significance of impact levels • identification of visual and landscape mitigation, including preparation of a landscape strategy.	Precinct-based	Refer section 3 of Technical Paper 10 – *Visual and Landscape Assessment* in Volume 5

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Planted trees	A preliminary tree assessment was undertaken by a qualified arborist on planted trees within the tree study area. The tree study area was defined as the area that would be directly affected by the CSELR proposal, including the likely extent of • physical works (e.g. light rail tracks, stops, overhead wires, substations and the maintenance and stabling facilities) • construction compounds • access roads • any other areas that would be physically disturbed during the construction of the proposal. The assessment was undertaken through a site walk to identify and survey the potentially affected trees. The scope of the assessment was to: • survey all subject trees within the tree study area and appraise the trees' condition, health, structure and safe useful life expectancy (SULE) at the time of inspection • assess landscape amenity/significance of individual trees • determine the tree protection zones (TPZ) and structural root zones (SRZ) in accordance with AS 4970-2009 *Tree Protection in Construction Sites* • provide comment and broad recommendations for each tree within the tree study area. Key considerations included: • any incursion of greater than 10–20 per cent of the TPZ would likely require removal of the tree • any incursion into the SRZ would likely require removal of the tree • potential kerb encroachments or impact of earthworks and retaining walls • consideration of the light rail kinematic envelope and overhead wires may require extensive pruning depending on branch clearances, possibly compromising the overall health, aesthetic and value of the tree. Trees that would be directly impacted (including trees within the construction footprint of the light rail) or potentially impacted (for example, trees that have minimal encroachment into their TPZ or require minimal pruning) were assessed as potentially requiring full removal. In accordance with the Transport for NSW *Vegetation Offset Guide* (Transport for NSW 2013e), a mitigation approach of 'avoid-mitigate-offset' was applied. This included consideration of trees to be retained where possible, that were viable for transplanting to nearby locations, and replacement plantings, as guided by the proposed CSELR Landscape Strategy.	Precinct-based	Refer methodology section of Technical Paper 9 – *Preliminary Tree Assessment* in Volume 5

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Noise and vibration	A noise and vibration impact assessment was prepared, including: • ambient noise surveys to determine the existing noise environment within the surrounding environment of the proposal • identification of receptors along the alignment that are potentially sensitive to noise and vibration • prediction of noise and vibration from the construction and operation of the light rail line, including stabling yard and maintenance depot, stops and ancillary infrastructure • assessment of potential noise and vibration impacts in accordance with relevant legislation and guidelines, including the NSW Environment Protection Authority's (2013) *Rail Infrastructure Noise Guideline* (RING) for operational noise from the light rail line; the NSW *Industrial Noise Policy* (INP) for noise from the stabling and maintenance depot sites, stops and electrical substations; the *Interim Construction Noise Guideline* (ICNG) for construction noise; and *Assessing Vibration: A Technical Guideline* for construction and operational vibration • identification of potential improvement to existing noise environments as a result of the proposal • recommendation of management and mitigation measures to reduce and control potential impacts where noise and vibration levels are predicted to be above the assessment criteria.	Precinct-based	Refer section 1 of Technical Paper 11 – *Noise and Vibration Impact Assessment* in Volume 6
Utilities and services	• Preliminary information on the location of existing services and utilities was reviewed through consultation with key utility and service providers. • Works likely to be required to protect or relocate affected services were identified. • Where required, appropriate environmental management measures for these works were developed to minimise impacts on the receiving environment.	Regional	No technical paper
Cumulative impacts	Potential cumulative impacts of the proposal and other major developments in the vicinity were assessed through: • consultation with stakeholders, councils and DP&I; a search of DP&I's major project's register on 25 July 2013; review of background documents and discussions with the CSELR project team • review of public environmental assessments and major facility master plans where available, and liaison with project proponents such as NSW Roads and Maritime Services (RMS) regarding potential cumulative impacts with the proposed bus changes in the CBD and South East • qualitative assessment of cumulative impacts • some quantitative assessment of cumulative traffic impacts for those projects incorporated into the traffic modelling undertaken for the CSELR EIS.	Regional	No technical paper

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Hydrology, drainage and surface water quality	A high level assessment of the likely impacts of the proposal on surface water was undertaken, including: • impacts on flooding and stormwater flows • impacts on surface water quality. At this early design stage for the CSELR, no drainage designs or flood mitigation measures have been developed. The scope of this impact assessment, therefore, provides a high level assessment of available information through the: • investigation of published flood study information and estimation of potential flood impacts of the light rail corridor • assessment of expected operational stormwater quality impacts • assessment of constructability and construction staging flood and water quality impacts • assessment of general construction stage erosion and sediment management controls.	Regional	No technical paper
Soils, geology and contamination	For assessment of soils, geology and contamination impacts: • A desktop soils and geology assessment was undertaken and management and mitigation measures have been proposed, where appropriate. • A desktop Phase 1 Environmental Site Assessment (ESA) was undertaken to assess the likelihood of the presence of contaminated material and potential contamination impacts. Management and mitigation measures were proposed, where appropriate, including a Remediation Strategy.	Regional	No technical paper
Groundwater	A desktop groundwater assessment was undertaken of the current hydrogeological conditions along the CSELR alignment to determine the potential construction and operational risks to groundwater. This included: • a high level desktop study summarising the current hydrogeological conditions in the study area to determine the potential construction and operational risks to groundwater • assessment of groundwater levels, groundwater quality, aquifers present, groundwater recharge and discharge conditions and potential groundwater contamination issues during construction and operation • identification of mitigation measures to minimise potential impacts on groundwater. Recognising that the cut-and-cover tunnel through Moore Park would be tanked, which would avoid potential groundwater drawdown impacts during operation of the CSELR, no detailed groundwater modelling was undertaken.	Regional (although impacts largely local to Moore Park Precinct where cut-and-cover tunnel proposed)	No technical paper
Aboriginal heritage	A due diligence Aboriginal archaeological assessment was undertaken, in accordance with the Office of Environment and Heritage's *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (2010). The assessment included analysis of the environmental context and archaeological background of the region, and a site inspection to assess potential harm to known or potential Aboriginal objects and/or Aboriginal places. Recommendations for management were also made in accordance with current best practice.	Regional	Refer section 1 of Technical Paper 5 – *Heritage Impact Assessment* in Volume 4

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Biodiversity	An ecology impact assessment was prepared to address impacts during construction and operation, including: • a desk-based search of relevant databases and historical records to identify threatened flora and fauna species, populations and ecological communities; Commonwealth listed migratory species; or critical habitat recorded previously or predicted to occur in the vicinity of the study area • a daylight site inspection by an ecologist to assess the nature, location and condition of vegetation and fauna habitats with a focus on threatened species, populations and ecological communities • consideration of the potential impacts of the proposal on the ecological value identified. The vegetation of the study area consists entirely of landscape plantings and, therefore, no detailed floristic surveys or condition assessments were conducted. The possible presence of planted threatened species of plant was assessed through desktop assessment and visual inspection.	Regional	No technical paper
Air quality	A qualitative air quality assessment was undertaken, including: • a review of all available information including corridor layout and proximity of nearby sensitive receptors • analysis of appropriate background air quality data from the nearest or most relevant air quality stations to determine the existing ambient air environment • review of existing meteorological conditions from the most appropriate Bureau of Meteorology monitoring station(s) • identification of potential air emission sources • qualitative assessment of potential air quality impacts for the construction phase • qualitative assessment of potential air quality impacts and/or improvements associated with the operational phase of the proposal • identification of mitigation measures for the construction phase of the proposal, to reduce potential impacts on the receiving environment.	Regional/whole of project (although impacts largely local)	Refer Technical Paper 7 – Air *Quality Impact Assessment* in Volume 4

Table 8.2 cont.

ISSUE	SUMMARY OF IMPACT ASSESSMENT APPROACH/METHODOLOGY	REGIONAL AND/ OR PRECINCT-BASED APPROACH	FURTHER DETAILS ON METHODOLOGY
Greenhouse gases	A quantitative greenhouse gas emissions assessment was undertaken for the proposal. This assessment comprised: • an inventory of likely greenhouse gas emissions for the proposal including construction phase emissions and annual operational emissions for major greenhouse gases attributable to specific components of the proposal, with total emissions expressed in tonnes of carbon dioxide equivalent (t $CO_{2\text{-}e}$) • an outline of the proposal's annual and overall contribution to the NSW and national greenhouse gas emissions profile • an outline of the upstream greenhouse gas generating activities associated with the proposal, including fossil fuel generated electricity • a high-level commentary on the significance of predicted greenhouse gas emissions on the environment and legislative implications of these emissions to the proposal (e.g. carbon tax) • a high-level investigation of greenhouse gas abatement opportunities, including a description of the intended measures to avoid and/or minimise greenhouse gas emissions • basic qualitative assessment of the potential benefits of using electric-powered light rail vehicles in terms of greenhouse gas emissions and energy intensity.	Regional	Refer Technical Paper 8 – *Greenhouse Gas Assessment* in Volume 4
Hazards and risks	A high level, desktop hazard and risks assessment was undertaken and management and mitigation measures were proposed, where appropriate. This incorporated findings from other studies such as safety aspects of the traffic and transport assessment.	Regional	No technical paper

9. Regional planning, transport and socio-economic impacts

Chapter 9 details the existing regional character and environment of the wider proposal area as well as the key regional environmental impacts of the CBD and South East Light Rail Project ('the CSELR proposal' or 'the CSELR'). The chapter focuses on the regional planning, transport and socio-economic issues. Other regional impacts of the CSELR proposal are discussed in Chapter 10. Local environmental impacts and other environmental issues are covered for each of the precincts in Chapters 12–17 of this Environmental Impact Statement (EIS).

9.1 Purpose and approach

Impacts from implementation of the Sydney CBD and South East Light Rail Project (the 'CSELR proposal' or the 'CSELR') that occur beyond the immediate vicinity of the alignment and identified stops would typically be a consequence of changes in traffic routes, volumes and composition brought about by the proposal. Such changes would be more pronounced closer to each of the stops and the alignment, and would diminish noticeably with distance away from the proposal. Beyond the extremities of the proposal at the northern and southern ends, any changes are anticipated to be small and unlikely to result in any perceived or actual social or environmental impacts.

This chapter (in conjunction with Chapters 10 and 11) provides an assessment of the potential impacts outside the immediate area of the proposal, as well as other impacts that are best described on a 'whole-of-project' basis. As the area that affected would vary depending on the identified issue, a precise study area has not been defined for these impacts. It would, however, cover at least the following defined sub-regions:

- the Sydney CBD
- Sydney's Inner East (including Surry Hills, Moore Park, and parts of Paddington and Woollahra)
- Sydney's Inner South (including parts of Ultimo, Waterloo, and Redfern)
- Sydney's Outer East (including Kensington, Kingsford, and Randwick)
- Sydney's Inner West (including parts of Lilyfield, Annandale and Leichhardt).

This chapter examines the impacts of the proposal on the regional road network, public transport, pedestrians and cyclists, regional accessibility and regional planning and land use issues. Finally, it provides a review of the proposal and its anticipated socio-economic affects at a regional level. An assessment of the proposal's other regional or whole-of-project environmental impacts is provided in Chapter 10, and a summary of the proposal's cumulative impacts is provided in Chapter 11.

9.2 Regional traffic, transport and accessibility

9.2.1 Existing transport network

The following sections provide a summary of the existing regional traffic, transport and access environment, based on Technical Paper 1 — *Transport Operations Report* in Volume 2.

Characteristics and constraints of the existing transport network

The proposed CSELR alignment travels through a diverse area with varying traffic, transport and accessibility characteristics, constraints and opportunities. An overview of the key features and constraints associated with the existing regional transport network is provided in the following sections.

A detailed description of the existing traffic, transport and accessibility environment along the CSELR alignment (i.e. key roads; intersections; parking and kerbside access; property access; cyclist facilities; and pedestrian movements) is provided on a precinct by precinct basis in sections 12.3.1 (City Centre Precinct), 13.3.1 (Surry Hills Precinct), 14.3.1 (Moore Park Precinct), 15.3.1 (Randwick Precinct), and 16.3.1 (Kensington/Kingsford Precinct).

Key features of the existing regional transport network

Sydney's existing regional transport network comprises key transport corridors that link the CBD with the Greater Sydney Metropolitan Area. Key entry points into the CBD are from the south, west and north of the city centre. Within the Sydney CBD, George Street is a key bus corridor and the main road through the city centre providing access between the Sydney City precincts.

Access into the CBD from the north is via the multi-modal Sydney Harbour Bridge and Sydney Harbour Tunnel. The majority of road users travelling in from the north mainly use the Harbour Bridge or Tunnel while buses and the North Shore Rail Line enter the CBD via the Harbour Bridge.

Access into the city centre from the south particularly from Sydney Airport is serviced by a Motorway link (Southern Cross Drive/Eastern Distributor) and an arterial road network providing access to Redfern, Central Railway Station and the southern end of the CBD. The East Hills Rail Line also connects the Airport and south-western Sydney to Central Railway Station and the City Circle Rail Line (NSW Government 2012a).

From the west, road users enter the CBD using both the Anzac Bridge (from Victoria Road and the City West Link) and Parramatta Road. Multiple rail lines from the west (e.g. Western Line, Inner West Line, South Line) run through Redfern and Central Railway Stations which are heavily used gateways into the city (NSW Government 2013b).

Constraints with the existing transport network

The Sydney CBD has very high transport demand and limited capacity to accommodate the additional public transport required to serve future growth in customers without a step change in service provision. The sheer volume of buses entering the CBD is reaching a critical point in Sydney's highly congested urban environment, with the addition of further buses unlikely to provide substantially new capacity without further degrading service provision.

Outside of the CBD, the CSELR alignment traverses through the South East suburbs of Surry Hills, Randwick, Kensington and Kingsford. This corridor services several regional community facilities and employment centres, including the major sporting precincts at Sydney Football Stadium (SFS; also referred to as Allianz Stadium), Sydney Cricket Ground (SCG), the Moore Park Entertainment Quarter, Royal Randwick racecourse; recreation and entertainment facilities at Centennial Parklands; and the Randwick Education and Health Specialised Centre including the University of NSW (UNSW) and the Randwick health precinct. It serves high density centres in Surry Hills, Randwick and Kensington and is a corridor that currently relies exclusively on buses for public transport.

The presence of multiple major event venues in the South East corridor places pressure on the public transport system to provide sufficient capacity to serve the peak loadings at the beginning and conclusion of these major events. Major events hosted at the SCG and SFS achieve a 5–20 per cent mode share to public transport compared to an average of 55 per cent at Sydney Olympic Park which is served by a much higher capacity heavy rail link (NSW Government 2012a). Provision of additional capacity to cope with the additional loads will be important if Sydney is to continue attracting hallmark events in the future. Additional capacity will have the added benefit of reducing the often heavy congestion in the area during major events.

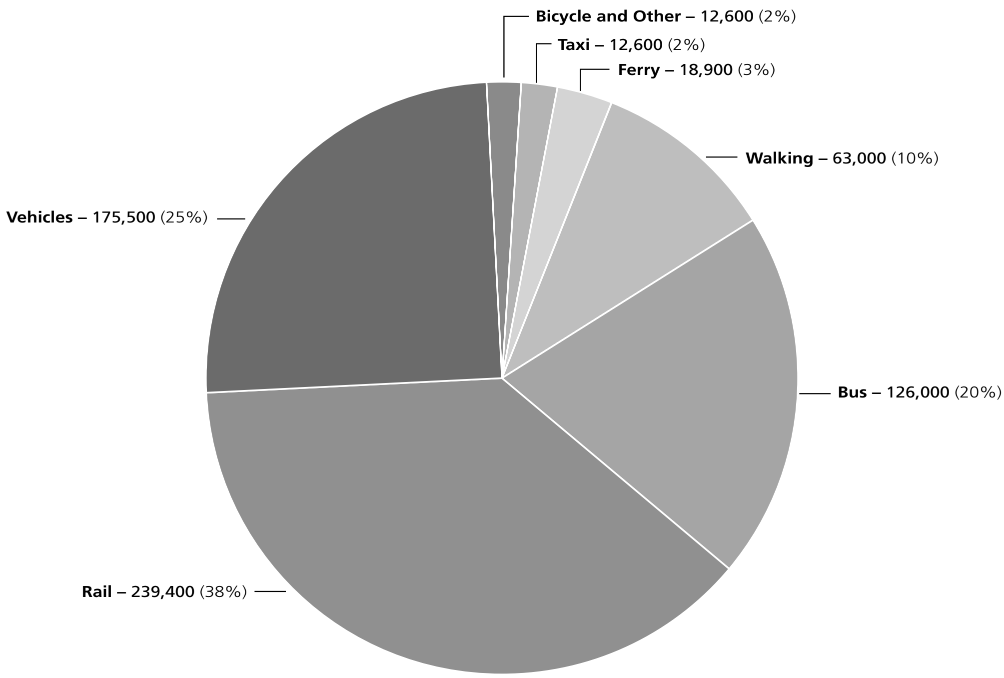
UNSW is also a major trip generator in the South East corridor, and requires a significant volume of buses to transport students and staff — primarily between Central Railway Station and the Kensington campus. Currently, over 340 bus trips per day operate this route in both directions; but even with this volume of buses, congestion is regularly experienced at the Eddy Avenue bus stand. The UNSW student population is expected to grow from 37,000 to about 50,000 — an increase of 35 per cent (Transport for NSW 2013a). It is clear that requiring buses to continue providing the majority of transport capacity for UNSW is unsustainable.

Current mode share for morning peak trips into the Sydney CBD

Currently over 600,000 people enter the CBD during the day, with public transport accounting for 61 per cent of trips. Over one-third of the total travel demand (38 per cent) is carried by the underground heavy rail system which places pressure on constrained CBD stations, particularly at Town Hall and Wynyard. The current transport mode share for commutes into the Sydney CBD during a typical day is shown in Figure 9.1.

The city's congested road network carries the remainder of trips, accommodating a mix of cars, buses, cyclists and pedestrians on relatively narrow streets. Of these street-based modes, buses carry the highest travel demand in and out of the CBD, servicing 20 per cent of total trips.

Figure 9.1 Current mode share for trips into the CBD on a typical day



Existing bus services

Sydney CBD

Approximately 1,600 bus services enter the Sydney CBD during the two-hour morning peak, through the primary CBD cordon points at the Sydney Harbour Bridge, Anzac Bridge, Broadway, Oxford Street, William Street and Elizabeth Street.

The substantial volume of buses entering the CBD, combined with high volumes of general traffic (i.e. private vehicles, commercial and service vehicles), contribute to congestion on major streets in the city centre, which deteriorates the reliability of bus services and negatively impacts amenity. George Street in particular carries up to 290 buses in the peak direction during the morning peak (7 am–9 am) and this is expected to increase to over 310 by 2015. The congested bus network in George Street, combined with the demands of other road users, impacts on customer service and delays essential business functions.

Average bus variability during the morning peak hour along key access routes through the CBD is between five and seven minutes behind schedule (NSW Bureau of Transport Statistics 2011). Average morning peak travel time variability for key bus corridors is summarised below:

- *Elizabeth Street* — A large number of buses approaching the CBD from the east merge with general traffic on Elizabeth Street, causing high levels of congestion which results in an estimated bus travel time variability in the morning peak of approximately seven minutes.
- *York Street* — Many inbound buses from northern Sydney travel on the Harbour Bridge and through the CBD via York Street. Buses travelling along York Street experience an estimated average morning peak travel time variability of approximately six minutes.

- *George Street* — This is a main corridor for western and southern region buses travelling through the CBD, along with the free shuttle bus (555). Buses travelling along George Street experience an estimated average variability in morning peak travel times of approximately five minutes.
- *Anzac Parade* — This is a key corridor providing access in to the CBD for a large number of South East region buses. Buses travelling along the Anzac Parade corridor experience an estimated average morning peak travel time variability of approximately five minutes.

The forecast growth in bus demand would increase bus congestion within the CBD putting more vehicles onto our roads and increasing overall traffic congestion.

South East suburbs

Outside of the CBD, the proposed CSELR alignment traverses through the South East suburbs where buses are currently the primary public transport mode. This corridor is within Transport for NSW's Metropolitan Bus System Contract Region 9 which is the most heavily patronised bus region in the Sydney metropolitan area.

The existing regular bus routes within the South East suburbs can be segmented into three broad service types which are summarised, together with their existing service numbers and average loadings, in Table 9.1. The existing bus services included as part of this study are illustrated in Figure 2.5 of Technical Paper 1, and listed in Table 2.1 of Technical Paper 1.

Table 9.1 Existing regular bus service routes within the South East suburbs

BUS SERVICE TYPE	SERVICE CHARACTERISTICS	EXISTING BUS TRIPS (2010 MORNING PEAK HOUR)	AVERAGE LOADING PER BUS (2010 MORNING PEAK HOUR)
CBD all-stop services	Stop frequently from their suburban origin to the CBD. Operate All Day in both directions. Primarily use Oxford, Cleveland, Elizabeth or Foveaux streets to access the CBD from the South East. A separate busway adjacent to Moore Park between Alison Road and Moore Park Road provides access to the CBD.	135	36 people
CBD express services	Stop frequently on suburban routes before reaching a key node and running direct to the CBD without stopping. Typically operate during the peak periods only in the peak direction. Most utilise the Eastern Distributor to access the CBD and operate contra-peak south along Elizabeth Street. A number of city express services use the Anzac Parade busway adjacent to Moore Park between Alison Road and Moore Park Road.	62	55 people
Cross-regional services	Do not enter the CBD but rather provide links between key centres, such as Bondi Junction. Operate All Day.	47	n/a

Source: Table 2-2 of Technical Paper 1 – Transport Operations Report, Volume 2.

The bulk of existing bus services within the South East CSELR corridor are CBD All Stop services (135 trips per hour) which operate to the CBD throughout the entire day. This includes the existing Metro Bus Routes M10 and M50. These services are supplemented when demand increases during the peak period by express bus services (62 trips per hour), which generally pick up passengers until Randwick or Kingsford and then run express into the northern end of the CBD via the Eastern Distributor. (Note the X39 is the only express service in the study area not operating via the Eastern Distributor).

Existing bus services within the CSELR corridor operating to the CBD carry approximately 8,300 customers during the morning peak hour. The bulk of CBD bus customers (59 per cent) in the CSELR corridor use the All-Stop services; although the loadings per bus trip are significantly lower when compared to express services. The CBD express services are currently experiencing the strongest growth in patronage.

Cross regional services are also provided to create connections to other key centres as well as linking the numerous education, shopping and health precincts.

In addition to regular route services, express university buses are provided to UNSW (approximately 350 express bus trips to and from UNSW per day), school special services are provided to Sydney Boys and Girls High Schools (55 bus services to and from the schools per day), and special event services are provided to Moore Park (3,020 total bus trips made in 2011) and Royal Randwick racecourse (876 total bus trips made in 2011 during races) during events.

Planned future transport and accessibility

As discussed in section 3.2.3, the NSW Government released the draft *Sydney City Centre Access Strategy* (SCCAS) in September 2013 in response to the *NSW Long Term Transport Master Plan* (NSW Government 2012a) commitments that relate to improving access within, and to, Sydney's city centre. This strategy includes a number of separate components across different transport modes (bus, heavy rail, light rail, ferry and cycling) that, as a whole, aim to unlock additional capacity within the Sydney CBD.

The CSELR proposal represents two components of the SCCAS — light rail and pedestrianisation of George Street. One other component of the SCCAS of particular relevance to the CSELR is the proposed bus network redesign to deliver a fully-integrated and coherent public transport system in inner Sydney.

The redesign of the city centre bus network would create an integrated public transport solution for the Sydney CBD through the coordination of light rail, rail and bus services. It includes rationalisation of Sydney bus services to accommodate the introduction of the North West Rail Link, expansion of light rail services, and the pedestrianisation of George Street.

A key objective of the redesign of the city centre bus network is to provide improved legibility and access for existing and future customers to use buses while the buses are operated more efficiently on the city streets and into the city centre. Objectives of bus network redesign specific to the city centre comprise the following:

- Create a simpler, all-day city centre bus network.
- Accommodate high volumes of buses through the city centre more efficiently with fewer turns and more bus priority.
- Minimise the need for terminating services in the city centre and provide sufficient capacity at convenient located layover facilities.

The proposed bus route paths for the redesign of the city centre bus network are shown in Figure 9.2. Key features of the redesign of the city centre bus network of relevance to the CSELR proposal comprise the following:

- No buses will travel along George Street between Rawson Place and Hunter Street to be consistent with the planning for the CSELR proposal.
- In-service buses will only be allowed to access George Street within the city centre to cross at Park Street/Druitt Street, to turn left from Rawson Place south into George Street and to turn left and right at Bridge Street/George Street. Out of service or dead running services will also be allowed to cross George Street at Market Street, Bathurst Street and Goulburn Street.

- Turning movements would be reduced at the Elizabeth Street and Park Street intersection. This would help simplify bus movements through the city centre.
- Sydney Harbour Bridge services will operate either via York Street to Town Hall/the Queen Victoria Building or via the Cahill Expressway and Castlereagh Street/Elizabeth Street.
- Buses from the Eastern Suburbs via William Street would run to Barangaroo and Walsh Bay to Pyrmont.
- About 50 per cent of Inner West bus routes will terminate after stopping at the Rawson Place light rail stop and in Campbell Street north of Belmore Park. The remaining Inner West bus routes will continue to the northern end of the city centre via the Elizabeth Street/Castlereagh Street couplet.
- Routes from the South East suburbs and from the Oxford Street corridor will only use Elizabeth Street to and from Circular Quay.
- Several routes would be connected to operate as through-routed services to reduce the overlap of bus services on city centre streets and the need for bus lay-over in the city centre.
- Victoria Road bus routes that currently use George Street and terminate at Circular Quay would either continue through the city centre via Druitt Street and Park Street to lay-over outside the city centre or terminate at Wynyard.

The proposed future bus service changes have been developed in parallel with the development of the CSELR proposal. Therefore, these changes would be consistent with the CSELR proposal to ensure a fully integrated transport solution.

The proposed redesign of the city centre bus network would be implemented by the NSW Government prior to the commencement of conflicting construction works for the CSELR proposal. As outlined earlier, the above proposed key features of the redesign of the city centre bus network would be addressed as part of the SCCAS (as discussed in section 3.2.3). Therefore, these changes do not form part of this EIS, with the exception of cumulative impact considerations, which are discussed in Chapter 11.

Special events

The following sections provide an overview of existing transport and access conditions occurring during special events at Moore Park and Royal Randwick racecourse. These two entertainment precincts have been considered at a regional scale (rather than at a local precinct level) due to the large number of trips that they generate and their large area of influence (i.e. patrons accessing these facilities travel through multiple precincts — for example, walking between Central Railway Station and Moore Park — and affect the wider transport network).

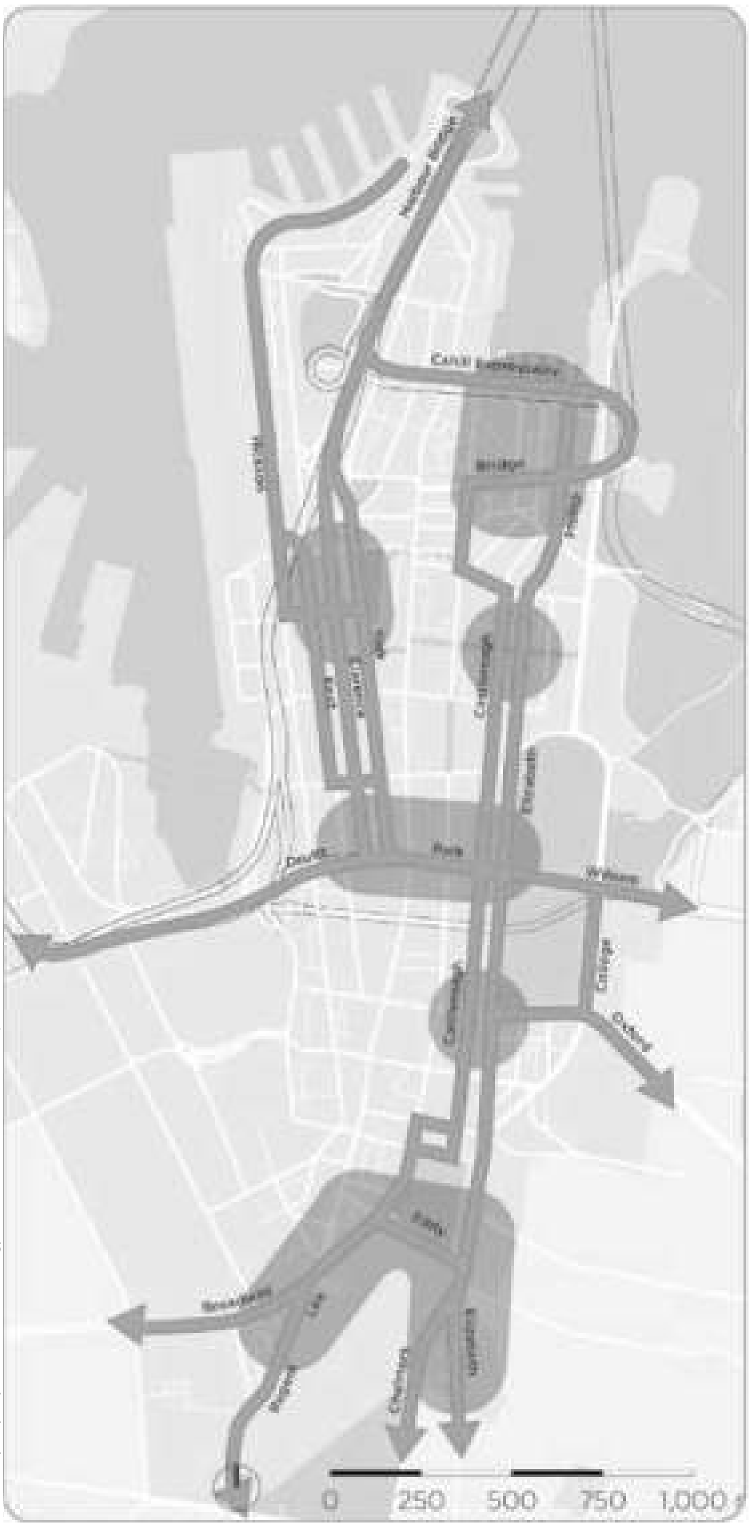
A number of other special events are held within Sydney which impact on traffic flows along the proposed CSELR alignment (for example, Chinese New Year Twilight Parade, the Anzac Day March, Vivid Festival, City 2 Surf and New Year's Eve). Consideration of these events is provided as part of the assessment undertaken for the City Centre Precinct (refer to section 12.3.2), as their influence is generally concentrated within this precinct.

Moore Park

Moore Park consists of three major precincts, the SFS (also referred to as Allianz Stadium), the SCG and the Entertainment Quarter, which hold a diverse array of events with varied transport requirements. The sporting stadiums receive the majority of patrons; however, the Entertainment Quarter (such as the Hordern Pavilion and Royal Hall of Industries) holds a greater number of smaller events. Key 2011 event statistics for Moore Park are summarised in Table 2.3 of Technical Paper 1 (Transport Operations Report), while a full breakdown of attendance and frequency at the Moore Park Precinct is presented in Figure 9.3.

The majority of events at Moore Park are characterised by a peak entry and exit period demand profile with a large surge in demand for transport services prior to and, particularly, at the conclusion of events such as sports games or concerts. While pre-game entertainment and opening acts tend to spread the demand for transport as patrons arrive, 75 to 85 per cent of attendees leave venues within 20 minutes of events finishing. Longer events such as cricket and the Australian Football League (AFL) experience higher numbers of patrons leaving before the event finishes.

Figure 9.2 Future City Centre bus network



Source: Sydney City Centre Access strategy - for further consultation (Transport for NSW 2013)

Planned city centre key bus corridors

Bus stop precincts (indicative)

Figure 9.3 Moore Park 2011 event attendance and frequency

Source: Figure 2-6 of Technical Paper 1 (Transport Operations Report)

Across the spectrum of events held at the sporting stadiums walking, driving and event bus are the main modes with:

- 40 to 50 per cent walking, including approximately 12,000 spectators that are estimated to walk to/from Central Railway Station for a capacity event
- 35 to 50 per cent driving
- 5 to 20 per cent catching an event bus.

Estimated event bus mode share for music festivals is significantly higher at 35 per cent, likely due to the younger average age of music festival attendees when compared with other event types. Mode share data for the Entertainment Quarter is unavailable; however, special event buses are not provided due to the relatively small crowd sizes.

Estimated transport mode share for Moore Park is presented in Table 2.4 of Technical Paper 1 – *Transport Operations Report.* Discussion on the three main modes of access to Moore Park (i.e. walking, driving and special event buses) is provided in Table 9.2.

Table 9.2 Summary of main modes of access to Moore Park

MODE	DISCUSSION
Walking	Significant numbers of customers walk to Moore Park, many of whom walk to access rail services at Central Railway Station. Upwards of 10,000 people attending a typical cricket or AFL game arrive on foot, of which approximately 30 per cent travel along Fitzroy and Foveaux streets from Central Railway Station. The walk between Central Railway Station and Allianz Stadium is 1.65 kilometres or approximately 25 minutes.
Driving	A typical cricket match currently attracts upward of 12,000 attendees arriving by car. Maximum car parking capacity is estimated at 5,700 spaces spread between a number of locations including on-grass, temporary and permanent facilities. Permanent parking facilities are available and supplemented by on-grass parking as follows: Permanent parking: • SFS Members Car Park (approximately 700 spaces) • Entertainment Quarter (approximately 2,000 spaces). Temporary parking: • Kippax and Area 2 on-grass parking areas (approximately 2,500 spaces) • Sydney Boys High School (approximately 500 spaces). Vehicles leaving Moore Park following an event cause congestion on the surrounding road network, frequently resulting in egress times from the precinct of 50 to 75 minutes.
Special event buses	Event bus mode share varies significantly by event type with music festivals, cricket and AFL matches comprising the highest shares. The spike in bus mode share for music festivals is likely due to the younger average age of attendees when compared with other event types. Routes operate between Moore Park and Central, Circular Quay, Goulburn Street car park and the UNSW; however, not all routes service every event. Further information on event bus operations is provided in section 2.4.2.3 of Technical Paper 1 (Transport Operations Report). Buses disembark passengers at a specially designed high-capacity bus hub located adjacent to the SCG and a short walking distance from Allianz Stadium and the Entertainment Quarter (as shown in Figure 9.3). Following large events passenger queues extend toward Driver Avenue and into the Area 2 parking area. Event bus services access the Moore Park event bus hub via the Anzac Parade Busway. Bus services from Central Railway Station approach via Albion Street and Flinders Street. Event bus services accessing via the Eastern Distributor access the bus roadway from Todman Avenue at Robertson Road. Event buses are stacked on the event bus loop road on the approach to the event bus hub as well as the Busway between Moore Park Road and Gregory Avenue (southbound).

Royal Randwick racecourse

Historically, Royal Randwick racecourse has only been heavily used by major events on designated race days. In 2011, this comprised 12 race days ranging in size from around 5,000 to over 25,000 attendees for the Randwick Derby and the Epsom Handicap. However, there is a growing trend toward hosting significant non-racing events at Royal Randwick (for example, UNSW bi-annual examinations and the annual Future Music festival). It is expected this trend will continue following the development of the site.

Race days are characterised by a greater 'spread' in their transport demand profile when compared with other major sporting and music events, with a much less pronounced peak demand in both the access and egress periods. In addition, races tend to be held on weekends and rarely coincide with the regular commuter peak, making events at Randwick easier to manage from a transport perspective.

Discussion on mode share and bus operations during special events at Royal Randwick racecourse is provided in the following sections.

Mode share

Event bus mode share for Saturday race days averages eight per cent of total attendance. Mode share increases for race days with higher attendance; those with greater than 15,000 attendees averaged 11 per cent bus share in 2011. Additionally, mode share is typically higher on the return leg away from Randwick. Taxis play a particularly significant role as a mode of access on race days.

Event bus mode share was significantly higher at the Future Music Festival in 2011, averaging 33 per cent overall, comprising 27 per cent on the forward leg and 40 per cent on the return leg. This higher mode share is likely a result of the lower average age of attendees to the music festival.

Special event bus operations

Special event buses operate to support transport to Saturday race days and Melbourne Cup day. Saturday race days attract on average 14,000 attendees, with major race days attracting up to 25,000 patrons. Additionally, event buses have supported the annual Future Music festival, which in 2011 had over 40,000 attendees.

In 2011, nearly 1,400 bus trips served events at Royal Randwick racecourse. A shuttle service, the Route 32, is offered between Central Railway Station (Eddy Avenue) and the racecourse. Buses disembark passengers at the Alison Road bus terminus at the northern edge of the site. Statistics on special event buses to and from Royal Randwick for 2011 are provided in Table 9.3.

Table 9.3 Royal Randwick racecourse 2011 special event bus statistics

METRIC	MUSIC FESTIVAL	RACES
Bus trips	471 (average number of trips)	73 (average number of trips)
Passengers forward (via Route 32)	11,234	787
Passengers return (via route 32)	16,874	1,992

Source: Table 2.7 of Technical paper 1 - Transport Operations Report, Volume 2

Future growth in travel demand

In the future, increasing travel demand across Sydney's transport network will be driven by ongoing growth in population and employment, and the accompanying major trip generating land uses, including retail, tourism, health and education. NSW Government forecasts depict strong growth in both population and employment in the City of Sydney and Randwick local government areas (LGA). Key changes within the City of Sydney and Randwick LGAs between 2006 and 2031 (based on Urbis 2011 and Destination NSW 2012) are expected to include:

- Large population increases expected in both the City of Sydney (99,000, growth of 60 per cent) and Randwick (24,000, growth of 19 per cent) LGAs. These population changes are expected to result in a large increase in residential density (persons/hectare) in the Sydney LGA and a moderate increase in the Randwick LGA.
- Employment increase of 140,000 workers in the Sydney LGA, up from 430,000 to 570,000 (growth of 33 per cent), and an employment increase of 13,000 in Randwick LGA (growth of 31 per cent). These employment changes are expected to result in a large increase in employment density (persons/hectare) in the Sydney LGA and a moderate increase in the Randwick LGA.

There are also a number of major developments proposed in the vicinity of the CSELR alignment, including:

- Barangaroo
- Sydney International Convention, Exhibition and Entertainment precinct
- UNSW Campus Development
- Randwick Urban Activation Precinct
- Green Square Town Centre.

An overview of the key features and anticipated timing of the above developments is provided in section 9.3 and Chapter 11 to 17.

As Sydney's CBD continues to expand due to population growth and development, the number of people commuting daily to and from the city will increase. The need to move large numbers of people into and through a constrained area within a narrow time period places strain not only on the transport network in the city centre, but on the whole metropolitan transport system. Car, bus and rail networks all experience congestion in the Sydney CBD and on major approaches from the South East.

Increasing development in the inner region of Sydney would place greater pressure on the surface transport system as new developments increase trip requirements to the area for residential, commercial and leisure purposes. Discussion on the anticipated growth in travel demand from the above major developments is provided in the following sections.

Barangaroo

When fully occupied, Barangaroo is forecast to generate about 22,000 trips in the morning peak two hours, and about 25,000 trips in the afternoon peak three hours, based on the 'moderate growth' scenario.

The Barangaroo Development Authority has forecast that 33,000 visitors per day (business and leisure) would arrive at the site. The majority are expected to be travelling off-peak and to come from many directions, not only via Wynyard. This leads to a demand profile with a greater 'spread' into the off-peak than is typical for the northern CBD. However, the development is still anticipated to contribute to growing peak hour demand and will contribute to a growing concentration of financial and professional service jobs in the northern CBD.

To ensure that Barangaroo does not contribute to additional CBD surface transport congestion, planning approval for Barangaroo south (the commercial, 'CBD extension' component of the wider Barangaroo development) is based on the principle of achieving high usage of public transport to the site. These targets anticipate only five per cent of trips will be undertaken by private vehicle.

Sydney International Convention, Exhibition and Entertainment precinct

The redevelopment of the Sydney International Convention, Exhibition and Entertainment precinct is anticipated to increase off-peak demand to the Darling Harbour precinct as increasingly large events are hosted in Sydney.

On completion, the precinct will be Australia's largest exhibition space to date with increased space to accommodate for more than 12,000 people in 35,000 square metres of dedicated space and 5,000 square metres of flexible space (Infrastructure NSW 2013). Banqueting and meeting facilities are estimated to double the current capacity, whilst there will be a reduction in capacity for entertainment facilities, indicating a focus on international and national conventions and exhibitions as key economic drivers, with aims to generate more and bigger events than current capacity constraints permit. Event attendee increases will be combined with both short-term and long-term increases in the precinct's population, with anticipated employment generation of 1,600 jobs during construction and 4,000 ongoing positions, and 2,100 construction jobs and 2,000 ongoing positions associated with the associated city hub 'The Haymarket'.

University of NSW

Historic growth in trips to UNSW has been relatively strong, with internal enrolments at UNSW (reflecting the majority of Kensington campus students) increasing at a rate of 3.9 per cent over the past decade. However, there has been significant variability in year to year growth over that time — particularly due to changes in Commonwealth Government policy settings. The removal of the cap on Commonwealth Supported Places in 2009 saw a reinvigoration of demand that may be expected to continue as Universities seek to ensure secure sources of funding in the future.

An increasing majority of students are using public transport to access the campus, as the supply of nearby parking spaces has remained static, with around half of students accessing the campus between 8 am and 10 am. In the evening, peak student departure times are more closely aligned with the regular peak period with 51 per cent of students departing between 4 pm and 7 pm (UNSW Travel Survey 2012).

Urban Activation Precincts

In March 2013, the NSW Government announced the Urban Activation Precincts (UAP) program. UAPs are important areas that the NSW Government considers to have a wider social, economic, or environmental significance for the community or have redevelopment significance of a scale that is important to implementing the State's planning objectives such as housing and employment targets. The aim of the UAPs program is to deliver more residential and employment opportunities in places with access to infrastructure, transport, services and jobs. Further detail of the UAP program and the potential impact on future growth in travel demand is provided in section 9.3 and Chapter 15.

Green Square Town Centre

Green Square is one of Australia's largest urban renewal projects, anticipated to attract 40,000 new residents and 22,000 new workers by 2030. This project will significantly alter transport patterns in the precinct from a primarily industrial and manufacturing use to a mixed-use commercial and residential precinct. While employment growth in the area is more moderate than residential growth, the nature of employment purposes in the precinct will change as the nature of businesses shifts from current industrial use to more generic commercial and retail. In addition, the peak flow nature of transport movements in the area driven by employment purposes will moderate, and residents who live in the Green Square precinct but work outside it will begin to increase demand for contra-peak transport flows.

9.2.2 Impacts during operation

A detailed operational traffic and transport assessment for the CSELR proposal was undertaken by Booz & Company and AECOM. A comprehensive technical report is available as Technical Paper 1 — *Transport Operations Report* in Volume 2.

A summary of the regional traffic, transport and accessibility impacts (both positive and negative) likely to be associated with the operation of the CSELR proposal is provided in the following sections. Discussion on local traffic, transport and accessibility impacts within each of the five precincts assessed in this EIS is provided in sections 12.3.2 (City Centre Precinct), 13.3.2 (Surry Hills Precinct), 14.3.2 (Moore Park Precinct), 15.3.2 (Randwick Precinct), and 16.3.2 (Kensington/Kingsford Precinct).

Key regional transport benefits

Introducing light rail to the CBD and South East suburbs would provide substantial regional transport benefits to address current transport challenges, as discussed in Chapter 3 and summarised here.

Buses currently cater for significant travel demand, and the need for capacity has caused significant growth in the number of buses accessing the CBD which deteriorates the reliability of bus services and negatively impacts the amenity of the CBD. The bus network cannot continue to grow to meet demand without increasing congestion levels.

The CSELR proposal would offer a high-capacity transport option that:

- carries up to 300 commuters per light rail vehicle, the equivalent of around five regular buses on the road space of only two buses, resulting in total capacity on the line for 9,000 passengers per hour
- results in 180 fewer buses entering the city centre in the morning peak hour between 8 am to 9 am (however, in combination with the revised city centre bus network, 220 fewer buses would enter the city centre during the same time period)
- accommodates future growth by providing additional capacity that is able to meet future challenges
- provides opportunities to connect to cross-regional destinations at major interchanges, growing the capacity of the broader transport system.

Customers currently receive transport services that do not meet expectations, with only 50 per cent of commuters satisfied with service timeliness (Bureau of Transport Statistics 2012). Transport for NSW analysis suggests only 19–24 per cent of buses arrive within two minutes of their scheduled times during the morning peak due to the substantial congestion they experience when accessing CBD gateways.

The CSELR proposal would offer a comfortable, reliable transport option that meets customer expectations by:

- delivering service reliability of 97 per cent, resulting in an improved experience for commuters
- partial pedestrianisation of George Street, which would improve pedestrian journeys and amenity
- integrated customer information and wayfinding between multi-modal connections, at all stops
- offering access to other public transport modes at interchanges along the route, such as heavy rail, bus and ferry.

Patronage of the CSELR

The future patronage demand profile for the CSELR proposal is estimated as follows:

- the proposal is expected to attract approximately 18,000 morning peak hour boardings in both directions in 2021, growing to around 23,000 by 2036
- patronage is predicted to peak at more than 5,300 passengers per hour in the 2021 morning peak on the approach to Central Railway Station
- driven primarily by student travel to UNSW, there is strong demand for contra-peak travel with patronage of approximately 4,100 passengers per hour in the 2021 morning peak hour and just over 3,300 alighting at the two UNSW stops
- in the 2021 morning peak hour, over 2,000 passengers are forecast to transfer from buses to light rail at the Kingsford stop and over 1,600 passengers at the Randwick stop
- total demand to the CBD from the CSELR corridor is expected to be almost 4,000,000 trips by 2036.

Light rail stop access and egress

Accessibility to light rail would play a significant role in the CSELR proposal's success. Access to light rail stops would need to cater for all modes (including pedestrians, cyclists, bus, heavy rail, light rail and car) and provide an easily accessible, legible and attractive public transport system.

The key issues for the proposed stops comprise:

- resolving stop access issues for pedestrians
- enabling a seamless transition from different public transport modes (including ferry, bus, light rail and heavy rail) to light rail
- positioning bus stops to allow for safe and efficient transfers.

An overview of the anticipated stop access mode share is provided in the following sections. Detailed access plans for each of the proposed light rail stops (including any key actions to address potential multimodal access, customer safety, or to improve access) are provided in section 7.3 of Technical Paper 1 – *Transport Operations Report*.

Stop access mode share

Forecasts of the future access mode share for the CSELR proposal have been derived from a Public Transport Project Model (PTPM) that was developed by the NSW Bureau of Transport Statistics. The anticipated light rail stop mode share across the entire light rail corridor for the assessment year 2021 is provided in Table 9.4.

Table 9.4 Light rail stop forecast mode share for 2021

YEAR	MORNING PEAK LIGHT RAIL TRIPS BY ACCESS MODE				ACCESS MODE SHARE		
	BUS/ FERRY	WALK	HEAVY/LIGHT RAIL	TOTAL	BUS/ FERRY	WALK	HEAVY RAIL
2021	9,497	5,589	2,782	17,867	53%	31%	16%

Source: Table 7-1 of Technical Paper 1 – Transport Operations Report, Volume 2.

Table 9.4 shows that buses would be the anticipated primary mode of access to light rail stops, accounting for more than 53 per cent of all passengers during the morning peak. The second highest forecast mode share for light rail access is walking, with over 31 per cent of all passenger access forecast by pedestrians. Heavy rail interchange is expected to provide the next highest at approximately 15 per cent of all passengers during the morning peak.

There would, however, be significant variance within the anticipated levels of modal demand for access to light rail across the system, dependent on the stop location and availability of complementary public transport stations, stops and services. Notable exceptions would be the Town Hall and Central Station stops, both of which would experience a significant heavy rail to light rail interchange due to the proximity of the major, established CBD heavy rail stations.

Vehicular access

Whilst it is not anticipated that there would be a significant need to provide vehicular access at stops (as the intent of the CSELR proposal is to contribute to the delivery of a high quality public transport system, with good local pedestrian access), it is inevitable that there would be a need to provide for some degree of access to the system by private vehicles. This would be especially critical at the terminus locations at Randwick and Kingsford. Therefore, it is proposed that a small number of car share bays and vehicles be accommodated at a number of locations along the CSELR alignment to cater for potential linked car trips. In addition, where appropriate and provision can be made within local conditions, a degree of very short-term parking, in the form of kiss-and-ride bays and taxi bays would be made available to cater for onward travel by private vehicle and taxi.

A review of potentially feasible car share locations has been undertaken based on a review of car share demand profile data. A number of priority locations along the CSELR have been identified and these are set out in Table 9.5.

Table 9.5 Car share priority locations along the CSELR alignment

PRIORITY	LOCATION
1	CBD, Grosvenor Street, Wynyard, Queen Victoria Building, Town Hall, World Square, Chinatown, Rawson Place, Central Station, Surry Hills
2	Randwick, Strachan Street, Kingsford
3	Wansey Road, UNSW Anzac Parade, Carlton Street, Todman Avenue, UNSW High Street

Source: Table 7-2 of Technical Paper 1 – Transport Operations Report, Volume 2.

Bicycle access

Bicycle u-rails are proposed at Circular Quay and at all non-CBD light rail stops, located on the street adjacent to, or at, the stop. This would cater for demand at strategic points on the light rail system in close proximity to the strategic bicycle network. Secure lockers would also be provided at the Randwick and Kingsford stops, supplemented by u-rails.

Integration with the existing road network

Light rail vehicle road network integration

An essential feature of the CSELR proposal would be the operation of light rail vehicles (LRVs) within the road network. The safe interaction of LRVs with other road users has been a major consideration of the development to date. Furthermore, this interaction would influence the overall journey time and service reliability of the CSELR proposal.

A key feature of the CSELR is that, for the majority of the proposed route, LRVs would operate within an exclusive right of way. This would provide an operating environment that is both safe and free from the adverse effects of road congestion. However, at intersections and at a limited number of other locations, LRVs would share the right of way with other road users.

It is proposed that LRVs would progress through intersections under signal control. Traffic signals would be designed to detect the approach of an LRV in sufficient time to activate a (‘call’) green signal for the LRV as it approaches the intersection. The traffic light controller would ensure that other conflicting movements (i.e. cross roads and pedestrian crossings) face red or stop signals. The design intent is for LRVs to be able to proceed through all intersections with minimal delay.

However, the design of each intersection would have regard to all road users and the overall performance of the transport network. The Sydney Coordinated Adaptive Traffic System (SCATS) is designed to ensure the operation of each intersection achieves the optimal performance for the network as a whole. The road network management system would be expanded in future to accommodate LRV operation as well.

In practice, LRVs would be expected to experience small delays at some intersections depending on the direction of travel and the time of day. This would be due to the need to maintain effective signal coordination for the road network. Estimates of these delays to LRVs have been factored into the proposed light rail journey time forecasts. The amount of delay would depend on the final design of the intersections and traffic light control system which would be completed during the detailed design phase of the proposal.

There are limited locations where LRVs would operate in a shared environment, which include:

- LRVs would share the existing (modified) busway from Anzac Parade to Doncaster Avenue
- buses would share the LRV right-of-way from the Kingsford stop through to UNSW
- right turning vehicles would be permitted to share the LRV right-of-way in High Street at Botany Street.

In each case these arrangements are proposed to avoid increasing the land required for the CSELR proposal and to avoid unreasonable impacts on other road users.

Functional changes to the road network

The CSELR proposal would be integrated within the existing surface street environment and, as such, would require a number of significant changes to be made to the way in which the road network is designed and operated. Ultimately, the objective of the CSELR proposal is to maximise the level of passenger carrying capacity along the corridor and ensure a superior customer experience to encourage public transport usage. To achieve this, a number of key network changes would be required, including:

- an increase in public transport carrying capacity along the corridor
- pedestrianisation of sections of George Street and Alfred Street in the CBD
- development of significant transport interchanges at Circular Quay, Rawson Place, Chalmers Street, Randwick and Kingsford
- re-prioritisation of the road hierarchy and kerbside uses in the CBD, Surry Hills, Randwick, Kensington and Kingsford.

The key functional changes and high level operational characteristics that are proposed as part of the CSELR proposal are described on a precinct by precinct basis in sections 12.3.2 (City Centre Precinct), 13.3.2 (Surry Hills Precinct), 14.3.2 (Moore Park Precinct), 15.3.2 (Randwick Precinct), and 16.3.2 (Kensington/Kingsford Precinct). A summary of these network changes is provided in Table 9.6.

Principles were defined to guide the development of the future road network strategy. The principles were designed to ensure that, in specifying the road network, the overall objective of maintaining safety for all users, maximising transport system performance and usage, and successfully integrating the light rail network with the road network, was upheld. The key principles comprised the following:

- consolidation of right turns movements across the alignment, which would only be permitted at signalised intersections. (This would provide light rail reliability benefits, as well as traffic capacity and safety improvements by minimising uncontrolled conflicting vehicle movements; however, some exceptions would apply on George Street for local property access.)
- balancing the future needs of the various transport modes within the limited road space available
- providing signal controlled pedestrian crossing access to stops, to ensure less mobile passengers or persons with a disability are given audible and visual invitations to cross traffic under full signal protection
- providing high quality interchange functionality with sufficient capacity for future operations
- minimising traffic capacity reduction
- providing sufficient capacity on footways and crossing points to accommodate the growth in pedestrian traffic (particularly around light rail stops)
- providing bus lanes where bus volumes are such that bus priority measures are warranted
- retaining all current property accesses on the corridor, although time or movement restrictions may be applied in specific locations.

Table 9.6 Key road network changes proposed as part of the CSELR

ROAD	DESCRIPTION OF KEY ROAD NETWORK CHANGES PROPOSED AS PART OF THE CSELR
George Street and Alfred Street	The most significant change would be the transformation of George Street from a vehicle-based corridor (that currently forms a significant north-south connection in the CBD) to a part-pedestrianised public transport spine for the city, dedicated to the efficient delivery of light rail services to the heart of the city. The pedestrian zone delivered in conjunction with the CSELR would yield substantial sustainability and amenity benefits through the provision of a high-quality, safe and comfortable pedestrian connections through the heart of the CBD. A pedestrian and vehicle shared zone is proposed on George Street, between Bathurst and Hunter Streets and adjacent to the proposed CSELR corridor. This shared zone would allow vehicles to use an area of the pedestrian zone to travel down the side of the CSELR corridor (at a maximum speed of 10 kilometres per hour) to access driveways and loading areas, where vehicles would be able to park to service properties on either side of George Street. At signalised intersections and stop lines, vehicle queuing and turning movements would be controlled. Signposting and traffic restrictions would be determined by the relevant road authority and could be flexible depending on policy. Taxis and hire cars exiting the Hilton Hotel would be permitted to turn left into the Park Street bus lanes, whilst general traffic would proceed southbound to Bathurst Street. Vehicles could be discouraged from travelling further than one block by signposting. Vehicle restrictions would ensure only local access, service delivery and emergency vehicles are permitted within the shared zone. The detailed streetscape design of George Street would include defined areas for pedestrians and LRVs through visual cues, such as changing pavement types. Outside of the pedestrian zone, the standard George Street cross-section would consist of a single kerbside traffic lane in each direction with centre running light rail. This would reduce the importance of George Street as a route for through-running traffic.
Pitt Street	Pitt Street would be converted into two-way operation between Bridge Street and Alfred Street. A turning circle would be provided at the northern terminus of Pitt Street.
Hunter Street	Hunter Street would be converted into two-way operation between George and Pitt Streets to provide enhanced east-west connectivity.
Chalmers Street, Randle Street, Elizabeth Street and Eddy Avenue	Chalmers Street would function as a major light rail/heavy rail interchange for Central Railway Station. The proposed Chalmers Street stop would be located on the western side of Chalmers Street, which would reduce the number of lanes available to buses and general traffic. A single general traffic lane would be provided on Chalmers Street, with traffic using this lane only permitted to turn left into Eddy Avenue as well as retaining access to existing properties on Chalmers Street. Buses would be retained in Chalmers Street and would be permitted to proceed into Elizabeth Street. To compensate, Randle Street would be reversed from one-way southbound to one-way northbound together with additional northbound lanes in Elizabeth Street between Randle Street and Chalmers Street. Signalisation of Elizabeth Street/Chalmers Street and the Randle Street intersection is required to ensure conflicting light rail, traffic and pedestrian movements are separated, whilst providing improved pedestrian access to Central Railway Station and light rail transport hubs. Due to the two-way movements in Elizabeth Street, direct access to Randle Lane from the north would not be possible, but would be maintained via Rutland, Chalmers and Randle streets.
Devonshire Street	Significant changes to Devonshire Street would be required to facilitate provision of light rail in the southern lanes. The primary changes would include: • provision of a single eastbound traffic lane • consolidating existing right turn movements for vehicles travelling eastbound along Devonshire Street wishing to head south to Elizabeth Street and Crown Street only • the closure of a number of connecting streets at the Devonshire Street intersection • removal of parking from Devonshire Street. To mitigate these local access impacts, a number of network changes are proposed to improve accessibility whilst maintaining the benefits to light rail operations including: • signalising the intersection of Devonshire Street and Marlborough Street • signalising the intersection of Devonshire Street and Bourke Street • reinstatement of the Cooper Street connection to Riley Street to provide access for local residents • introduction of a westbound service lane connection between Bourke Street and Crown Street; all turning movements would be provided at the Bourke Street intersection to provide entry, with left turns out permitted from side roads and in to Crown Street.
South Dowling Street	The CSELR proposal would cross South Dowling Street at grade, passing over the Eastern Distributor via a new light rail bridge (consolidated with a pedestrian footway) to enter the proposed Moore Park tunnel. To manage traffic in this area, southbound and northbound traffic on South Dowling Street would be controlled by signals.

Table 9.6 cont.

<table>
<tr><th>ROAD</th><th>DESCRIPTION OF KEY ROAD NETWORK CHANGES PROPOSED AS PART OF THE CSELR</th></tr>
<tr><td>Anzac Parade</td><td>The CSELR would generally operate in the existing median on Anzac Parade, with the exception for a section of track situated within Moore Park, on the eastern side of Anzac Parade, where the proposal would run adjacent to the eastern side of the existing segregated bus roadway (which would be retained). A section of track near UNSW would also come to the eastern edge. The available corridor width enables the retention of at least two general traffic lanes on Anzac Parade in each direction, with a third lane provided for peak hour bus priority and off-peak local parking, where possible.
Due to the operation of light rail in the median, a reduction in permitted right turn locations would be required. South of Alison Road, right turn locations would be restricted to:
• southbound right turn into Dacey Avenue
• southbound and northbound right turn into Todman Avenue
• northbound right turn into High Street
• southbound and northbound right turn into Barker Street
• southbound right turn from Anzac Parade into Gardeners Road.
Existing right turn movements from signalised side roads into Anzac Parade would be retained.
Other design considerations include:
• a fully integrated light rail stop design at the Kingsford stop, permitting cross-platform interchange for the significant volume of customers expected to access the CSELR proposal by bus
• a shared running arrangement between the Kingsford stop and UNSW Mall, providing an opportunity to deliver operational priority for buses while also improving the functioning of the Gardeners Road/Anzac Parade intersection through the signalisation of the current Nine Ways intersection
• redesign of the Anzac Parade/Alison Road intersection to allow a two stage transition of the alignment from the eastern side to centre running
• conversion of the Nine Ways roundabout to a signalised intersection with controlled pedestrian access points.</td></tr>
<tr><td>Alison Road</td><td>The CSELR would operate within the existing busway alignment on the north/east side of Alison Road between Anzac Parade and Doncaster Avenue, which would facilitate the retention of existing traffic movements and lane configurations on the northern side of Alison Road. The CSELR would cross Alison Road at Doncaster Avenue to run adjacent to Royal Randwick racecourse on the southern side of Alison Road, before turning into Wansey Road.
Corridor width restrictions would restrict citybound traffic to two through-lanes adjacent to the Darley Road/Alison Road intersection. On-street parking would also be removed in this section of the corridor.</td></tr>
<tr><td>Wansey Road</td><td>The CSELR alignment would be located on the western edge of Wansey Road, with two-way traffic retained; however, on-street parking would be removed. The existing cycleway and footpath would be retained on the western side of Wansey Road.</td></tr>
<tr><td>High Street</td><td>The CSELR alignment would adopt a ‘centre-running’ arrangement along High Street (between Wansey Road and the Randwick stop) with a single kerbside traffic lane maintained in each direction (i.e. road vehicles would operate on either side of the CSELR tracks). Key design considerations include:
• introduction of traffic signals at the intersection of High Street and Hospital Road, as well as the intersection of High Street and Clara Street
• consolidation of the vehicular entrance to at the Prince of Wales Private Hospital to a four way intersection at Clara Street
• restriction of access to Eurimbla Avenue to left-in left-out
• additional parking restrictions and the removal of parking spaces on High Street and Wansey Road
• provision for indented bus bays for westbound buses on High Street adjacent to the Prince of Wales Private Hospital and between Botany Street and Wansey Road
• removal of the eastbound bus stop in High Street, between Wansey Road and Botany Street, with eastbound buses required to use the existing bus stop in High Street, west of Wansey Road and the proposed new stop in Clara Street
• relocation of the westbound bus stop adjacent to the Sydney Children’s Hospital emergency entrance to Clara Street, with access to the hospital via a signalised intersection.</td></tr>
</table>

An information and education program would be developed and implemented for the CSELR proposal to advise road users of the changed traffic conditions with respect to the introduction of the proposal and any interactions with LRVs on the road network.

Intersection performance – Proposed South Dowling Street at-grade crossing

As outlined in section 5.2.1, the CSELR proposal would cross South Dowling Street at-grade, passing over the Eastern Distributor via a new bridge prior to entering the proposed Moore Park tunnel. To manage traffic in this area, southbound and northbound traffic on South Dowling Street would be controlled by signals.

VISSIM traffic modelling of South Dowling Street (between Cleveland Street and Fitzroy Street) was undertaken to test the impact of the proposed at-grade CSELR crossing of South Dowling Street for the following four scenarios:

- *Base case* — existing situation (i.e. operation without implementing the CSELR proposal)
- *No priority* — LRVs receive no form of pre-emptive signal priority and have to wait for their phase to appear as part of the traffic signals sequence
- *Medium priority* — LRVs receive a degree of pre-emptive signal priority but with some restrictions (i.e. LRVs are detected on approach to the crossing and if detected at a time when the main north-south traffic movements are on red at the adjacent intersections the light rail phase is called immediately)
- *Special events* — 90 metre long LRVs operating in the afternoon peak under medium light rail signal priority (as described for the 'medium priority' option). (No morning peak modelling was undertaken for this scenario as special event, 90 metre long LRVs, would only coincide with the afternoon peak hour.)

Intersection performance for each of the three CSELR operating scenarios (i.e. no priority, medium priority and special events) was compared with the base case using the following statistics:

- vehicle travel times on South Dowling Street (northbound and southbound)
- vehicle maximum queue lengths
- intersection level of service
- delay experienced by LRVs
- 'green time distribution' (the length of time that a traffic signal is green for a particular traffic movement) at the proposed light rail intersection.

Results of the VISSIM traffic modelling for South Dowling Street are provided in section 5.4.2 of Technical Paper 1 – *Transport Operations Report* and summarised in Table 9.7. Details on the extent of the model and key assumptions used during the assessment are also provided in section 5.4.2 of Technical Paper 1 – *Transport Operations Report*.

In summary, the introduction of a signalised at-grade crossing of South Dowling Street for the CSELR proposal would slightly affect current road network performance. Introduction of this crossing would result in a seven per cent increase in vehicle travel times (or seven seconds) on South Dowling Street during the morning peak under the medium CSELR operating scenario (when compared to the base case — existing situation); however, intersection levels of service and queue lengths would not be significantly affected. Further analysis using special event traffic volumes and post light rail traffic assignments would be undertaken during the development of detailed design.

Table 9.7 Summary of VISSM traffic modelling results for South Dowling Street

STATISTIC	SUMMARY OF RESULTS
Vehicle travel times	Relative to existing road operation (i.e. the 'base case'), the CSELR proposal would result in a seven per cent increase (or seven seconds) in vehicle travel times on South Dowling Street during the morning peak; however, travel times during the afternoon peak would remain unchanged. Under the 'special event' scenario, the afternoon peak travel times would be expected to increase by five per cent (or six seconds) when compared to the 'base case'.
Vehicle maximum queue lengths	Maximum queue lengths at the South Dowling Street/Cleveland Street intersection and the South Dowling Street/Moore Park Road/Fitzroy Street intersection would be unaffected by the proposed CSELR crossing. However, maximum queue lengths at the proposed CSELR crossing of South Dowling Street would increase by up to 158 metres during the 'special events' scenario. These queue lengths would be contained within the existing available road storage space and would not affect network operations.
Intersection level of service	Intersection levels of service would be largely unaffected by the introduction of the CSELR proposal.
Delay experienced by LRVs	The level of delay experienced by a light rail would vary considerably depending upon the level of intersection priority adopted. Delays of between 11 and 23 seconds could be achieved with a medium level of priority that maintains traffic coordination of the adjacent key north-south intersections. Under the 'special events' scenario, this delay would decrease to 4–9 seconds as a result of the longer green times provided at the crossing.
Green time distribution	A comparison of the green time distribution between road and LRV movements under the 'no priority' and 'medium priority' scenarios is provided in Table 5-17 of Technical Paper 1 – *Transport Operations Report*.

Road network performance

Implementation of the CSELR proposal, along with the wider associated bus network changes in the CBD and South East suburbs (as discussed in section 9.2.1), would result in a considerable change to current traffic operating patterns. A key objective of the CSELR proposal is to provide a step change in public transport carrying capacity and journey time reliability that is achieved through reallocation of available road space and providing segregated running of light rail wherever possible. As such, a likely outcome of the CSELR proposal is that existing traffic on the light rail corridor would be displaced. This traffic would adopt one of three alternative behaviours:

- *Change mode* — A proportion of current road users are predicted to change mode from private vehicles to public transport, taking advantage of the reduced journey times and improved reliability the light rail system would provide through the CBD.
- *Change time of travel* — Increasingly flexible working arrangements provide some commuters with the ability to adjust their time of travel to avoid the most congested periods of the day.
- *Reroute to other corridors* — Displaced traffic would seek alternative routes that provide a lower level of delay. However, given much of the network is congested during the peak hours, alternative options are likely to be limited.

The potential effects of the proposed reallocation of road space from traffic lanes to dedicated light rail running were assessed (using an assessment year of 2021) through a mesoscopic modelling assessment (regionally based traffic modelling technique) using the following two scenarios:

- *Do-minimum (year 2021)* — accounts for future traffic growth on the road network without the implementation of the CSELR proposal.
- *Implement the CSELR proposal (year 2021)* — accounts for the reallocation of road space for the CSELR proposal and associated change to existing traffic patterns and network performance, as well as the forecasted future traffic growth on the road network (as per the 'do-minimum' scenario).

Results of the mesoscopic modelling of road network performance are provided in section 5.4.3 of Technical Paper 1 – *Transport Operations Report* and summarised in Table 9.8. Details on the extent of the model and assessment methodology are also provided in section 5.4.3 of Technical Paper 1 – *Transport Operations Report*.

In summary, by the year 2021, traffic volumes in the assessed area are forecast to grow by seven per cent (19,400 extra vehicles) for the 'do-minimum' scenario (i.e. not implementing the CSELR proposal). This level of traffic growth would likely result in a 10 per cent reduction in average vehicle speeds in comparison to current road traffic levels.

The implementation of the CSELR proposal is predicted to reduce the level of traffic growth forecasted for the 'do-minimum' scenario due to the positive effect the CSELR proposal would have on the public transport mode share which, as a result, would contribute to improved traffic and bus operations. The modelling shows that the reallocation of road space from general traffic would not have a significant adverse impact on the functionality of the wider network.

In the morning peak, the CSELR proposal would only result in a small reduction in travel speeds for general traffic of 0.2 kilometres per hour, when compared to the 2021 'do-minimum' scenario. Similarly, a small reduction in bus travel speeds of 4 per cent is predicted as a result of the CSELR proposal, when compared to the proposed redesign of the city centre bus network without the CSELR proposal (as per the 'do-minimum' scenario). However, when compared to the existing situation, the CSELR proposal, in conjunction with the proposed redesign of the bus network, would deliver a 12 to 25 per cent increase to existing bus speeds on the network.

In the afternoon peak, the CSELR proposal would improve general traffic speeds in the wider network by one kilometre per hour or four per cent, with bus speeds relatively stable with only a 0.2 kilometre per hour (approximately one per cent) reduction. In the CBD, the CSELR proposal would result in a general improvement in operations with an increase in general traffic speeds of 2.5 kilometres per hour or 13 per cent and bus speeds increasing by 0.4 kilometres per hour or five per cent. It is noted that the results of the mesoscopic modelling represent average road network performance and, therefore, road network performance could vary between locations.

Generally, the traffic analysis demonstrates that the CSELR proposal could be introduced into the road network without significant detrimental impact to general traffic and buses. A number of critical intersections have been identified where further design and optimisation work is underway, with potential solutions identified.

To address the effects of the identified future traffic patterns, Transport for NSW and NSW Roads and Maritime Services (RMS) are working together to develop an appropriate Network Management Plan. This includes intersection modifications, traffic signal changes and traffic management measures that integrate to deliver the overall strategy for network operations with CSELR proposal in place. This work is ongoing and the modelling assessment undertaken to date represents the first stage in the development of this wider Network Management Plan. As this plan is refined, further improvement to the operation of the network is likely to be achieved.

Transport for NSW would continue to work closely with RMS and local councils to mitigate the potential network and local traffic impacts, including potential increased traffic flows that may occur on local roads as a result of the CSELR proposal.

Further discussion of bus network benefits associated with the CSELR proposal is provided in Chapter 3.

Table 9.8 Road network performance statistics

STATISTIC[1]	AM/PM PEAK ASSESSMENT PERIODS	DO-MINIMUM SCENARIO						IMPLEMENT THE CSELR PROPOSAL					
		MORNING PEAK			AFTERNOON PEAK			MORNING PEAK			AFTERNOON PEAK		
		2012 BASE	2021 'DO-MINIMUM'	% CHANGE	2012 BASE	2021 'DO-MINIMUM'	% CHANGE	2021 'DO-MINIMUM'	2021 WITH CSELR	% CHANGE	2021 'DO-MINIMUM'	2021 WITH CSELR	% CHANGE
Full model area													
Vehicle hours travelled	8–9 am 5–6 pm	11,045 h	12,776 h	+16%	11,816 h	15,433 h	+31%	12,776 h	13,015 h	+2%	15,433 h	14,540 hrs	-6%
Normalised vehicle hours travelled	3–7 pm	36,338 h	43,642 h	+20%	46,278 h	60,956 h	+32%	43,642 h	43,155 h	-1%	60,956 h	58,377 h	-4%
Vehicle kilometres travelled	5–6 pm	364,316 km	381,468 km	+5%	370,895 km	379,403 km	+2%	381,468 km	383,269 km	0%	379,403 km	379,212 km	0%
Normalised vehicle kilometres travelled	3–7 pm	1,259,408 km	1,314,229 km	+4%	1,429,419 km	1,590,409 km	+11%	1,314,229 km	1,366,034 km	+4%	1,590,409 km	1,584,329 km	0%
Average speed – all vehicles	5–6 pm	34.0 km/h	31.4 km/h	-8%	32.8 km/h	28.3 km/h	-14%	31.4 km/h	31.2 km/h	-1%	28.3 km/h	29.9 km/h	+6%
Normalised average speed – all vehicles	3–7 pm	34.6 km/h	31.4 km/h	-9%	30.9 km/h	26.1 km/h	-16%	31.4 km/h	31.6 km/h	+1%	26.1 km/h	27.1 km/h	+4%
Average bus speed	5–6 pm	18.6 km/h	22.2 km/h	+19%	16.8 km/h	15.4 km/h	-8%	22.2 km/r	21.1 km/h	-5%	15.4 km/h	16.0 km/h	+4%
	3–7 pm	19.4 km/h	22.6 km/h	+16%	17.2 km/h	16.8 km/h	-2%	22.6 km/h	21.7 km/h	-4%	16.8 km/h	16.6 km/h	-1%
Average delay	5–6 pm	64 s/km	74 s/km	+16%	70 s/km	106 s/km	+51%	74 s/km	79 s/km	+7%	106 s/km	96 s/km	-9%
	3–7 pm	56 s/km	68 s/km	+21%	69 s/km	99 s/km	+43%	68 s/km	70 s/km	+3%	99 s/km	94 s/km	-5%
Vehicles in network	At 7 pm	8,705	13,015	+50%	12,057	22,616	+88%	13,015	10,986	-16%	22,616	15,102	-33%

Table 9.8 cont.

STATISTIC[1]	AM/PM PEAK ASSESSMENT PERIODS	DO-MINIMUM SCENARIO						IMPLEMENT THE CSELR PROPOSAL					
		MORNING PEAK			AFTERNOON PEAK			MORNING PEAK			AFTERNOON PEAK		
		2012 BASE	2021 'DO-MINIMUM'	% CHANGE	2012 BASE	2021 'DO-MINIMUM'	% CHANGE	2021 'DO-MINIMUM'	2021 WITH CSELR	% CHANGE	2021 'DO-MINIMUM'	2021 WITH CSELR	% CHANGE
CBD													
Vehicle hours travelled	8–9 am 5–6 pm	2,651 h	3,103 h	+17%	2,894 h	4,236 hrs	+46%	3,103 h	3,224 h	+4%	4,236 hrs	3.630 h	-14%
	6–10 am 3–7 pm	8,216 h	10,288 h	+25%	10,829 h	15,031 hrs	+39%	10,288 h	10,115 h	-2%	15,031 hrs	13,562 h	-10%
Vehicle kilometres travelled	8–9 am 5–6 pm	243,603 km	251,814 km	+3%	278,874 km	279,102 km	0%	251,814 km	253,369 km	+1%	279,102 km	285,792 km	+2%
	6–10 am 3–7 pm	27.2 km/h	23.8 km/h	-13%	24.8 km/h	16.9 km/h	-32%	23.8 km/h	23.0 km/h	-3%	16.9 km/h	19.6 km/h	+16%
Average speed – all vehicles	8–9 am 5–6 pm	27.2 km/h	23.8 km/h	-13%	24.8 km/h	16.9 km/h	-32%	23.8 km/h	23.0 km/h	-3%	16.9 km/h	19.6 km/h	+16%
	6–10 am 3–7 pm	29.6 km/h	24.5 km/h	-17%	25.7 km/h	18.6 km/h	-28%	24.5 km/h	25.0 km/h	+2%	18.6 km/h	21.1 km/h	+13%
Average bus speed	8–9 am 5–6 pm	10.5 km/h	13.5 km/h	+29%	9.6 km/h	7.4 km/h	-23%	13.5 km/h	13.0 km/h	-4%	7.4 km/h	7.9 km/h	+7%
	6–10 am 3–7 pm	10.9 km/h	13.4 km/h	+23%	9.9 km/h	8.0 km/h	-19%	13.4 km/h	13.6 km/h	+1%	8.0 km/h	8.4 km/h	+5%

Source: *Adapted from Figures 5-33 to 5-36 of Technical Paper 1 – Transport Operations Report, Volume 2.*

Note 1: *h = hours; km = kilometres; km/h = kilometres per hour; s/km = seconds per kilometre.*

Traffic flow changes

The CSELR proposal, in conjunction with the redesign of the city centre bus network, would result in complex and varied changes in traffic conditions throughout the average weekday. These traffic pattern changes would comprise the following:

- Traffic accessing the CBD from Parramatta Road/Broadway is likely to divert to Wattle Street/Harris Street to access the city via the Western Distributor/King Street, William Henry Street/Pier Street and Ultimo Road to avoid George Street/Pitt Street where capacity would be reduced due to the CSELR proposal.
- Kent Street, Sussex Street and Clarence Street (for buses) would take on a higher order role for access to the northern CBD as well as access to the Harbour Bridge. There would be a need to consider the management of these streets in terms of their arterial function as opposed to their local access function.
- Kent Street would take on a more important access role for the Rocks, Dawes Point, and Barangaroo.
- Castlereagh Street and Elizabeth Street would be subject to significant increased usage by general traffic and buses and there would be a need to develop supplementary north-south traffic corridors on the CBD eastern periphery, such as Macquarie Street, College Street, and Wentworth Avenue, as per the redesign of the city centre bus network.
- Capacity reduction due to the CSELR proposal along Devonshire Street and the Railway Square precinct is likely to result in increased traffic filtering through Surry Hills via Campbell Street, Hunt Street, and Goulburn Street.
- A significant east-west traffic diversion to Cleveland Street is forecast due to changes on George Street, Pitt Street, Eddy Avenue, Chalmers Street, Elizabeth Street and Devonshire Street. This would require a management plan to be developed to further improve the operation of this already congested corridor.
- In the north-south direction, there would be diversions to the Cahill Expressway/Eastern Distributor to avoid the CBD surface road system.
- To the south in Kensington, Randwick and Kingsford, CSELR implementation would require a number of turn restrictions on Anzac Parade as well as capacity reductions along the entire CSELR corridor. This would result in forecast traffic diversions to the local street network.

Intersection performance statistics

Traffic modelling was undertaken to assess the predicted change in intersection average delay for key signalised intersections during the morning and afternoon peaks. This assessment was undertaken to determine the effect that the CSELR proposal would have on intersection average delays. Results of the traffic modelling are provided in the following sections. The intersection average delay was calculated in the model by determining the average delay for each approach to the node.

Performance of intersections within the CSELR corridor – CBD and Surry Hills

The CBD is subject to other major changes in its functionality as part of the SCCAS, of which the CSELR and the city centre bus network redesign form part. The SCCAS and bus network redesign will undergo a separate public consultation process and, therefore, do not form part of this EIS. Due to the ongoing work to define the network management approach at the intersection level, detailed assessment of the CSELR impacts has been restricted to the proposed CSELR corridor, as shown in Table 9.9.

Table 9.9 Performance of intersections within the CSELR corridor – CBD and Surry Hills

INTERSECTION	INTERSECTION PERFORMANCE – 8–9 AM		INTERSECTION PERFORMANCE – 5–6 PM	
	DELAY (SECONDS)	LEVEL OF SERVICE	DELAY (SECONDS)	LEVEL OF SERVICE
George St/Albert St	10	A	8	A
George St/Essex St	14	B	22	B
George St/Grosvenor St/Bridge St	37	C	42	B
George St/Bond St	46	D	71	F
George St/Hunter St	47	D	49	D
George St/King St	15	B	14	A
George St/Market St	39	C	31	C
George St/Park St/Druitt St	27	B	18	B
George St/Bathurst St	27	B	38	C
George St/Central St	6	A	12	A
George St/Liverpool St	12	A	19	B
George St/Goulburn St	12	A	32	C
George St/Campbell St	14	A	14	A
George St/Hay St	31	C	13	A
George St/Ultimo Rd	26	B	37	C
George St/Rawson Pl	55	D	57	E
Pitt St/Rawson Pl	81	F	57	E
Eddy Ave Crossing	55	D	4	A
Elizabeth St/Eddy Ave/Foveaux St	49	D	19	B
Devonshire St/Chalmers St	27	B	35	C
Devonshire St/Elizabeth St	30	C	41	C
Devonshire St/Crown St	27	B	31	C
Devonshire St/Bourke St	16	B	20	B

Source: *Table 5-19 of Technical Paper 1 – Transport Operations Report, Volume 2*

Table 9.9 indicates that, of the 23 assessed key signalised intersections, 22 would operate within capacity at an acceptable level of service (LoS between A and D) in the morning peak, reducing to 20 in the afternoon peak. Those intersections that are operating either at or over capacity comprise the following:

- George Street/Bond Street is expected to operate at LoS F in the afternoon peak. This is due to increased demand on Bond Street making use of the westbound connection provided by Bond and Jamison streets across the CSELR corridor.

- George Street/Rawson Place is expected to operate at LoS E in the afternoon peak. This is due to the competing bus, light rail and traffic movements that occur at this intersection. Opportunities to optimise the phase timings would be investigated to provide improved performance.
- Pitt Street/Rawson Place is expected to operate at LoS F in the morning peak and LoS E in the afternoon peak. This is due to the provision of an additional right turn bus only phase to allow buses to turn right from Pitt Street into Eddy Avenue. The requirement for this phase is under review as part of the bus planning process and its removal would result in an improved intersection LoS.

Performance of CBD intersections within the wider road network

The future intersection performance of the wider CBD network with and without the introduction of the CSELR proposal is shown in Figure 9.4 (morning peak) and Figure 9.5 (afternoon peak). Figures 9.4 and 9.5 compare the forecast peak hour intersection performance of the 2021 Do Minimum and 2021 light rail scenario. The colour coding illustrates the performance of key intersections that operate at LoS D or worse in either scenario. The green denotes improved level of service with the CSELR proposal, whilst the amber identifies deterioration in level of service. The performance comparisons are shown in Figures 9.4 and 9.5.

The modelling results demonstrate a shift in intersection delay to the southern section of the CBD and away from the George Street corridor as a result of its reduced importance as a strategic traffic route. Exceptions to this trend are noted at the following locations:

- Bathurst Street provides an important connection to the Cross City Tunnel and northern most point before the pedestrian zone.
- Goulburn Street experiences additional traffic volumes as a result of the closure of Rawson Place.
- The Hunter Street and Grosvenor Street intersections represent the key northern CBD east-west traffic routes.
- Essex Street experiences additional traffic volumes due to its importance in providing access to the Rocks.

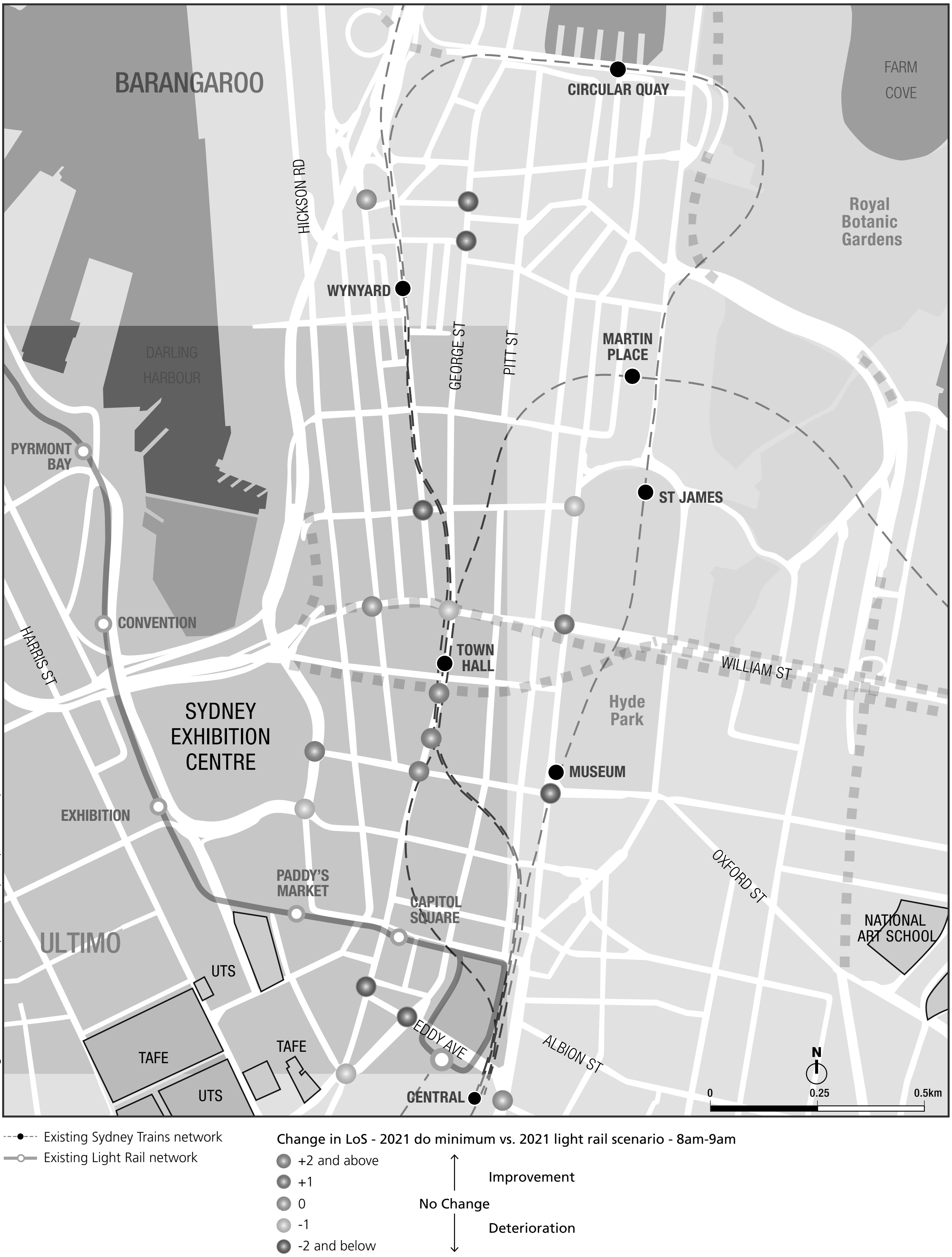
Increases in intersection delays are also predicted on the alternative north-south corridors such as College, Elizabeth and York Streets.

The CBD network modelling forecast that there would be decreased congestion and decreased delay at most intersections in the CBD under a future scenario, whereby the CSELR proposal is implemented, compared to a scenario in which the proposal is not implemented (business as usual). The future intersection performance changes in the CBD would be the result of the implementation of the CSELR proposal (including the pedestrianisation of George Street) and the CBD bus network redesign, which would re-prioritise certain north-south CBD routes, notably George Street, Elizabeth Street and Castlereagh Street, diverting some demand onto alternative north-south routes.

The introduction of the CSELR proposal and the CBD bus network re-design would, however, facilitate a degree of modal shift from cars to public transport. The broader CBD road network changes would result in changes to the distribution and volumes of traffic. If the CSELR proposal is not implemented, and a business as usual scenario eventuates, traffic congestion is forecast to worsen significantly, especially in the PM peak, resulting in increased delays to all modes. Overall, implementation of the proposed road network changes to accommodate the CSELR proposal, pedestrianisation and the bus network changes are forecast to improve the future year operation of the road network relative to a business as usual scenario.

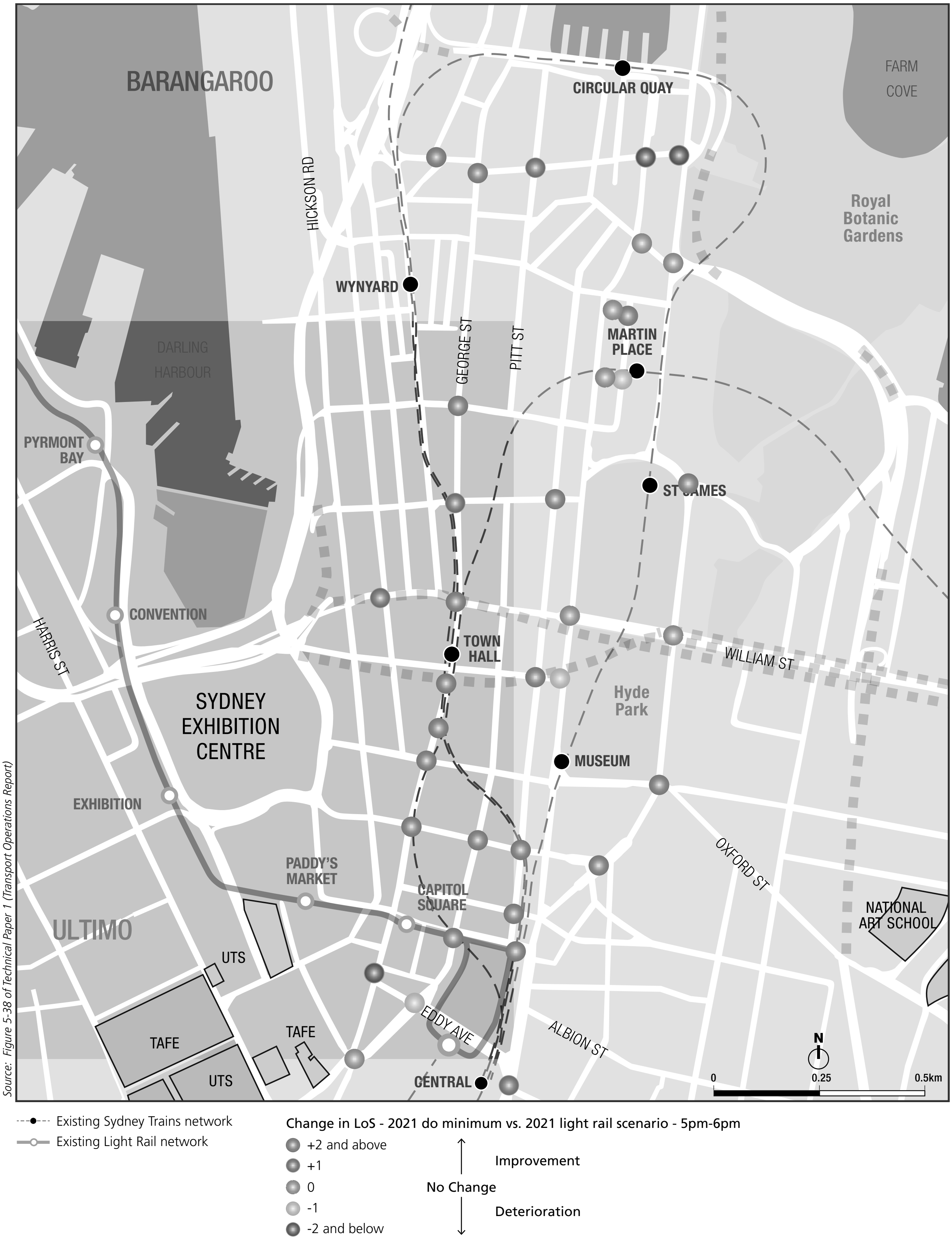
The modelling demonstrates that College Street, Castlereagh Street and George Street would perform better in the future in the afternoon peak if these road network changes are implemented, whilst some ‘hotspots’ are predicted on Elizabeth Street, notably in the morning peak hour. However, it should be feasible to minimise any adverse impacts on the Elizabeth Street corridor through further work currently being undertaken by RMS and Transport for NSW to refine the modelling and design options presented with the aim of further reducing the impacts across the CBD road network.

Figure 9.4 Change in LoS at key intersections currently experiencing LoS to F within the CBD in 2021 – morning peak



Source: Figure 5-38 of Technical Paper 1 (Transport Operations Report)

Figure 9.5 Change in LoS at key intersections currently experiencing LoS to F within the CBD in 2021 – afternoon peak



Performance of intersections within the CSELR corridor – South East corridors

Intersection levels of service and delay for the South East corridors are provided in Table 9.10. The traffic modelling results in Table 9.10 show that the key intersections experiencing degraded levels of service are:

- *Anzac Parade/Alison Road* — An LoS F is expected to be achieved in the morning peak. Whilst this is a reduction from existing LoS, this intersection would still provide improved performance in comparison with the 'do-minimum' scenario. This intersection is the subject of ongoing design refinement to optimise its operation in consultation with RMS.
- *Anzac Parade/High Street* — This intersection is expected to operate at LoS E in both the morning and afternoon peak periods. This reduction in LoS from A/B in the existing and 'do-minimum' scenarios is a result of the proposed switch in the CSELR alignment from centre running to enter UNSW land on the eastern side of Anzac Parade. This change in the alignment is proposed to ensure the high volumes of passengers can access the light rail stop without crossing Anzac Parade. Further refinement of the design is underway in consultation with RMS to optimise operation.
- *Anzac Parade/Middle Street* — This intersection is expected to operate at LoS E in the morning peak. This reduction in LoS from A in the existing and 'do-minimum' scenarios is due to the loss of through-traffic lanes on Anzac Parade, combined with increased eastbound demand on Strachan Street. Improved performance may be achievable through further optimisation of the signal phasing.

Performance of South East intersections within the wider road network

Predicted intersection LoS and delay for key intersections in the wider South East road network are provided in Table 9.11. The traffic modelling results in Table 9.11 show that the key intersections predicted to experience degraded LoS are:

- Anzac Parade/Moore Park Road
- Lachlan Street/South Dowling Street
- O'Dea Avenue/South Dowling Street
- Cleveland Street/South Dowling Street
- Avoca Street/Darley Road.

Reductions in LoS at the above intersections would occur as a result of changed traffic patterns on the network once the CSELR proposal is implemented. These changed traffic patterns require revised traffic signal control plans and corridor strategies to ensure the movements with the heaviest demands are adequately catered for. As part of the Network Management Plan to be implemented with the CSELR proposal (as discussed in section 9.2.4.1), potential upgrade measures would be considered at these locations or in the surrounding area.

Table 9.10 Performance of intersections within the CSELR corridor – South East corridors

INTERSECTION	INTERSECTION PERFORMANCE – 8–9 AM						IMPLEMENT THE CSELR PROPOSAL					
	2012 BASE		2021 'DO-MINIMUM'		2021 SCENARIO[1]		2012 BASE		2021 'DO-MINIMUM'		2021 SCENARIO[1]	
	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS
Anzac Pde/Alison Rd	57	E	88	F	83	F	38	C	57	E	44	D
Anzac Pde/Todman Ave	22	B	45	D	55	D	24	B	37	C	34	C
Anzac Pde/Addison St	10	A	24	B	3	A	14	A	13	A	3	A
Anzac Pde/Doncaster Ave	14	A	18	B	23	B	19	B	25	B	41	C
Anzac Pde/High St	12	A	12	A	66	E	20	B	24	B	63	E
Anzac Pde/Barker St	18	B	19	B	42	C	34	B	50	D	35	C
Anzac Pde/Middle St	10	A	11	A	62	E	13	A	34	C	12	A
Anzac Pde/Borrodale Rd	23	B	31	C	41	C	21	B	18	B	19	B
Anzac Pde/Rainbow St	n/a	n/a	n/a	n/a	62	E	n/a	n/a	n/a	n/a	35	C
Alison Rd/Doncaster Ave	20	B	18	B	29	C	24	B	22	B	26	B
Alison Rd/Darley Rd	28	B	29	C	44	D	21	B	45	D	42	B
Alison Rd/John St	16	B	24	B	21	B	13	A	12	A	20	B
Alison Rd/Cowper St	14	A	13	A	14	A	19	B	17	B	21	B
Alison Rd/Wansey Rd	n/a	n/a	n/a	n/a	27	B	n/a	n/a	n/a	n/a	21	B
High St/Wansey Rd	n/a	n/a	n/a	n/a	13	A	n/a	n/a	n/a	n/a	17	B
High St/Botany St	29	B	25	B	22	B	26	B	20	B	29	C
High St/Avoca St	19	B	18	B	25	B	29	C	35	C	47	D
Avoca St/Cuthill St	12	A	14	A	24	B	12	A	13	A	17	B
Belmore Rd/Cuthill St	8	A	9	A	24	B	6	A	6	A	13	A

Source: Adapted from Figures 5-39 and 5-40 of Technical Paper 1 – Transport Operations Report, Volume 2

Table 9.11 Performance of South East intersections within the wider road network

INTERSECTION	INTERSECTION PERFORMANCE – 8–9 AM						IMPLEMENT THE CSELR PROPOSAL					
	2012 BASE		2021 'DO-MINIMUM'		2021 SCENARIO[1]		2012 BASE		2021 'DO-MINIMUM'		2021 SCENARIO[1]	
	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS	DELAY (SEC)	LOS
Anzac Pde/Moore Park Rd	28	B	30	C	57	E	38	C	50	D	51	D
Moore Park Rd/Lang Rd	35	C	41	C	33	C	28	B	41	C	29	C
Oxford St/Ocean St	32	C	31	C	46	D	30	C	27	B	28	B
Oxford St/York Rd	21	B	26	B	44	D	10	A	12	A	10	A
Cleveland St/South Dowling St	48	D	50	D	51	D	45	D	81	F	57	E
Anzac Pde/Lang Rd	38	C	45	D	42	C	44	D	65	E	45	D
Lachlan St/South Dowling St	69	E	63	E	83	F	47	D	50	D	41	D
O'Dea Ave/South Dowling St	49	D	60	E	94	F	83	F	86	F	89	F
Todman Ave/Lenthall St	16	B	15	B	19	B	16	B	20	B	20	B
Alison Rd/Botany St	25	B	24	B	27	B	20	B	14	A	19	B
Alison Rd/Belmore Rd	25	B	27	B	35	C	18	B	21	B	23	B
Alison Rd/Avoca St	33	C	30	C	33	C	32	C	29	C	30	C
Avoca St/Rainbow St	27	B	30	C	31	C	31	C	47	D	32	C
Avoca St/Barker St	30	C	34	C	32	C	31	C	39	C	27	B
Avoca St/Frenchmans Rd	39	C	36	C	34	C	35	C	41	C	32	C
Avoca St/Clovelly Rd	21	B	21	B	21	B	26	B	28	B	27	B
Avoca St/Darley Rd	46	D	52	D	58	E	56	D	52	D	43	D
Gardeners Rd/Eastern Ave	9	A	11	A	19	B	7	A	9	A	13	A

Source: *Adapted from Figures 5-41 and 5-42 of Technical Paper 1 – Transport Operations Report, Volume 2*

Special events

The introduction of the CSELR proposal would provide an opportunity to significantly enhance access to the major event precincts within the corridor, increase public transport mode share and reduce congestion. Public transport mode share to special events along the proposed CSELR corridor (particularly to Royal Randwick racecourse) has historically been relatively low in comparison with other major special event locations. Sydney Olympic Park at Homebush, which offers a multi-modal transport solution, averaged a public transport mode share of 69 per cent in 2010 (Parsons Brinckerhoff 2013).

The CSELR proposal presents a number of benefits over the existing special event bus transport solution. Light rail would be more reliable and more comfortable than event buses, which would contribute to higher customer satisfaction and should serve to increase mode share.

Public transport mode share could further benefit from redeployment of duplicated bus services to link events to new areas of Sydney. In all instances, increasing public transport mode share would ultimately result in reduced congestion around event venues.

As discussed in section 5.4.2, during periods of high demand, such as sporting events and concerts, a special event service would operate between the Central Station and the Moore Park stops. Special event services would be in addition to normal scheduled services. These services would include two 45-metre long LRVs joined together to form a 90-metre long vehicle with special event services running in combination with regular services at a frequency of one LRV every 2.5 minutes.

The following sections provide an assessment of the effects that the CSELR proposal would have on existing and future special events at Moore Park and Royal Randwick racecourse.

It is noted that a number of other special events are held within Sydney which have the potential to conflict with the operation of the CSELR proposal (for example, Chinese New Year Twilight Parade and the Anzac Day March). An assessment of the effects that the CSELR proposal would have on these events is provided as part of the assessment undertaken for the City Centre Precinct (refer to section 12.3.2).

Moore Park

Moore Park will continue to host a significant number and wide variety of special events in future years. A traffic and transport services strategy for Moore Park was developed by Parsons Brinckerhoff (2013) with the purpose of providing an integrated transport master plan for the precinct for both event and regular transport operations.

The services strategy outlined that special events at Moore Park would target the following mode share following the introduction of the CSELR proposal:

- Cricket/AFL capacity event (48,000 attendees) with 45-metre LRVs — 26 per cent light rail (a total of 68 per cent non-car, comprising light rail, event bus/coach services, walking, cycling and taxis/limousines)
- Cricket/AFL typical event (34,000 attendees) with 45-metre LRVs — 36 per cent light rail (a total of 66 per cent non-car, comprising light rail, event bus/coach services, walking, cycling and taxis/limousines)
- Rugby League/Rugby Union/Football typical event (34,000 attendees) with 45-metre LRVs — 33 per cent light rail (a total of 63 per cent non-car, comprising light rail, event bus/coach services, walking, cycling and taxis/limousines)
- Cricket/AFL capacity event (48,000 attendees) with 90-metre LRVs — 37 per cent light rail (a total of 71 per cent non-car, comprising light rail, event bus/coach services, walking, cycling and taxis/limousines).

It is intended that light rail would replace the current special event bus operations between Moore Park and Central Railway Station. Regular light rail services would also replace the operation of dedicated park-and-ride shuttles to UNSW and Royal Randwick racecourse that operate for some events.

With a combination of event shuttles and regular services, a maximum gap between services of 2.5 minutes can be achieved in the peak direction during the post-match period. With passenger capacity of five passengers per square metre, a total hourly capacity is possible of:

- *45-metre long LRVs* — 9,836 passengers per hour (both directions combined) (shuttle between Moore Park and Central Railway Station), comprising:
  - 2,748 passengers per hour due to regular demand to peak direction
  - 4,340 passengers per hour due to event shuttle demand to peak direction
  - 2,784 passengers per hour due to regular demand to contra-peak direction (Parsons Brinckerhoff 2013).
- *90-metre long LRVs* — 14,176 passengers per hour (both directions combined) (shuttle between Moore Park and Central Railway Station), comprising:
  - 2,748 passengers per hour due to regular demand to peak direction
  - 8,680 passengers per hour due to event shuttle demand to peak direction
  - 2,784 passengers per hour due to regular demand to contra-peak direction (Parsons Brinckerhoff 2013).

Based on maintaining a 36 per cent mode share to light rail for all crowd sizes (as adopted in Parsons Brinckerhoff 2013), the likely duration of event specials would range from 20–55 minutes following an event depending on the capacity required and operational strategy employed.

In addition to light rail, buses would continue to play an important role in the event transport task in the Moore Park Precinct. The current major event bus hub at Moore Park is required to be relocated to facilitate the construction of a light rail stop in its place. The new facility is proposed to be located north of the existing AFL training field between the bus roadway and Kippax Lake (shown in Figure 9.6). The facility is proposed to be 235 metres long and 37 metres wide with sufficient capacity for ten standard buses or four standard and five articulated buses (which is the same capacity as the existing bus hub facility at Moore Park).

While the main event bus connection between Central and Moore Park would be replaced by the CSELR proposal, it is envisaged that a number of bus routes would remain to provide access to catchments in the Sydney metropolitan area not well served by the heavy or light rail network. These are likely to include:

- existing event bus services between Circular Quay and Moore Park (Route 3)
- Castle Hill to Moore Park (Route 15A)
- Dural to Moore Park (Route 18)
- Warringah Mall to Moore Park (Route 50).

Routes 1, 52, 60 and 62 would be replaced by the CSELR.

Walking has always been a popular mode of access to Moore Park, with up to 9,000 spectators expected to walk to the precinct for a capacity event, including people walking the 1.5–2 kilometres from Central Railway Station and other transport nodes.

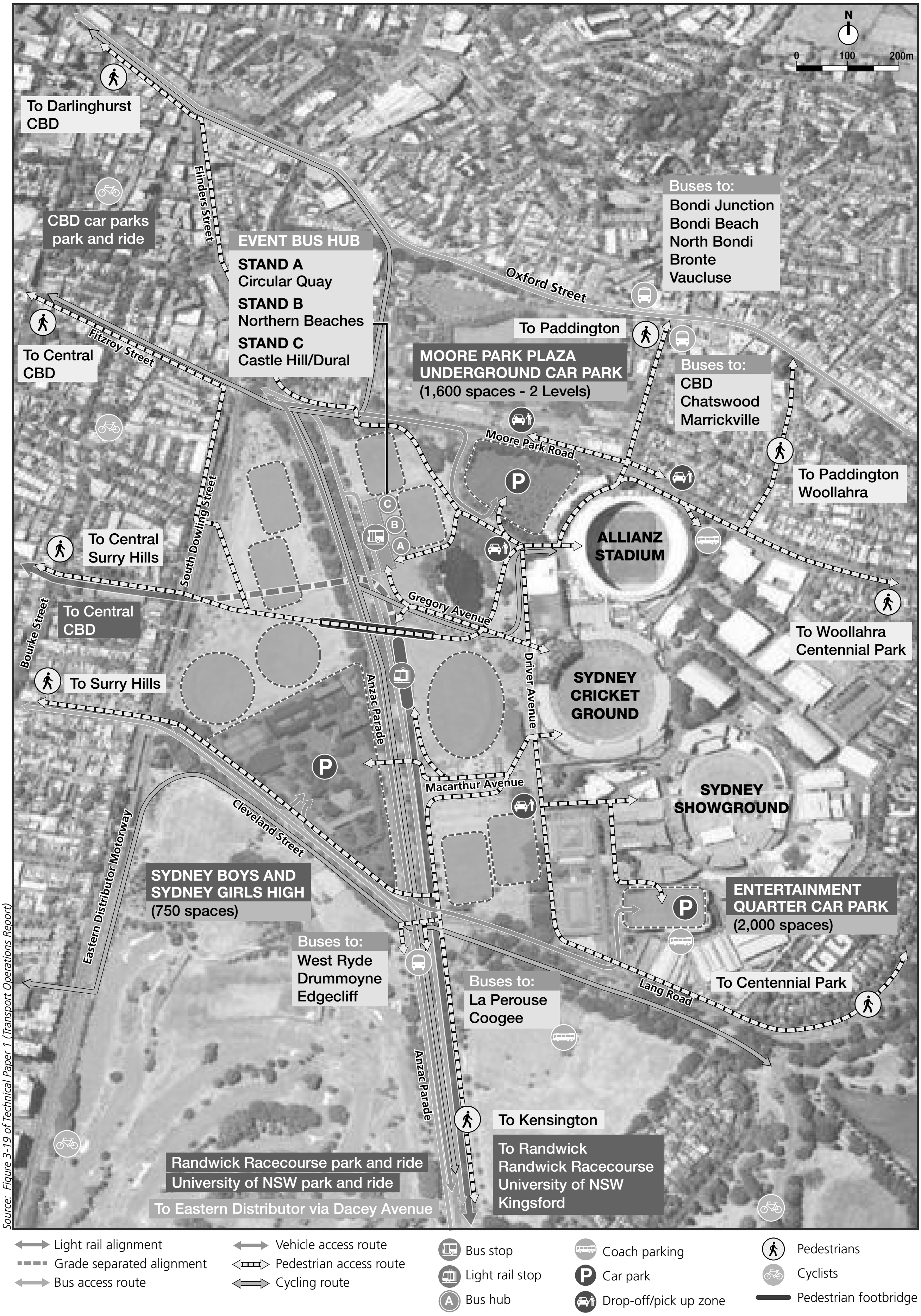
The complete event transport plan for Moore Park is shown in Figure 9.6.

Royal Randwick racecourse

Discussion on the existing mode share and bus operations during special events at Royal Randwick racecourse is provided in section 9.2.1. In summary, Royal Randwick racecourse is currently served by special event buses (Route 32) during Saturday race days throughout the year, and the Future Music festival held annually in March. While bus mode share to the Future Music festival averages 33 per cent, race day mode share averages less than 10 per cent.

The CSELR proposal presents an opportunity to increase public transport mode share to Royal Randwick racecourse events. Given the CSELR proposal would duplicate the event bus transport solution provided by the Route 32, these bus services could either be redirected elsewhere on the network or redeployed to supplement the new light rail service, linking the venue with other parts of Sydney. Redeployed services could run from other key transport hubs, resulting in increased public transport mode share to events at Royal Randwick racecourse.

Figure 9.6 Moore Park Precinct integrated event transport plan



Source: Figure 3-19 of Technical Paper 1 (Transport Operations Report)

As discussed in Chapters 11 and 14, the Royal Randwick racecourse is anticipated to undergo a major development including construction of a 170 room hotel (expected completion 2015), a convention centre and a centre of excellence/lifestyle centre. The development is expected to increase attendance and attract a more diverse array of events. Future transport solutions would have to meet both the changing needs of existing events, as well as the transport demand from new events.

The addition of new facilities and modernisation of existing facilities is likely to increase attendance of currently held special events, as well as facilitating a shift in the type and number of special events held at Royal Randwick racecourse. Increases in attendance for future race days would be better supported under the new light rail transport solution, as compared with the existing event buses. In addition, the higher capacity, improved reliability and proportional increases of light rail would make it better positioned to respond to the shifting nature of events to be held at Royal Randwick racecourse.

Impacts on known future major trip generating developments

Barangaroo

Given the significant numbers of people that will commute to and from the Barangaroo development it is imperative that appropriate transport solutions are in place. The CSELR proposal would positively contribute to linking Barangaroo with Sydney's South East. Customers travelling to the development would disembark at the Wynyard stop and proceed on foot to Barangaroo via Wynyard Walk.

Sydney International Convention, Exhibition and Entertainment precinct (SICEEP)

The CSELR proposal would complement the existing light rail system adjacent to the SICEEP and would provide for an efficient connection to the primary CBD spine and key areas of accommodation for international and interstate visitors who are anticipated to be major users of the site.

The SICEEP design recognises the increase in transport demand resulting from the higher activity-levels within the precinct. The responding environmentally sustainable design strategy promotes the use of public transport, specifically through supporting accessibility to existing light rail stops on Darling Drive via new pathways and pedestrian crossings. Parking provisions will concurrently be reduced by around 500 spaces to promote a shift towards sustainable transport modes. The initiatives would promote patronage of light rail and support investments such as the Inner West Light Rail Extension and the CSELR proposal.

UNSW

As outlined in section 9.2.1, an increasing majority of students are using public transport to access the campus, as the supply of nearby parking spaces has remained static, with around half of students accessing the campus between 8 am and 10 am. In the evening, the peak student departure time is more closely aligned with the regular peak period with 51 per cent of students departing between 4 pm and 7 pm (UNSW Travel Survey 2012).

It is anticipated that this profile of demand will continue in the future, with public transport assuming an increasing share of the transport task due to ongoing limitations to parking supply in the precinct. The CSELR proposal would be well-positioned to take up this task, with the current design including stops near the University Mall on Anzac Parade and Gate 9 on High Street, used by more than half of students and staff to access the University.

Urban Activation Precincts (UAPs)

As outlined in section 9.3 and Chapter 15, the future development of the Randwick UAP would increase travel demand as a result of the proposed development within this area. While still in the early stages of planning, the NSW Government has recognised that the construction of the CSELR proposal in the precinct would provide a catalyst for urban renewal and consolidation.
The delivery of a high-capacity and reliable mode of transport through the area would support the additional social and community infrastructure being delivered through the UAP program.

Green Square Town Centre

Despite the significant increase in travel demand as a result of the development, the precinct is already relatively well-served by public transport with a mix of buses and heavy rail services nearby. While Green Square will shift travel patterns over time, travel demand would be manageable through a reorganisation of the transport system and mode hierarchy in the future. The introduction of the CSELR proposal could play a part in this as a reduction in demand for bus fleet in the eastern suburbs permits the reallocation of the fleet for other purposes, including if necessary, supplementary services along the Botany Road corridor.

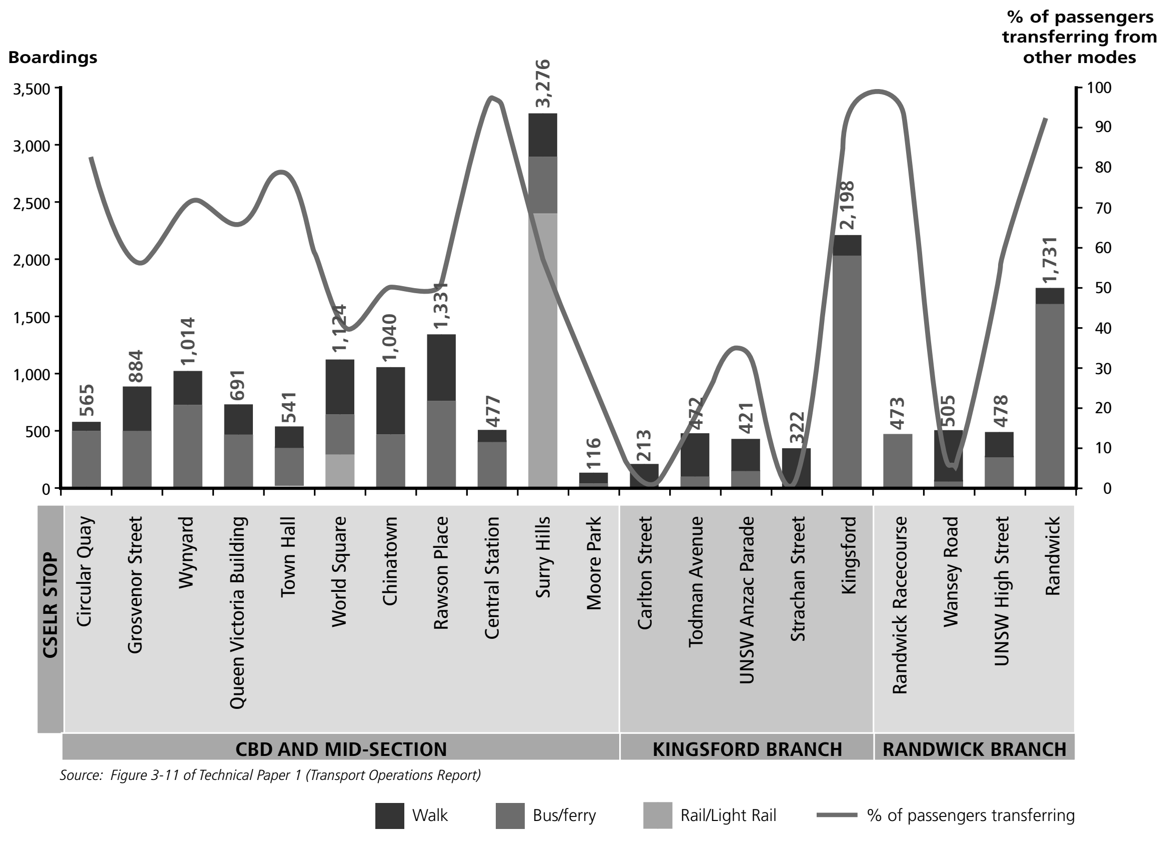
Ability of the CSELR proposal to serve future travel demand

Ongoing population and employment growth in major developments, land release areas and urban regeneration sites will all drive additional demand for transport services within the study area. While the effect is likely to be more pronounced at the key interchange stops of Central Station, Randwick and Kingsford, intermodal use would be a key feature of the CSELR at all stops. As shown in Figure 9.7, transfers from other modes are anticipated at most stops to varying degrees depending upon the nature of the catchment and the style of stop.

The CSELR is also anticipated to take a significant proportion of the growth in future demand from the eastern suburbs to the CBD. As shown in Figure 9.8, peak line loads inbound are predicted to exceed 5,300 passengers per hour in the 2021 morning peak hour.

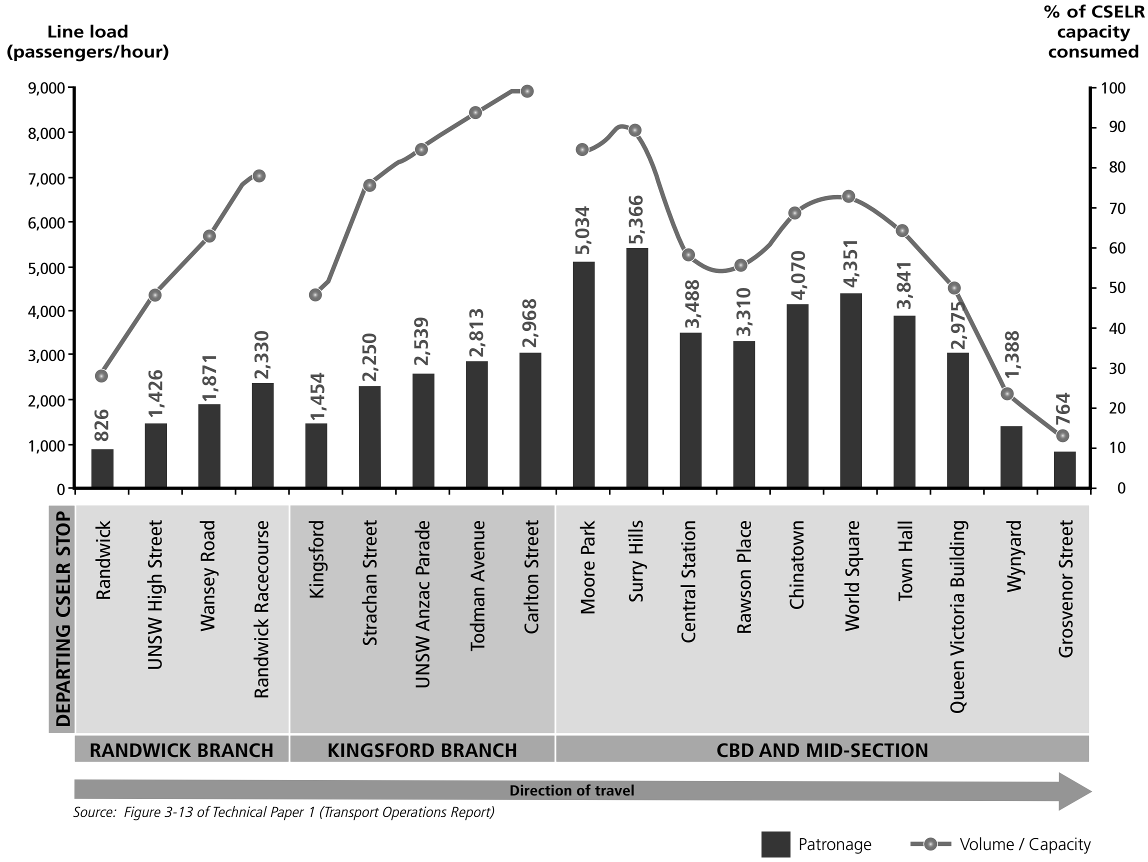
As shown in Figure 9.9, peak line loads outbound, while lower than inbound, are still predicted to exceed 4,100 passengers per hour in the 2021 morning peak hour. This represents a good balance of demand, with the fixed and rolling infrastructure assets well-utilised in both directions due to the significant demand for access to UNSW and the Randwick health precinct.

Figure 9.7 2021 morning peak CSELR boarding and mode of access by light rail stop



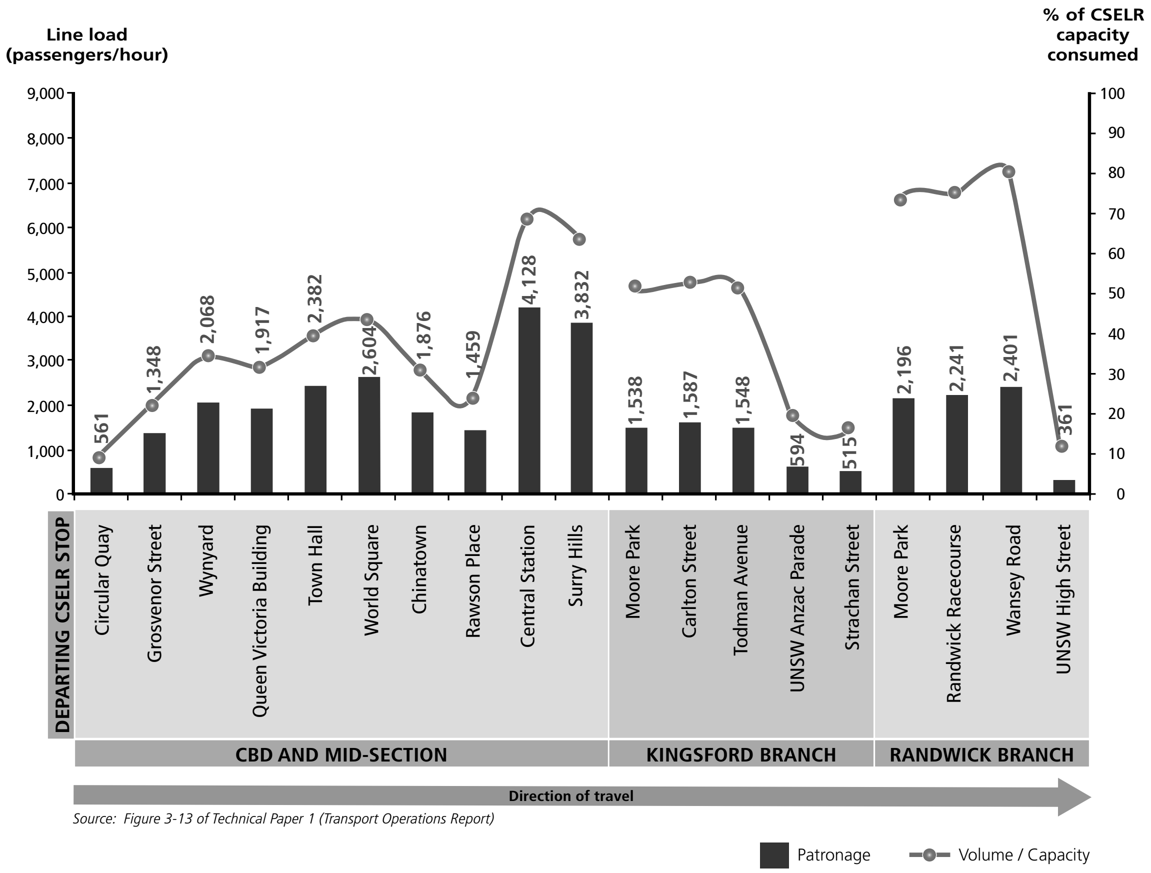
Source: Figure 3-11 of Technical Paper 1 (Transport Operations Report)

Figure 9.8 2021 inbound morning peak CSELR line load and capacity consumed



Source: Figure 3-13 of Technical Paper 1 (Transport Operations Report)

Figure 9.9 2021 outbound morning peak CSELR line load and capacity consumed



Source: Figure 3-13 of Technical Paper 1 (Transport Operations Report)

9.2.3 Impacts during construction

A detailed construction traffic and transport assessment for the CSELR proposal was undertaken by Booz & Company and AECOM. A comprehensive technical report is available as Technical Paper 2 — *Construction Traffic and Transport Management Plan* in Volume 2 of this EIS.

A summary of the regional traffic, transport and accessibility impacts likely to be associated with the construction of the CSELR proposal is provided in the following sections. Discussion on local traffic, transport and accessibility impacts within each of the five precincts assessed in this EIS is provided in sections 12.3.3 (City Centre Precinct), 13.3.3 (Surry Hills Precinct), 14.3.3 (Moore Park Precinct), 15.3.3 (Randwick Precinct), and 16.3.3 (Kensington/Kingsford Precinct).

Road network performance

Road network impacts during construction of the CSELR proposal were assessed through mesoscopic modelling (a regionally based traffic modelling technique) using a traffic forecast year of 2016. Modelling was undertaken for both the morning peak (6 am–10 am) and afternoon peak (3 pm–7 pm) time periods.

The modelled scenario represented a worst-case assessment in terms of network traffic demand and capacity reductions. Under this scenario, it is assumed that the full length of the CSELR corridor is an active worksite and, as such, all proposed road closures are in place concurrently. However, once a construction contractor is appointed and detailed construction staging established, it is likely that roads would be progressively reopened resulting in improved levels of network performance.

Results of the mesoscopic modelling of road network performance are provided in section 3.9 of Technical Paper 2 and summarised in Table 9.12.

In summary, the road network is expected to function satisfactorily during the morning peak period; however, the afternoon period conditions may present problems in the CBD. In particular, the afternoon peak period forecasts indicate that implementation of adequate management measures would be critical to ensure priority bus corridors are protected against increased levels of congestion. In the South East corridor, challenges would relate to maintaining acceptable operations on Anzac Parade and Alison Road during construction. Measures to address these impacts are discussed in section 9.2.4.

Table 9.12 2016 construction scenario road network performance statistics for the morning and afternoon peak periods

STATISTIC[1]	AM/PM PEAK ASSESSMENT PERIODS	MORNING PEAK			AFTERNOON PEAK		
		2012 BASE	2016 CONSTRUCTION SCENARIO	% CHANGE	2012 BASE	2016 CONSTRUCTION SCENARIO	% CHANGE
Full model area							
Vehicle hours travelled	8–9 am 5–6 pm	11,045 h	12,582 h	+14%	11,816 h	13,572 h	+15%
Normalised vehicle hours travelled	6–10 am 3–7 pm	36,338 h	41,691 h	+15%	46,278 h	53,148 h	+15%
Vehicle kilometres travelled	8–9 am 5–6 pm	364,316 km	377,465 km	+4%	370,895 km	375,996 km	+1%
Normalised vehicle kilometres travelled	6–10 am 3–7 pm	1,259,408 km	1,354,122 km	+8%	1,429,419 km	1,543,499 km	+8%
Average speed – all vehicles	8–9 am 5–6 pm	34.0 km/h	31.8 km/h	-6%	32.8 km/h	30.9 km/h	-6%
Normalised average speed – all vehicles	6–10 am 3–7 pm	34.6 km/h	32.5 km/h	-6%	30.9 km/h	29.0 km/h	-6%
Average bus speed	8–9 am 5–6 pm	18.6 km/h	21.1 km/h	+13%	16.8 km/h	16.7 km/h	-1%
	6–10am 3–7 pm	19.4 km/h	22.3 km/h	+15%	17.2 km/h	17.4 km/h	+1%
Average delay	8–9 am 5–6 pm	64 s/km	73 s/km	+14%	70 s/km	88 s/km	+26%
	6–10am 3–7 pm	56 s/km	65 s/km	+16%	69 s/km	82 s/km	+19%
Vehicles in network	At 10 am At 7 pm	8,705	11,038	+27%	12,057	15,377	+28%

Table 9.12 cont

STATISTIC[1]	AM/PM PEAK ASSESSMENT PERIODS	MORNING PEAK			AFTERNOON PEAK		
		2012 BASE	2016 CONSTRUCTION SCENARIO	% CHANGE	2012 BASE	2016 CONSTRUCTION SCENARIO	% CHANGE
CBD							
Vehicle hours travelled	8–9 am 5–6 pm	2,651 h	2,970 h	+12%	2,894 h	3,321 h	+15%
	6–10am 3–7 pm	8,216 h	9,103 h	+11%	10,829 h	12,180 h	+12%
Vehicle kilometres travelled	8–9 am 5–9 pm	72,287 km	72,138 km	0%	71,778 km	71,427 km	0%
	6–10 am 3–7 pm	243,603 km	251,289 km	+3%	278,874 km	279,816 km	0%
Average speed – all vehicles	8–9 am 5–6 pm	27.2 km/h	24.3 km/h	-11%	24.8 km/h	21.5 km/h	-13%
	6–10am 3-7 pm	29.6 km/h	27.6 km/h	-7%	25.7 km/h	23.0 km/h	-11%
Average bus speed	8–9 am 5-6 pm	10.5 km/h	13.5 km/h	+29%	9.6 km/h	8.2 km/h	-15%
	6–10 am 3–7 pm	10.9 km/h	14.4 km/h	+32%	9.9 km/h	8.5 km/h	-14%

Source: *Adapted from Figures 3-10 and 3-11 of Technical Paper 2 – Construction Traffic and Transport Management Plan, Volume 2*

Note 1: *h = hours; km = kilometre; km/h = kilometres per hour; s/km = seconds per kilometre.*

Travel times

Construction scenario travel times for key road corridors within the CBD and South East during the morning and afternoon peaks are detailed in Table 9.13.

As shown in Table 9.13, the following changes to travel time have been predicted during the morning peak:

- the Anzac Parade corridor would experience an increase in travel times in both directions
- traffic travelling on High Street would be subject to unchanged travel times in the eastbound direction; however, an increase in the order of 70 seconds is predicted in the westbound direction
- travel time along the Alison Road westbound corridor is predicted to increase by approximately 180 seconds.

During the afternoon peak, the travel time forecasts in Table 9.13 indicate the construction of the CSELR proposal would have the following impacts within the CBD and South East:

- travel times on Liverpool Street would improve
- the King Street corridor would see increased travel times of approximately 80 seconds
- travel time is generally predicted to increase for the routes within the South East, with the exception of Alison Road eastbound which would experience a travel time reduction of approximately 20 seconds.

Intersection delays

Changes in LoS (both positive and negative changes) predicted to occur at key intersections that currently experience an LoS D within the CBD during the construction of the CSELR proposal (2016 construction scenario) are shown in Figure 9.10 (morning peak) and Figure 9.11 (afternoon peak). Figures 9.10 and 9.11 compare the forecast intersection performance of the 2012 Base and the 2016 construction scenario. The colour coding illustrates the performance of key intersections that operate at LoS D or worse in either scenario. The green denotes improved level of service during construction, whilst the amber identifies deterioration in level of service.

As shown in Figure 9.10, the morning peak period results illustrate that the construction scenario would impact on the performance of the intersections in the mid-city, especially along Park Street, Market Street, College Street and Hunter Street. Redesign of the city centre bus network (as part of the SCCAS) would improve intersections along Bridge Street as well as Bent Street.

As shown in Figure 9.11, the afternoon peak period results for the construction scenario show a contrasting pattern to the morning peak, with the increase in intersections delays concentrated around Bridge Street and King Street in the northern CBD and around Elizabeth Street and Liverpool Street in the southern CBD. The increased delays along the Elizabeth Street and Castlereagh Street corridors are due to increased bus activity associated with the redesign of the Sydney bus network as part of the SCCAS.

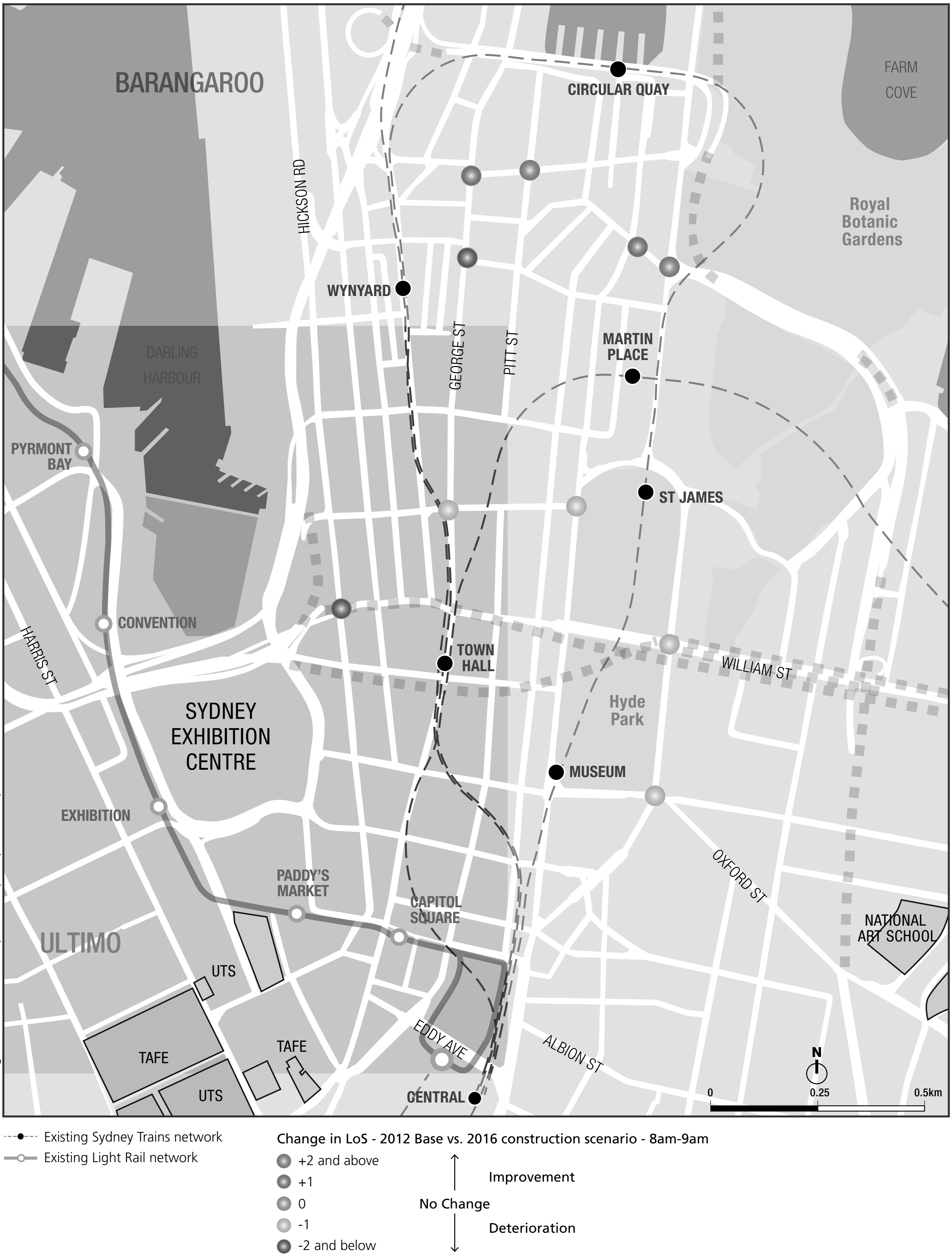
Table 9.13 2016 construction scenario travel times for key corridors during the morning and afternoon peaks

CORRIDOR	DIRECTION OF TRAVEL	MORNING PEAK				AFTERNOON PEAK			
		2012 BASE		2016 CONSTRUCTION SCENARIO		2012 BASE		2016 CONSTRUCTION SCENARIO	
		TRAVEL TIME (S)	AVERAGE SPEED (KM/H)	TRAVEL TIME (S)	AVERAGE SPEED (KM/H)	TRAVEL TIME (S)	AVERAGE SPEED (KM/H)	TRAVEL TIME (S)	AVERAGE SPEED (KM/H)
Bathurst Street, between Day Street and Elizabeth Street	Eastbound	89	24	92	23	146	15	160	14
Liverpool Street, between College Street and Harbour Street	Westbound	145	20	179	16	232	12	230	13
King Street, between Sussex Street and Elizabeth Street	Eastbound	113	25	117	25	109	26	192	15
Market Street, between Elizabeth Street and Sussex Street	Westbound	106	20	122	18	124	17	131	16
Alison Road, between Anzac Parade and Belmore Road	Eastbound	264	29	242	31	262	29	241	31
	Westbound	211	36	486	16	214	35	398	19
Anzac Parade, between Oxford Street and Sturt Street	Northbound	628	31	894	22	560	35	888	22
	Southbound	711	27	742	26	865	22	918	21
High Street, between Anzac Parade and Belmore Road	Eastbound	271	20	225	24	275	20	277	19
	Westbound	237	23	314	17	232	23	302	18

Source: *Figures 3.12 and 3.13 of Technical Paper 2 – Construction Traffic and Transport Management Plan, Volume 2*

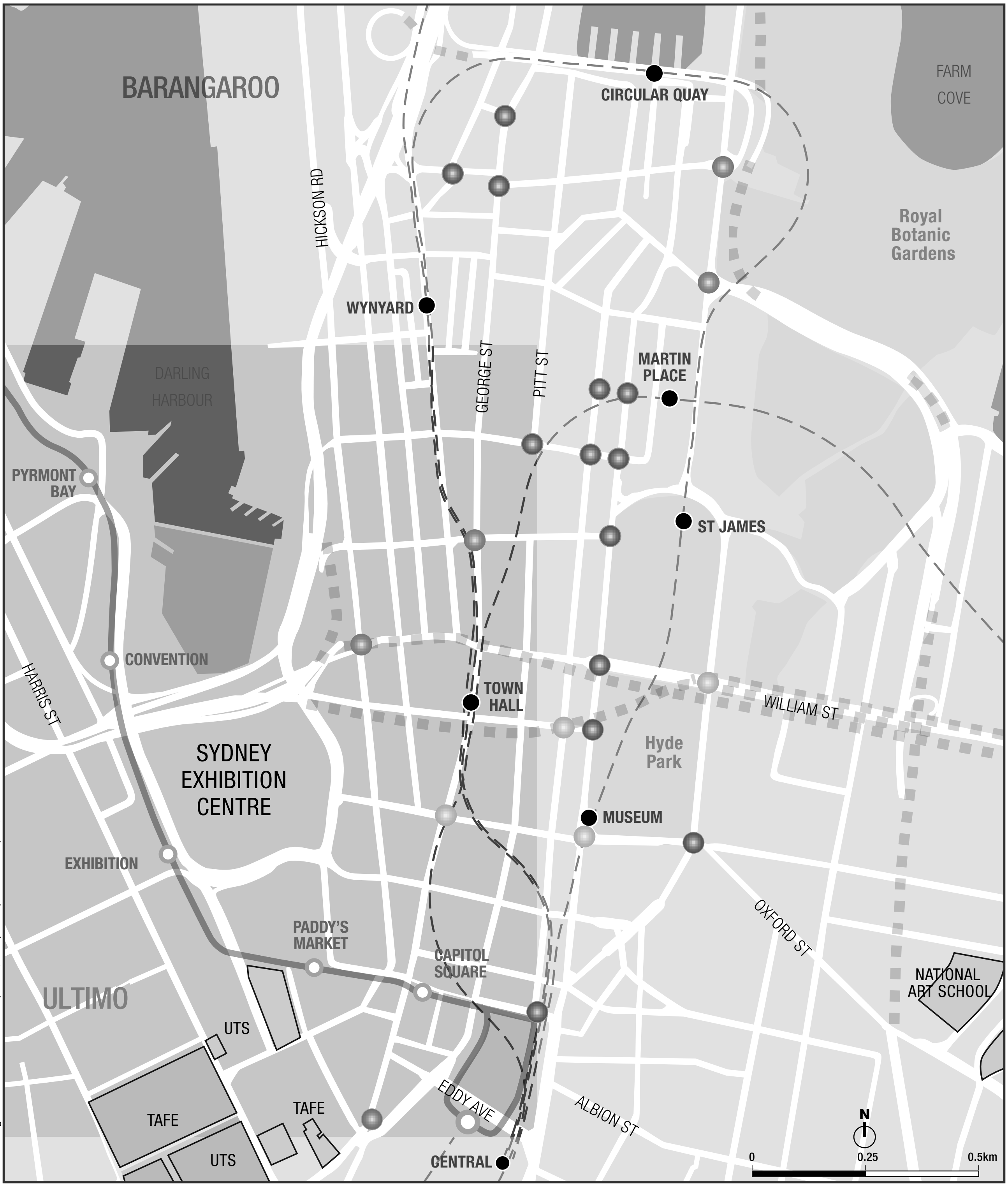
Notes: *s = seconds; km/h = kilometres per hour.*

Figure 9.10 Change in LoS at key intersections currently experiencing LoS to F within the CBD during construction of the CSELR proposal – morning peak



Source: Figure 5-38 of Technical Paper 1 (Transport Operations Report)

Figure 9.11 Change in LoS at key intersections currently experiencing LoS to F within the CBD during construction of the CSELR proposal – afternoon peak



Source: Figure 5-38 of Technical Paper 1 (Transport Operations Report)

- Existing Sydney Trains network
- Existing Light Rail network

Change in LoS - 2012 Base vs. 2016 construction scenario - 5pm-6pm

- +2 and above
- +1
- 0
- -1
- -2 and below

↑ Improvement
No Change
↓ Deterioration

Impacts on bus services

Sydney CBD bus services

As discussed in section 9.2.1, the NSW Government proposes to make a number of changes to existing bus routes within the Sydney CBD as part of the redesign of the city centre bus network. The proposed redesign of the city centre bus network would be implemented by the NSW Government prior to the commencement of conflicting construction works for the CSELR proposal. As outlined in section 6.10.6, the proposed new city centre bus network would interface with the construction of the CSELR proposal at the following four locations:

- Chalmers Street
- Eddy Avenue
- Rawson Place
- Park Street/Druitt Street/George Street intersection.

Local bus arrangements that would be implemented to manage the impact on bus operations at the above four locations are described in Table 12.19 (refer to the City Centre Precinct assessment provided in section 12.2.3).

South East bus services

Impacts to the operation of the South East bus network during construction would be managed through a mixture of local route diversions and construction staging to ensure continuity of access. Key areas where this approach would be adopted to manage construction impacts include:

- Anzac Parade, particularly at Kingsford and Kensington
- High Street
- Alison Road
- the Anzac Parade/Alison Road intersection
- the Moore Park Busway.

Impacts on pedestrians

A detailed assessment of the CSELR proposal's impact on pedestrian access and movements within, adjacent to and around the CSELR construction footprint is provided on a precinct by precinct basis in sections 12.3.3 (City Centre Precinct), 13.3.3 (Surry Hills Precinct), 14.3.3 (Moore Park Precinct), 15.3.3 (Randwick Precinct), and 16.3.3 (Kensington/Kingsford Precinct).

Generally, the CSELR corridor would traverse areas of high pedestrian activity, particularly within the City Centre Precinct. Many of the footpaths within the CBD experience high levels of congestion at peak times, which includes weekday lunchtimes. The construction methodology has been developed to minimise impacts to footpath widths and crossing facilities to ensure sufficient pedestrian capacity is provided in a safe environment.

For the majority of the main construction works, existing longitudinal pedestrian movements (i.e. pedestrian movements running parallel to the CSELR alignment) would be maintained along the footpaths. Transverse pedestrian movements (i.e. pedestrian movements crossing the CSELR alignment) would generally be maintained at existing pedestrian crossing facilities either at signals or controlled by traffic controllers. While the mid-block pedestrian crossing at Martin Place would be maintained during construction, the mid-block crossings at the Strand Arcade, Queen Victoria Building and Event Cinemas (on George Street) would be closed during the entire construction period.

Installation of overhead wiring foundations and service relocations would require the closure of the footpaths, where such works encroach onto footpaths. During such cases, the footpaths would be temporarily narrowed past the worksite or pedestrians would be diverted to adjacent footways via safe crossing facilities with appropriate barriers and signs. Alternatively, temporary structures would need to be installed to facilitate the pedestrians over the worksites. Footpaths adjacent to worksites with high volumes of construction vehicle movements would require traffic controllers to manage the conflict between construction vehicles and pedestrians.

Where worksites have an impact on footpaths, consideration would be given to the requirements of all pedestrians and especially vulnerable users (e.g. those with mobility limitations). *Disability Discrimination Act 1992* requirements would be adopted (e.g. with drop kerbs, etc. provided at crossings). Footpath widths would allow two-way pedestrian traffic, with sufficient space provided to accommodate pushchairs and wheelchairs. Where high numbers of vulnerable users utilise a footpath, special provision and design consideration would be undertaken to minimise impacts to these pedestrians.

All worksites would consider issues of pedestrian safety and security as detailed in the proposed construction traffic mitigation measures in section 9.2.4.

Footway lighting would be provided, where required. Any barriers and pedestrian screens adjacent to pedestrian footways would be designed so as to permit observations from the worksite and opposite footway. During the daytime, local businesses would provide some overview of footways. Traffic controllers (located at intersections) would also be able to monitor pedestrian movements and respond to incidents on footpaths and at crossings.

At night, pedestrian numbers would be lower; however, personal security would be more important. Depending on the extent of the work zone and whether frontage premises have extended operating hours, it may be necessary to maintain traffic controllers and/or security staff. Prior to the start of work, the coverage provided by existing monitoring and the need for and type of any support at particular locations, would be agreed with NSW Police and local councils.

Impacts on cyclists

A detailed assessment of the CSELR proposal's impact on cyclist access and movements within, adjacent to and around the CSELR construction worksite is provided on a precinct by precinct basis in sections 12.3.3 (City Centre Precinct), 13.3.3 (Surry Hills Precinct), 14.3.3 (Moore Park Precinct), 15.3.3 (Randwick Precinct), and 16.3.3 (Kensington/Kingsford Precinct).

Where existing cycle routes or facilities are occupied by the construction worksites, alternate routes would be identified. Alternative cycle route changes that are anticipated to be required during the construction of the CSELR proposal include the following:

- to avoid Devonshire Street, an alternative route along Cooper Street/Author Street is proposed
- to avoid Wansey Road and Alison Road, an alternative route along Botany Street, Church Street and Kings Street is proposed.

In developing these temporary diversions, consideration has been given to the suitability of alternative routes based on the road environment and current function. Alternative cycle routes would be reviewed by the relevant roads authority with input from local bicycle user groups and local communities, prior to their implementation.

Existing cycle paths located within the construction corridor but not occupied by the worksite would be maintained during construction.

Impacts on emergency vehicle access

Access for emergency vehicles would be maintained at all construction sites and emergency services would be advised of all planned changes to traffic arrangements prior to applying the changes. Advice would include information about upcoming traffic switches, anticipated delays to traffic, extended times of work, locations of road possession or any likely major disruptions.

Measures to facilitate the movement of emergency vehicles through a worksite would be made available at all worksites and would be defined in the worksite specific traffic management plans. These measures may include the establishment of clearways adjacent to worksites and/or the installation of road plates.

During short periods when major construction and loading/unloading activities are underway, it may not be possible to allow emergency vehicles to traverse the full block length. Access to an emergency within the block would be maintained at an identified access point and diversion routes would be agreed with the emergency services prior to the commencing the major construction and loading/unloading activities. The construction contractor would consult with

NSW Fire and Rescue during the preparation of the site specific traffic management plans, to obtain any specific requirements for any of the buildings adjacent to the CSELR alignment. An emergency management plan would coordinate these measures and provide a framework for input to the individual worksite traffic management plans.

Emergency management

An emergency comprises an unforeseen event that requires urgent action to protect life or property, or an occasion when emergency services (Police, Fire Brigade, Ambulance or State Emergency Services) take control of a portion of the road network. Examples of such events include traffic accidents, hazardous spillages, power failures, and structural damage to a rail line, building, road tunnel or bridge.

In the event of an emergency during the construction of the CSELR proposal, RMS's *Incident Response Plan Manual* would be consulted to determine the appropriate procedure and responses required to address the emergency.

All details of emergencies that occur within a Road Occupancy Licence area would be recorded and forwarded to the relevant road authority within seven days of the incident occurring, with details of where the incident occurred, any contributing factors related to the Road Occupancy Licence and any actions that have been taken with respect to the Road Occupancy Licence conditions.

Incident management plans for proposed worksites would be developed in the site specific construction traffic management plans. A record of all traffic accidents and incidents reported at worksites would be maintained in the Road Occupancy Licence database.

9.2.4 Management and mitigation

Operation and construction

Network Management Plan

A network management plan would be developed for the CSELR proposal during detailed design to identify key management measures that would be implemented to minimise impacts to journey times and congestion levels. The network management plan would operate in four main phases — planning, pre-construction, construction and operation. Transport for NSW would be responsible for developing and maintaining the network management plan in consultation with stakeholders.

Through consultation with agencies and assessment of forecast impacts to the transport network, the network management plan would result in a holistic approach to mitigate the effects of construction and operation of the CSELR proposal and result in the maximum effectiveness of these measures. The plan would consist of the following three main elements:

- incident management strategy
- demand management strategy
- network optimisation strategy.

The incident management strategy would be in place to increase resilience of the road network when unplanned events occur on the network. This would include detailed contingency measures to address issues such as flooding, fallen trees/branches and LRV breakdowns which could impact on the operation of CSELR services and/or other modes of transport. The demand management and network optimisation strategies would seek to maximise the efficiency of the network in response to the changed conditions following light rail implementation. The latter two strategies would seek to address the impacts identified through the traffic analysis and would develop as the CSELR proposal design is optimised by during detailed design.

Demand management strategy

A reduction in travel demand would ensure the changes to the road network bought about by the CSELR proposal do not lead to a significant increase in congestion on the network. Managing traffic generation by congestion is considered an inappropriate way to reduce demand as it leads to increased travel times, amenity impacts, and a higher road accident rate. Further congestion also adversely impacts on public transport trips, thus deceasing the efficiency of the whole transport system.

Transport for NSW would work alongside the relevant road authorities to develop appropriate demand management strategies for the construction and operational phases of the CSELR proposal. The successful implementation of these measures would reduce peak hour travel demand and ensure network efficiency is not compromised. These demand management strategies would be integrated with network optimisation measures being developed as part of the SCCAS, to ensure their maximum effectiveness.

Network optimisation strategies

In conjunction with the demand management measures, targeted traffic management upgrades are proposed to be undertaken to improve general traffic circulation in the vicinity of the CSELR proposal. Within the CBD, these measures would also form part of the SCCAS which identifies the priority traffic routes shown in Figure 9.12 and the redesign of the city centre bus network. These plans seek to ensure the CBD operates effectively from the perspective of all modes. Any traffic management upgrades would be undertaken through the staged implementation of the SCCAS and are not part of the CSELR proposal.

Outside of the CBD, Transport for NSW would continue to work with local councils and RMS to mitigate the local traffic impacts and potential increased traffic flows that may occur on local roads as a result of the CSELR proposal.

Construction

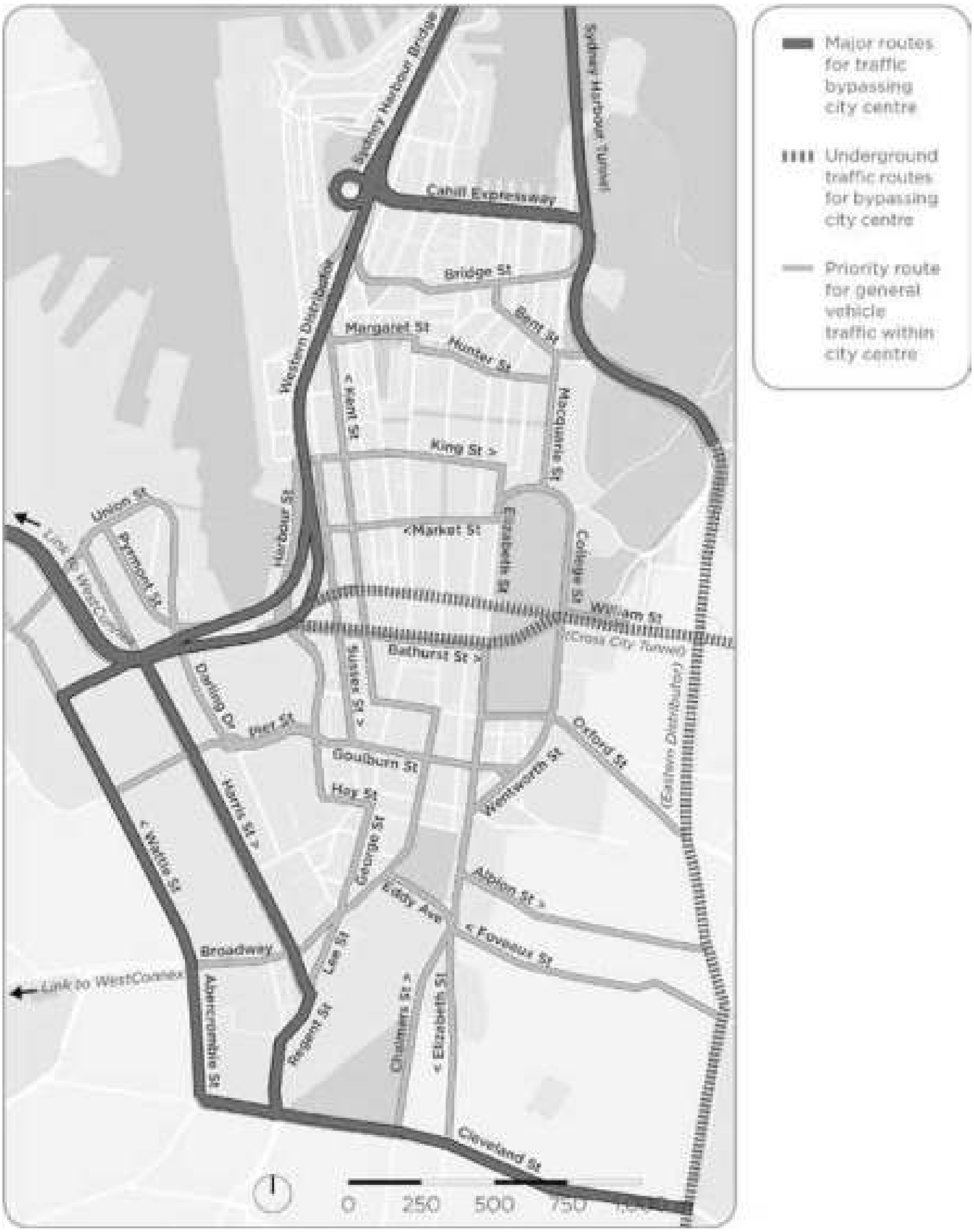
The traffic, transport and access management strategies that would be adopted during the construction of the CSELR proposal are provided in section 6.10. These strategies address the following aspects:

- intersection works (refer to section 6.10.1)
- South Dowling Street regrading works (refer to section 6.10.2)
- traffic signal modifications (refer to section 6.10.3)
- midblock works (refer to section 6.10.4)
- road changes (refer to section 6.10.5)
- bus operations (refer to section 6.10.6)
- interaction with the Inner West Light Rail (refer to section 6.10.7)
- pedestrian traffic management (refer to section 6.10.8)
- cyclist routes (refer to section 6.10.9)
- on-street parking (refer to section 6.10.10)
- emergency access (refer to section 6.10.11)
- emergency evacuation procedures for buildings (refer to section 6.10.12)
- property and utility access (refer to section 6.10.13)
- special event management (refer to section 6.10.14).

The following sections provide an outline of additional regional measures that Transport for NSW proposes to manage potential regional traffic, transport and access impacts associated with the construction of the CSELR proposal.

Additional environmental management measures that Transport for NSW proposes to address precinct specific traffic, transport and access impacts are provided on a precinct by precinct basis in sections 12.3.4 (City Centre Precinct), 13.3.4 (Surry Hills Precinct), 14.3.4 (Moore Park Precinct), 15.3.4 (Randwick Precinct) and 16.3.4 (Kensington/Kingsford Precinct).

Figure 9.12 Priority traffic routes in the Sydney CBD (under the SCCAS)



Source: Sydney City Centre Access strategy - for further consultation (Transport for NSW 2013)

Construction network management plan

A construction network management plan would be developed during detailed design to identify key management measures during construction to minimise impacts to journey times and congestion levels. The plan would also establish a framework for coordinating the implementation of such management measures during the construction of the CSELR proposal.

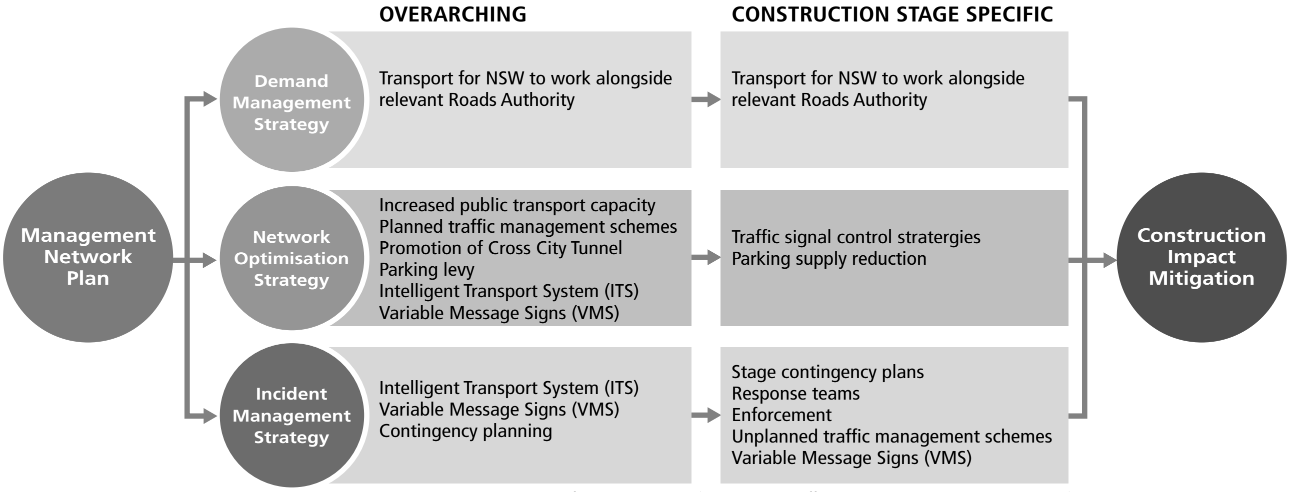
The construction network management plan would seek to align the peak period travel demand with the traffic capacity available during construction. It would be essential that the key strategic traffic management measures are planned and coordinated to maximise their effectiveness across the network. The plan would ensure this holistic approach is adopted to mitigate the negative impacts of construction on the road network. The structure of the plan is illustrated in Figure 9.13. It would consist of the following three elements:

- *Demand management strategy* — These are strategies that would be promoted and implemented prior to construction to reduce peak period demands on the network, as listed previously in the operational management and mitigation section above.
- *Network optimisation strategy* — These are strategies that would be promoted and implemented prior to construction, and represent network optimisation objectives. These objectives include overarching strategies (i.e. planned traffic management measures) and construction stage strategies (i.e. implementation of traffic signal control strategies or temporary restriction of localised parking) closely associated with the operational phase of the CSELR proposal, including:
  - the environmental management measures outlined in sections 6.10, 12.3.4, 13.3.4, 14.3.4, 15.3.4 and 16.3.4
  - increased public transport capacity to supplement the redesign of the city centre bus network before the CSELR is operational, as well as the promotion of increased public transport usage during construction
  - promotion of the Cross City Tunnel to increase usage of this asset to reduce demand on the congested surface streets
  - implementation of traffic signal control strategies that minimise delay based on the corridor and road network capacities associated with the current construction stage (to be implemented by RMS).
- *Incident management strategy* — These are strategies that would seek to pre-empt possible unplanned events based on general network operations during construction. These strategies are likely to represent enhancements to current incident management tools that would remain in place following construction to assist light rail network operations. These strategies would include:
  - inclusion of adequately designed intelligent transport systems into the CSELR design to facilitate quicker detection of events and provide additional management tools to respond to these events (e.g. full closed-circuit television coverage of the light rail corridor to enable the Transport Management Centre to identify incidents as they occur)
  - the provision of temporary and permanent variable message signs (VMS) to advise drivers of likely delays, upcoming works and diversion routes (in consultation with the relevant roads authority)
  - the development of contingency plans to address possible events as they arise.

The construction network management plan would comprise a live document that would be updated as a greater understanding of the required construction staging is developed and as new management measures are identified in response to unforseen events during construction and light rail operations.

Further discussion on the construction network management plan is provided in section 3.4.1 of Technical Paper 2 – *Construction Traffic and Transport Management Plan*.

Figure 9.13 Structure of the construction network management plan and site specific traffic control plans



Source: Figure 3-6 of Technical Paper 2 (Construction Traffic and Transport Management Strategy)

Traffic management plans

Site specific traffic management plans would be prepared for the construction of the CSELR. The site specific traffic management plans would provide details of individual traffic control plans and road occupancy licence requirements. The site specific traffic management plans would be prepared in accordance with RMS construction specifications and RMS *Traffic Control at Work Sites Manual Version 4.0*. Approval of these documents would be sought from the relevant roads authority, which would be submitted through Transport for NSW.

As part of the construction network management plan, targeted traffic management measures would be developed to address the reduction in traffic capacity that is predicted during construction.

Road occupancy licence

The contractor would comply with the relevant roads authority procedures in applying for road occupancy licences. Road occupancy licences and supporting traffic control plans would include applications to the relevant roads authority for any required speed zone authorisations. The applications would be submitted to Transport for NSW, which would coordinate all submissions on behalf of the construction contractor. Prior to the commencement of any changes to the existing traffic arrangements, a toolbox or daily pre-start meeting of all personnel involved would be held, where the nature of the changed arrangements and procedures for their implementation would be discussed.

Transport for NSW would oversee road occupancy licence applications in and around the CSELR construction corridor to manage cumulative impacts. The cumulative impact on travel time resulting from multiple road occupancy licences operating concurrently would be assessed by the road authority.

Where necessary concurrent works are expected to have unreasonable impacts on travel time or create unreasonable levels of disruption, communication strategies would be provided to advise motorists of extended journey times in accordance with the project community consultation protocols.

Speed zone authorisation

An application to the RMS would be made through Transport for NSW for any proposed adjustment to speed limits whether they are temporary (such as those required for short-term road occupancies), longer term (such as for the duration of a construction stage) or permanent. No adjustments to speed limits would be undertaken without an approved speed zone authorisation.

General traffic, transport and access measures

Other traffic, transport and access management measures that are proposed to be implemented during construction include:

- The indicative planned traffic management measures described in section 3.9.4 of Technical Paper 2 – *Construction Traffic and Transport Management Plan* would be considered and, where appropriate, implemented to manage a reduction in traffic capacity along the CSELR corridor.
- Opportunities to stage construction works on the Anzac Parade and Alison Road corridors would be investigated during detailed design to provide additional capacity during construction and reduce increases to travel time.
- Opportunities to signpost and promote alternative road corridors in the South East would be investigated during detailed design and/or construction phases with the aim of lowering traffic volumes along the proposed construction corridor. Alternative corridors could include:
  - Wentworth Avenue, Gardeners Road and Botany Road for traffic travelling to/from south eastern suburbs such as La Perouse, Little Bay, Malabar and Maroubra
  - Avoca Street, Carrington Road, Arden Street, York Road, Syd Einfield Drive and Oxford Street from eastern suburbs such as Coogee, Clovelly, Bronte and Bondi.
- The use of alternative routes which bypass the CBD would be promoted, such as the Eastern Distributor, Cross City Tunnel and Cleveland Street.
- Current and proposed bicycle corridors in the CBD would be reviewed to ensure they are integrated with the newly defined traffic priority routes.
- Subject to further investigation, tidal flow operation on Anzac Parade during construction would be considered, to provide a bus priority lane in the peak direction and protect bus journey time reliability along the corridor. This would involve further review by RMS, including traffic modelling, to assess the impacts and feasibility in more detail.
- A single lane would be retained along the entire length of the existing Anzac Parade Busway and complementary bus priority measures on Alison Road. This would facilitate bus priority through these congested sections of the network, but may have an impact upon the construction program for this section.
- The traffic, transport and access management strategies described in section 6.10 of the EIS would be adopted during the construction of the CSELR proposal.
- Where possible, existing longitudinal pedestrian movements (i.e. pedestrian movements running parallel to the CSELR alignment) would be maintained along footpaths. Similarly, where possible, transverse pedestrian movement (i.e. pedestrian movements crossing the CSELR alignment) would be maintained at existing pedestrian crossing facilities either at signals or controlled by traffic controllers.
- Where appropriate, traffic controllers would be used when undertaking construction works adjacent to footpaths with high volumes of construction vehicle movements to manage the conflict between construction vehicles and pedestrians.
- *Disability Discrimination Act 1992* requirements would be adopted (e.g. with drop kerbs, etc. provided at crossings). Footpath widths would allow two-way pedestrian traffic, with sufficient space provided to accommodate pushchairs and wheelchairs. Where high numbers of vulnerable users utilise a footpath, special provision and design consideration would be undertaken to minimise impacts to these pedestrians.
- Any hoardings or other fixed site boundaries would have lighting if required by current standards.
- Consideration would be given in design to the layout of any hoarding/fence lines to maximise sight lines for pedestrians, and design out hiding places and blind spots to improve pedestrian personal security. Any gantry arrangements or tunnels would have internal lighting.
- Consideration would be given to relocating or supplementing existing CCTV cameras if the worksite creates unacceptable blind spots.
- Footway lighting would be provided, where required. Any barriers and pedestrian screens adjacent to pedestrian footways would be designed so as to permit observation from the worksite and opposite footway.

- Pedestrian capacity on footpaths would be enhanced by the removal of bus stops and increased crossing opportunities at intersections, due to the reduction or elimination of George Street traffic movements.
- Prior to the start of work, the coverage provided by existing surveillance/monitoring and the need for and type of any support at particular locations around the worksite, would be agreed with NSW Police and local councils.
- Emergency evacuation requirements would be agreed with emergency service providers (Fire Brigade). Depending on the stage of work this may require:
  - temporary road plates to permit crossing of the work zone
  - assistance of traffic controllers in restricting public access to the street block and facilitating access for emergency service vehicles
  - protocols for managing emergency response, which would need to be agreed with service providers prior to the start of work
  - protocols to manage the evacuation of occupants adjacent to the worksite, which would need to be agreed with the building owners and service providers prior to the start of work.
- Where required, alternative cycle routes would be reviewed by the local authority with input from local bicycle user groups.
- Existing cycle paths located within the construction corridor but not occupied by the worksite would be maintained during construction.
- Access for emergency vehicles would be maintained at all construction sites and emergency services would be advised of all planned changes to traffic arrangements prior to applying the changes.
- In the event of an emergency occurring during the construction of the CSELR proposal, RMS's *Incident Response Plan Manual* would be consulted to determine the appropriate procedure and responses required to address the emergency.
- Heavy vehicles would be restricted to specified routes, with the aim of avoiding local streets, high pedestrian areas and school zones. Where feasible, route markers would be installed for heavy vehicles along designated routes.
- Off-site construction vehicle parking would be limited to designated areas. Areas of temporary on-street parking during peak construction events would be identified in the traffic management plans to minimise the impact on surrounding properties and businesses.
- The queuing and idling of construction vehicles in residential streets would be minimised, where possible.
- An emergency response plan would be developed for construction traffic incidents.
- A pre and post construction assessment of road pavement assets would be conducted in areas likely to be used by heavy construction vehicles.
- Where required, public communications would be conducted to advise the community and local residents of vehicle movements and anticipated effects on the local road network relating to site works in accordance with the construction environmental management plan (CEMP).
- During project inductions, all heavy vehicle drivers would be provided with the emergency response plan for construction traffic incidents.
- Construction vehicle traffic movements would be undertaken outside of peak road traffic periods and outside of school peak periods where feasible.
- Affected stakeholders, such as local government authorities, emergency services, utility providers, local schools, public transport operators, public transport users, road users, local businesses, local employees and residents, would receive advance notification of scheduled construction works to allow for planning of required journeys.
- Appropriate information, road and traffic signage, pavement markings and line markings would be implemented to advise commuters, pedestrians and road users of changed conditions.

9.3 Regional land use and community outcomes

As highlighted previously in Chapter 3, the CBD is the major employment hub in Sydney, accounting for approximately 16 per cent of all Sydney's jobs (equating to around 450,000 employees). The CBD also supports a significant residential population of around 193,000 (Bureau of Transport Statistics 2012a and 2012b).

By 2031 an additional 99,000 residents and approximately 140,000 workers are expected within the CBD, as well as 24,000 new residents and 13,000 new workers in inner South East Sydney (Bureau of Transport Statistics 2012a and 2012b). The draft *Metropolitan Strategy for Sydney 2031* (NSW Government 2013a) also estimates that the area encompassed by Sydney's CBD and North Sydney is predicted to have an increase of more than 114,000 new jobs during this same period. This significant growth forecast for the CBD and inner east Sydney is likely to exacerbate existing issues, resulting in a further decline in productivity and amenity, which would ultimately have a negative impact on the international competitiveness of Sydney.

9.3.1 Regional land use plans and strategies

Regional land use planning endeavours to manage the development of land in an effective, orderly, transparent and equitable manner for the benefit of all people for the present and for the future. The regional development of land uses within a region such as Sydney is controlled by a hierarchy of strategic plans, policies and other guiding local development plans. These strategies are developed at a number of levels and provide for a range of purposes from overarching strategic planning to specific development controls for site-specific land uses.

This hierarchy of plans provides a clear and focused framework for strategic land use planning across an urban region. At the higher strategic level, this hierarchy focuses on identifying areas for the facilitation of economic growth and environmental and social outcomes, emphasising issues appropriate to this scale of future planning. At a local level, these strategies focus on providing the specific development controls and process that facilitates development of an urban area, including the scale form and function of land uses and the way in which these land uses interact.

A summary of the major land use strategic plans and policies that affect land use within the Sydney region, in particular within the vicinity of the CSELR proposal, is shown in Figure 9.14.

Figure 9.14 Hierarchy of planning and land use strategies

NSW Government overall 10-year plan	• NSW 2021 – A Plan to make NSW number one (2011)
Long term strategies and delivery plan	• Draft Metropolitan Strategy to 2031 (2013) • NSW Long Term Transport Masterplan (2012) • Sydney's Light Rail Future (2012) • Sydney City Centre Access Strategy (2013)
Local land use strategic plans and policies	Sydney City Council local government plans and policies: • Sustainable Sydney 2030 Community Strategic Plan (2011) • Sydney Local Environmental Plan (2012) • Sydney Development Control Plan (2012) • City of Villages – 2030 in Your Village – City Transformation (2011) • Draft George Street Concept Design (2012)
	Randwick City Council local government plans and policies: • An Inclusive Randwick City (2010) • Randwick Local Environmental Plan (2012) • Randwick Development Control Plan (2013) • Randwick City Plan: A 20-year Plan • Kingsford Town Centre Strategy • The Randwick Urban Activation Precinct
	Other plans and policies: • Redfern Waterloo Authority Built Environment Plan Stages 1 and 2 • Centennial Parklands Strategic Land Use Vision • Royal Randwick Racecourse masterplan • Randwick hospitals campus masterplan

9.3.2 Existing land use, communities and facilities

The CSELR proposal would traverse a varied urban environment. The area surrounding the CSELR proposal contains a wide variety of land uses, incorporating residential areas, employment areas, retail, educational centres, health precincts and major recreational destinations.

At the northern end of the alignment, the proposal would facilitate interchanges with the Sydney Trains network and the Sydney Ferry network and service the Sydney CBD region. This area provides a range of land uses, which are mostly commercial and financial uses; however, it also provides a series of retail, residential, and tourist facilities and attractions.

The suburb of Surry Hills denotes the transition from the CBD to an area with a mixed-residential development pattern of terraced houses, smaller former warehouses that have been adapted for retail and residential uses. Further to the east of Surry Hills, the crossing of South Dowling Street denotes another change in land use, providing a range of key destinations at Moore and Centennial Parks including the SCG, SFS, the Entertainment Quarter, Centennial Parklands, and the Moore Park Golf Course. To the south of this precinct, the proposal would service the greater Randwick and Kingsford regions. These areas are dominated by a mixture of low to medium rise residential apartment buildings and strip retail uses along the main transport routes of Alison Road, High Street and Anzac Parade. The land use of this region is also influenced by three major land uses; the Royal Randwick racecourse, the UNSW campus, and the Prince of Wales Hospital complex.

Chapters 12 to 17 identify existing land uses within the immediate vicinity of the CSELR alignment and each light rail stop. These chapters discuss the potential of local development within each of the precincts associated with the CSELR and illustrate how development could be integrated with the proposed light rail stops.

9.3.3 Regional planning and land use implications of the CSELR proposal

In general, the introduction of a major new public transport infrastructure into the existing network would have the potential to result in a changed pattern of passenger trips to take advantage of the improved capacity. Integrated planning of transport and land uses recognises that land use generates demand for travel while the available transport system influences how land is used for particular purposes. The ability to access housing, employment, retail outlets, education and other community services impacts on the quality of life of residents of a city. Effectively integrated land use patterns and transport systems make it possible to move people in ways that make the most of available economic and human resources.

An area of land that currently has limited access to transport options could potentially become much more attractive (and valuable, refer to section 9.4) if a major new public transport facility is constructed adjacent (or within close proximity) to it. The influence of a new public transport facility could represent a major change in accessibility and could have the potential to lead to pressures for future development (and/or redevelopment of existing, established areas) that might succeed if the circumstances of these developments are favourable. That is, where light rail stops are in areas where the existing surrounding land uses and policies are conducive to higher-density development.

Planning and land use changes associated with the CSELR proposal could have the potential to occur on two key levels. These are the introduction of opportunities for:

- Changes in the location and type of development within the region to take advantage of perceived improvements in environmental amenity and/or accessibility — this would be most pronounced around the proposed stop locations along the alignment.
- Changes to planning and land use controls to enable greater or lesser intensities of development to take place where local councils identify that factors such as improved access have the potential to allow for increases in the development allowed at certain locations.

Future urban development

As discussed above, the structure and service of the available transport system is a key determinant of the way in which an urban area evolves. However, inner Sydney's existing public transport system is currently limiting the potential for future urban development within this region due to congestion and limitations in the quality and level of public transport access. Future urban development can be used to describe a range of transformations that could occur within an urban region including:

- *improvements in the public domain* — including the quality of streetscape, connections and connectivity
- *intensification of urban form in appropriate locations* — including increases in density or modification of land uses
- *increase in value* — including increases or changes to the types of activities taking place to deliver increase in economic activity or value.

The future urban development of fringe areas surrounding the CBD has traditionally been heavily influenced by activities generated in the central area and is subject to pressures for change and intensification of development. This is particularly the case where the conversion of redundant industrial or harbour side land to residential land uses is possible. This is currently evident with the ongoing residential and commercial conversions of previous industrial sites for major residential and mixed use renewal sites within the vicinity of the CBD. This includes the former shipping terminal at Barangaroo at the northern end of the CBD and Green Square, Zetland and Broadway (Central Park development) which are all former industrial sites towards the south and south-western ends of the CBD.

This process of urban development has also been stimulated in part by other transport infrastructure that has been introduced into the area, such as the Eastern Distributor and the Airport Rail Link, and supported by current and previous NSW Government planning policies as described in Chapter 3.

While the significant improvements in accessibility resulting from these new infrastructure developments are important contributing influences, a multitude of other factors are also driving these future urban development processes. In terms of regional planning and land use, the CSELR proposal would be consistent with broad transport, environmental and equity policies and strategies identified for the central Sydney region by State and local governments (refer to Chapter 3 and section 9.3.1). The CSELR proposal would potentially provide the opportunity to catalyse future urban development along its route (in conjunction with appropriate local land use control changes) and could assist in providing the connectivity, amenity and permanence that would support investment in future transit oriented developments. In this way, it would not only further supporting the viability of the light rail service itself, but also provide secondary environmental and social benefits associated with more affordable, compact communities.

Integration with existing urban development opportunities

The CBD and South East regions of Sydney currently contain a wide variety of land uses, incorporating residential areas, employment areas, retail, educational centres, health precincts and major recreational destinations, all within a short to moderate distance from the Sydney CBD. The CSELR proposal provides opportunities underway or proposed for the short to medium-term future within the vicinity of the CSELR proposal.

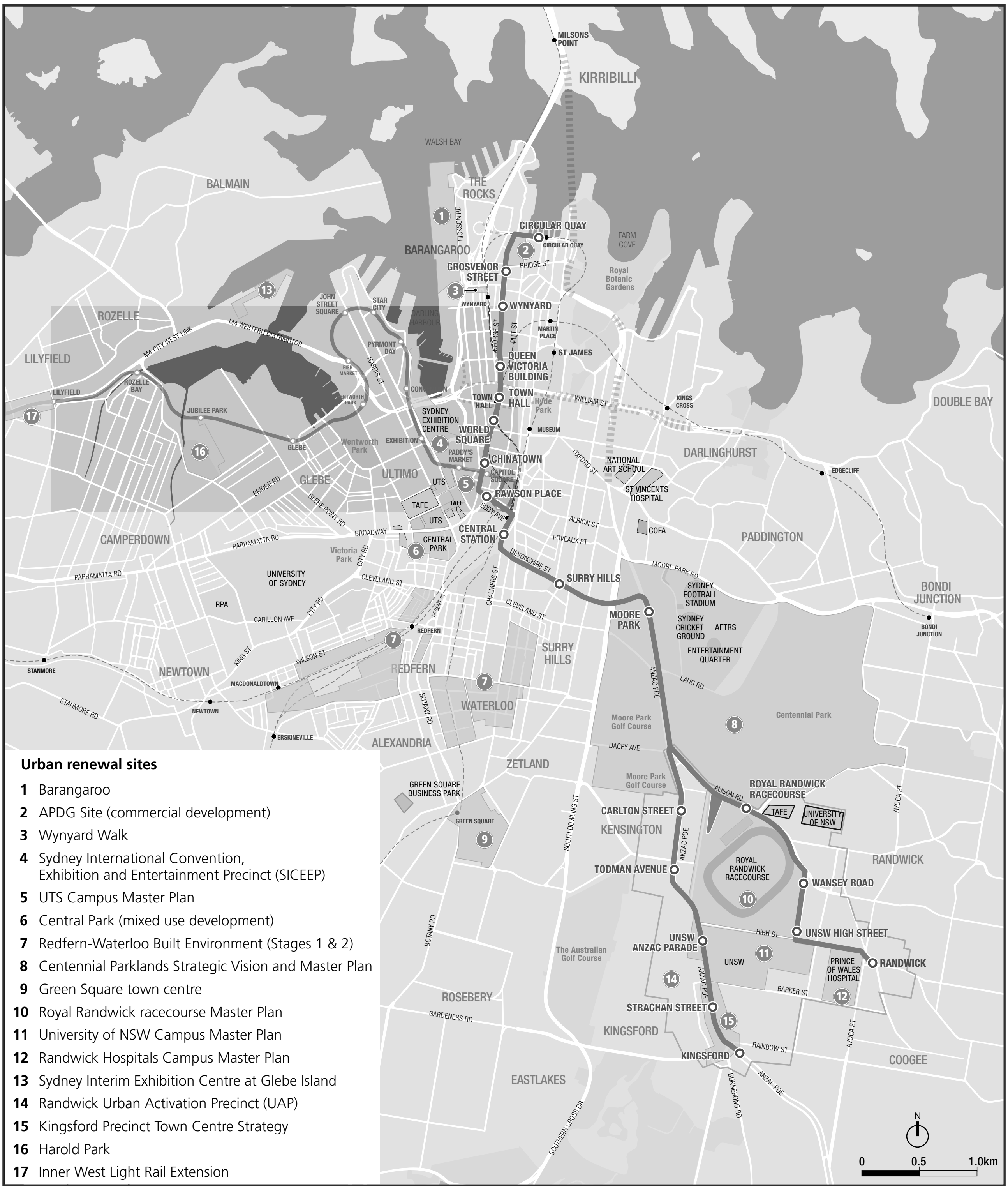
Current and proposed urban development within the CBD and South East regions, is identified in existing and draft local environmental plans (LEPs), available master plans, local planning strategies, high level planning strategies (including the draft *Metropolitan Strategy for Sydney 2031* and the Sydney City, East and Inner West Draft Subregional Strategies), and the NSW Department of Planning and Infrastructure's (DP&I's) major projects register. Additionally, in March 2013, the NSW Government announced the UAP program. UAPs are important areas that the NSW Government considers to have a wider social, economic, or environmental significance for the community or have redevelopment significance of a scale that is important to implementing the State's planning objectives such as housing and employment targets. The aim of the UAPs program is to deliver more residential and employment opportunities in places with access to infrastructure, transport, services and jobs. Further discussion of the potential influence of the UAP program on the CSELR proposal is provided in section 15.4.

Figure 9.15 provides a summary of the major planned future land use developments that have been identified within the CBD and South East regions that may impact on, or be influenced, by the CSELR proposal.

In addition to the renewal sites identified, it is anticipated that a range of further smaller scale redevelopments could occur throughout the region to take advantage of the improved transport network. In particular, the CSELR proposal would be expected to improve the existing shopping strips that currently exist along major roads such as the Kensington and Kingsford shopping strips along Anzac Parade, and the retail and medical precinct on High Street and Belmore Road in Randwick.

Local land use and property impacts associated with the CSELR proposal within each of the identified precincts are described in Chapter 12 to Chapter 17.

Figure 9.15 Planned future land use developments within the CBD and South East regions



Existing Sydney Trains network
Existing Light Rail network
Inner West Light Rail extension
CBD and South East Light Rail route
Proposed CSELR stop
Area of renewal site or investigation
Proposed Randwick stabling facility
Urban Activation Precinct boundary

9.3.4 Impacts on community values

Social and community value impacts of the CSELR proposal may directly affect the social well-being of the region's residents, visitors and employees by changing the social amenity and character of the region, the access to local community services and open spaces, the degree of social interaction and connectivity of residences, and the social sustainability and community functioning of the region. In many cases, very different types of impacts would be expected in the construction stage relative to the operational stage. Some impacts would be permanent, rather than temporary, and would carry forward from construction to operation. These issues, with respect to the CSELR proposal are described below.

Local social and community value impacts associated with the CSELR proposal within each of the identified precincts are also described in Chapter 12 to Chapter 17.

The following sections provide a summary of the potential regional social impacts of the proposal, based on Technical Paper 3 — *Social impact assessment* in Volume 3 of this EIS.

Amenity, character and environment

Overall regional amenity is likely to improve overall upon operation of the CSELR proposal. While construction would have some short-term negative impacts along the length of the alignment, the wider region would benefit in the longer-term from a reduction in bus congestion and the potential for new public spaces, greater pedestrian activity, and new business opportunities. Both George Street and Anzac Parade would experience significantly less bus congestion. The pedestrianisation of George Street would improve the amenity of this area for pedestrians, and increase opportunities for businesses and retail services during both day and night-time periods. Additionally, Anzac Parade is likely to benefit from the opportunity for development of new commercial centres around light rail stops (refer to section 9.3.2). Surry Hills and Randwick may also see benefits; however, activation of new public spaces and integration of light rail within the current urban environment would require careful planning given the introduction of a new form of transport infrastructure into these areas. The proposed George Street pedestrian zone and the current Olivia Gardens apartment complex site would represent candidates for new community hubs.

Access to local community services

The CSELR proposal would increase access options for important community services along the route and across the wider region. The greatest benefits would be felt by those travelling to and from Randwick and Kensington/Kingsford. Students and staff travelling from outside the inner city to UNSW would benefit from a more reliable and comfortable experience than the current express buses from Central. The expanding Randwick health precinct would also be able to better accommodate an increasing number of visitors travelling to the precinct for specialist care from across the wider Sydney and South East regions.

Access to public spaces and urban connectivity

The CSELR proposal would introduce a much-needed form of transport to connect Sydney's CBD with the South East, contributing to the long-term vision of a connected Sydney. Connectivity may be impaired at some locations during construction, although this impact would only occur in the short-term.

Access to public spaces within the region would dramatically improve, particularly for Moore Park and Centennial Park, and the associated Entertainment Quarter. The CSELR proposal would also allow for the existing major traffic route of George Street to be reclaimed for the public, and the pedestrianisation of this area would improve access to this major civic spine throughout the CBD region. Several opportunities also exist along the route of the CSELR proposal to create dynamic new public spaces, such as along the George Street pedestrian zone and the current site of the Olivia Gardens apartment complex.

Construction would temporarily affect access to some public spaces throughout the region, resulting in some short-term amenity and social impacts. Upon operation, however, the CSELR proposal would provide the opportunity for enhanced connectivity and expanded public spaces to connect the various communities within the region. It would also provide opportunities for activities and events that would improve the connection and social cohesion between these communities.

Health and wellbeing

During operation, the CSELR proposal would generally decrease transport congestion within the region, especially in areas such as George Street and Anzac Parade, which would reduce the burden of such congestion on human health and wellbeing. Research also indicates that people would walk longer distances to catch light rail than to catch a bus, which may encourage people who currently drive to work to walk or cycle to light rail stops. Construction would have the potential to result in potential health issues along the alignment from issues such as noise and dust. These issues would be of greater concern where construction is proposed to take place close to residences or other sensitive receivers such as health and medical practices.

Social sustainability and community functioning

The CSELR proposal would create the potential to improve social sustainability and community functioning across the CBD and South East regions, primarily by linking communities with recreational facilities, community services, and other communities themselves. Residents along the alignment would be able to more conveniently access a wider range of job and business opportunities. Businesses and facilities would also be able to access a wider range of customers. Businesses such as the Moore Park Entertainment Quarter, and the commercial centres of Kensington and Kingsford, would generally benefit greatly from the improved transport connections (refer to section 9.4 for details).

Potential severance issues created by the proposed light rail track could be offset by the planning and creation of new dynamic public spaces. For example, concerns about severance of existing land uses along Devonshire Street could be offset by incentivising the creation of small shops and cafes around the proposed Surry Hills stop at Ward Park (the development of which is outside the scope of the CSELR proposal and would be subject to a separate development approval process).

9.3.5 Management and mitigation

The amenity issues associated with the proposal, such as traffic and transport, noise and vibration, visual and air quality impacts, would be mitigated through environmental management responses described in Chapters 12–17). Consultation would play a vital role in the construction phase of the CSELR proposal to mitigate land use and property impacts, particularly impacts on directly affected land owners. Information would be provided regularly to community members throughout the construction process to ensure that they are adequately informed of planned works and relocations. The detailed design of the CSELR proposal would be undertaken in consultation with directly affected land owners. Additionally, the appropriate sequencing of construction activities would be managed to ensure that impacts on public land use are minimised.

9.4 Regional economic development

An economic 'impact' affects the level of economic activity generated in a defined area either positively or negatively. The assessment of likely impacts resulting from a particular project allows for the identification (and where possible) quantification of impacts as either likely benefits or negative impacts.

Economic impacts may directly affect the economic well-being of an area's residents, the viability of businesses, workforce availability or trade, by changing factors that influence opportunities for employment or business growth, the ease of doing business and the environment in which business is conducted. Economic impacts may also alter the scope of demand for services and the level of accessibility to those services. The geographic range of an economic impact is dependent on the nature of the proposed development and its scope of influence. The geographic influence of an impact can range from individual dwellings or streets through to suburbs, local government areas, states and countries.

The following sections provide a summary of the potential regional economic impacts of the CSELR proposal, based on Technical Paper 4 — *Economic impact assessment* in Volume 3 of this EIS.

9.4.1 Existing regional economy

Global Sydney

The significance of Global Sydney is reflected in its ranking by the 2012 Global Cities Index as the twelfth most influential metropolitan area in the world (AT Kearney 2012). The Global Cities index is based on a range of criteria, including business activity, human capital, information exchange, cultural experience and political engagement. With this global recognition comes a range of positive economic benefits including increased business investment, tourism, as well as broader international media and financial market coverage.

Global Sydney contains Australia's most significant concentration of economic, educational, medical, creative and cultural activities and accounts for over one-third or $99 billion of the NSW Gross Regional Product. The NSW Government's draft *Metropolitan Strategy for Sydney 2031* (NSW Government 2013a) states Global Sydney is the 'primary focus for national and international business' and a cultural, recreation and entertainment destination for the Sydney Metropolitan Area. Under the same draft Strategy, Central Sydney is expect to accommodate approximately 144,000 additional jobs between 2011 and 2031, whilst the Randwick Education and Health Specialised Centre has been set a target of 6,000 additional jobs over the same period.

At a more regional level, the CBD is Sydney's central commercial centre and is characterised by densely populated buildings for centres of commerce, finance, major retail centres, entertainment and tourist venues, in addition to hotels and other accommodation uses. A range of civic buildings are also located throughout the CBD region. Barangaroo is being significantly redeveloped to provide additional places for work, a significant new foreshore park and residences.

The South East subregion of Sydney is typified by residential communities with smaller businesses and commercial precincts, as opposed to the high-density business environment of the Sydney CBD. A range of open spaces and recreational uses are also prevalent, including significant economic generators such as the Moore Park Entertainment Quarter and Royal Randwick racecourse.

Lilyfield (within the vicinity of the proposed Rozelle maintenance depot) is characterised as a primarily residential suburb, with housing typologies varying from detached houses to terrace and unit dwellings. A small range of boutique retail and service businesses, community and leisure services are also located within the broader Lilyfield and Rozelle region.

Retail

Retailing is a major contributor to Global Sydney's economy, employing approximately 52,000 people and 13.5 per cent of the City's workforce (SGS 2011). The Sydney CBD contains an estimated 500,000 square metres of retail floor space, of which approximately 156,000 square metres has a frontage to George Street. It is estimated that retail within the Sydney CBD serves a trade area population in the order of 1.9 million persons, generating a retail expenditure capacity of approximately $26.3 billion per annum. This market is projected to increase by about 1.5 per cent per annum, to approximately $32.6 billion by 2026. In addition, over the next 14 years it is forecast that the total available retail spending capacity of the Sydney CBD residential catchment alone would increase by $6.3 billion in real terms.

Tourism

Sydney forms an important part of the Australia's tourist economy with more than half of all foreign visitors and two-thirds of international business travellers to Australia visiting Metropolitan Sydney (SGS 2011). According to one study, 29.9 million people visited Sydney in the 12-months to June 2011 of which 2.6 million were international visitors, 7.9 million were domestic overnight visitors and 19.4 million were domestic day visitors (MacroPlan Dimasi 2013). The same study estimated the quantum of expenditure generated by visitors to metropolitan Sydney in 2012 as being:

- international visitors — $5.4 billion
- domestic day trippers — $2.2 billion
- domestic overnight visitors — $5.6 billion.

Circular Quay in particular is a key gateway to Sydney and a location of local, national and international significance. Circular Quay is strategically positioned amongst Sydney's commercial core; the city's most historic, entertainment, leisure and cultural precinct (The Rocks, Sydney Opera House and the Royal Botanic Gardens). This multifaceted role and the range of stakeholders that underpin it, creates a vibrancy and vitality that defines Circular Quay as a major tourist attraction, a place of public celebration and congregation, and an economic driver for Sydney.

Education

In 2010/11 international education generated over $5.8 billion in export income and was NSW's second largest export (NSW Government 2012c). A world class university (UNSW) is located within the vicinity of the CSELR proposal, and numerous other universities and educational institutions are located within its broader region of influence, including Sydney University, University of Technology Sydney, University of Notre Dame, Sydney Institute TAFE, Randwick TAFE and Ultimo College TAFE.

Hospitals and health clusters

The Randwick Education and Health Specialised Centre includes UNSW, the Prince of Wales Hospital, Royal Hospital for Women, Sydney Children's Hospital and Prince of Wales Private Hospital. The centre employs 14,000 workers and is expected to grow to around 20,000 workers by 2031 (NSW Government 2013a). In support of the hospitals is a range of complementary and ancillary services, including short-term accommodation for patients and families, medical centres, retail facilities, and specialist medical services.

9.4.2 Macroeconomic impacts

Increased transport capacity

By 2031 the NSW Government is planning for Sydney's population to grow by 1.3 million people and forecasts that an additional 625,000 jobs would need to be generated over the same period (NSW Government 2013a). Of this growth, approximately 16 per cent of all new job growth is anticipated to occur within central Sydney, which underlies the importance of better utilising existing capacity and stimulating additional capacity within the wider region of the CSELR proposal.

As described in section 9.3, the number of people living and working in Sydney's CBD is forecast to increase dramatically over the next 35 years. At the same time, substantial growth is also forecast in the suburbs of Surry Hills (including approximately 9,700 residents and 5,300 jobs), Kensington and Kingsford (including approximately 8,900 residents and 6,300 jobs) and Randwick (including approximately 5,500 residents and 14,300 jobs). With Sydney's transport network presently almost at peak capacity, accommodating this level of growth will be a challenge. Unless the capacity of Sydney's transport network is increased it is unlikely the Sydney CBD, in particular, can accommodate the anticipated level of growth without incurring significant economic, social and environmental costs.

Housing supply and density uplift

In recent years Sydney has experienced its lowest rate of housing growth in 50 years, exacerbating the gap between housing demand and supply. Between 2007 and 2008 only 15,000 additional dwellings were built in the Sydney Statistical Division in comparison to 32,000 between 1999 and 2000 (NSW Government 2010b). Housing completions in NSW peaked in 1999–2000 and have since fallen by 47 per cent. Over the same period, private completions across Australia increased by 26 per cent implying that NSW is not keeping pace with other States in terms of housing developments.

The NSW Government recognises that constrained housing supply within Sydney is adversely impacting housing affordability and the economic competitiveness of NSW. A key objective of the draft Metropolitan Strategy for Sydney is to improve the affordability of homes by increasing supply to meet market demand. The delivery of new housing would be accelerated through a number of policies including the UAP program. The draft Metropolitan Strategy identifies that areas suitable for transformative future urban development and regeneration under the UAP program – such as Randwick and Anzac Parade South – would be supported by new infrastructure and improvements to public transport.

This approach recognises that higher density development is only attractive and sustainable when integrated with public transport connections that offer a convenient alternative to the private car. The NSW Government's policy to support urban densification with transport improvements is underpinned by the concept that:

> 'strong connections … can create economic opportunities, reduce congestion, and connect people to a greater range of jobs, educational opportunities and services. These connections make it easier for people to be a part of their local community and can complement sustainable active transport choices like walking and cycling that have environmental and health benefits and contribute to more attractive vibrant communities.' (NSW Government 2013a).

The CSELR proposal would support the NSW Government's policy objective to improve housing supply, choice and affordability. It would also improve the work/life balance of existing and new residents that live on or adjacent to the proposed CSELR alignment by providing improved access to homes, jobs, services and recreation facilities. Finally, the CSELR proposal would drive improvements to amenity and liveability through public domain upgrades and the activation of streets and public spaces. Businesses, residents and visitors alike would benefit from streetscape improvements made to George Street, Surry Hills, Kingsford and Randwick, including the removal of traffic and congestion, pedestrianisation of the streetscape and improvements to paving, lighting, furniture and street tree planting.

The economic cost of congestion

As existing public transport in the City of Sydney LGA and inner city areas becomes increasingly constrained (particularly during peak periods), travel by private car potentially becomes more attractive, despite mounting road congestion. The effect of increased road congestion has a negative impact on the attraction of Sydney as a place to invest in and to operate a business as a result of:

- increased travel times and therefore business service times, transportation costs and vehicle operating costs
- impeded staff access and therefore access to workforce and work related skills
- the reduced attraction of Sydney as a place to base a business and invest.

In relation to the regional area influenced by the CSELR proposal, congestion currently severely impacts the amenity and experience of pedestrians, businesses and public/private transport uses along George Street. During the morning peak (7 am to 9 am) George Street carries 290 buses and by 2015 this is expected to increase to 310. Similarly buses servicing the major trip generators around Moore Park (including the Entertainment Quarter, SCG and SFS), Kingsford and Randwick (Royal Randwick racecourse and the Randwick Health and Education Specialised Centre) are often operating at or near capacity.

The CSELR proposal would help to address the congestion issues within the wider region by:

- increasing capacity on Sydney's public transport network
- reducing the need for a large number of bus services
- encouraging a modal shift away from private car usage
- reducing congestion and improving amenity and pedestrian safety across the region
- reducing the potential economic cost of congestion to business operations as well as the socio-economic cost to factors such as mental and physical health and wellbeing.

Tourism

The considerable number of visitors to Sydney and NSW annually has a positive flow-on effect to the local, State and National economy. Tourism generates over 159,000 direct jobs and a further 120,000 indirect jobs in NSW, contributing around $30.5 billion to the NSW economy per annum. In the Sydney metropolitan region over 26,800 businesses are tourism based with a further 98,500 related to the tourism industry. However, the attraction of Sydney as a place to visit for leisure or business, relates to more than its iconic attractions. The lifestyle attributes of Sydney are an important factor as is the ease of moving around the city. Transport systems such as the CSELR can provide clear and user-friendly travel options for visitors.

Additional reasons why visitors to a city may prefer light rail networks as a means of moving around a city include:

- the ability to easily compare a light rail system to similar transport infrastructure in other international cities
- the comparative ease with which tourists can understand the direction of travel or a route network
- the frequency of service
- the price point — cheaper than a taxi yet more readily understood than a bus network.

The benefits of light rail to both domestic and international tourism also relate to the extended hours of service and the support this can bring to Sydney's night-time economy. A stronger night-time economy is not only beneficial for economic reasons but also creates activity and excitement in a city centre, improving its sense of safety and lifestyle appeal.

Land values

Land values have a tendency to move in response to positive and negative influences in a given area. As such they can be seen as a barometer of the net effectiveness of various changes. With respect to the impact of rail infrastructure to land value (including light rail), Vladimir Bajic found that when the metro was introduced in Toronto, Canada 'the direct savings in commuting costs have been capitalized into housing values' (Bajic 1983). Research suggests that land values are likely to increase in response to transport infrastructure improvements in inner city areas such as the Sydney CBD, Haymarket, Surry Hills, Randwick and Kingsford, as people are willing to pay more to live in accessible locations. The intensity of the effect would be related to the net transport benefit resulting from the new system.

Agglomeration

Agglomeration relates to the concentration of related or similar activities within a common geographic area such as a city centre. Sydney CBD has grown to support the agglomeration of economic activity through an increase in the density of the built environment and the associated clustering of industries. Improvements to the existing Sydney CBD transport network would enhance workforce accessibility thereby allowing for greater building densities and agglomeration.

The Sydney CBD has developed a strong cluster of businesses in the finance, telecommunications, scientific, technical, legal, retail and property industries. These industries seek to co-locate within Sydney CBD despite its comparatively higher cost of space because of the productivity benefits of agglomeration. Productivity is one of the main effects of agglomeration.

More specifically, investment in public transport can:

- lead to higher density employment and increase urban productivity by enabling agglomeration economies
- bring economic agents closer, increasing the potential for interaction and therefore enhance the benefits of agglomeration economies.

Consumers also benefit from the economic effect of agglomeration through better access to choices and lower prices as a result of price competition. The CSELR proposal would therefore play an important role (as part of the wider public transport system in inner Sydney) in supporting the densification of the CBD and surrounding region, in addition to areas currently identified as UAPs or which may be identified in the future (refer to section 9.3.2). This would in turn enhance Sydney CBD's capacity to support the agglomeration of businesses, the associated economic benefits to private business and consumers, and Sydney's role as a global city.

Employment

The CSELR proposal would generate employment during construction and operation. It is estimated that based on a six year construction period, 4,562 direct (on-site) job years would be created between 2014 and 2020, which is the equivalent to 760 jobs per annum. Furthermore, approximately 6,103 indirect (off-site) job years would be generated, equivalent to 1,017 jobs per annum based on a similar project period.

An estimated 203 permanent jobs per annum would be generated by the management, operation and maintenance of the CSELR proposal. New business opportunities would also be fostered by commercial outlets at the new stops and surrounding areas, resulting in a slight positive macroeconomic impact.

Economic multipliers

Economic multipliers refer to the level of additional economic activity generated by a source industry and the flow-on benefits to other industries. For example, the benefits of construction and job generation would flow through to the wider economy on commencement of the CSELR proposal's planning, design and construction works.

There are two types of multipliers:

- *Production induced* — which consist of:
  - a first round effect: which is all outputs and employment required to produce the inputs for construction
  - an industrial support effect: which is the induced extra output and employment from all industries to support the production of the first round effect
- *Consumption induced* — which relates to the demand for additional goods and services due to increased spending by the wage and salary earners across all industries arising from employment.

For the purposes of analysis, the capital investment value of the CSELR proposal has been estimated as $1.6 billion. Table 9.14 below shows the estimated first round effects, industrial support effects, and consumption induced multiplier effects at rates of $0.646, $0.673 and $0.989 respectively to every dollar of construction.

Table 9.14 Construction multiplier effect

	DIRECT EFFECTS	PRODUCTION INDUCED EFFECTS		CONSUMPTION INDUCED EFFECTS	TOTAL
		FIRST ROUND EFFECTS	INDUSTRIAL SUPPORT EFFECTS		
Output multipliers	1	0.646	0.673	0.989	3.309
Output ($million)	$1,600m	$1,034m	$1,077m	$1,582m	$5,294m

Source: *Data Sources: Australian National Accounts: Input-Output Tables 2008-09 (ABS Pub: 5209.0), Price Index of the Output of the Building Industry - Producer Price Indexes (6427.0), CPI All Groups - RBA Bulletin (Table G2) These multipliers are based on both the building and non-building industry and therefore the effects are an approximation only.*

Table 9.14 indicates that an initial investment of approximately $1.6 billion would generate a further $2.1 billion of activity in production induced effects and approximately $1.6 billion in consumption induced effects. Total economic activity generated by the construction of the CSELR would therefore be approximately $5.3 billion.

Economic appraisal

As discussed in Chapter 3, an economic appraisal for the CSELR proposal indicates that the project economic benefits significantly outweigh the project costs. A benefit-cost ratio (BCR) is used to compare the total expected cost of each option against the total expected benefits to see whether the benefits outweigh the costs and by how much. A BCR above one indicates that the benefits outweigh the costs. For the CSELR, total project benefits of $4.11 billion were calculated against a capital cost of approximately $1.6 billion, and a BCR of 2.5 when including wider benefits of the proposal (i.e. a benefit of $2.50 for every $1.00 spent) (pwc, AECOM, Booz 2013).

9.4.3 Impacts during operation

The following section identifies some of the likely regional economic impacts of the CSELR proposal during the operational. Additional local impacts are also identified in Chapters 12 to 17.

Likely positive impacts

- *Enhanced access for customers* — Numerous businesses that were consulted (as part of a series of business surveys that were undertaken in June 2013) identified improved customer access and enhanced passing trade as a likely benefit of the CSELR proposal. The reduction in traffic along the alignment and the removal of some left and right hand turning lanes (particularly along George Street) could lead to increased footpath dimensions, a reduction in time required to cross roads, greater frequency of pedestrian crossing times, and relocation of taxi ranks to areas that are better aligned with major trip generators (including improved special event operations) in support of both the daytime and night-time economies. These benefits, in addition to the provision of a quicker and more reliable public transport option (that operates at a greater frequency for longer periods), have the potential to retain a larger target market within the wider region, and increase legibility of the public transport system. This may also extend peak shopping, dining and leisure times to the benefit of businesses.
- *Increased capacity and development opportunities* — The implementation and operation of the CSELR is likely to stimulate and support an increase in the capacity and density of floor space and activities within close proximity of the alignment and stops. This would enhance opportunities for redevelopment and therefore the viability of development-related businesses, including development organisations, architects, property consultants, construction-related industries, property services and real estate agents.
- *Land values* — Improvements to transportation and the public realm can have a positive correlation with land values, with the benefits experienced as early as the announcement of a project.

- *Commercial rents* — As a result of the likely enhanced attraction of locating a business in close proximity to the CSELR, the proposed light rail stops and within the pedestrianised section of George Street, competition for space (and thereby commercial rents) could increase across the wider region. This would represent a benefit for landowners.
- *Staff access, recruitment and retention* — The CSELR would enhance workforce accessibility, creating a larger labour pool, increasing staff choice and broadening the available skill set to businesses located within reasonable proximity to the alignment.
- *Business viability* — Owing to the potential cumulative effect of the positive outcomes of the CSELR proposal on the wider region, businesses would benefit from potential increased turnover, improving the overall viability of their businesses once the proposal is operational.
- *Noise, vibration and dust* — Whilst the CSELR is expected to have lower noise generating potential than existing vehicle traffic within the wider regional area, potential adverse impacts of the CSELR proposal during operation may occur including operational noise and vibration or dust.

Likely negative impacts

- *Commercial rent* — Whilst there may be some potential positive impacts to commercial rent (as identified above) the likely enhanced attraction of locating a business in close proximity to the CSELR, light rail stops and within the pedestrianised section of George Street, may result in competition for space. As a result, commercial rents could increase across the wider region. Where this occurs there would be some negative impacts to smaller businesses that are not able to quickly absorb higher rents, or the businesses that are presently experiencing challenges to viability.
- *Changed behaviour during construction* — This impact relates to the effect that a forced change in consumer behaviour (such as travel route or diversion) may have to longer-term trends. For example, an alternative pedestrian route during construction (that moves passing trade away from a given business) may result in a permanent change in behaviour or travel direction even when no longer enforced. This can negatively affect businesses from which trade was diverted and conversely may benefit others.
- *Perceived fear of crossing tracks* — Although a less apparent issue, initial consultation regarding the proposal identified concerns that customers and clients would be less inclined to cross the street to alternative businesses and services, owing to a fear of crossing the light rail tracks or alignment. This concern would reduce over time as Sydneysiders become more comfortable with light rail and sharing the pedestrian/road space with it. The implementation of a public education program regarding light rail (and the course of time) would help to efficiently address these concerns.
- *Customer access and parking* — Upon operation of the CSELR proposal, some changes to customer access and vehicle parking would occur. Impacts would largely relate to the permanent loss of street frontage car parking in locations such as Devonshire Street, Anzac Parade and High Street. Impacts would be most prevalent for businesses reliant on passing trade to pick up goods (i.e. trade supplies, newsagents, bakeries or convenience stores) or parking to service less mobile clients (i.e. patients, the elderly or children).

9.4.4 Impacts during construction

The following section identifies some of the likely regional economic impacts of the CSELR proposal during the construction phase across the wider regional area. Additional local impacts are also identified in Chapters 12–17.

Likely positive impacts

- *Passing trade* — Depending on their location, some businesses may benefit from a net gain in passing trade during construction owing to changes to pedestrian traffic and vehicle access. In the case of the Sydney CBD, these improvements could be experienced by businesses that are located at pedestrian crossing points (i.e. at breaks along the alignment or by businesses located in connecting streets that would be used more frequently during the construction phase).

- *Trade increase* — This benefit is most likely to be experienced by businesses located in close proximity to construction sites or on routes to construction sites that sell goods to construction workers or related industries such as service stations, take-away food shops and hotels.
- *Demand for services* — This potential positive impact relates to the growth in demand for construction related businesses such as construction recruitment agencies, construction companies and resource suppliers. Owing to the range of businesses located across the wider region, there would be multiple opportunities for these types of businesses to benefit.

Likely negative impacts

- *Servicing and deliveries* — One of the key challenges identified for the construction phase relates to business deliveries and servicing. Businesses rely on deliveries for products to sell and products to distribute as well as services such as refuse collection. These activities are often required to occur daily, and in some cases, multiple times a day. It therefore follows that temporary street closures, the relocation/removal of car parking along the street frontage and the location of construction sites could collectively restrict and hinder servicing and delivery opportunities in the region resulting in time and vehicle related costs as well as lost revenue for businesses.
- *Parking* — During the construction phase, customer access by vehicles to businesses would be adversely affected. More specifically, potential negative impacts would be associated with the removal of street level car parking during construction. This would potentially impact opportunities for deliveries and servicing along with parking convenience for workers, clients and customers, potentially leading to decisions by customers/clients to use an alternative service or visit a different business. The reduction or relocation of car parking would be likely to have the greatest impact to businesses like convenience stores that rely on customer access, as well as uses that have less mobile customers and clients such as child care centres and medical centres/medical specialists.
- *Noise, vibration and dust* — A noticeable level of noise is likely to be generated during the construction phase of the CSELR proposal, with particular concentrations likely to be experienced around construction compounds (such as Belmore Park, Ward Park, and Moore Park).

  Whilst the background noise levels in the wider region are already considered higher than many locations in Sydney (particularly in the CBD and town centre locations), noise generated during the construction process has the potential to negatively affect employee productivity, interaction with clients and workplace ambience. It can also affect the function of services, especially those that are dependent on a serene environment (such as beauticians or outdoor dining areas).

  Further detail regarding potential noise and vibration issues are discussed in each of the precinct impact assessment sections in Chapter 12 to Chapter 17. A discussion on mitigation for potential air quality impacts associated with the construction of the proposal is provided in Chapter 10.

- *Customer access and passing trade* — The construction phase of the CSELR proposal would result in changes to vehicle and pedestrian flows that could influence the level of trade passing businesses and subsequent customers and sales. Some businesses could benefit as trade is re-directed towards their business (i.e. through pedestrian or traffic diversions), whilst others might be adversely affected as traffic is diverted away or construction hoardings reduce the ease of access to and visibility of their business.
- *Traffic congestion and travel times* — Impacts to businesses as a result of traffic delays and congestion may be both direct and indirect. Businesses may be directly affected as a result of a delayed or hindered access to work places or servicing areas owing to local traffic constraints and congestion. A business may be indirectly affected by increased traffic and therefore travel times for staff or deliveries on major thoroughfares such as Anzac Parade owing to construction works. Additional impacts may result from the redirection of buses along Elizabeth Street and the closure of the Moore Park Busway between Robertson Road and Doncaster Avenue to allow for the construction of light rail tracks within the proposed shared busway and light rail corridor.

- *Vehicle operating costs* — Owing to potential disruptions to travel/route redirections and extended travel times, businesses could incur an increase in vehicle operating costs. This would be a particular issue for service and delivery based businesses (i.e. couriers or distributors) in more congested parts of the wider regional area of the CSELR proposal, such as the CBD and Devonshire Street.
- *Loss of power and utilities* — This was a concern voiced by some businesses surveyed, as a result of accidental or planned shutdowns of electricity or other utilities to enable construction works. Whilst significant advance notice would be given to all businesses of a power or utility shutdown, accidental events would be more difficult to manage.
- *Visual amenity* — Construction sites and disturbances have the potential to negatively affect the visual and aesthetic amenity of locations within the wider region such as the Rocks, Ward Park, Belmore Park and High Cross Park. A reduction in the quality of these environments and their amenity value could influence the number of visitors to these locations, which could have an economic impact to local businesses dependent on passing trade and tourism such as cafes, newsagents and clothing stores.
- *Business turnover* — The cumulative effect of elements of the construction phase could have an adverse impact on business viability for specific businesses.

9.4.5 Management and mitigation

At a regional level, three key plans are recommended to be prepared to address the potential economic and business impacts identified as a result of the CSELR proposal. These include:

- Access management plans — Such plans would be prepared in liaison with businesses and landowners to understand their servicing and delivery requirements. These plans would then identify and implement means of maintaining (and where possible enhancing) access to businesses for deliveries and servicing during both the construction and operational phases of the CSELR proposal.
- A business landowner and engagement management plan — This plan would support the preparation and effective implementation of the access management plans. It would also identify and implement means by which to keep businesses informed of the CSELR proposal and methods to proactively support businesses through the construction phase.
- The CEMP — This would be a comprehensive document setting out in detail means to minimise the level of disturbance created as a result of the construction process to businesses, pedestrians, visitors and workers across the study area. The CEMP would include a series of management plans including a series of construction traffic management plans, a parking management plan, and a construction noise and vibration management plan.

Details of the proposed mitigation measures are presented in Technical Paper 4 — *Economic impact assessment* in Volume 3 of this EIS.

Additional precinct-specific management and mitigation measures to address the potential local economic and business impacts of the CSELR proposal are described in the relevant management and mitigation section of Chapters 12 to 17.

10. Other regional environmental impacts

10.1 Purpose and approach

This chapter provides an assessment of the potential environmental impacts associated with the CBD and South East Light Rail Project ('the CSELR proposal' or 'the CSELR') that are either not precinct-specific (i.e. they are whole-of-project and not locally specific impacts), or would have an impact on the broader Sydney region. Regional cumulative impacts are covered in Chapter 11.

Environmental issues that have been considered in this chapter comprise:

- hydrology, drainage and surface water quality (refer to section 10.2)
- land stability, soils and contamination (refer to section 10.3)
- groundwater (refer to section 10.4)
- Aboriginal heritage (refer to section 10.5)
- biodiversity (refer to section 10.6)
- air quality (refer to section 10.7)
- utilities and services (refer to section 10.8)
- greenhouse gases (refer to section 10.9)
- hazards and risks (refer to section 10.10)
- privacy (refer to section 10.11).

10.2 Hydrology, drainage and surface water quality

The following sections provide a summary of the desktop hydrology and drainage assessment undertaken for the CSELR proposal. This assessment describes the potential impacts to surface water quality, flooding and drainage as a result of the CSELR proposal.

10.2.1 Existing environment

Catchments

The CSELR alignment crosses eight drainage catchments which ultimately drain to Sydney Harbour, Botany Bay or the Tasman Sea. In general, the Sydney catchment areas traversed by the proposed CSELR alignment are highly urbanised, with large areas of impermeable surface created by roads, footpaths and buildings, interspersed with areas of parkland and construction sites. All predevelopment waterways have been replaced with underground drainage systems which ultimately discharge into the downstream receiving environments.

The receiving environments for each catchment along the proposed CSELR alignment are described in Table 10.1 and are shown in Figure 10.1.

Table 10.1 Receiving water environments

CATCHMENT	CSELR ALIGNMENT REFERENCE	RECEIVING ENVIRONMENT
Darling Harbour	George Street (Circular Quay) to Central Station	Sydney Harbour
Blackwattle Bay	Central Station to corner Crown Street and Bourke Street	Blackwattle Bay and Darling Harbour
Alexandra Canal	Corner of Crown Street and Bourke Street to Moore Park stop	Botany Bay via Alexandra Canal and Cooks River
Centennial Park	Moore Park stop to corner of Anzac Parade and Alison Road	Centennial Park (Kensington Pond)
Kensington	Corner of Anzac Parade and Alison Road to Kingsford stop	Centennial Park and Botany Bay via Mill Stream
Randwick	Corner of Anzac Parade and Alison Road to Kingsford stop	Coogee Bay and Centennial Park
Coogee	Corner of Anzac Parade and Alison Road to Randwick stop	Coogee Bay
Leichardt	Rozelle maintenance depot	Rozelle Bay, Johnstons Bay and Sydney Harbour

Surface water bodies that form part of the drainage from the proposal area are shown on Figure 10.1 and include:

- Kippax Lake (Moore Park)
- Kensington Pond (Centennial Park)
- Alexandra Canal
- Cooks River
- Mill Stream (including Eastlakes, Lachlan Swamps and Mill Pond).

Surface water quality environmental values

Environmental values are the qualities of waterways that need to be protected from the effects of pollution, waste discharges and deposits to ensure they are safe and suitable for community use (Office of Environment and Heritage 2013). They reflect the ecological, social and economic values and uses of the waterway. The receiving environments for the CSELR are predominantly within the Sydney Harbour and Parramatta River Catchment, with the exception of Botany Bay, which is part of the Georges River Catchment. The Environmental values are the same for each site and are listed below:

- aquatic ecosystems
- visual amenity
- primary contact recreation
- secondary contact recreation.

Table 10.2 describes the receiving environments in terms of their water quality and current strategies in place to improve water quality. Trigger values for various water quality parameters taken from the Environmental values are used to determine the current water quality condition. If trigger values are frequently exceeded, the water quality is considered poor; if water quality parameters are within trigger values, the water quality is considered good.

Table 10.2 Water quality of receiving environments

RECEIVING ENVIRONMENT	CURRENT ENVIRONMENT	WATER QUALITY CONDITION	CURRENT MEASURES TO IMPROVE WATER QUALITY
Sydney Harbour	Sydney Harbour is the natural harbour around Sydney. It is an inlet of the South Pacific Ocean. Pre 1970 there was dumping of toxic waste which has contaminated the water and many of the aquatic species. Although the pollution rate is improving in this respect, stormwater runoff results in current high pollution levels.	The extent of development has resulted in poor water quality and changed flow regimes. Often quality is affected by weeds and rubbish.	SewerFix Program, stormwater management and water harvesting programs.
Darling Harbour (including Blackwattle Bay)	Darling Harbour and Cockle Bay are the responsibility of the Sydney Harbour Foreshore Authority. Darling Harbour has frequently been the most polluted of the Sydney Harbour sites. The Harbour naturally has a low flushing rate. With pollution from sewage overflows, leaky sewerage systems, stormwater discharges and illegal waste discharges from recreational vessels, it maintains a high pollution level.	Sampling over the last five years has shown variable compliance for primary contact (23–59% of sampling for faecal coliform and 32–74% for enteroccocci). Secondary contact compliance was 65–100% for faecal coliform and 60–100% of enteroccocci over the last five years of sampling. Poor water quality is contributed to over developed and degraded waterways.	SewerFix Program, stormwater management and water harvesting program.
Botany Bay	Botany Bay is a wide shallow bay. The Cooks River and Georges River flow into the bay. Land use in the Botany Bay catchment includes residential, industrial, commercial, recreational and bushland. Main sources of pollution come from stormwater runoff.	Five of the nine swimming sites complied at least 87% of the time with both faecal coliform and enteroccocci guidelines. However due to stormwater runoff, pollution remains high.	Stormwater management plans, stormwater re-use, Botany Bay Water Quality Improvement Plan.
Centennial Park	Ponds of Centennial Parklands form the upper catchment of the Botany wetlands. These water bodies cover approximately 26 hectares and provide important habitat for water birds and aquatic life. They act as a detention basin and receive stormwater runoff from surrounding catchments including Randwick. The main sources of pollution are from stormwater runoff.	Water quality has been poor in the past and is currently improving due to recent measures put in place to improve it.	Gross pollutant traps have been installed at stormwater entry points to reduce the amount of pollutants entering the system. Macrophytes have been planted to provide improved habitat and filter dissolved pollutants. Gutters and streets are swept regularly to minimise the amount of leaf litter and sediment washed into the ponds.
Coogee Bay	Coogee Beach is 400 metres long and is backed by a promenade and parklands. Stormwater drains discharge to the beach in dry and wet weather.	Microbial water quality is suitable for swimming (primary contact) most of the time. Enterococci levels often exceed the primary contact guidelines after 5 millimetres or more of rain has fallen.	Coogee Bay is part of Randwick local government area where soil and water management programs are currently being implemented with the aim to prevent degradation of waterways and stormwater systems by minimising the loss of soil and other building materials from building and construction sites.

Figure 10.1 Surface water resources

Existing flooding and drainage

The drainage systems traversed by the CSELR alignment are located in the City of Sydney and Randwick City Council local government areas (LGAs). Both councils have existing flood models for specific catchments. The City of Sydney is currently updating various flood models within the LGA. A number of the larger stormwater trunk mains are Sydney Water assets.

There is a greater quantity of existing flood risk information available for the Randwick and Kensington/Kingsford sections of the CSELR than for the CBD section. This reflects the early stage of the detailed flood studies that are currently in progress for the 'City Area' and 'Darling Harbour', rather than a real absence of flood risk issues.

Anecdotally, it is reasonable to expect there are a number of flooding issues associated with stormwater network capacity issues within the CBD, with ponding during heavy rainfall observed at a number of locations including:

- junction between Bridge Street and George Street
- junction between King Street and George Street
- between Eddy Avenue and Hay Street.

Sydney Water capacity assessments for the City Area and Darling Harbour catchments undertaken in 1996 provide an indication that the Sydney Water trunk mains through the CBD area vary in capacity from less than a one in two year average recurrence interval (ARI) event through to in excess of a 1 in 20 year ARI event, with the lesser capacity primarily evident at the northern end of the alignment.

The existing flood studies covering the Randwick and Kensington/Kingsford sections of the CSELR alignment include:

- *Alexandra Canal Catchment Flood Study,* Cardno (NSW/ACT) Pty Ltd, Draft Report, December 2010
- *Leichhardt Flood Study,* Cardno (NSW/ACT) Pty Ltd, Draft Report, June 2010
- *Centennial Park Flood Study,* WMA Water, Draft Report, February 2013
- *Kensington – Centennial Park Flood Study,* WMA Water, Final Report, April 2013.

These studies have identified that flooding occurs on a frequent basis at a number of locations along the southern sections of the proposed CSELR alignment as summarised in Table 10.3. This reflects that the existing roads act as overland flow paths. The studies reviewed suggest that most of the affected locations will suffer some degree of flooding following a rainfall event with an ARI of one in five years. Along the southern section of Anzac Parade the flooding is predicted to occur more frequently, during a one in two year ARI event.

Table 10.3 Existing known flooding issues along CSELR alignment

FLOODING LOCATIONS	FLOOD DEPTH (METRES)						
	1 YEAR ARI	2 YEAR ARI	5 YEAR ARI	10 YEAR ARI	20 YEAR ARI	100 YEAR ARI	PMF
Location 1: Location of the current housing complex bounded by Nobbs Lane, Parkham Lane, Parkham Place and Olivia Lane	0.1–0.29	0.30–0.49	0.70–0.99	> 1.0	> 1.0	> 1.0	> 1.0
Location 2: Proposed location for the Moore Park tunnel portal entrance	No flooding	No flooding	No flooding	0.1–0.29	0.1–0.29	0.1–0.29	0.1–0.29
Location 3: Anzac Parade between Lang Road and Dacey Avenue	No data	< 0.1	0.2–0.5	0.2–0.5	0.5–1.0	1.0–2.0	1.0–2.0
Location 4: Alison Road	No data	No data	0.5–1.0	0.5–1.0	1.0–1.5	1.0–1.5	> 1.5
Location 5: Wansey Road	No data	No data	< 0.25	< 0.25	0.25–0.5	0.25–0.5	0.5–1.0
Location 6: Anzac Parade	No data	No data	0.5–1.0	0.5–1.0	1.0–1.5	> 1.5	> 1.5
Location 7: Rozelle maintenance depot	No data	0.01–0.1	No data	No data	No data	0.1–0.3	0.1–0.3

Note: ARI = Annual recurrence interval; PMF = probable maximum flood

10.2.2 Impacts during operation

Surface water quality impacts

At the Randwick stabling facility and Rozelle maintenance depot there is the potential for contamination of stormwater to result from the storage of oil and other substances in significant quantities if not appropriately managed. Pollutants may include:

- oils and lubricants
- degreasers
- wash-down water.

Storage of hazardous substances or other potential stormwater contaminants would therefore require bunding and spill management at these locations.

The batteries used in the proposed light rail vehicles (LRVs) are generally rechargeable lithium type batteries. It is therefore not anticipated that storage of large quantities of spare batteries or battery fluid would be needed.

Small amounts of metals, oils and particulates may be generated from the operation of the LRVs (i.e. from wheel/rail contact and braking). This is not anticipated to result in the generation of large volumes of contaminants.

The LRVs would spray small quantities of sand on the rails ahead of the main traction units to increase friction and improve the contact in wet conditions. In some circumstances, the application of sand to the rails may lead to generation of small amounts of material that might be carried in suspension should the activity coincide with or follow heavy rain. The resultant impact on water quality and drainage systems is not expected to be significant given the small quantities in question.

Overall the CSELR is anticipated to contribute to a reduction in contaminant sources from current road operations (brake dust, motor oil etc. from buses and light motor vehicles) through the anticipated reduction in light motor vehicle traffic.

Flooding and drainage impacts

The proposed CSELR alignment intersects a number of existing catchments and would unavoidably intersect existing stormwater drainage infrastructure and overland flow paths along roadways. Where the CSELR alignment intersects existing overland flow paths, the potential exists for stormwater to pond along the alignment, thereby affecting operation of the LRVs.

Flooding of the rail alignment would impose restrictions on the operation of the CSELR as water ingress into the electrical and moving parts of the LRVs may prevent operation or exacerbate the wear of moving parts. The typical operating requirement for LRVs at full design speed is a maximum depth of 15 millimetres of standing water. Operation at reduced speed is then possible up to a limit of 50 to 100 millimetres of standing water.

As referenced in section 10.2.1 above, despite an absence of modelled information, there are known to be existing flooding issues due to stormwater constraints along sections of the alignment in the vicinity of King Street within the proposed George Street pedestrian zone. The proposal would require raising the average ground level in this area by around 100 to 150 millimetres. This would result in a loss of overland flow capacity in this area, which has the potential to exacerbate any flooding in this section. As discussed above, localised flooding is reported around the King Street junction after rainfall.

It is proposed that the alignment would cross at street level over South Dowling Street and the Eastern Distributor via a bridge before entering the proposed Moore Park tunnel. In order to achieve an adequate clearance over the Eastern Distributor it would be necessary to raise the existing ground level across South Dowling Street by up to 600 millimetres. This would have an impact on the existing drainage on South Dowling Street and potentially also the distribution of overland flow in the area. This would require further investigation in the detailed design phase.

There would also be a small increase in impermeable area adjacent to the busway at Moore Park resulting in a slight increase in runoff at this location.

The results of Kensington Centennial Park Flood Study show that the proposed Randwick stabling facility is inundated in the one in five year ARI flood event and all events beyond this. The depth of flooding across the site varies up to 200 millimetres in the one in five year ARI flood event. This is based on the existing ground levels and not the proposed stabling facility levels which are likely to be closer to the existing road levels in Alison Road. Inundation of the site appears to be as a result of a break out of flood water down Alison Road which uses an existing low point to cross the stabling site. The Kensington Centennial Park Flood Study recommended augmentation of the current drainage scheme to minimise flood impacts and management of the flood risk in this area.

Management levels to address these potential impacts are detailed in Section 10.2.4.

10.2.3 Impacts during construction

Surface water quality impacts

During construction, the key impacts on stormwater quality would include sediment mobilisation and deposition, oil and petrol from construction vehicles and accidental spills of chemicals and other hazardous construction materials.

If uncontrolled, runoff from the worksites could result in discharge of contaminants to receiving waterways, further contributing to the poor water quality in the catchments downstream.

Flooding and drainage impacts

During construction, sections of the CSELR would be isolated from the drainage network to allow works to commence. Water entering the construction area or falling directly into the construction area has the potential to cause localised flooding issues. Further detail on construction phase flood management is set out in section 10.2.4.

With appropriate management, construction phase stormwater flows should not result in additional flow velocities or volumes. Consequently, no impact on the downstream drainage network is expected.

10.2.4 Management and mitigation

Surface water quality

Contemporary good practice guidelines would be followed to ensure stormwater runoff water quality does not worsen water quality in downstream receiving environments. This would include consideration of water quality treatment devices such as subsurface trash screens and sediment collection systems. The location and specification for these would be determined through the detailed design.

During construction any water collected from the worksites would be treated and discharged in accordance with current guidelines to avoid any potential contamination or local stormwater system impacts. These guidelines include:

- Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) *Guidelines for Fresh and Marine Water Quality*
- *The Blue Book – Managing Urban Stormwater:* Soils and Construction (Landcom 2004).

Depending on the quality of any collected water that requires disposal, treatment could be required during either the construction and/or operation phase of the proposal to meet the requirements of the above guidelines.

Where existing longitudinal pit and pipe drainage exists and needs to be reinstated or repaired, appropriate scour protection measures would be reinstated or improved at outlets to watercourses or drainage lines. Typical scour protection might include concrete energy dissipating structures or dumped stone rip rap.

Flooding and drainage

For flood affected locations, the CSELR would be designed to ensure compliance with the *NSW Floodplain Development Manual* which includes a requirement to not increase flood levels above existing levels.

Flood mitigation measures that could be considered include:

- increasing downstream drainage capacity
- diverting upstream flows around or under the track formation
- providing stormwater detention under or adjacent to the track formation.

All additional flow diversions and new drainage would not exceed the capacity of the existing downstream drainage network and receiving environments. This would be achieved by a range of the following methods:

- diverting the existing drainage and crossing the track formation at a location that allows it at a point up slope of the alignment
- providing new drainage parallel to the CSELR alignment and crossing the track formation at a location that allows it at a point down slope of the alignment
- providing new drainage to discharge to an alternative outlet downstream without crossing the track formation
- recycling of wash-down water at the Rozelle maintenance depot and Randwick stabling facility.

These measures aim to prevent increased flood risk and hazard for property and infrastructure.

Operational protocols would be developed by the CSELR operator to ensure safety for customers and protect infrastructure and LRVs in the event that flooding affects the CSELR alignment. During construction, the potential for localised flooding of excavation sites would need to be managed. Water pumping facilities may be required at specific locations along the alignment to remove any water that would pool within or adjacent to construction areas. Temporary drainage pipes or channels would also be provided to drain any open excavation areas.

10.3 Land stability, soils and contamination

The following sections provide a summary of the desktop geology, soils and contamination assessments undertaken for the CSELR proposal.

10.3.1 Existing topography, geology and soils

The proposed CSELR alignment is underlain by various geological and soil landscape units. Table 10.4 provides an overview of the general topography and anticipated geological and soil landscape units along the alignment, and the potential occurrence of acid sulfate soils (ASS); these attributes are discussed further in the following sections.

Table 10.4 Physical setting summary – topography, geology and soils

CSELR SECTION	APPROXIMATE ELEVATION (mAHD)[1]	ANTICIPATED GEOLOGICAL UNIT	ANTICIPATED SOIL LANDSCAPE UNIT	POTENTIAL OCCURRENCE OF ASS
Circular Quay to Haymarket	10–20	Imported fill/disturbed terrain Quaternary Alluvium Hawkesbury Sandstone Ashfield Shale	Disturbed terrain Gymea Lucas Height Deep Creek Blacktown	No known occurrence
Haymarket to Moore Park via Surry Hills	20–40	Quaternary Alluvium Hawkesbury sandstone	Blacktown Tuggerah	No known occurrence
Moore Park to Randwick	30–60	Quaternary Alluvium	Tuggerah	No known occurrence
Moore Park to Kingsford	20–30	Quaternary Alluvium	Tuggerah	No known occurrence
Rozelle maintenance depot	10–20	Imported fill/disturbed terrain Quaternary Alluvium Hawkesbury Sandstone	Disturbed terrain	No known occurrence
Randwick stabling facility	20–30	Quaternary Alluvium	Tuggerah	No known occurrence

Note 1: mAHD – metres above Australian Height Datum

Topography

Sydney is situated in a flat low-lying coastal basin, bounded by the Pacific Ocean to the east, the Blue Mountains to the west, and the Hawkesbury River to the north. To the south of the basin lies the Royal National Park. The topography of the CSELR alignment ranges between approximately 10 metres above Australian Height Datum (mAHD) in the CBD climbing through the Surry Hills area to almost 50 mAHD. From Riley Street the alignment drops gradually to around 35 to 40 mAHD at Moore Park. Between Moore Park and Randwick the alignment climbs slightly to a peak of around 60 mAHD, but remains relatively flat along the alignment to Kingsford, varying only slightly between 20 and 30 mAHD.

Geological units

The CSELR alignment is underlain by unconsolidated quaternary sediments and Middle Triassic age sedimentary rocks. The Middle Triassic Ashfield Shale (part of the Wianamatta Group) present beneath the CSELR alignment overlies Hawkesbury Sandstone. A regional geology map for the proposed CSELR alignment is included in Figure 10.2.

The City Centre, Surry Hills and Randwick precincts are underlain by Middle Triassic age Ashfield Shale and Hawkesbury Sandstone. Quaternary Alluvium overlies the Ashfield Shale and Hawkesbury Sandstone in some areas and comprises silty to peaty quartz sand, silt and clay. Given the level of urban development across the area, fill materials may also occur in the upper part of the profile.

The Moore Park, Kensington/Kingsford and Randwick precincts are underlain by Quaternary age unconsolidated sands known as Botany Sands. The Botany Sands comprise medium to fine grained marine sand with podsols.

Quaternary alluvial deposits

Quaternary Alluvium occurs near the coastal areas around Sydney and in the major portion of the CSELR alignment to the south. These sediments are generally associated with former creeks that drained the area during the Holocene. The nature of the alluvium varies considerably, depending on the lithology of the source material and the distance it has been transported, but generally it comprises clayey low strength material, described as silty to peaty quartz sand mixed with clay.

In the southern portion of the CSELR alignment, the geology comprises medium to fine grained marine sand, associated with marine deposition during Holocene sea level changes. In lower parts of the sequence, the marine sand sequence is interspersed with lenses of peat, peaty sands, silts and clays.

Ashfield Shale

Ashfield Shale is the lowest unit of the Wianamatta Group and covers a small portion of the CSELR alignment. It is potentially encountered in the vicinity of Central Railway Station and along the Surry Hills section of the alignment. The thickness of Ashfield Shale varies between 45 and 62 metres. It comprises a lower sequence of black to dark grey shale, claystone to siltstone, which coarsens upwards into fine grained sandstone-siltstone laminate.

Hawkesbury Sandstone

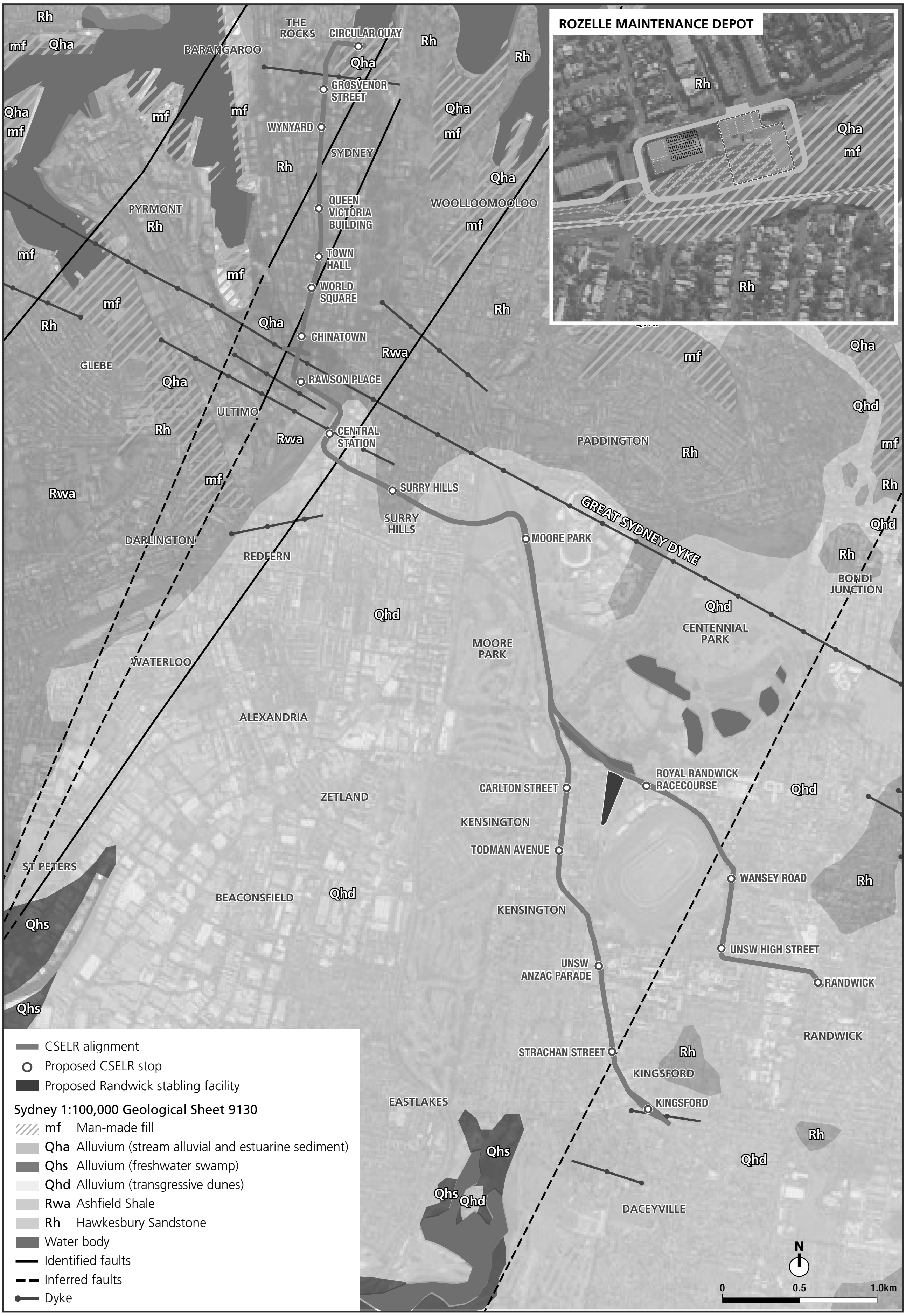
Hawkesbury Sandstone comprises mainly medium to coarse grained quartz sandstone, with minor laminated mudstone and siltstone lenses. The beds may be up to 15 metres thick, but generally range between 1.5 to 3 metres. Relatively thick and laterally discontinuous layers of dark grey and black shale and lenses of siltstone occur throughout the Hawkesbury Sandstone, constituting approximately five per cent of the formation thickness.

Geological structures

Geological structures associated with the various rock formations encountered within the region of the proposal include doleritic dykes (igneous intrusions), either singly or in swarms, and minor faults.

The main dyke orientation is associated with faulting, with strikes mainly in a north-west to south-east direction. Individual dykes vary in width, but are typically less than three metres wide, although dykes more than 10 metres wide have been encountered in greater Sydney. The Great Sydney Dyke, which runs immediately north of Central Railway Station on a north-west strike, is reported to be about eight metres wide. Whilst faulting is not extensively developed in the Ashfield Shale or Hawkesbury Sandstone within the Sydney area, a number of fault zones have been identified as shown in Figure 10.2.

Figure 10.2 Existing geology



Source: Herbert C., Sydney 1:100 000 Geological Sheet 9130, 1st edition, Geological Survey of New South Wales, Sydney

Soil landscapes

Soil landscapes are areas of land that have recognisable and specifiable topographies and soils that can be presented on a map, and can be described by concise statements. The CSELR proposal is underlain by seven types of soil landscapes as identified by the NSW Soil Conservation Service (Chapman and Murphy 1989). A soil landscape map is provided in Figure 10.3.

Disturbed Terrain soil landscape

The Disturbed Terrain landscape is typically characterised by level plain to slight undulating terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil. In many locations natural soil has been replaced with fill that includes soil, rock, building and construction waste materials due to urban development. Original vegetation has been replaced with turf or grassland.

Disturbed terrain areas are found in the northernmost portion of the CSELR alignment and are often landscaped and artificially drained. Landform elements include berms, cut faces, embankments, mounds, pits and trenches. The soils typically comprise a mixture of artificial fill, dredged estuarine sand and mud, demolition rubble, industrial and household waste; although they also include rocks and local soil materials. Turfed fill areas are commonly capped with up to 40 centimetres of sandy loam or up to 60 centimetres of compacted clay over fill or waste material.

Limitations of the Disturbed Terrain landscape depend on the nature of the fill material present, which is subject to mass movement hazards, impermeable soil, poor drainage, and localised very low fertility and potential toxic and contaminated materials.

Gymea soil landscape

The Gymea soil landscape is derived primarily from erosion processes and is characterised by undulating to rolling rises and low hills on Hawkesbury Sandstone. Limitations of the landscape include localised steep slopes, high soil erosion hazard, rocky outcrops, shallow highly permeable soil, and very low soil fertility.

Lucas Height soil landscape

The Lucas Height soil landscape is typified by gently undulating crests and ridges on plateau surfaces overlying the shale and fine grained sandstones of the Mittagong Formation.

Lucas Height soils are typically stony, dry soils with low soil fertility. This soil comprises loose, fine sand grains and low to moderate organic matter content, with some silt held in the clay matrix. The erosion potential of this type of soil is moderate to high.

Deep Creek soil landscape

The Deep Creek soil landscape is characterised by an alluvial sandy soil type associated with flooded river valleys which have been infilled with alluvium and are surrounded by steep Hawkesbury Sandstone slopes. The alluvial floodplain terrain itself is level to gently undulating. Typical landform elements include stream banks, stream beds, and meander plains. This soil landscape reflects major geomorphological processes in the form of periodic flooding and channel stream flow. Erosive potential is very high during flooding. This is an active, aggrading soil landscape comprising generally stable, sandy soils with high binding organic matter content.

Figure 10.3 Existing soil landscape

Source: Chapman G.A., Murphy C.L., Tille P.J., Atkinson G., Morse R.J., 2009 Ed. 4, Soil Landscape of the Sydney 1:100 000 Sheet Map, Department of Environment, Climate Change and Water, Sydney

Blacktown soil landscape

The Blacktown soil landscape is derived primarily from weathering processes and is characterised by gently undulating hills on Wianamatta Group (Ashfield) shales. The soil landscape profile comprises shallow to moderately deep hard setting topsoils. Limitations of the landscape include moderately reactive, highly plastic subsoil, low soil fertility and poor soil drainage.

Blacktown soil materials have moderate erodibility. The topsoils are often hardsetting and they have high fine sand and silt content but they also have moderate to high organic matter content. The subsoils are very low in organic matter. Where they are also highly dispersible and occasionally sodic, the erodibility is high.

Tuggerah soil landscape

A large proportion of the CSELR alignment falls within the Tuggerah soil landscape. This soil landscape is characterised by gently undulating plains and rolling undulating rises of low lying broad, very gently inclined, swales and dunes. Elevation is usually less than 30 metres, although the northern part of the Botany Lowlands dunefield rises to elevations up to 40 metres, meaning that the soils often display high water tables and may be subject to localised flooding.

Coastal hind-dunes run sub-parallel to the coast. With increasing distance from the coast the dunes assume a north-south trend. Most rainfall infiltrates directly into the soil. Run-off, when it occurs, collects in a series of depressions, lagoons and swamps. The soil type is characterised aeolian (windblown) Quaternary fine to medium grained marine quartz sand, reflecting an extreme wind erosion hazard. Shell fragments are absent and the sand appears to be finer than sands found on foredunes and on beaches.

Tuggerah soils have low erodibility as they consist of highly permeable, coarse sand grains. However, their lack of cohesion makes them very susceptible to erosion from concentrated flows. At depth, they are podzolic, forming weak impermeable ‘pans’ cemented by iron oxide or aluminium organic compounds and have a very low erodibility. Generally, Tuggerah soils comprise non-cohesive, highly permeable soil with an associated very low soil fertility.

Newport soil landscape

Formed from aeolian sediment, the Newport soil landscape is characterised by gently undulating plains to rolling rises of Holocene sands mantling other soil materials or bedrock. The medium grained windblown sands of the Newport soil landscape are usually shallow, with the landform influenced by the shape of underlying Hawkesbury Sandstone bedrock.

The soils comprising the Newport soil landscape are moderately erodible comprising weakly coherent loose sands with low organic matter. In some areas sand grains are weakly cemented by organic compounds or iron compounds. In general the soils reflect a very high soil erosion hazard, localised steep slopes, very low soil fertility, and non-cohesive topsoils.

Acid Sulfate Soils (ASS)

ASS are known to occur in low-lying coastal floodplain areas. Based on the Commonwealth Scientific and Industrial Research Organisation’s (CSIRO’s) *Acid Sulfate Soil Risk Map*, the overall risk of disturbing ASS is considered to be low. In addition, no known occurrences of ASS have previously been identified along the CSELR alignment. An ASS risk map for the site is provided in Figure 10.4.

Figure 10.4 Acid Sulfate Soils risk

Source: NSW Office of Environment and Heritage

10.3.2 Existing contamination

This section and Table 10.5 present a summary of a Phase 1 Environmental Site Assessment (Phase 1 ESA) undertaken to identify potential sources of historic contamination along the CSELR alignment.

Circular Quay to Haymarket

There are no known contaminating activities occurring in this section of the CSELR alignment. Land uses have been primarily commercial premises or eateries since as early as the 1800s.

The historical land use in this area is unlikely to have had a major effect on soil and groundwater quality in regard to with respect to contamination. However, some contaminants may be present in the fill (roadbase), road and/or roadworks, parks and open spaces, underground services, electrical substations and historic buildings or structures. Because there are no known sources of gross contamination, and no property in this section has been identified as being regulated by the NSW Environment Protection Authority (EPA), the contaminants, if present, are considered unlikely to exist at unacceptable concentrations.

Haymarket to Moore Park (terminating at corner of Anzac Parade and Alison Road) via Surry Hills

The potential sources of contamination in this section are associated with fill, road and road works, parks and open spaces, underground services, electrical substations and historic buildings or structures. In addition, a cemetery was sited at the location of Central Railway Station until the construction of the station in 1901. Also, a tannery was operated on the future alignment of Devonshire Street between Bourke and Crown streets from 1842 until the second half of the nineteenth Century. This site has since been redeveloped several times in the past 120 years. A stonemason’s workshop operated by the City of Sydney Council and a factory identified as belonging to Sellers Pty Ltd are shown on 1943 aerial photography. These sites have since been redeveloped to the current land uses of Wimbo Park and the Olivia Gardens apartment complex.

The construction of Central Railway Station is thought to have removed the majority, if not all, of the contamination associated with the cemetery in that area. With the exception of the cemetery and the tannery noted above, the land uses in this section of the CSELR have remained consistent since the early 1800s. There are no known specific contaminating activities currently taking place in this area. Based on this, the probability of encountering significant contamination between Haymarket and Moore Park is considered to be low. Asbestos and polycyclic aromatic hydrocarbon (PAH) impacted fill materials were identified previously in the Moore Park showground. Although the contamination has been managed by the Moore Park Trust, there is potential for some of these contaminants to persist in the vicinity. Nevertheless, these are near surface impacts and can be visually identified if the contamination is present.

Moore Park to Kingsford

Several potentially contaminating activities were identified in this section, including service stations, automotive workshops and dry cleaning establishments. In addition, the potential sources of contamination were identified to be associated with fill materials, road and road works, parks and open spaces, underground services and electrical substations. The EPA has also identified contamination associated with land uses in this section of the CSELR. It is therefore considered likely that contamination may be encountered at some locations in this section of the CSELR alignment.

Moore Park to Randwick

The Moore Park to Randwick section is bound mainly by parkland (Centennial Park), residential dwellings and the Royal Randwick racecourse. A service station is also located along the alignment. Potentially contaminating activities relate to the service station, underground services and the racecourse. Due to their proximity, these two potential contaminating activities require additional investigation to confirm whether these land uses have impacted the surroundings.

Randwick stabling facility

The potential sources of contamination in this area are likely to be associated with historical land uses and the nearby racecourse and horse stables. It is unlikely that contamination, if present, is widespread across the whole area. Therefore, the sampling plan designed for the proposed Randwick stabling facility is a grid based approach based on the minimum sampling density outlined in the EPA (1995) *Sampling Design Guidelines*. This sampling approach is considered adequate to assess the contamination status of this area.

Rozelle maintenance depot

Soil contamination at the existing Rozelle Goods Yard was identified during ESAs undertaken in 2003 by Parsons Brinckerhoff and in 2011 by Coffey Environments (Coffey Environments 2011) (refer to Table 10.5). There is considered to be sufficient information to establish contamination status in this area, and therefore no sampling plan is recommended for the site.

Table 10.5 Summary of potential contamination sources within the existing environment

<table>
<tr><th>SECTION OF CSELR ALIGNMENT</th><th>SUMMARY OF KNOWN CONTAMINATION RISKS</th></tr>
<tr><td>Circular Quay to Haymarket</td><td rowspan="2">The areas between Circular Quay and Moore Park via Surry Hills have been developed as a business district since the early nineteenth century and there is no known contamination in this area. The potential sources of contamination identified include:
• fill, road and roadworks, parks and open spaces
• electrical substations
• underground services
• historic buildings or structures.
Information available on the Centennial Park and Moore Park Trust website indicates bonded asbestos materials (Centennial Parkland News 2005a) and other PAHs (Centennial Parklands News 2005b) were identified in the Showground Field in 2005. The Showground Field is bounded by Anzac Parade, Lang Road and Driver Avenue. The Centennial Park and Moore Park Trust has planned a long-term remediation program for the area to remove the contaminants.</td></tr>
<tr><td>Haymarket to Moore Park via Surry Hills</td></tr>
<tr><td>Moore Park to Kingsford</td><td rowspan="2">Several potential sources of contamination were identified adjacent to the proposed alignment in this area including:
• service stations and car wash bays
• dry cleaning businesses
• underground services
• electrical substations
• bus depot
• mechanics and auto workshops
• electrical substations
• Royal Randwick racecourse and associated horse stables
• fill, road and roadworks.</td></tr>
<tr><td>Moore Park to Randwick</td></tr>
<tr><td>Rozelle maintenance depot site</td><td>This area is currently utilised by the Australian Rail Track Corporation as a yard. The hydrocarbon and metals contamination previously identified (Coffey 2011) in the fill is associated with fuel and oil spills, maintenance of the trains and the yard. Dissolved phase hydrocarbon impact was identified in the previous assessment.</td></tr>
<tr><td>Randwick stabling facility site</td><td>The ground in this area is unsealed and occasionally used as a car park for the racecourse. The chemicals of potential concern are likely to be associated with the former land uses as a tram depot, a racecourse or the nearby horse stables.</td></tr>
</table>

10.3.3 Impacts on land stability, soils and geological integrity

Material encountered within existing roadways (i.e. man-made fill) during the CSELR construction is likely to be more stable than fill in the area adjacent to the roadways and Quaternary Sands. Road fill material will have been selected, graded, and compacted to a standard suitable for road construction.

Away from the roadways, the majority of the soils likely to be encountered across the CSELR alignment are characterised by low levels of cohesion and are likely to be highly erosive when exposed to either wind or water. The Botany Sands formation, in particular, has high wind blown erosive potential when exposed. The Botany Sands, through which the Moore Park tunnel would be constructed, are largely unconsolidated, with a high water table. Construction of the tunnel, if not designed and managed effectively, may result in loss of stability and localised failure in this geology through both direct disturbance and settlement as a result of groundwater depressurisation. Measures to manage these potential risks are outlined in section 10.3.5.

An existing brick built retaining wall runs parallel with the CSELR alignment between Wansey Road and the Royal Randwick racecourse. The construction of the CSELR requires the replacement of this wall with a new structure approximately 125 metres in length and a maximum height of 4.5 metres. Accounts of ground conditions in the area indicate that the material retained in this area is consistent with descriptions of the Botany Sands in the area (loose to medium dense sand with very dense sand at depths below six metres). Measures to avoid stability impacts of these works are detailed in section 10.3.5.

10.3.4 Contamination impacts

Based on the Phase 1 ESA, a number of potential sources of contamination exist along the proposed CSELR alignment. Table 10.6 sets out these sources and a qualitative consideration of the risk of associated contamination. This list would be reviewed and refined through the detailed design of the CSELR.

Table 10.6 Qualitative contamination risk assessment

POTENTIAL CONTAMINATING ACTIVITY	CONTAMINANT SOURCE	SECTION OF CSELR	RISK OF CONTAMINATION
Fill; road and road reserve; park and open space	Imported fill, and reworked local soils, ash, asphalt and bitumen Application of pesticides, fertilisers	Entire site	High
Power poles	Treatment of timber with copper chrome arsenate	Entire site	High
Underground services	Asbestos containing materials	Entire site	High
Electrical substations	Leak of transformer oil	Circular Quay to Haymarket	High
		Haymarket to Moore Park via Surry Hills	High
		Moore Park to Kingsford	High
Old building/structures	Paint containing lead Asbestos containing materials	Circular Quay to Haymarket	High
		Haymarket to Moore Park via Surry Hills	High
		Moore Park to Randwick	High
		Moore Park to Kingsford	High
		Rozelle maintenance depot	High

Table 10.6 cont

POTENTIAL CONTAMINATING ACTIVITY	CONTAMINANT SOURCE	SECTION OF CSELR	RISK OF CONTAMINATION
Rail corridor including embankments Light rail and monorail (Note: Monorail will have been removed prior to the construction of CSELR)	Fuel and oil spills, engine emissions, rail corridor maintenance, brake lining, historical cable and/or pipework Ash from historical use of rail corridor Asbestos cable trays	Circular Quay to Haymarket	Low to moderate
		Haymarket to Moore Park (via Surry Hills)	High
		Rozelle maintenance depot	High
Cemetery	Weeds and pest control, pathogens	Haymarket to Moore Park (via Surry Hills)	Low
Racecourse; horse stables	Applications of pesticides and or herbicides, fertilisers and imported fill Use of solvents for polishing metals and/or leather goods	Moore Park to Randwick	Moderate
		Randwick stabling facility	Moderate
Service stations	Spills and leaks from service station bowsers and storage tanks	Moore Park to Kingsford	High
		Moore Park to Randwick	High
Mechanics and auto workshops	Run-off from storage and hydraulic oils	Moore Park to Kingsford	High
		Moore Park to Randwick	High
Dry cleaning establishments	Spills or inappropriate handling of dry cleaning chemicals	Moore Park to Kingsford	High
Car wash bays or facilities	Run-off of oil and grease and detergent from car wash	Moore Park to Kingsford	High

A review of potential environmentally sensitive receptors was also undertaken as part of the Phase 1 ESA. In the context of the CSELR construction works, these sensitive receptors are considered to have the potential to be affected through mobilisation of existing contamination or through potentially contaminating activities undertaken during the construction phase. The groups of receptors comprise:

- surface water receiving environment (refer to Figure 10.1)
- parks, playing fields and/or open spaces including Belmore Park, Haymarket, Moore Park, Kippax field (Moore Park), Bandstand playfield, High Cross Park, Centennial Park, Wimbo Park, Ward Park and Easton Park
- school and educational institutes including Sydney Girls High School and Sydney Boys High School on Anzac Parade, TAFE college on Alison Road, and UNSW on Anzac Parade
- residential and commercial properties near to the CSELR alignment.

In addition to the receptors identified above, the workers directly involved in the construction works are also identified as sensitive receptors. Excavations could potentially expose the workers to potentially contaminated subsurface material.

Contamination impacts during operation

Operational impacts to the soils and land environment are anticipated to be restricted to those arising from accidental spills or leakage, primarily from stabling and maintenance activities at the proposed facilities at Rozelle and Randwick. Unless carefully managed, the soils in these areas could become contaminated with hazardous materials (such as fuels, lubricants and hydraulic oils) during maintenance activities, resulting in the development of a contamination plume over time. Although unlikely, should this occur, migration of contaminants to groundwater might also result. Potential operational impacts would largely be avoided and/or managed through the application of adequate hazardous material procedures (refer to section 10.3.5).

Contamination impacts during construction

Potentially contaminating activities that have the potential to occur during the construction phase of works include:

- disturbance of potentially contaminated materials
- temporary storage of building materials
- increased dust and noise levels
- increased traffic flow
- sediment run-off.

The anticipated primary transport media for the migration of contaminants include:

- vertical migration of chemicals through underlying soils into groundwater beneath the work sites
- lateral migration of dissolved phase contaminants within the groundwater beneath the work sites, typically along the hydraulic gradient
- migration of vapours through soils, underground service trenches and/or pits and beneath building slabs
- airborne dispersion of contaminated particulates released into the air from work sites.

These impacts would be managed through both the development of the detailed design and appropriate construction management. Further details are provided in section 10.3.5 below.

10.3.5 Management and mitigation

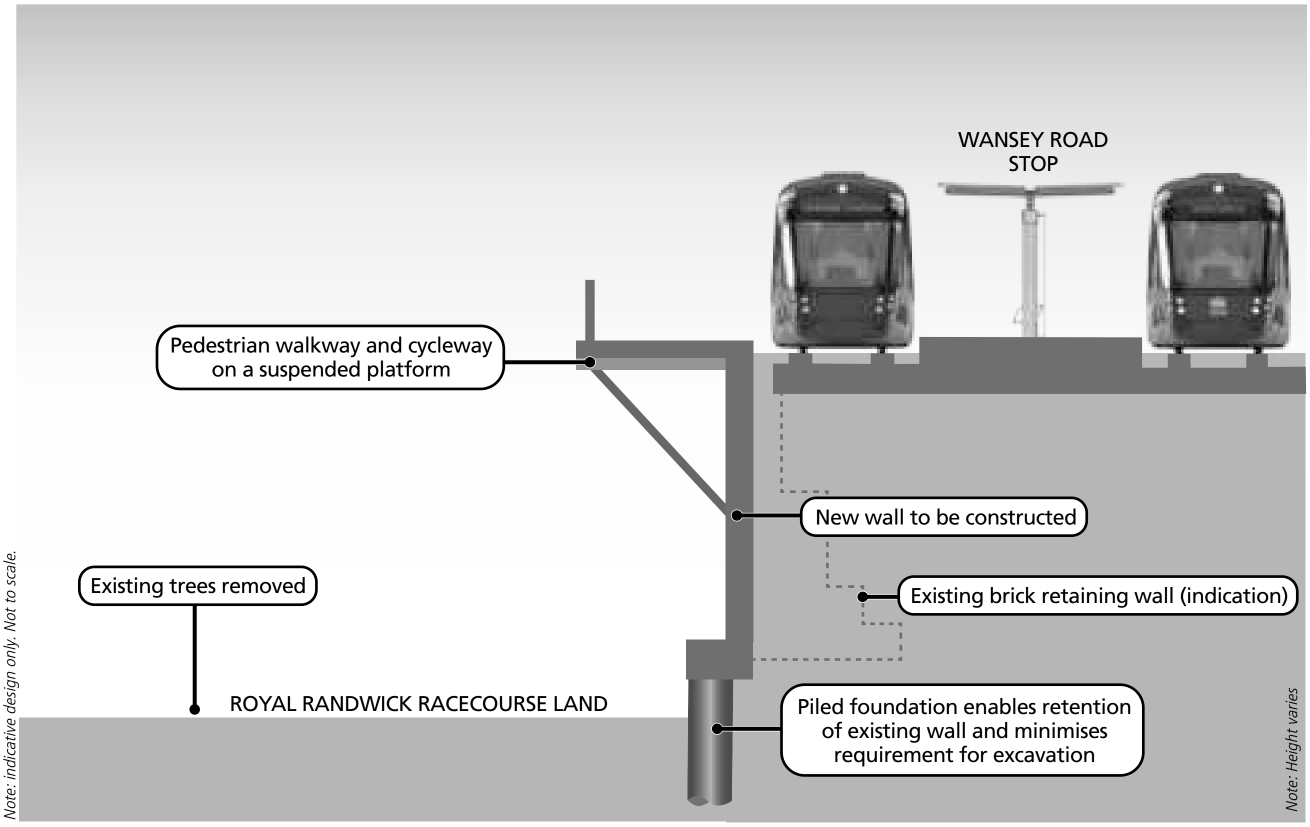
Land stability, soils and geological integrity

Management of soil erosion during and following construction would be an important consideration in the development of appropriate construction methods and final surface treatments during the detailed design stage. This would build on the construction methods outlined in Chapter 6. In addition where the need for specific environmental controls is identified, requirements would be set out in the construction environmental management plan (CEMP) to describe any additional requirements associated with key elements such as:

- pavement finishes and planting schemes in the urban design to protect and retain the soil during CSELR operations
- construction of the Wansey Road retaining wall to avoid loss of soil stability during construction
- construction of the Moore Park cut-and-cover tunnel to avoid loss of soil stability during construction.

The design of the Wansey Road retaining wall allows for construction without the removal of the existing retaining wall. Figure 10.5 provides a representation of a section through the wall. This section is indicative only and would be developed further using information from further geotechnical investigations (currently being undertaken) and the detailed design development.

Figure 10.5 Wansey Road stop – retaining wall



Construction of the cut-and-cover tunnel across Moore Park would employ construction techniques aimed at minimising the risk of settlement. Precondition surveys of building and structures in the vicinity of the Moore Park tunnel would be undertaken prior to the commencement of construction of the structure. Monitoring would continue for identified baseline buildings and structures throughout the construction period. Further detail on construction methods is given in Chapter 6 and section 10.4 in relation to groundwater impacts.

Soil erosion and sediment control

The following environmental management measures would be implemented during construction to minimise impacts associated with soil erosion and the subsequent sedimentation of receiving waterways:

- Erosion and sediment control plans would be prepared for each worksite in accordance with Volume 2D of *Managing Urban Stormwater: Soils and Construction* (DECC 2008). The erosion and sediment control plans would be established prior to the commencement of construction and be updated and managed throughout as relevant to the activities during the construction phase.
- Stabilised surfaces would be reinstated as quickly as practicable after construction.
- All stockpiled materials would be stored in bunded areas and kept away from waterways to avoid sediment entering the waterways.
- Sediment would be prevented from moving off-site and sediment laden water prevented from entering any watercourse, drainage line or drainage inlet.
- Clean water would be diverted around the work site in accordance with Landcom's (2004) *Managing Urban Stormwater: Soils and Construction*.
- Erosion and sediment control measures would be regularly inspected (particularly following rainfall events) to ensure their ongoing functionality.
- Erosion and sediment control measures would be left in place until the works are complete and areas are stabilised.
- Works would be avoided during rainfall (or whilst the ground remains sodden) to minimise vehicle disturbance to the topsoil.

Contamination

As part of the detailed design, a Phase 2 ESA would be undertaken to further characterise the nature of potential contamination along the proposed CSELR alignment. The Phase 2 ESA would focus on the following:

- General contamination along the route. This would be assessed through a program of conventional field testing involving groundwater wells, soil cores and test pits and lab testing of collected samples. Test locations would be derived from a Sampling, Analysis and Quality Plan (SAQP) which would be developed based on the Phase 1 ESA discussed in Section 10.3.2
- Building contamination (including asbestos and lead paint). This would include areas where demolition works are proposed (e.g. Olivia Gardens and at the Rozelle maintenance depot)
- Contamination from existing underground services (e.g. pits, pipes and substations). This would involve a review of existing detailed utilities data including 'Dial-Before-You-Dig', survey and data provided by asset owners (e.g. hazard logs) to categorise the likelihood of contamination, followed by field testing to confirm the presence of contaminated materials.

An Asbestos Management Plan would be developed in accordance with the *Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia* (Western Australia Department of Health 2009) and included as part of the CEMP.

Where there is a potential for the presence of hazardous materials to be disturbed, for example during demolition activities or excavation of underground services, the works would be monitored by an occupational hygienist.

Where suspected asbestos and/or lead paint containing materials are identified, work in the affected area would cease, and an investigation would be undertaken to determine the nature, extent and degree of contamination. A report would be prepared which would include a methodology for the removal, handling and disposal of the contaminated material. Works would only recommence upon receipt of a validation report from a suitably qualified occupational hygienist that the contaminated materials had been removed.

From the Phase 2 work, it will be possible to detail specific remediation requirements to be applied to the proposal; however, based on the current understanding of the contamination likely to be encountered it is possible to identify high level mitigation measures and an outline remediation strategy.

Outline remediation strategy

A CEMP would be prepared and implemented for the construction phase of works for the proposal. Under the CEMP a remediation strategy would be identified which would outline any measures required to manage contaminated materials during construction. Measures would be based on the results obtained during the Phase 2 ESA works, with an unexpected finds protocol also included to outline the methodology for managing potentially contaminated materials identified during the construction works that were not encountered during the Phase 2 ESA.

The remediation strategy would identify opportunities for remediation of affected areas prior to or during construction where the Phase 2 ESA confirms the presence of contaminated materials in concentrations above the intended land use criteria, as specified in the following guidelines:

- *Contaminated Site Guidelines for Assessing Service Station Sites* (EPA 2004)
- National Environment Protection Council (NEPC, 2013) *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)* (NEPM).
- *Waste Classification Guidelines* (DECCW 2009).

All contaminated materials disturbed during construction would be managed and either re-used or disposed of appropriately in accordance with all relevant legislation and guidelines, including the *Protection of the Environment Operations Act 1997,* the *Waste Avoidance and Resource Recovery Act 2001,* the NSW Department of Environment and Climate Change (DECC 2009a) *Waste Classification Guidelines* and the National Environment Protection Council (NEPC, 2013) *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)* (NEPM).

As the ongoing land use of the proposal area would be commercial/industrial (light rail) with minimal or no access to soil, it is not considered likely that large-scale soil remediation would be required as part of the proposal. The remedial methodology adopted is likely to primarily comprise segregation of potentially impacted materials during the construction phase and assessment of materials for suitability for re-use on-site. Materials would be identified as potentially impacted in areas where elevated concentrations of contaminants were identified during the Phase 2 ESA, or where indicators of contamination are encountered during excavation works. Field observations during the excavation works that could suggest the presence of previously unidentified contamination could include:

- unusual or strong odours
- discolouration or staining of soil or rock
- seepage of unusual liquids from soil or rock
- unusual odours or sheens on groundwater
- the presence of unusual/heterogeneous materials or fill.

Segregated materials would be inspected and sampled, with samples submitted for analytical testing for contaminants of concern. Results would be compared to relevant assessment criteria to assess whether there is any potential health or environmental risk posed by re-using the material on site. This assessment would be undertaken on a case by case basis by a qualified and experienced environmental consultant, depending on the location where the material is proposed to be re-used. Where concentrations of contaminants are above the intended land or appropriate human/ecological health criteria, the assessment would identify opportunities for remediation of affected areas.

Attempts would be made to re-use material on-site where assessment indicates that there is no risk, or where materials can reasonably and feasibly be remediated. Remediation of impacted materials would be dependent on the type of contaminant encountered but could potentially include:

- bioremediation of hydrocarbons (through on-site or offsite methods)
- re-use of material against waste classification examples
- excavation and on-site or off site treatment
- containment of non-leachable contaminants such as asbestos and heavy metals.

Areas requiring remediation would be validated to confirm that the surrounding soil meets site land use criteria requirements. In the event of any previously unidentified contaminated materials being identified on site during construction, works in the affected area would cease and would not recommence until sampling and remedial actions are instigated. This would be undertaken in accordance with the applicable EPA guidelines and statutory requirements. Work health and safety requirements and appropriate management measures would be followed for works that have the potential to contain contaminated soil.

Where contaminated soils are encountered that are deemed inappropriate for re-use (either through identified potential health or environmental risks, or where remediation is not feasible), or where materials are considered surplus and cannot be re-used, these would be classified in accordance with the NSW DECC (2009) *Waste Classification Guidelines*. Depending on the classification, the material would then be transported to an appropriate waste facility licensed to accept waste of the relevant classification.

Table 10.7 identifies the high level mitigation requirements for contaminants likely to be encountered.

Table 10.7 Mitigation requirements for contaminants

POTENTIAL CONTAMINATING ACTIVITY	CONTAMINANT SOURCE	SECTION OF CSELR	MITIGATION MEASURES
Fill; road and road reserve; park and open space	Imported fill, and reworked local soils, ash, asphalt and bitumen Application of pesticides, fertilisers	Entire site	Fill material to remain on-site where possible and where contaminant concentrations meet the site assessment criteria. All material required for off-site disposal should be appropriately tested and classified against the *Waste Classification Guidelines* (DECC 2009).
Power poles	Treatment of timber with copper chrome arsenate	Entire site	Should any signs of contamination be identified during works in areas near or down gradient of bus depots, service stations, mechanics/auto workshops or dry cleaning establishments, the material should be tested against the *Waste Classification Guidelines* (NSW DECC 2009) for off-site disposal. If groundwater is to be encountered during the works, groundwater quality should be investigated. Appropriate management plans should also be developed to outline the management and handling of any contaminated materials during construction.
Electrical substations	Leak of transformer oil	Circular Quay to Haymarket Haymarket to Moore Park via Surry Hills Moore Park to Kingsford	Should any signs of contamination be identified during works in areas near or down gradient of bus depots, service stations, mechanics/auto workshops or dry cleaning establishments, the material should be tested against the *Waste Classification Guidelines* (NSW DECC 2009) for off-site disposal. If groundwater is to be encountered during the works, groundwater quality should be investigated. Appropriate management plans should also be developed to outline the management and handling of any contaminated materials during construction.
Old building/ structures	Paint containing lead Asbestos containing materials	Circular Quay to Haymarket Haymarket to Moore Park via Surry Hills Moore Park to Randwick Moore Park to Kingsford Rozelle maintenance depot site	A hazardous material inspection should be undertaken of any areas where historical infrastructure is to be disturbed and/or demolished to assess the material to be disturbed for the presence of asbestos and/or lead paint. Appropriate management plans (such as an Asbestos Management Plan) should also be developed to outline the management and handling of hazardous materials during construction. Should any signs of contamination be identified during the works, the materials should be tested and assessed against the site assessment criteria. All material required for off-site disposal should be appropriately tested and classified against the *Waste Classification Guidelines* (DECC 2009).
Rail corridor including embankments Light rail and monorail (Note: Monorail is likely to have been removed prior to the construction of CSELR)	Fuel and oil spills, engine emissions, rail corridor maintenance, brake lining, historical cable and/or pipework Ash from historical use of rail corridor Asbestos cable trays	Circular Quay to Haymarket Haymarket to Moore Park (via Surry Hills) Rozelle maintenance depot site	A hazardous material inspection should be undertaken of any areas where historical infrastructure is to be disturbed and/or demolished to assess the material to be disturbed for the presence of asbestos and/or lead paint. Appropriate management plans should also be developed to outline the management and handling of hazardous materials during construction. Should any signs of contamination be identified during the works, the materials should be tested and assessed against the site assessment criteria. All material required for off-site disposal should be appropriately tested and classified against the *Waste Classification Guidelines* (DECC 2009).

Table 10.7 cont

POTENTIAL CONTAMINATING ACTIVITY	CONTAMINANT SOURCE	SECTION OF CSELR	MITIGATION MEASURES
Cemetery	Weeds and pest control, pathogens	Haymarket to Moore Park (via Surry Hills)	It is unlikely that contamination associated with this contaminating activity would be identified; however, should any signs of contamination be identified during the works, the material should be tested against the *Waste Classification Guidelines* (DECC 2009) for off-site disposal.
Racecourse; horse stables	Applications of pesticides and or herbicides, fertilisers and imported fill Use of solvents for polishing metals and/or leather goods	Moore Park to Randwick Randwick stabling facility	Should any signs of contamination be identified during works in this area, the material should be tested and assessed against either the site assessment criteria to remain on-site or the *Waste Classification Guidelines* (DECC 2009) for off-site disposal.
Service stations	Spills and leaks from service station bowsers and storage tanks	Moore Park to Kingsford Moore Park to Randwick	If groundwater is to be encountered during the works, groundwater quality should be investigated. Appropriate management plans should also be developed to outline the management and handling of any contaminated materials during construction
Mechanics and auto workshops	Run-off from storage and hydraulic oils	Moore Park to Kingsford Moore Park to Randwick	
Dry cleaning establishments	Spills or inappropriate handling of dry cleaning chemicals	Moore Park to Kingsford	
Car wash bays or facilities	Run-off of oil and grease and detergent from car wash	Moore Park to Kingsford	

10.4 Groundwater

The following sections provide a summary of a desktop groundwater assessment undertaken for the CSELR proposal.

10.4.1 Existing environment

Aquifer systems

Two major aquifer systems are located in the vicinity of the CSELR alignment (refer Figure 10.6):

- the Sydney Basin Central aquifer
- the Botany Sands aquifer.

A description of the aquifer systems is provided in Table 10.8.

Table 10.8 Aquifer systems in the vicinity of the CSELR proposal

AQUIFER SYSTEM	DESCRIPTION
Sydney Basin Central aquifer	This consolidated rock aquifer comprises Hawkesbury Sandstone and Ashfield Shale, and generally underlies sections of the CSELR alignment located within the City Centre, Surry Hills and Randwick precincts (refer to Figure 10.6). Groundwater flow within the aquifer is predominantly controlled by joints, faults and bedding planes. The inferred groundwater flow is likely to follow topography towards Sydney Harbour and the Alexandra Canal respectively. Existing tunnels (the Cross City Tunnel, Eastern Distributor tunnel and cable tunnels) are likely to influence the flow direction. Aquifer recharge is likely to occur via infiltrating rainfall; however, given the large proportion of surface sealing within the study area (e.g. the establishment of roads and other impermeable surfaces), the natural recharge may be limited. Leaking pipes are likely to also contribute to aquifer recharge. Within areas traversed by the CSELR alignment, the water table is approximately 2 to 3 metres below ground level (refer to Table 10.9). The height of the water table is likely to fluctuate seasonally (due to seasonal rainfall fluctuations), and in the case of Circular Quay, tidally (i.e. associated with the tidal flow of Sydney Harbour). Groundwater in the CBD area is reported to have elevated concentrations of iron and manganese, but generally is of relatively good quality. During construction of the City South Cable Tunnel, poor water quality was observed in the Haymarket area which is thought to be associated with flows from the Great Sydney Dyke.
Botany Sands aquifer	This is an unconsolidated aquifer that predominantly consists of sand, and partly underlies the Kensington/Kingsford, Randwick, Moore Park and Surry Hills precincts (refer to Figure 10.6). Groundwater in the shallower beds is unconfined, but in the deeper layers is partially confined. Groundwater flow direction generally is from north to south, partly tending to the north-east to south-west. Potential sensitive receptors include groundwater bores, a stormwater channel on Alison Road and the Alexandra Canal. Recharge mainly occurs via rainfall infiltration. Ponds in Centennial Park receive stormwater, which recharges the aquifer. It is likely that some recharge from leaking pipes also occurs. Groundwater levels fluctuate over time in response to recharge, pumping, and (in locations where the water table is shallow), evapotranspiration. The amplitude of fluctuations, however, is likely to be spatially variable. Table 10.9 summarises water table levels taken from the NSW Office of Water's (2013) database which range between 0.5 metres and 7 metres below ground level. Groundwater within the Botany Sands is mostly low in salinity. In 2003, an embargo was implemented under section 113A of the *Water Act 1912* in the northern part of the aquifer (where the alignment is located), because available water was depleted by plumes of contamination.

Table 10.9 Depth of groundwater in the Sydney Basin Central and Botany Sands aquifers

PRECINCT/AREA	PURPOSE OF BORE	STANDING WATER LEVELS (mBGL)[1]	AQUIFER
City Centre	Monitoring	2.0–3.0	Sydney Basin Central
Surry Hills	Domestic, irrigation	2.0–7.0	Sydney Basin Central, Botany Sands
Moore Park	Domestic, irrigation, monitoring	2.0–7.0	Botany Sands
Randwick	Irrigation, monitoring	3.0–5.0	Sydney Basin Central, Botany Sands
Kensington/Kingsford	Domestic, irrigation, monitoring	2.0–5.0	Botany Sands
Randwick stabling yard	Irrigation, monitoring	3.0–5.0	Botany Sands
Rozelle maintenance depot	Monitoring	0.5–6.0	Sydney Basin Central

Note 1: mBGL = metres below ground level

Groundwater quality

Groundwater in the city centre area is reported to have elevated concentrations of iron and manganese but is generally of relatively good quality (GHD Pty Ltd 2010). During construction of the City South Cable Tunnel, poor water quality was observed in the Haymarket area which is thought to be associated with flows from the Great Sydney Dyke.

Sensitive groundwater receptors

Registered bores

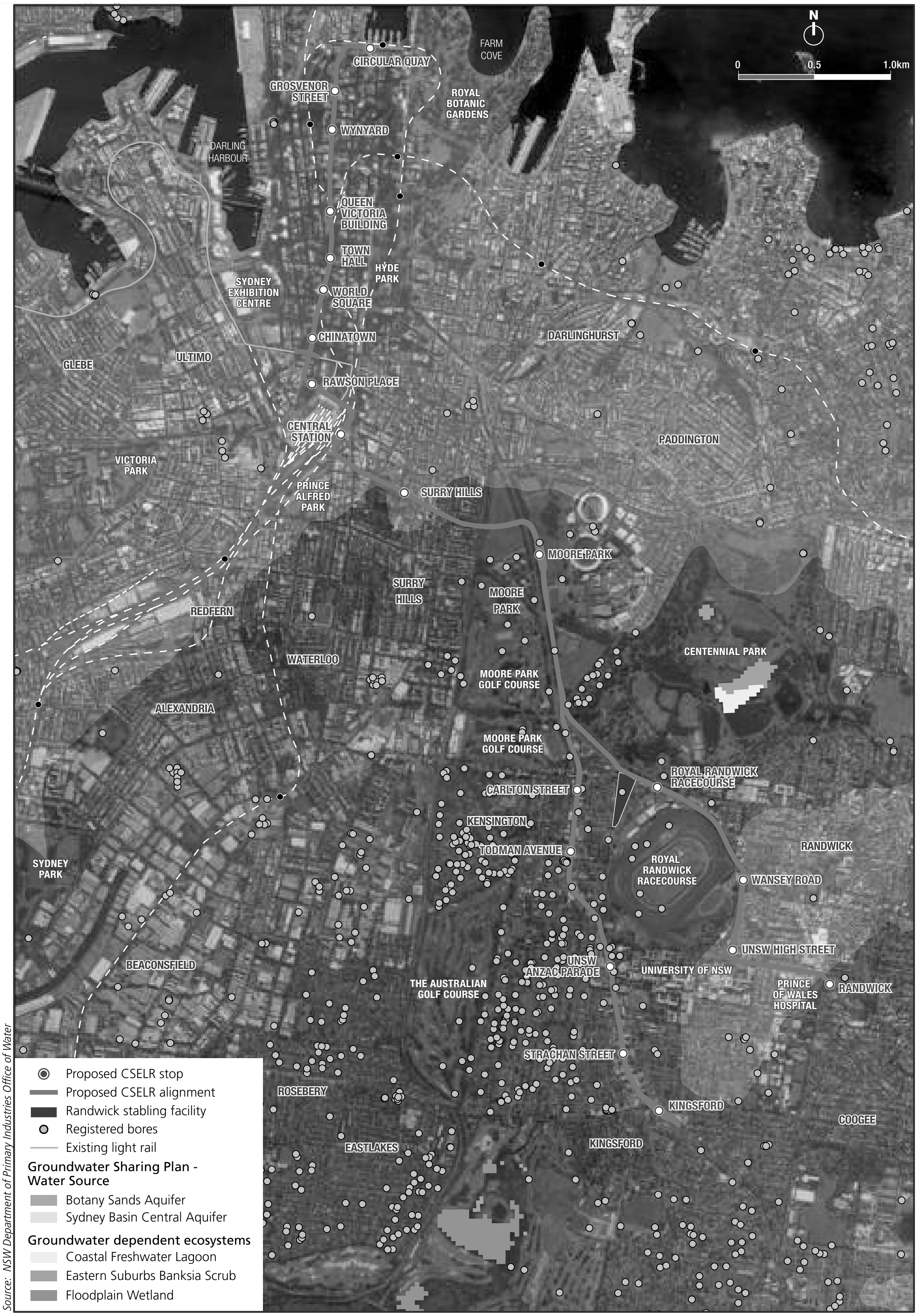
A search of the NSW Office of Water's Groundwater Data System in July 2013 identified 131 registered groundwater bores within 300 metres of the CSELR proposal. The locations of these bores are shown in Figure 10.6, while the beneficial uses of the bores (e.g. monitoring, irrigation) and groundwater levels (measured at the time of bore installation) are summarised in Table 10.9. Sixteen of the registered groundwater bores located within 600 metres of the proposed cut-and-cover tunnel at Moore Park are used for purposes other than groundwater monitoring (e.g. domestic and irrigation purposes). Details on these 16 bores are provided in Table 10.10.

Table 10.10 Registered bores located within 600 metres of the Moore Park tunnel

GROUNDWATER WORK ID	PURPOSE OF BORE	PROPERTY	APPROXIMATE DISTANCE AND DIRECTION FROM TUNNEL
GW200690[1]	Private	Not available	500 metres north-west
GW105525	Domestic	Gorrick	300 metres south-west
GW104133	Recreation	Centennial Park	150 metres south
GW104131	Recreation	Centennial Park	150 metres south
GW105920	Domestic	Sydney Boys High School	200 metres south
GW105076	Domestic	Sydney Girls School	150 metres south
GW106328	Domestic	Sydney Girls School	250 metres south
GW100546	Test bore	Unknown	500 metres south
GW017340, GW017869, GW017870	Industrial	Unknown	500 metres south-west
GW100293	Irrigation	Centennial Park, Moore Park	500 metres south-east
GW101640	Irrigation	Centennial Park, Moore Park	300 metres south-east
GW024058	Recreation/irrigation	Unknown	350 metres east
GW105485	Bore	Old Members Property	500 metres east
GW024057	Irrigation	Old Members Property	400 metres east

Note 1: Review of the bore data suggests the bore may not actually be located near the CSELR alignment.

Figure 10.6 Location of groundwater aquifers and registered bores



Source: NSW Department of Primary Industries Office of Water

Groundwater dependent ecosystems

As discussed in section 10.6 and shown on Figure 10.6, three groundwater dependent ecosystems are located within 1.2 kilometres of the CSELR proposal. Impacts on these ecosystems are discussed in section 10.6.

10.4.2 Impacts during operation

Changes to aquifer permeability

The CSELR proposal would involve the sealing of the ground surface (in some areas) using concrete or similar. Sealing the ground surface could reduce the amount of rainfall recharging the aquifers, leading to lowered groundwater levels and reduced access for bore owners and groundwater dependent ecosystems. Areas where this could occur include:

- sections of light rail track that are not currently situated within existing paved road reserves, including:
  - Moore Park and Centennial Park
  - Royal Randwick racecourse (adjacent to Alison Road between Doncaster Avenue and Darley Road)
  - adjacent to Alison Road, between Darley Road and Wansey Road
  - adjacent to Wansey Road, between Alison Road and High Street
  - south of the Nine Ways intersection (area between the northbound and southbound lanes of Anzac Parade)
- at the Randwick stabling facility.

The above areas are situated within the Botany Sands aquifer, which is predominantly recharged by rainfall infiltration. However, as the area to be sealed for the CSELR alignment is relatively small compared to the recharge area of the Botany Sands aquifer, the risks to groundwater recharge are likely to be relatively low.

According to the *NSW Aquifer Interference Policy* (NSW Department of Primary Industries 2012), if more than a two metre decline in groundwater level at any water supply work is obtained, then ‘make good’ provisions (which could involve deepening a bore or drilling a new bore) should apply. A groundwater level decline of greater than two metres is unlikely as a result of changes to aquifer permeability.

Piling also has the potential to reduce the permeability of aquifers. As outlined in Chapter 6, piling would generally be required during the construction of light rail stops, overhead wiring, the Wansey Road retaining wall, the Eastern Distributor Road overbridge and the Moore Park cut-and-cover tunnel.

Contamination of groundwater

Accidental spills or leakage from stabling and maintenance activities at the proposed Rozelle maintenance depot and Randwick stabling facility have the potential to contaminate aquifers. Groundwater could become contaminated with hazardous materials (such as fuels, lubricants and hydraulic oils) during maintenance activities, resulting in the development of a contamination plume. A decline in water quality or the contamination of groundwater could be problematic for groundwater users and sensitive receiving environments, including Sydney Harbour, which is likely to interact with the Sydney Basin Central aquifer; Alexandra Canal, which is likely to interact with the Sydney Basin Central and Botany Sands aquifer; and a stormwater channel on Alison Road, which is likely to interact with the Botany Sands aquifer. This impact would be largely avoided and/or managed through the application of adequate water quality and hazardous material procedures (refer to section 10.3.5).

Groundwater intersection

As outlined in section 5.2.5.2, the proposed Moore Park tunnel would be ‘tanked’ (i.e. designed to include sealed tunnel walls) to minimise the ingress of groundwater. Therefore, significant impacts due to groundwater intersection are not anticipated to occur during the operational phase of the CSELR proposal. However, the sealing of the proposed Moore Park tunnel walls would locally alter the groundwater flow regime as two sections of the aquifer would be separated by the tunnel structure.

Disposal of groundwater from the Moore Park tunnel

As outlined in section 5.2.5.2, the proposed Moore Park tunnel would include a drainage system to collect, treat and discharge any groundwater seepage into the tunnel. Wastewater that is not required for fire suppression purposes (as discussed in section 5.2.5.2) would be treated to a quality standard suitable for discharge into the surrounding stormwater drainage network. All groundwater encountered during the operational phase of the proposal would be managed in accordance with the requirements of the *Waste Classification Guidelines* (DECC 2009) and Transport for NSW's (2012a) *Water Discharge and Re-use Guideline*. Groundwater will be disposed to ensure it does not cause the pollution of waters in accordance with Section 120 of the *Protection of the Environment Operations Act 1997*.

10.4.3 Impacts during construction

Groundwater intersection and dewatering

Groundwater is likely to be intersected during the construction of the cut-and-cover tunnel at Moore Park and during excavations for foundations (including piling), services and stops, where the excavations are proposed to be deeper than two metres below ground level.

Excavations for foundations (including piles), services and stops would intersect the Sydney Basin Central and Botany Sands aquifers, while the cut-and-cover tunnel would intersect the Botany Sands aquifer.

The *NSW Aquifer Interference Policy* clarifies the requirements for obtaining water licences for aquifer interference (NSW Department of Primary Industries 2012). Under the policy, the NSW Office of Water will assess a project's potential impacts and identify where further avoidance, prevention or mitigation measures may be required. The NSW Office of Water will be consulted to ensure all necessary licences are obtained.

The groundwater inflow rate into excavations would be dependent on the permeability of the intersected geological unit, groundwater level and dimensions (i.e. length, depth and width) of the proposed underground structure. Higher permeability and deeper intersection of the groundwater would result in higher inflow rates.

Modelling of potential groundwater inflow rates during the construction of the CSELR proposal was not undertaken as part of the Environmental Impact Statement (EIS). However, average reported groundwater inflow rates for the Eastern Distributor and Cross City Tunnels are approximately one litre per second per kilometre of tunnel length (Hewitt 2012). It is noted that potential groundwater inflow hazards (such as heavily fractured zones or dykes) exist within the study area (refer to Figure 10.2). Therefore, there is the potential for higher groundwater inflow rates to occur during the construction of the CSELR proposal in instances where such groundwater inflow hazards are encountered.

Groundwater inflows from the Botany Sands are expected to be much higher than from the Ashfield Shale and Hawkesbury Sandstone due to the higher permeability of this aquifer.

Groundwater modelling will be undertaken during the detailed design phase to estimate the potential groundwater inflow rates during construction and operation of the Moore Park tunnel and the potential impacts from the interruption of groundwater flow.

As outlined in section 6.2.5, groundwater is expected to be encountered during the construction of the Moore Park tunnel and, therefore, dewatering would be required. Dewatering during construction of the CSELR would result in a localised drawdown of the water table, causing a change in groundwater flow direction. If groundwater flow patterns are changed, water from further afield would be drawn towards the CSELR structure being constructed.

Risks associated with a localised drawdown of the water table would include:

- *Limiting the use of nearby bores* — The area of highest risk is the proposed cut-and-cover tunnel at Moore Park. A bore search identified 16 bores within 600 metres of the proposed tunnel with a purpose other than monitoring. Details of the bores are provided in Table 10.10. According to the *NSW Aquifer Interference Policy* (NSW Department of Primary Industries 2012), if more than a two metre decline in water level at any water supply work is obtained, then make good provisions should apply.

- *Settlement* — Settlement could adversely impact neighbouring buildings and structures. Settlement was observed during the construction of the Eastern Distributor and may be of particular concern where the Botany Sands aquifer is intersected.
- *Reducing baseflow* — Reducing baseflow to groundwater dependent ecosystems (including swamps and wetlands), or access to groundwater for groundwater dependent ecosystems by lowering the groundwater table. Further discussion on potential impacts to groundwater dependent ecosystems is provided below.

Risks associated with changed flow patterns would include:

- *Mobilisation of an existing contamination plume towards the structure* — As discussed in section 10.3.4, the Phase 1 ESA identified a number of potential contamination sources near the proposed CSELR alignment, including service stations, auto mechanics, fill and road base and car wash bays. The risk of drawing contaminated groundwater towards excavations would be further considered following the Phase 2 ESA, which would be completed during detailed design.
- *Drawing water of a different water quality towards the structure* — Groundwater in the Ashfield Shale or associated with the Great Sydney Dyke is potentially of poorer quality than groundwater in the Hawkesbury Sandstone and Botany Sands.

Environmental management measures that Transport for NSW would implement to manage potential groundwater impacts during the construction of the CSELR are discussed in section 10.4.4.

Disposal of groundwater encountered during construction

Groundwater encountered during construction would need to be managed and disposed of to minimise potential environmental impacts. The groundwater encountered is expected to be of relatively good quality, although groundwater from the Sydney Basin Central aquifer may have elevated concentrations of iron and manganese and groundwater from the Ashfield Shale may have elevated salinity. Treatment of groundwater for iron, manganese and salinity, or for contamination, may be required before discharge. This would be further considered in the Phase 2 ESA, to be completed during detailed design.

All groundwater encountered during the construction of the proposal would be managed in accordance with the requirements of the *Waste Classification Guidelines* (DECCW 2009) and Transport for NSW's (2012a) *Water Discharge and Re-use Guideline.*

Contamination of groundwater

Accidental spills or leakage from construction plant, vehicles and equipment have the potential to contaminate aquifers. Groundwater could become contaminated with sediment and/or construction materials, such as fuels, lubricants and hydraulic oils, during construction activities, resulting in the development of a contamination plume.

A decline in water quality or the contamination of groundwater could be problematic for groundwater users and sensitive receiving environments, including Sydney Harbour (which is likely to interact with the Sydney Basin Central aquifer), Alexandra Canal (which is likely to interact with the Sydney Basin Central ad Botany Sands aquifer) and a stormwater channel on Alison Road (which is likely to interact with the Botany Sands aquifer). This impact would be manageable through the application of adequate water quality and hazardous material procedures (refer to section 10.3.5).

Impacts to bores

Bores located within the construction footprint of the CSELR alignment may be destroyed during construction.

As outlined earlier in this section (refer to the groundwater intersection and dewatering subsection above), drawdown of groundwater levels would occur during proposed dewatering activities associated with the construction of the Moore Park tunnel. This has the potential to limit the use of nearby bores. For example, if water levels are drawn down below the depth of the pump or the depth of the bore. Sixteen bores are located within 500 metres of the proposed tunnel (refer to Table 10.10) and are considered at risk of being impacted during the construction of the CSELR proposal. If more than a two metre decline in water level at any water supply work is obtained, then make good provisions should apply (in accordance with the *NSW Aquifer Interference Policy* (NSW Department of Primary Industries 2012)).

Potential water quality impacts to bores have been outlined earlier in this section (refer to the impacts to groundwater quality subsection above).

Impact to groundwater dependent ecosystems

Impacts on groundwater dependent ecosystems are discussed in section 10.6. No direct or indirect impacts to groundwater dependent ecosystems are anticipated as a result of the proposal.

10.4.4 Management and mitigation

Design development

Environmental management measures that Transport for NSW would implement during the detailed design phase to manage potential groundwater impacts associated with the CSELR proposal are as follows:

- Additional investigation/assessment of dewatering requirements for the construction of the Moore Park tunnel would be undertaken during detailed design and in consultation with the NSW Office of Water. Groundwater modelling would be undertaken to determine the potential impacts from the permanent interruption of groundwater flow, including the extent of the drawdown and the potential for settlement.
- A dewatering system for excavations proposed in the Botany Sands aquifer would be developed. This could comprise the reinjection of groundwater back into the same aquifer to minimise the spatial extent of drawdown (and therefore settlement).
- A field survey would be undertaken to confirm the existence, usage and condition of any bore located within the construction footprint of the CSELR proposal, or potentially affected by the CSELR proposal (e.g. those located in the vicinity of proposed excavations). This would cover an area appropriate to identify potential dewatering impacts.
- The design of embankments would incorporate adequate drainage to reduce compaction and/or sealing of the underlying aquifer.
- Adequate drainage and runoff management would be incorporated into the design of the Rozelle maintenance depot and the Randwick stabling facility.
- A condition assessment of existing buildings and infrastructure would be undertaken to monitor the risk of settlement from groundwater drawdown.

Operation

Hazardous material procedures (including procedures for managing spills, and the refuelling and maintenance of vehicles/equipment) would be developed and implemented during the operation of the CSELR proposal to minimise potential for groundwater quality impacts associated with chemical spills and leaks. These procedures would adequately address activities at the proposed Rozelle maintenance depot and Randwick stabling facility, as well as other general maintenance facilities that would occur along the CSELR alignment.

Construction

Potential groundwater impacts associated with the construction of the CSELR proposal would be managed through the implementation of the following environmental management measures:

- A construction groundwater management plan will be prepared prior to construction, and will detail the control measures that aim to minimise potential impacts to groundwater resources and receiving environments during construction. The purpose of the plan is to provide practical impact mitigation principles and measures for the design and construction of the proposal consistent with relevant legislation and standard guidelines.
- The construction groundwater management plan will include details of a groundwater monitoring program, which would be implemented prior to construction to identify changes in groundwater quality and levels during construction. The monitoring program would be developed in consultation with the NSW Office of Water.
- Excavation techniques would be adopted to minimise impacts on aquifers.
- Groundwater encountered during the construction of the proposal would be managed and disposed of in accordance with the *Waste Classification Guidelines* (DECC 2009) and Transport for NSW's (2012a) *Water Discharge and Re-use Guideline*. Groundwater will be disposed to ensure it does not cause the pollution of waters in accordance with Section 120 of the *Protection of the Environment Operations Act 1997*.
- Hazardous material procedures (including procedures for managing spills and refuelling and maintaining construction vehicles/equipment) would be developed and implemented as part of the CEMP to minimise potential for groundwater quality impacts due to chemical spills

The Moore Park tunnel would be constructed through the Botany Sands aquifer using a tanked construction technique (where practicable) to reduce the volume of groundwater inflow, drawdown and settlement risk. In this case, diaphragm walls would be used to construct sections of the open dive structure where large retaining walls are required, while precast walls would be used in locations with lower retaining wall heights.

The following construction sequence may be used to reduce the volume of dewatering required at the deeper sections of the tunnel:

- Extend alternate diaphragm wall panels to form a groundwater cut-off in the swamp deposits underlying the Botany Sands. The other panels would be founded at a shallower depth to allow continued groundwater flow towards Botany Bay.
- Construct bentonite slurry cross walls at approximately 50 metre centres to confine the extent of drawdown.
- Excavate the entire tunnel to the underside of headstock level (excluding Anzac Parade), which is expected to be above groundwater level.
- Dewater one bay at a time with a line of wells at the centre of the excavation.
- Deep excavation of one bay at a time and construct the base slab.

10.5 Aboriginal heritage

This section presents a summary of the assessment of Aboriginal archaeological potential and impacts along the proposed CSELR alignment, prepared in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* (the then Department of Environment, Climate Change and Water (DECCW) 2010). Appropriate management and mitigation protocols for potential impacts are also identified.

Further detail on the assessment of the impact of the CSELR on Aboriginal archaeology for each precinct is provided the Aboriginal heritage assessment. This is presented in full in Technical Paper 5 – *Heritage Impact Assessment*.

10.5.1 Existing environment

Aboriginal history and recorded sites

Accounts of Governor Arthur Phillip and Philip Gidley King identified the Gadigal (also spelt Cadigal) people as the inhabitants of the area between South Head and Darling Harbour. The Wangal were said to have occupied the land from Darling Harbour west to Rose Hill (Parramatta). This indicates that the area of the CSELR proposal was likely to have been located within Gadigal lands, and was close to the tribal boundary with the Wangal.

The Aboriginal archaeological potential of the CSELR alignment varies along its length. These variations are dependent on the way certain parts of the landscape were used by Aboriginal people, and how archaeological deposits may have been disturbed by modern activities. As reflected in Table 10.11, the patterning of Aboriginal archaeological sites revealed by the Aboriginal Heritage Information Management System (AHIMS) and relevant archaeological studies in the local area indicate that there is a concentration of Aboriginal sites around the foreshore of Port Jackson (the natural harbour of Sydney).

A variety of site features and site types are represented in both the AHIMS data and other relevant literature. This range of site types is indicative of the different activities that were undertaken by Aboriginal people in the vicinity.

The evidence suggests that Aboriginal people were collecting marine and terrestrial food resources available in the local area, and were processing them close to the CSELR alignment. Archaeological data suggests that other activities were also carried out nearby, such as stone tool manufacture and use, burials, the creation of rock art, and performing traditions that embedded Aboriginal culture and Dreaming across the landscape.

Ethnohistorical accounts of Aboriginal people and activities at and around the Sydney CBD support this patterning of archaeological data. Written accounts and illustrations record Aboriginal people extensively using foreshore and estuarine environments for a range of activities, such as subsistence resource collection and resource processing, including stone tool manufacture and food preparation. This is reflected in the archaeological record. Midden remains are indicators of what foods were eaten in the area, while tools found at archaeological sites were often made to be used in marine resource collection and processing (such as fish hooks).

Table 10.11 Summary of AHIMS entries

CSELR SECTION	SEARCH AREA	NUMBER OF AHIMS REGISTERED SITES	COMMENTS
City Centre Precinct (Circular Quay to Chalmers Street at Central Station)	9 km^2	21	Site features registered include assemblages of artefacts, shell/middens, Aboriginal ceremony and Dreaming, burial features and other potential archaeological deposits (PADs).
Surry Hills Precinct (Devonshire Street to South Dowling Street)	3 km^2	3	Site features registered include assemblages of artefacts, shell/middens and Aboriginal resource and gathering.
Moore Park Precinct (South Dowling Street to Alison Road)	3 km^2	1	Now destroyed engraved rock art site at Darvall Street.
Randwick Precinct (Alison Road to High Cross Park)	9 km^2	1	Search area covered both Randwick and Kensington/Kingsford precincts. Registered site located at Prince of Wales Hospital featuring artefacts and hearths.
Kensington/Kingsford Precinct (Alison Road to University of New South Wales)			
Randwick stabling facility			
Rozelle maintenance depot		6	Site features registered include shelters and midden and rock engraving.

Although middens are often the most obvious Aboriginal archaeological deposit along the CSELR alignment, particularly in the Sydney CBD area, recorded artefacts make up the majority of site types registered, other than potential archaeological deposits (PADs).

Aboriginal archaeological potential

Archaeological potential is defined as a site's potential to contain archaeological relics. This potential is identified through historical research and by judging whether current building or earlier building or development activities have removed all evidence of known previous land uses. Archaeological potential will typically range from low and medium to high.

As existing development and road surfacing across the region has modified and obscured the natural landforms and covered all natural ground surfaces it is difficult to define specific areas of Aboriginal archaeological potential.

The data from archaeological investigations undertaken in the CBD indicates that some Aboriginal archaeological deposits survive in Sydney, even in highly developed locations. Some of these archaeological deposits have been subjected to varying levels of disturbance, but still survive in small pockets of natural soil and/or at depth in truncated soil profiles. In other cases Aboriginal objects (stone tools) may be present in historical archaeological stratigraphic layers.

Based on consideration of known archaeological activity, the level of nineteenth century and modern development, and the distribution of the soils landscape, the CSELR proposal alignment has been assigned an archaeological potential between Zone 1 and Zone 4 (refer to Figure 10.7). Zone 1 has the highest Aboriginal archaeological potential and Zone 4 has the least or no Aboriginal archaeological potential, usually as the result of extensive disturbance and modification through development. Details of the criteria for the archaeological potential zones are presented in Table 10.12 below.

Figure 10.7 Aboriginal archaeological management zones

Table 10.12 Definition of Aboriginal archaeological potential zones

ZONE	ABORIGINAL ARCHAEOLOGICAL POTENTIAL	DETAIL
Zone 1	Aboriginal archaeological potential for Aboriginal objects to be found and/or impacted.	Aboriginal archaeological potential present within identified impact zone of CSELR.
Zone 2	Upper stratigraphic levels likely to be disturbed and have nil–low Aboriginal archaeological potential for Aboriginal objects to be found and/or impacted. Due to the nature of local soils, deeper stratigraphic layers may be intact and still have Aboriginal archaeological potential.	Identified impact zone of CSELR is primarily within upper stratigraphic levels with nil–low Aboriginal archaeological potential. Identified impact zone may not extend to deeper stratigraphic levels and impact on intact Aboriginal archaeology, but mitigation measures will need to ensure flexibility to allow for any impacts identified during works.
Zone 3	Aboriginal archaeological evidence may be present; however due to nature and extent of modern land use it is likely to be disturbed. It may be present in isolated pockets, truncated soil profiles or in historical/modern layers of activity. The location of such deposits is not able to be accurately predicted.	Aboriginal archaeological evidence may be present in isolated pockets within the impact zone of the CSELR; however the exact locations of Aboriginal archaeology are not able to be accurately predicted.
		Where Aboriginal archaeological evidence is absent, CSELR construction would not have an impact.
		Where Aboriginal archaeological evidence is present, CSELR construction would have an adverse impact.
Zone 4	No Aboriginal archaeological potential, due to large scale excavations, and demolition and construction activities which would have removed any Aboriginal archaeological deposits in these locations.	CSELR construction would have no impact on Aboriginal archaeology in Zone 4.

Table 10.13 presents the allocation of the Aboriginal potential zones, which reflect the level of previous development along the proposal alignment. Areas that are classified as Zone 1 require extensive excavation (up to and over 750 millimetres deep) and may extend into intact soil profiles with Aboriginal archaeological potential. Additional geotechnical investigations would be needed to confirm this. Further details are discussed in Section 3 of Technical Paper 5.

Table 10.13 Allocation of Aboriginal archaeological potential zones

CSELR SECTION	ARCHAEOLOGICAL POTENTIAL ZONES
City Centre Precinct (Circular Quay to Central station)	Zone 3 throughout, except at Central Station (Zone 2).
Surry Hills precinct (Central station to South Dowling Street)	Zone 2 between Central Station and Holt Street, Zone 3 between Holt Street and Bourke Street, Zone 1 between Holt Street and South Dowling Street.
Moore Park Precinct (South Dowling Street to Alison Road)	Zone 1 between South Dowling Street and Dacey Avenue (through Moore Park along the track alignment), Zone 2 construction lay down area adjacent to Anzac Parade.
Randwick Precinct (Alison Road to High Cross Park)	Zone 1 between Dacey Avenue to end of proposed CSELR alignment (track alignment), Zone 2 construction laydown area adjacent to proposal alignment.
Kensington/Kingsford Precinct (Alison Road to University of New South Wales)	Zone 1 between Dacey Avenue to end of proposed CSELR alignment (track alignment), Zone 2 construction laydown area adjacent to proposal alignment.
Rozelle maintenance depot	Zone 3 throughout the proposed Rozelle maintenance depot.

Given the high degree of landscape modification across the CBD, it is not possible to predict exactly where areas of Aboriginal archaeological potential may be present. Geotechnical testing or Aboriginal archaeological test excavations may assist in further refining areas of Aboriginal archaeological potential. Such data would allow for definition of areas of low–high archaeological potential, or identification of areas with no Aboriginal archaeological potential. Based on additional data, the allocation of Aboriginal archaeological management zones shown in Figure 10.7 may be revised.

Away from the CBD, Aboriginal archaeological deposits may survive in locations where modern disturbance has not extended right through upper soil horizons capable of bearing Aboriginal archaeological deposits. Sand sheets, such as the Botany Sands, are associated with Aboriginal archaeological deposits that can date back to the early Holocene or Pleistocene periods (older than 4,000 BP).

The absence of Aboriginal sites in the immediate area is likely to represent a lack of investigation and understanding of how these areas were used by Aboriginal people rather than a 'lack' of evidence of the use of the wider area by Aboriginal people. Activities such as stone tool manufacture, resource gathering and processing were likely to have been undertaken in the local area. Landscapes characterised by both Blacktown soils/Ashfield Shale and Tuggerah soils/Botany Sands are likely to have been used by Aboriginal people. However, it is not possible to determine from the available archaeological background if there are differences in the way the areas were used that would influence the nature of the Aboriginal archaeological record in each area.

A small number of Aboriginal archaeological studies have been undertaken within the Botany Basin sand dune environment such as that present within the Moore Park, Randwick and Kensington/Kingsford precincts, and part of the Surry Hills precinct. A limited amount of archaeological research has been undertaken in the immediate area. Other investigations have been undertaken within the dune environment in the Botany Basin and on nearby sand sheets. Sand sheets in Sydney are well known as they tend to be geomorphological features many thousands of years old and yield very early dates for Aboriginal occupation in the region (30,000 years BP). Examples dating to between 6,000 and 10,000 years BP have been retrieved within the Botany Basin. Further discussion is provided in Technical Paper 5.

Tay Reserve, within the Kensington/Kingsford Precinct may have Aboriginal archaeological deposits dating to the nineteenth century, as it was known to be used by Aboriginal people in the historical period. For example, the nineteenth century toll house on the site was staffed and occupied by an Aboriginal man known as King Billy Timbery. The occupation of the tollhouse by an Aboriginal toll collector could be expected to be recognised in the archaeological record if representative remains such as stone objects were identified (refer Technical Paper 5 – *Heritage Impact Assessment*).

10.5.2 Impacts during operation

Impacts to Aboriginal archaeology would primarily be associated with the construction phase as the proposal would be set within an already highly modified landscape. As a result no operational impact in the context of Aboriginal archaeology is anticipated.

10.5.3 Impacts during construction

Potential impacts during the construction phase of the proposal might arise from:

- construction of the CSELR track slab
- regrading of the soils landscape, including the remnant dune landscape around the Wansey Road CSELR track, the Wansey Road stop and the area around the Moore Park stop and associated landscaping works
- construction of stops and associated infrastructure (such as stop shelters)
- installation of substations and overhead cabling
- the cut-and-cover tunnel across Moore Park west and Anzac Parade
- installation of two crane pads adjacent to the cut-and-cover tunnel alignment.

In all cases, the impacts would include loss of archaeological potential and destruction of remains.

10.5.4 Management and mitigation

General management and mitigation measures proposed to minimise potential impacts to Aboriginal archaeology include the following:

- Further information gathered from the geotechnical investigations would be reviewed to further refine the areas of potential and the extent of impact on potential Aboriginal archaeological deposits.

- A program of targeted test excavations and geotechnical investigations would be undertaken. This would follow on from the desktop review and site inspections of the CSELR proposal area which were completed for this EIS to assist in accurately determining areas of Aboriginal archaeological potential, and more accurately inform the impact assessment. This in turn would refine the nature and distribution of further mitigation measures, such as salvage excavation.
- In areas where impacts on Aboriginal archaeology are not anticipated, an archaeological watching brief would be implemented. As part of this brief, an archaeologist would be on call to investigate archaeological remains identified during ground works, where an archaeologist is not on-site.
- Any Aboriginal archaeological works would require the involvement of and consultation with local Aboriginal stakeholders.
- All contractors would receive a Heritage Induction advising and informing them of the archaeological potential and actions to be implemented in the event of any unexpected remains.
- If human remains were to be discovered during any phase of works associated with the CSELR proposal, works would cease immediately in the surrounding area. Any finding would need to be reported immediately to the NSW Coroner's Office and/or the NSW Police. If the remains are suspected to be Aboriginal, the NSW Office of Environment and Heritage (OEH) would also need to be contacted. A specialist would also be consulted to determine the nature of the remains.

Management and mitigation measures would be applied to the assigned zones shown in Figure 10.7 as indicated in table 10.14 below.

Table 10.14 Aboriginal heritage management and mitigation measures by archaeological potential zone

ZONE	ADDITIONAL SURVEY REQUIREMENTS AND MITIGATION MEASURES
Zone 1	Further information from geotechnical investigation is required to further refine the area of potential and the extent of impact on potential Aboriginal archaeological deposits, where possible.
	Test excavation is proposed to more accurately determine areas of Aboriginal archaeological potential and more accurately inform the impact assessment. This may help refine the nature and distribution of mitigation measures, such as salvage excavation.
	Data revealed by the geotechnical investigation and/or Aboriginal test excavation may allow reassessment of the Aboriginal archaeological potential and/or impact assessment. This may allow the allocation of Aboriginal archaeological management zones to be refined. Where the allocation of zones is altered, mitigation measures would be employed as relevant to the updated zoning.
	Any Aboriginal archaeological works would require the involvement of and consultation with local Aboriginal stakeholders.
	All contractors are to receive a Heritage Induction.
Zone 2	Further information from the geotechnical investigation is required to further refine the area of potential and the extent of impact on potential Aboriginal archaeological deposits, where possible. Test excavation is proposed to more accurately determine where areas of Aboriginal archaeological potential are, and more accurately inform the impact assessment. This may help refine the nature and distribution of mitigation measures, such as salvage excavation.
	Data revealed by the geotechnical investigation and/or Aboriginal test excavation may allow reassessment of the Aboriginal archaeological potential and/or impact assessment. This may allow the allocation of Aboriginal archaeological management zones to be refined. Where the allocation of zones is altered, mitigation measures would be employed as relevant to the updated zoning.
	In areas where impacts on Aboriginal archaeology are not anticipated, an archaeological watching brief would be implemented. As part of this brief, an archaeologist would be on call to investigate archaeological remains identified during ground works, where an archaeologist is not on site.
	Any Aboriginal archaeological works would require the involvement of and consultation with local Aboriginal stakeholders.
	All contractors are to receive a Heritage Induction.

Table 10.14 cont

ZONE	ADDITIONAL SURVEY REQUIREMENTS AND MITIGATION MEASURES
Zone 3	Further information from geotechnical investigation and/or Aboriginal archaeological test excavation is required to further refine the area of potential and the extent of impact on potential Aboriginal archaeological deposits, where possible.
	An archaeological watching brief would be implemented, where an archaeologist is on call to investigate archaeological remains identified during ground works where an archaeologist is not present on-site.
	Any Aboriginal archaeological works would require the involvement of and consultation with local Aboriginal stakeholders.
	All contractors are to receive a Heritage Induction.
Zone 4	No further assessment or investigation of Aboriginal archaeology is required.
	An archaeological watching brief would be implemented, where an archaeologist is on call to investigate unexpected archaeological remains identified during ground works where an archaeologist is not present on-site.
	Should Aboriginal objects or other archaeological evidence be identified in these areas during works, works should cease in the immediate area and the archaeologist contacted to assess the evidence. Additional investigation, such as salvage excavation, may be required.
	Any Aboriginal archaeological works would require the involvement of and consultation with local Aboriginal stakeholders.
	All contractors are to receive a Heritage Induction.

10.6 Biodiversity

This section summarises the ecological assessment undertaken for the CSELR proposal. This comprised a desk-based search of relevant databases and historical records, a site inspection to assess vegetation and habitat characteristics (26 June 2013), and consideration of the potential impacts of the proposal on the ecological values identified.

10.6.1 Existing environment

Landscape context

The study area is located within the Pittwater Part B subregion within the Sydney Metro Catchment Management region, within the broader Sydney Basin Bioregion (Thackway & Cresswell 1995). The study area for this assessment included the design footprint and an additional five metres around the footprint to account for construction access and indirect impacts on adjacent areas. The Sydney Basin Bioregion lies on the Central East coast of NSW, extending from just north of Batemans Bay to Nelson Bay on the Central Coast, and almost as far as Mudgee NSW. The bioregion has a total area of 3,624,008 hectares occupying 4.53 per cent of the State.

The Pittwater B subregion consists of Triassic Hawkesbury sandstone with thin ridge cappings of Ashfield shale. Narrabeen sandstones are exposed in valleys and along the coast with quaternary coastal sands. The climate of the area is temperate. Dominant vegetation includes eucalypt woodlands, rainforest, coastal forest, open forests and swamp vegetation.

Vegetation communities

The field survey and desktop assessment identified that vegetation within the study area contained no native vegetation communities. The vegetation consisted of predominantly planted street trees and garden plantings of both native and exotic trees, shrubs, grasses and forbs.

Species of plant

Thirty-five (35) tree species were recorded in the *Preliminary Tree Assessment* (refer Technical Paper 9) including 18 Australian native species and 17 introduced species.

Habitat

The main habitat types identified along the CSELR alignment comprised street planted trees and gardens. This habitat type occurred throughout the entire study area and is subject to substantial human disturbance. This habitat type does not correspond to any native vegetation community.

Native vegetation in this habitat type is restricted to occasional trees, shrubs and groundcover plants within otherwise exotic vegetation. Some canopy species (such as *Ficus macrocarpa var hillii, Ficus macrophylla, Ficus obliqua, Melaleuca quinquenervia* and Eucalyptus species) provide marginal foraging habitat for nectar-feeding and fleshy fruit-eating animals such as the Grey-headed Flying-fox.

This habitat is only likely to provide habitat for native and introduced fauna species that are adapted to open environments and tolerant of major human disturbance. The large open spaces interspersed with vegetation provide marginal foraging habitat for mobile insect-feeding species such as the Eastern Bent-wing Bat and a number of bird species. Many such disturbance tolerant native species (e.g. Noisy Miner and Australian Ibis) have increased in abundance in response to human disturbance.

The Powerful Owl has been recorded in inner Sydney in parkland and street trees. The vegetation of the site is located along roadways and the edges of parkland and is subject to disturbance from pedestrians and passing vehicles. These trees are considered to be marginal foraging and roosting habitat for the species, which is likely to chiefly utilise more densely vegetated areas in the core of parklands where disturbance is likely to be less intensive.

Overall this habitat type is in poor condition generally providing only marginal habitat for threatened species of animal (Grey-headed Flying-fox, Powerful Owl and Eastern Bent-wing Bat).

Some existing structures along the CSELR alignment may potentially serve as roosting habitat for microbats. In particular, the existing sandstone-faced railway bridge at Central Railway Station and other buildings or structures with cracks, cavities or spaces in their façade. Whilst this may provide temporary roosting for microbat species it is considered unlikely that these structures would serve as maternity roosts or hibernacula.

Species, populations and communities of conservation concern

Threatened ecological communities

Threatened ecological communities (critically endangered, endangered and vulnerable) are listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Plan Act 1994* (FM Act) and Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

No threatened ecological communities were recorded as present during the recent field survey.

The *Heritage Impact Assessment* (Technical Paper 5) refers to two occurrences, comprising a total of four specimens, of the native tree Woody Pear (*Xylomelum pyriforme*). The report refers to these trees as remnants of Eastern Suburbs Banksia Scrub. Eastern Suburbs Banksia Scrub is an endangered ecological community listed under the TSC Act and the EPBC Act that was once widespread on low nutrient sand deposits in the locality. Woody Pear is not listed as a characteristic Eastern Suburbs Banksia Scrub species in the final determination to list the community under the TSC Act; however, it is listed in the Eastern Suburbs Banksia Scrub Endangered Ecological Community Recovery Plan (DEC 2004) as a component of the atypical 'dry Eastern Suburbs Banksia Scrub' variant of the community.

While the Woody Pear on the site may be a vestige of 'dry Eastern Suburbs Banksia Scrub' (ESBS) that once occurred on the site, the presence of four individuals of this single species does not constitute an occurrence of the endangered ESBS community. Woody Pear occurs in a variety of vegetation communities on sandstone derived soils in the Sydney region. Although the specimens on the site are of botanical interest in the local context, they are of low ecological value to native wildlife in the locality due to their isolation from other indigenous vegetation.

Endangered populations

Endangered populations are listed under Schedule 1, Part 2 of the TSC Act. Results of the desk-top assessment indicate that one endangered population, White-fronted Chat in the Sydney Metropolitan Catchment Management Authority (CMA) area, is predicted or has the potential to occur within the study locality.

The White-fronted Chat is considered to have a low likelihood of occurrence based on the lack of suitable habitat within the study area.

Threatened species of plant

Sixty-seven (67) species of threatened plant listed under the TSC Act and/or the EPBC Act are known to occur or predicted to occur within and surrounding the study area. Details of these species and their habitat requirements are provided in Appendix H (*H1. Threatened species of plant*). No threatened species of plant were recorded within the study area.

All of these species are considered to have a low likelihood of occurrence based on the lack of suitable habitat and field survey results.

Threatened species of animal

Of the 102 species identified, three species of threatened animal listed under the TSC Act and/or the EPBC Act are considered to have a moderate or greater likelihood of occurrence (refer to Table 10.15), based on the presence of suitable habitat.

The remaining species are considered to have a low likelihood of occurrence based on the absence of suitable habitat.

Table 10.15 Threatened species of animal with potential to occur in habitat within the study area

SCIENTIFIC NAME	SCIENTIFIC NAME	TSC ACT	EPBC ACT	LIKELIHOOD OF OCCURRENCE
Birds				
Ninox strenua	Powerful Owl	V		Moderate
Bats				
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	High
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	V		Moderate

Note: *V=Vulnerable*

Migratory species

Migratory species are protected under international agreements to which Australia is a signatory, including the Japan Australia Migratory Bird Agreement (JAMBA), the China Australia Migratory Bird Agreement (CAMBA), the Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) and the Bonn Convention on the Conservation of Migratory Species of Wild Animals. Migratory species are considered to comprise 'matters of national environmental significance' and are protected under the EPBC Act.

Based on the findings of the desk-top assessment (Department of Sustainability Environment Water Population and Communities 2013; Office of Environment and Heritage 2013), a total of 55 migratory species have been recorded or have the potential to occur in the area. However, potential habitat along the proposed CSELR alignment is only considered to be suitable for the Fork-tailed Swift and White-throated Needletail. These species are only likely to fly in the vicinity of the alignment as they are rarely recorded as roosting in the region, typically remaining in flight constantly during their visits to the region.

While terrestrial migratory species of bird may potentially use the area, the CSELR alignment would not be classed as 'important habitat' as defined *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of the Environment Water Heritage and the Arts 2009) as the site does not contain:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- habitat of critical importance to the species at particular life-cycle stages
- habitat utilised by a migratory species which is at the limit of the species range
- habitat within an area where the species is declining.

Critical habitat

Critical habitat is listed under the TSC Act and/or the EPBC Act. Critical habitat is the whole or any part or parts of an area or areas of land comprising habitat critical to the survival of an endangered species, population or ecological community.

There is no listed critical habitat within the study area.

Groundwater dependent ecosystems

Groundwater dependent ecosystems are communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater (Department of Land and Water Conservation 2002). Groundwater dependent ecosystems can potentially include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps and near-shore marine ecosystems.

As set out in section 10.4, groundwater discharge is important in maintaining baseflow in rivers and streams and sustaining springs. Ecosystems associated with these discharge areas have a high dependency on groundwater for their water requirements. Springs are sometimes located along lithological changes, such as interbedded shale and sandstone. Shallow groundwater is also important for sustaining native trees, particularly more deep rooted varieties.

Three groundwater dependent ecosystems are located within 1.2 kilometres of the CSELR proposal. These comprise:

- a Coastal Freshwater Lagoon located in Centennial Park, approximately 1.2 kilometres east of Anzac Parade and 800 metres north east of Alison Road
- the Eastern Suburbs Banksia Scrub, neighbouring the Coastal Freshwater Lagoon to the north in Centennial Park and in small patches situated approximately one kilometre west of the proposed Kingsford stop
- a Floodplain Wetland (Lachlan Swamps) located approximately 1.2 kilometres west and south-west of the proposed Kingsford stop.

The locations of the above groundwater dependent ecosystems, relative to the proposed CSELR alignment, are shown in Figure 10.6.

10.6.2 Impacts during operation

Potential impacts to biodiversity during the operations phase of the proposal include:

- loss of vegetation
- direct loss of animals (e.g. from vehicle strike)
- habitat fragmentation, isolation and barrier effects
- potential environmental impact of noise on wildlife.

Fauna injury or death could occur during the operation of the CSELR though the incidence is unlikely to increase significantly above current levels. Vehicle strike during operation and maintenance works is unlikely to be significant and injury or mortality of wildlife is not likely to significantly increase as a result of the proposal.

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with the occurrence of a new habitat type in the area between the fragments. This new dividing habitat type is often artificial and inhospitable to the species remaining. Vegetation in the study area currently exists as highly fragmented and isolated individual street trees that have been planted. Furthermore, the existing road corridor is already likely to form a potential barrier to many locally occurring terrestrial and arboreal fauna species. While the proposal would potentially increase the distance between habitat fragments, it is not likely to add significantly to distances between vegetation/habitat patches in the study area.

Many animals detect and depend on sound to communicate, navigate, evade danger and find food, but human-made noise can alter the behaviour of animals or interfere with their normal functioning (Bowles 1997). The study area is already affected by noise levels associated with vehicle movements along the alignment. How fauna occupying the local area would respond to noise from the LRVs is not known, but given the degree of current habitat disturbance and existing noise environment, impacts are not likely to be significant.

No direct or indirect impacts to groundwater dependent ecosystems are anticipated as a result of the proposal during operation.

10.6.3 Impacts during construction

Potential impacts to biodiversity from the construction of the proposal include:

- loss of vegetation
- direct loss of animals
- habitat fragmentation, isolation and barrier effects
- potential environmental impact of noise on wildlife
- introduction or spread of plant diseases.

The proposal would result in habitat modification along approximately nine kilometres of road and parkland edges through the Sydney CBD and South East suburbs. This would involve the removal a number of potential foraging and roosting (Powerful Owl only) trees for threatened biodiversity such as the Grey headed Flying-fox, Eastern Bent-wing Bat and Powerful Owl. The number of trees to be directly and indirectly impacted upon by the proposal is subject to change during further design stages. A *Preliminary Tree Assessment* is included as Technical Paper 9.

Fauna injury or death could occur as a result of the proposed activities during the construction phase, particularly when vegetation and habitats are being cleared. Vehicle strike during construction works is unlikely to be significant and injury or mortality of wildlife is not likely to significantly increase as a result of the proposal.

Vegetation in the study area currently exists as highly fragmented and isolated individual street trees that have been planted. Furthermore, the existing road corridor is already likely to form a potential barrier to many locally occurring terrestrial and arboreal fauna species. While the construction activities associated with the proposal would potentially increase the distance between habitat fragments, it is not likely to add significantly to distances between vegetation/habitat patches in the study area.

Many animals detect and depend on sound to communicate, navigate, evade danger and find food, but human-made noise can alter the behaviour of animals or interfere with their normal functioning. In some cases it can harm their health, reproduction, survivorship, habitat use, distribution, abundance, or genetic composition. During construction, noise levels would increase in the study area and surrounds due to ground disturbance, machinery operation and vehicle movements and vegetation clearing (refer to Technical Paper 11). This may cause disturbance for some fauna. A number of factors are thought to influence the reaction of animals to noise including the volume, the frequency and the characteristic of the noise (e.g. short and percussive versus long and constant).

The study area is already affected by noise levels associated with vehicle movements and construction along the alignment. How fauna occupying the local area would respond to increased noise is not known, but given the degree of current habitat disturbance and the existing noise environment, impacts are not likely to be significant.

Construction within the study area has the potential to disperse plant pathogens such as Cinnamon fungus into areas where they do not currently occur. The most likely causes of disease dispersal associated with the proposed construction would be from movement of soil attached to vehicles and machinery, introduction of soil and other landscaping materials to the site and tree planting. Disease introduction may cause the decline or death of trees and, in turn, reduce the habitat quality of the sites for threatened species.

As outlined earlier in section 10.4, drawdown of groundwater levels would occur during proposed dewatering activities associated with the construction of the Moore Park tunnel. This has the potential to reduce access to groundwater for groundwater dependent ecosystems. For example, if groundwater levels are drawn down below the base of a swamp or wetland or below the root depth of trees and other vegetation.

The risk of impacts to groundwater dependent ecosystems is considered to be low because the groundwater drawdown would be temporary (i.e. during the construction of the Moore Park tunnel) and the groundwater dependent ecosystems identified within the vicinity of the CSELR proposal:

- are located up hydraulic gradient of any potential excavation
- are at least 800 metres away from the proposed CSELR alignment
- are adjacent to recharge ponds.

10.6.4 Management and mitigation

In order to effectively manage and mitigate the potential impacts identified above, the construction contractor(s) would implement appropriate pre-clearing and construction protocols. These would include:

- confirm the location of the hollow-bearing trees identified in this assessment. Inform and plan procedures for the removal of these features
- locate nearby suitable habitat for the release of any fauna that may be encountered during the pre-clearing or habitat removal processes
- check for the presence of flora and fauna species and habitat on-site before clearing begins such as the presence of bird nests or trees that contain hollows
- conduct an appropriate level of emergence survey to confirm absence of microbats in any buildings or structures likely to be directly impacted by the works
- prior to construction, site personnel would be adequately informed of environmental management procedures including, but not limited to, issues related to flora and fauna management, disease prevention, erosion and sediment control
- implement recommended mitigation measures as described in the relevant sections of the precinct chapters (sections 12.6.3, 13.6.3, 14.6.3, 15.6.3 and 16.6.3) to ensure protection and management of all trees identified to be retained
- avoid excessive soil disturbance
- minimise noise where possible
- implement flora and fauna control measures including:
  - clearing of vegetation would be restricted to vegetation that is absolutely required to be removed in order to undertake work
  - noxious weeds within the study area would be managed in accordance with the *Noxious Weeds Act 1993*
- the potential for the introduction or spread of plant diseases would be managed. Management techniques may include ensuring that equipment is clean prior to commencement of earthworks, disease free certification of landscaping materials, and disposal of pathogen-contaminated soils at appropriate weed disposal facilities.

10.7 Air quality

The following sections provide a summary of a desktop air quality assessment that was undertaken for the CSELR proposal. The full assessment is provided in Technical Paper 7 – *Air Quality Impact Assessment.*

10.7.1 Existing environment

Emission sources

Ambient air quality along the CSELR alignment is affected by a number of factors including topography, prevailing meteorological conditions and local and regional air quality emissions sources.

A number of emission sources have the potential to influence the local air shed to varying degrees. These sources include:

- traffic emissions from the existing road network (the greatest source of air pollution)
- light commercial and industrial activities
- general residential sources (including domestic wood heaters).

A search of the National Pollution Inventory database (www.npi.gov.au) indicated that no individual facilities reported air emissions within one kilometre of the CSELR alignment during the 2010/2011 reporting period. The primary contributor to air pollutant levels in the vicinity of the proposal is expected to be emissions from motor vehicles along arterial and local roads.

Human made sources of pollutants in the Sydney region include motorised vehicles, domestic, commercial and industrial sources. Regional air quality can also be influenced by naturally occurring events such as bushfires and dust storms.

Ambient concentrations of pollutants along the CSELR alignment are expected to be primarily dependent on local and regional weather conditions and overall regional air quality.

Background air quality

Background air quality data (for the 2011–2012 reporting period) from the OEH operated monitoring locations at Rozelle and Randwick is provided in section 5 of Technical Paper 7, and summarised Table 10.16. These monitoring station locations are considered to be representative of the broader CSELR area, which includes residential, commercial and light industrial land uses. Land uses are discussed further in Chapters 12 to 17. In summary, air quality within the CSELR area was generally recorded to be good during the 2011–2012 periods, with concentrations of measured pollutants (i.e. nitrogen dioxide, sulphur dioxide, ozone and particulates with a diameter less than 10 micrometres (PM_{10})) below applicable air quality criteria. NSW ambient air quality criteria are provided in the Department of Environment and Conservation (now the Environmental Protection Authority) document entitled *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC 2005).

PM_{10} levels were measured at the Randwick and Rozelle monitoring stations using a tapered element oscillating microbalance. The maximum measured 24-hour PM_{10} concentration throughout the 2011 and 2012 period was 43.7 micrograms per cubic metre at Randwick and 40.7 micrograms per cubic metre at Rozelle. These measured concentrations were below the OEH goals of 50 micrograms per cubic metre. Monthly average PM_{10} concentrations ranged between 12 micrograms per cubic metre and 24 micrograms per cubic metre during 2011 and 2012.

Table 10.16 Summary of existing background air quality data for the 2011–2012 reporting period

POLLUTANT[1]	AVERAGE PERIOD	APPLICABLE AIR QUALITY CRITERIA[2]	DISCUSSION OF EXISTING AIR QUALITY[3]
Nitrogen dioxide (NO_2)	1 hour	246 µg/m^3	Measured concentrations of NO_2 were well below air quality criteria for the 1 hour NO_2 average. The highest 1 hour maximum NO_2 concentrations were recorded in August 2011 at Randwick (108.7 µg/m^3) and in December 2012 at Rozelle (127.1 µg/m^3). These concentrations were well below the air criterion of 246 µg/m^3.
	Annual	62 µg/m^3	Annual average NO_2 concentrations at Randwick (2011 = 14.4 µg/m^3; 2012 = 12.3 µg/m^3) and Rozelle (2011 = 22.6 µg/m^3; 2012 = 24.6 µg/m^3) were below the annual air criterion of 62 µg/m^3.
Sulphur dioxide (SO_2)	1 hour	570 µg/m^3	Maximum 1 hour SO_2 concentrations at Randwick were well below the air quality criterion of 570 µg/m^3. Data on SO_2 concentration were not available for the Randwick monitoring station.
Ozone	1 hour	214 µg/m^3	Maximum 1 hour ozone levels at Randwick (143.8 µg/m^3) and Rozelle (183.2 µg/m^3) were below the air quality criterion of 214 µg/m^3.
	4 hour	171 µg/m^3	Maximum 4 hour ozone levels at Randwick (135.9 µg/m^3) and Rozelle (157.6 µg/m^3) were below the air quality criterion of 171 µg/m^3.
Carbon Monoxide (CO)	8 hour	10,000 µg/m^3	Maximum 8 hour concentration between 2011 and 2012 were 2.53 µg/m^3 which is well below the air quality criterion of 10,000 µg/m^3.
PM_{10}	24 hour	50 µg/m^3	The maximum 24 hour PM10 concentration recorded throughout the 2011 to 2012 period at Randwick (43.7 µg/m^3) and Rozelle (40.7 µg/m^3) were below the air quality criterion of 50 µg/m^3.

Note 1: µg/m3 = micrograms per cubic metre particulates with a diameter less than 10 micrometres.

Note 2: Applicable air quality criteria are described in detail in section 3 of Technical Paper 7 — Air Quality Impact Assessment.

Note 3: A full set of background air quality data for the Randwick and Rozelle monitoring stations is provided in Tables 5.1 and 5.2 of Technical Paper 7 — Air Quality Impact Assessment.

Sensitive land uses and receivers

The CSELR proposal is located directly adjacent to a large number of sensitive receivers and land uses, which include residential properties, highly trafficked pedestrian areas, recreation areas and educational facilities. Separation distances between these sensitive receivers and the proposed CSELR construction worksite and infrastructure varies along the CSELR alignment. Further discussion on land uses surrounding the CSELR proposal is provided in sections 12.4 (City Centre Precinct), 13.4 (Surry Hills Precinct), 14.4 (Moore Park Precinct), 15.4 (Randwick Precinct), 16.4 (Kensington/Kingsford Precinct) and 17.4 (Rozelle locality).

10.7.2 Impacts during operation

Particulate emissions

Operation of the CSELR proposal would generate minor particulate matter emissions, which would be mainly caused by:

- *Entrainment (lift-off) of surface particles along the light rail corridor* — These emissions would be dependent on particulate loading, meteorological conditions and LRV speeds.

- *Wheel and rail wear* — Wear from wheels on rails would cause very low levels of emissions of metal particulates as the wheels and rail wear with use. These particulate emissions are expected to be minimal and would not significantly contribute to ambient PM_{10} concentrations beyond the light rail corridor (Lorenzo *et al* 2006).
- *Traction sanding* — This involves the deposition of sand between the LRV wheels and the rails to provide additional traction. Examples of when this may be required include stopping during wet weather and travelling up steep sections of the track. Modern LRV sanding systems include a targeted application of sand at the wheel and rail contact point to maximise traction and minimise excessive sand deposits.

Particulate emission rates from the above sources would be dependent on climatic conditions, particulate loads along the CSELR alignment and the frequency of sanding. These minor particulate emissions are expected to be relatively minor and would not significantly affect local air quality along the CSELR alignment.

Gaseous emissions

As discussed in Chapter 3, the CSELR proposal (in tandem with the proposed redesign of the Sydney bus network) would remove up to 220 buses per hour from the Sydney CBD during the am peak period. This reduction in buses would be expected to result in a net benefit to local air quality for land uses located along the affected bus routes due to an associated reduction in bus combustion engine emissions (including CO_2, oxides of nitrogen and SO_2).

While this assessment has not quantified the economic and social benefits of reducing air pollution emissions from Sydney CBD, the benefits of reducing pollutant levels are well known and researched. The association between air quality and human health was first identified in the 1990's in a study by Dockery *et al* (1993) *An Association between Air Pollution and Mortality in Six U.S. Cities.* Since then many studies have been undertaken internationally identifying the benefits of reducing air pollutants for the general health of the population. The EPA has contributed to and published on this topic, including the economic benefits to the NSW Health service from improvements in air quality. This research has provided estimates on costs per unit of pollution (NSW Department of Environment and Conservation (DEC) 2005a).

Notwithstanding the potential reductions in air pollution emissions from buses within the Sydney CBD, the maintenance of CSELR infrastructure and activities at the proposed Rozelle maintenance depot and Randwick stabling facility would generate minor gaseous emissions from maintenance vehicles and equipment. These emissions would be associated with the combustion of fuel (diesel and petrol) in construction plant, vehicles and machinery. These sources would generate emissions of CO, oxides of nitrogen (NO_x), SO_2 and trace amounts of non-combustible hydrocarbons. Gaseous emissions from maintenance vehicles and equipment would be intermittent and transient in nature, and would be manageable through the application of standard mitigation measures.

Overall, the CSELR proposal would be expected to have a positive net benefit (both economic and social) due to the reduction in buses and associated exhaust emissions in the Sydney CBD.

Fugitive emissions

Fugitive emissions would be expected from fuel and chemicals stored at the proposed Rozelle maintenance depot and Randwick stabling facility (e.g. liquid petroleum LPG, diesel, lubricant oils, cleaning chemicals). These emissions are anticipated to be minor and would be readily manageable through the application of standard mitigation measures.

10.7.3 Impacts during construction

During construction, potential air quality impacts would be primarily associated with the generation of dust and emissions from the operation of on-site machinery, excavation works, materials handling and material storage. Vehicle movements within the construction footprint would also contribute to emission loads.

Particulate matter

Anticipated sources of dust and dust-generating activities would include:

- handling, transfer and storage of structural fill materials and excavated materials
- excavation and earthworks
- wind erosion of stockpiles and freshly exposed areas
- vehicle movements along unsealed haulage/access roads/tracks and on paved roads
- demolition activities.

The potential for dust emissions during the above construction activities would be dependent on the moisture content and particle size characteristics (silt content) of the materials being excavated or handled, as well as the volume of material being handled. The Botany Sands soils series in particular has a high wide erosion potential. The location of the activity, relative to surrounding sensitive receivers and land uses, and exposure to wind would also influence the potential for dust impacts.

Dust generation would be primarily be limited to construction activities as they progress along the CSELR alignment and would be expected to increase where higher dust generating activities are undertaken. Dust emissions would also be expected to increase during unfavourable weather, such as dry windy conditions.

An indicative estimate of potential dust emissions (in terms of total suspended particulates, PM_{10} and particulates with a diameter less than 2.5 micrometres ($PM_{2.5}$)) during key dust generating construction activities is provided in Table 10.17. Discussion on the assumptions that were used to estimate these dust emissions is provided in section 7.1.2 of Technical Paper 7.

Table 10.17 Indicative estimate of potential dust emission during construction

ACTIVITY	ESTIMATED DUST EMISSIONS		
	TOTAL SUSPENDED PARTICULATES	PM_{10}	$PM_{2.5}$
Material loading onto trucks	1,618 kg over the construction of the CSELR proposal	765 kg over the construction of the CSELR proposal	116 kg over the construction of the CSELR proposal
Bulldozer operation	25.5 kg/day or 2.3 kg/hour	5.5 kg/day or 0.5 kg/hour	0.8 kg/day or 0.075 kg/hour

Note: kg = kilograms

In addition to the key construction activities listed in Table 10.17, wind erosion from exposed surfaces would also generate dust emissions. Dust entrainment (i.e. lift-off) rates from exposed surfaces would vary with wind gusts, threshold wind speeds, friction velocities, precipitation events, silt loadings and the number of disturbances that restore the erosion potential.

Assuming a silt content of 11 per cent, 68 days of precipitation and no hourly wind events above 5.4 metres per second, the following dust emissions could be expected from exposed surfaces:

- total suspended particulates — 0.04 kilograms per square metre of exposed area
- PM_{10} — 0.002 kilograms per square metre of exposed area
- $PM_{2.5}$ — 0.00002 kilograms per square metre of exposed area.

Over a 24 hour period, dust emissions from a 100 square metre area of exposed surfaces could be expected to comprise the following:

- total suspended particulates — 0.1 kilograms per hour
- PM_{10} — 0.05 kilograms per hour
- $PM_{2.5}$ — 0.001 kilograms per hour.

The dispersion of particulate matter would depend on the meteorological conditions present during the works. It is expected that these particulate levels would drop significantly with distance. During unfavourable meteorological conditions, such as dry and windy conditions, particulate emissions may be higher and would require specific corrective measures.

Based on the dust emission rates listed in Table 10.17, particulate emissions generated during the construction of the CSELR proposal are considered to be manageable through the application of standard mitigation measures.

Gaseous emissions

Vehicle emissions

Emissions from vehicles would be associated with the combustion of fuel (diesel and petrol) in construction plant, vehicles and machinery. These sources would generate emissions of CO, oxides of nitrogen (NO_x), SO_2 and trace amounts of non-combustible hydrocarbons. The rates of emission and potential impact on surrounding land uses would depend on the number and power output of the combustion engines, the quality of the fuel used, the condition of the engines and the intensity of use.

An indicative list of the types of construction plant, vehicles and equipment that would be used during various construction activities is provided in section 6.3, while average daily heavy vehicle movements estimated during the construction are outlined in section 6.9.

As outlined in section 6.9, average daily heavy vehicle movements of up to 22 movements per day (including movements to and from the worksite) are predicted within the Randwick Precinct during construction. Heavy vehicle movements in the remaining four precincts are generally anticipated to range between 1 and 18 movements per day. Gaseous emissions from plant and equipment along the works corridor would be intermittent and transient in nature. Short-term peaks in pollutant loads would be expected as works progress.

Given the anticipated duration of works at any given location, the likely number of emission sources, the staging of construction, and scheduling of activities (i.e. not all machinery would be operating in the same location simultaneously), gaseous emissions would be adequately manageable through the implementation of standard management measures.

Fugitive emissions

Fugitive emissions would be expected from fuel and chemicals stored at construction compounds (e.g. LPG, diesel, lubricant oils, cleaning chemicals). These emissions are anticipated to be minor and would be readily manageable through the application of standard mitigation measures.

10.7.4 Management and mitigation

Operation

Potential air quality impacts associated with the operation of the CSELR proposal would be managed through the implementation of the following environmental management measures:

- Street sweeping of the CSELR alignment would be undertaken where an excessive build-up of material has occurred.
- Ancillary maintenance service vehicles and equipment would be maintained and operated in accordance with the manufacturers requirements.
- Unnecessary release of air pollutants would be avoided from the Rozelle maintenance depot and Randwick stabling facility.

Construction

Dust emissions

A dust management plan would be developed and implemented as part of the CEMP. This plan would identify triggers and procedures for dealing with significant dust generating activities, with the aim of minimising impacts to surrounding sensitive receivers. Dust management measures that would be included in the CEMP comprise:

- Dust minimisation measures would be developed and implemented prior to commencement of construction.
- Methods for management of emissions would be incorporated into project inductions, training and pre-start talks.
- Activities with the potential to cause significant dust emissions (such as bulk earthworks or demolition works) would be identified in the CEMP. Work practices which minimise emissions during these activities would be investigated and applied where reasonable and feasible.
- A mechanism for responding to complaints from the community would be put in place for the duration of construction.
- Vehicle movements would be limited to designated site entrances/exits, haulage routes and parking areas. Site exits would be fitted with hardstand material, rumble grids or other appropriate measures to limit the amount of material transported off-site (where required).
- Work sites and exposed areas would be screened to assist in capturing airborne particles and reduce potential entrainment of particles from areas susceptible to wind erosion.
- Visually monitor dust and where necessary implement the following measures:
  - Apply water (or alternative measures) to exposed surfaces that are causing dust emissions. Surfaces may include any stockpiles, hardstand areas and other exposed surfaces (for example recently graded areas and those areas recently scraped). Regular watering would ensure that the soil is moist to achieve 50 per cent control of dust emissions from scrapers, graders and dozers.
  - Appropriately cover loads on trucks transporting material to and from the construction site. Securely fix tailgates of road transport trucks prior to loading and immediately after unloading.
  - Prevent or remove mud and dirt from sealed road surfaces.
  - Apply water to internal unsealed access roadways and work areas. Application rates would be related to atmospheric conditions (e.g. prolonged dry periods) and the intensity of construction works. Paved roads would be regularly swept and watered when necessary.
- Dust generating activities (particularly clearing and excavating) would be avoided or minimised during dry and windy conditions.
- Site speed limits of 20 kilometres per hour would be imposed on all construction vehicles at the site.
- Material stockpiles would be regularly watered so as to control potential dust emissions.
- Minimise drop heights during loading and unloading of bulk materials.
- Exposed areas and stockpiles would be limited in area and duration. For example, stage vegetation stripping or grading where possible, cover unconsolidated stockpiles, or apply hydro mulch or other revegetation applicant to stockpiles or surfaces left standing for extended periods.
- Revegetation or rehabilitation activities would proceed once construction activities are completed within a disturbed area.
- On-site monthly dust deposition monitoring would be undertaken to measure dust fallout at selected sensitive receivers during construction.
- Real time dust monitoring would be undertaken during significant dust generating activities close to sensitive receivers.

Gaseous and fugitive emissions

Air quality management measures would be developed and implemented during the construction of the CSELR proposal as part of the CEMP. These measures would include the following:

- Construction plant and equipment would be well maintained and regularly serviced so that vehicular emissions remain within relevant air quality guidelines and standards.
- Emissions from trucks would be regulated in accordance with the requirements prescribed in National Environment Protection Council's (2001) *In Service Emission Testing – pilot study, fault identification and effect of maintenance* (diesel vehicle emissions).
- All construction vehicles would be tuned so as to not release excessive level of exhaust smoke, and would be compliant with the NSW OEH's Smokey Vehicles Program under the (NSW) *Protection of the Environment and Operations Act 1997* and associated regulations.
- All on-road trucks would comply with the latest emission standards.
- All new off-road construction equipment would meet, at a minimum, the United States Environmental Protection Agency's Tier 3 emission standards for non-road diesel engines.
- All chemicals and fuels would be stored in sealed containers as per appropriate regulations and guidelines.
- The on-site storage of fuel would be kept to a minimum.
- Unloading of fuels (diesel or liquefied nitrogen gas (LNG)) would be vented via return hoses that recirculate vapours from delivery to receiver.
- Chemical/fuel storage tanks would be fitted with a conservation vent (to prevent air inflow and vapour escape until a pre-set vacuum or pressure develops).
  - Strategies would be investigated to reduce the usage of chemical and fuels in addition to using alternative fuel technologies as recommended in the NSW OEH's *Action for Air – 2009 Update* (DECCW 2009a). Particular focus would be on those products with the potential to release high levels of air toxics.

10.8 Utilities and services

10.8.1 Existing utilities

Underground utilities in the Sydney area have a substantial footprint and interface with the existing road infrastructure. As such, the utilities protection or relocation component of the CSELR proposal would require detailed management. Utility investigations to date include dial-before-you-dig (DBYD) enquiries in December 2011 and September 2012, as well as limited visual inspections and ground survey to ascertain the location of existing utility services along the length of the overall CSELR alignment. Overall, a large number of utilities are located along the CSELR alignment. The types of utilities with the potential to be affected by the CSELR proposal include:

- power
- telecommunications
- water
- sewer
- stormwater
- secondary gas mains
- City of Sydney and Randwick City street lighting
- NSW Roads and Maritime Services (RMS) traffic lights
- Sydney Trains power and communications systems.

Further detailed utility investigations and consultations with utility providers are currently in progress to inform the design development (refer consultation process in Chapter 2).

10.8.2 Planned utilities

In addition to known/existing utilities, a series of planned utilities which may be impacted by or impact on, the CSELR proposal include the following:

- the National Broadband Network (NBN)
- 'green infrastructure' options which the City of Sydney are currently investigating. including:
  - a thermal reticulation network
  - an automated waste collection system
  - recycled water
- Ausgrid's current and planned projects to:
  - transfer load from its Dalley Street zone substation to its new City North substation
  - commission its new zone substation at Belmore Park
  - establish a new zone substation in Bligh Street
  - at least four major new connections requiring the establishment of new distribution substations in progress along George Street.

As described in Chapter 2, consultations with utility and service providers are currently in progress and would continue during detailed design to determine any other planned utilities with the potential to affect or be affected by the CSELR construction or operation.

10.8.3 Interaction with existing and proposed services and utilities

Utility relocations and/or protection would form a critical and complex part of the CSELR construction process. The details of the proposed relocations/protections are currently being developed as both the design and consultations with utility and service providers progress.

Ongoing access arrangements to public and private utilities and services along the CSELR corridor are also a key issue for utility providers for their maintenance and future development needs. This is also a key issue for the CSELR delivery, to ensure construction and operation of the proposal are not significantly disrupted.

An interface agreement with utility providers is currently being developed. Once finalised, this agreement would be incorporated into the design and delivery of the CSELR proposal. Securing active cooperation from all affected utility providers will help ensure relocation and/or protection of utilities can be designed, agreed and constructed in an efficient manner, and ongoing maintenance and access arrangements can be agreed for the construction and operation phases. These agreements would also clarify responsibility for affected assets.

Although complex, the interactions with existing and proposed services and utilities are expected to be manageable through the process of interface agreements and ongoing consultations with utility and service providers. Consultation with the City of Sydney, Randwick City Council and other utility providers would be undertaken during detailed design to ensure that appropriate measures are taken regarding the potential integration of future utilities requirements along the alignment and to ensure that the CSELR proposal does not preclude the development or installation of these proposed utilities.

10.8.4 CSELR utility requirements and impacts

Operation phase

The operation of the CSELR would require an additional draw of power to run the LRVs and electrical equipment at each of the stops (such as lighting and emergency help points). This would require an additional level of power to be supplied over the existing amount supplied for the local area. Infrastructure required would include the overhead catenary cabling for power distribution to the CSELR and communications cabling that would be installed in ducts within the track-bed footprint, as described in Chapter 5.

The proposal would therefore include the installation of approximately 12 substations across the overall alignment. These would augment the local power systems and provide the required level of power required to operate the light rail network extension. The location and design of these substations are described in section 5.2.12.

Buried cables and leakage of stray currents from the running rails into surrounding earth can cause electrolysis corrosion of nearby buried metalwork. This can however be mitigated through the design of the track bed cable duct insulation.

Other operational utilities connections for the CSELR comprise water supply and sewer connections for toilet facilities at major stops.

Construction phase

Construction impacts on services and utilities could include potential damage to services and utilities as well as injury to persons (construction workers or the community) in the unlikely event that cables, mains or pipelines are accidentally damaged during excavation, plant movement or general civil works.

Transmission of large electrical currents through the ground (known as 'earth potential rise') could potentially occur as a result of damaged power cables or mains. In the unlikely event that an existing electrical cable is damaged during construction, this could have the potential to injure construction workers and members of the public standing close to the damaged power utility. This potential hazard is highly unlikely to occur due to the management measures proposed as part of the CSELR proposal. Damage to other mains (such as gas, water or sewer) could also result in injury to construction workers and the general public. Users may also experience short disruptions to telecommunication connections, street lighting or water, wastewater and gas mains where these services are required to be relocated as part of the CSELR proposal.

Investigations would be carried out during the detailed design phase to ensure that all appropriate measures are in place to minimise the potential risks to existing utilities and services prior to commencement of construction works.

Construction would be required over the location of the State significant Tank Stream culvert where the CSELR crosses Alfred Street. Detailed consideration will be given to the design development and execution of the proposal in this area to ensure the heritage significance of this item is protected. Further details on the heritage significance on this item and impacts of the CSELR are provided in Technical Paper 5 – *Heritage Impact Assessment*.

10.8.5 Management and mitigation

Detailed design

The CSELR proposal would be designed to operate in the most energy efficient manner possible with minimum drawdown on local power. However, as previously described, the operation of the proposal would require the installation of approximately 12 substations across the overall alignment to operate the LRVs. The substations would be located so that they minimise amenity impacts along the CSELR alignment. Impacts would be minimised by:

- locating substations underground where appropriate
- locating the substations away from sensitive receivers where possible (e.g. within existing buildings)
- planting appropriate vegetation around the above-ground substations to minimise visual impacts for adjoining properties

Access points would also be required to allow for access during routine maintenance operations by relevant services providers. These access points would be designed to take into account their setting to minimise impacts on amenity around the substations. Site specific urban design treatments would be identified, in particular for substations located in sensitive settings such as near the cenotaph in Martin Place.

Consultation with the City of Sydney, Randwick City Council and other utility/service providers would be undertaken during detailed design to ensure that appropriate measures are taken regarding the potential integration of future utilities requirements along the alignment and to ensure that the CSELR proposal does not preclude the development or installation of these proposed utilities.

Pre-construction measures and utilities treatment strategy

The CSELR proposal would aim to minimise and manage any hazards or risks of working in close proximity to existing utilities. In addition to current investigations into the location of buried utilities in the vicinity of the CSELR alignment, the construction contractor(s) would be required to check the locations of existing underground utilities and services prior to commencing construction works. This would include a revised and detailed DBYD investigation. This would be undertaken through pot-holing and/or hand-digging and in accordance with guidelines provided by the relevant utility authority.

Should the location of any utilities be identified to be in conflict with the proposal, a formal review of the proposed works at these location(s) would be undertaken in consultation with the construction contractor. Alternative arrangements would then be determined to provide the most beneficial outcome for the community, service provider and proposal in terms of safety and constructability.

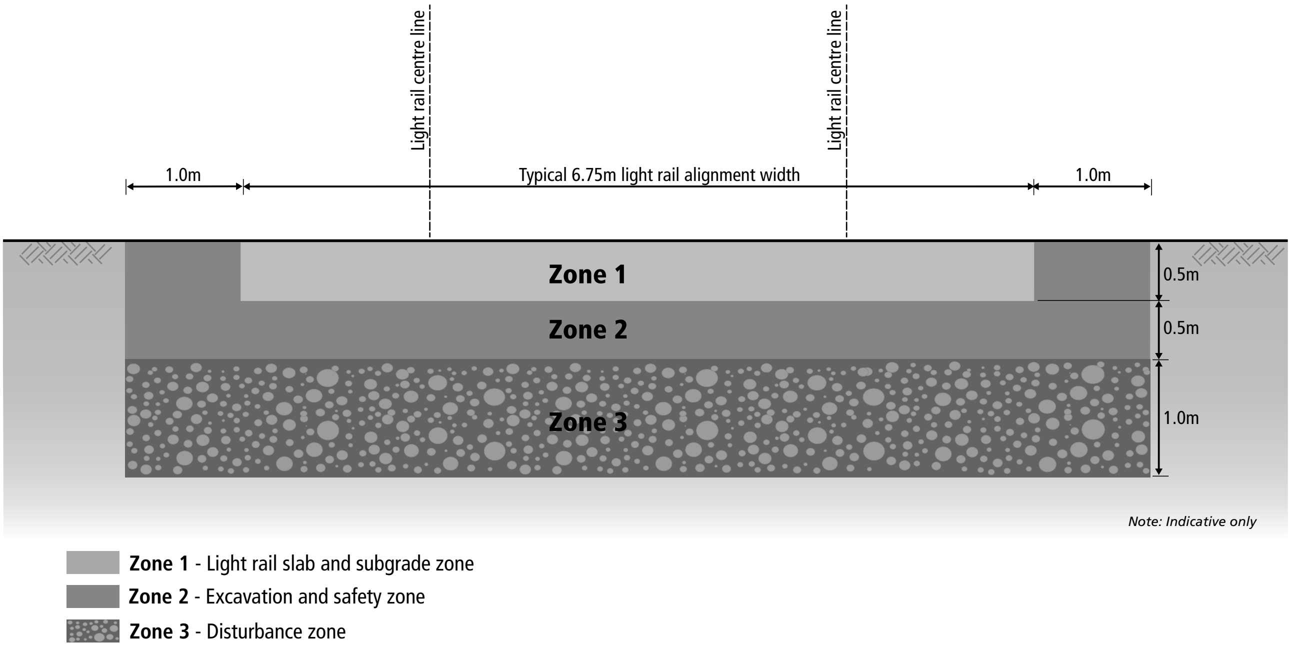
The strategy for the preferred hierarchy of utilities treatment as part of the CSELR proposal is as follows:

- *do nothing* – avoid impact on utilities where possible
- *protect* – protect utilities in their existing locations where feasible
- *modify access* – modify manholes/chambers to provide side access outside the alignment of the CSELR proposal, where these are located beneath the proposed alignment
- *relocate* – utilities to be relocated only where no other options are feasible or acceptable.

For most utilities, no depth information is currently available. If the existing utilities were to be installed to current standards, they would typically be within approximately 0.6 to 1.2 metres below the existing surface. However, due to the age of many utilities within the city, and the surface works that have occurred over the years, some utilities could be quite shallow, potentially sitting just under the pavement in some locations. In order to provide a limited guide to potential treatments, three zones of potential impact have been identified and are shown Figure 10.8. The anticipated treatment requirements for each zone would typically include:

- *Zone 1* – Utilities within this zone are likely to require relocation due to the physical clash with the structural rail slab (including its construction).
- *Zone 2* – Utilities crossing this zone may be protected where feasible. Longitudinal sewers, electricity lines and stormwater drains (otherwise unaffected by the proposal) may remain in place provided alternative access can be provided outside this zone. Longitudinal water, gas, communication lines and stormwater (affected by the proposal) are likely to require diversion to maintain accessibility.
- *Zone 3* – Utilities may require protection but have the potential to remain undisturbed, subject to accurate identification and consultation with the relevant utility authorities.

Figure 10.8 Typical treatment zones for utilities under the proposed CSELR alignment



Consultation with utility owners and service providers

A range of consultation has already been undertaken with various utility and service providers. A summary of this consultation has previously been described in Chapter 2. In addition to the utilities strategy identified above, all appropriate service utility providers (e.g. electricity, communication, water and other utility services) would continue to be consulted throughout detailed design and construction.

Consultation would be undertaken with all affected utility owners, including (but not limited to):

- Ausgrid (electrical assets)
- Transgrid (electrical assets)
- Sydney Water Corporation (water, sewer and drainage assets)
- National Broadband Network (NBN) (communications assets)
- Telstra (telecommunications assets)
- Optus/Uecomm (telecommunications assets)
- Visionstream (telecommunications assets)
- City of Sydney (drainage assets)
- Randwick City Council (drainage assets).

Services or utilities that may be impacted by the CSELR would be protected and/or relocated using the hierarchy identified above. It is also anticipated that some services such as power poles, existing street lighting and other such services would require relocation or replacement as part of the CSELR proposal. The extent of these impacts and any works required to relocate or replace services (including funding arrangements) would be confirmed during detailed design in consultation with the relevant utilities providers including the City of Sydney and Randwick City Council.

10.9 Greenhouse gases

This section provides a summary of a preliminary greenhouse gas assessment undertaken for the CSELR proposal. The full assessment is provided in Technical Paper 8 in Volume 4.

The preliminary greenhouse gas assessment was based on current design information and construction staging (as described in Chapters 5 and 6). Detailed information on the quantities of resources and materials required for the construction and operational phases of the proposal (e.g. diesel fuel, electricity, concrete and steel) was not available at the time of writing this EIS. Therefore, this section provides an indicative estimate of greenhouse gas emissions, based on available information.

Transport for NSW would undertake a more detailed greenhouse gas assessment (involving an inventory of Scope 1, 2 and 3 emissions) when more accurate information is available during the detailed design development stage. This assessment would be undertaken in accordance with Transport for NSW's (2013b) *Sustainable Design Guidelines for Rail (Version 2.0).*

10.9.1 Introduction

There is a general consensus amongst climate experts that climate change is occurring and that most of the warming observed over the last 50 years is attributable to human activities that have increased atmospheric concentrations of greenhouse gases (International Panel on Climate Change (IPCC) 2007a).

The IPCC's (2007a) *IPCC Fourth Assessment Report: Climate Change 2007* states that 'carbon dioxide (CO_2) is the most important anthropogenic (sourced from human activities) greenhouse gas'. Other important greenhouse gases include water vapour (H_2O), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) (IPCC 2007b).

The global warming potential of each greenhouse gas (i.e. the amount of heat that a particular greenhouse gas traps in the atmosphere) is measured relative to that of CO_2 (which has a global warming potential of 1). For example, methane is a greenhouse gas with a global warming potential 21 times greater than that of CO_2 (Department of Climate Change and Energy Efficiency 2012).

For the purposes of this assessment, greenhouse gas emissions associated with the construction and operational phases of the CSELR proposal have been expressed in terms of a standardised 'carbon dioxide equivalent' ($CO_{2\text{-}e}$) value, which represents the equivalent volume of CO_2 that would need to be emitted into the atmosphere to cause the same global warming potential. For example, emitting one tonne of methane would have the same effect (in terms of global warming potential) as emitting 21 tonnes of CO_2 and thus would be expressed as 21 tonnes of 'carbon dioxide equivalent' ($CO_{2\text{-}e}$).

The standardised carbon dioxide equivalent ($CO_{2\text{-}e}$) values quoted in this assessment take into account the following greenhouse gases:

- CO_2
- methane (CH_4)
- nitrous oxide (N_2O)
- synthetic gases including hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and tetrafluoromethane (CF_4).

The major sources of greenhouse emissions have also been classified into one of the following categories:

- *Scope 1 emissions* — direct emissions arising from activities from which Transport for NSW, the construction contractor and/or the CSELR Operator would be directly responsible for (for example, the consumption of diesel fuel in construction vehicles)
- *Scope 2 emissions* — indirect emissions from the consumption of purchased electricity steam or heat produced by another organisation (i.e. not produced by Transport for NSW, the construction contractor and/or the CSELR Operator) (for example, purchasing electricity from a supplier to power light rail infrastructure)
- *Scope 3 emissions* — other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the Transport for NSW, electricity-related losses, outsourced activities, waste disposal etc. For example, embodied energy of materials used in the construction of the CSELR proposal, and emissions from the extraction, production, transmission and distribution of fuel and electricity used on-site, waste and wastewater usage, commuting of workers.

10.9.2 Emissions during operation

Operational greenhouse gas emissions would primarily be associated with the operation and maintenance of LRVs and infrastructure. Greenhouse gas emissions would predominantly be generated by the following activities:

- electricity consumption to power LRVs, signalling, lighting, closed-circuit television and communications systems and other activities undertaken at stops, the maintenance depot at Rozelle, the stabling facility at Randwick (electricity indirect emissions, occurring off-site at the electricity power plant)
- combustion of fuel in maintenance plant, equipment and vehicles (direct emissions occurring on-site)
- disposal of waste from LRVs (e.g. from bins), the maintenance depot at Rozelle and the stabling facility at Randwick (indirect emissions from the decomposition of waste material, occurring off-site and waste disposal facilities)
- embodied energy (and associated greenhouse gas emissions) in materials used in the maintenance of light rail infrastructure (the energy and resources that were consumed to produce a particular construction material).

An estimate of the likely annual volume of directly emitted (scope 1) and indirectly emitted (scope 2 and 3) greenhouse gas emissions during the operational phase of the CSELR proposal is provided in Table 10.18.

It is noted that detailed information on the likely electricity demand of CSELR infrastructure (e.g. LRVs) was not available at the time of writing this EIS. Therefore, electricity demands have been assumed, based on information provided in the *Sydney Light Rail Extension Stage 1 Inner West Extension* project (Transport for NSW 2010) and the North West Rail Link Project (Transport for NSW 2012c). Discussion on the assumptions that were used to inform this assessment is provided in Technical Paper 8.

Greenhouse gas emissions documented in Table 10.18 are preliminary estimates, which can be refined as further details on the electricity demand of CSELR infrastructure (e.g. types of LRVs to be operated) are provided. This information would be determined during detailed design and project procurement.

Table 10.18 Estimated annual greenhouse gas emissions from the operation of the CSELR

ACTIVITY[1]	ASSUMED ANNUAL QUANTITY USED[1]	ANNUAL GREENHOUSE GAS EMISSIONS (TONNES CO_{2-e})				% OF TOTAL EMISSIONS
		SCOPE 1	SCOPE 2	SCOPE 3	TOTAL	
Electricity consumption	15,580,850 kWh	0.0	14,425.3	3,150.4	17,575.7	95.42
Diesel fuel consumption in light and heavy maintenance vehicles	1.0 kL	2.6	0.0	0.2	2.8	0.02
Diesel fuel consumption in stationary maintenance vehicles	27.6 kL	73.9	0.0	5.6	79.6	0.43
Leakage of SF_6 from electricity infrastructure	0.2 tonnes	22.9	0.0	0.0	22.9	0.12
Leakage of refrigerants (HFC) from air-conditioning	3.8 tonnes	656.6	0.0	0.0	656.6	3.57
Wastewater disposed at Municipal plant	40 people	0.0	0.0	7.8	7.8	0.04
Waste from operations	40 people	0.0	0.0	72.0	72.0	0.39
Construction worker commute to site	various (GJ)	0.0	0.0	0.9	0.9	0.01
Total	—	**756.1**	**14,425.3**	**3,263.9**	**18,418.4**	**100.0**
Per cent of total	—	**4.1**	**78.3**	**17.6**		

Source: *CSELR Preliminary Greenhouse Gas Assessment, Table 4.2, Technical Paper 8.*

Note 1: *kWh = kilo Watt hours; kL = kilolitres; CO_{2-e} = carbon dioxide equivalent; SF_6 = Sulphur hexafluoride; HFC = hydrofluorocarbons.*

As outlined in Table 10.18, operation of the CSELR proposal is estimated to generate 18,418.4 tonnes of CO_{2-e} in 2020/2021, with the consumption of electricity to power LRVs and infrastructure accounting for 95.4 per cent of these emissions.

Overall, the operation of light rail services would result in increased greenhouse gas direct emissions through increased electricity use. However, this increase is expected to be small on a per capita basis (i.e. the amount of electricity consumed relative to the number of passengers using the light rail services). The proposal is expected to generate a modal shift from private vehicles to public transport. Consequently the increase in emissions in use is likely to be offset by minimising increases in greenhouse gas emissions from private motor vehicles and more energy intensive modes of transport such as buses. In addition, the proposed construction of an integrated movement corridor is expected to reduce private vehicle use through increased active transport around the region of the proposal, such as walking and cycling.

As discussed in Chapter 7, opportunities to reduce operational greenhouse gas emissions would be investigated during detailed design. These opportunities could include purchasing electricity derived from a renewable energy source (where available), the use of regenerative braking on rolling stock, promoting the selection of energy efficient rolling stock, the use of photovoltaic lighting at stops and undertaking a traction power assessment during detailed design.

Purchasing 20 per cent of the total electricity demand for the CSELR proposal from a renewable energy source would have the potential to reduce annual greenhouse gas emissions to 14,903.2 tonnes (total scope 1, 2 and 3 annual emissions of 18,418.4 tonnes of CO_{2-e}). Purchasing 100 per cent of this electricity demand would reduce emissions to 842.7 tonnes (total scope 1, 2 and 3 annual emissions of 18,418.4 tonnes of CO_{2-e}).

A comprehensive list of sustainability initiatives has been developed for the CSELR proposal based on a review of Transport for NSW's (2012b) *NSW Sustainable Design Guidelines for Rail (Version 2.0).* These initiatives are documented in Chapter 7 of this EIS and would form a sustainable management strategy for the CSELR proposal. The sustainability management strategy would be regularly reviewed and updated throughout the design development, construction and operational phases.

Overall, operational greenhouse gas emissions and energy usage are considered to be manageable through design and the application of standard mitigation measures, as outlined in section 10.9.4.

10.9.3 Emissions during construction

Greenhouse gas emissions would be generated during the construction of the CSELR proposal, with substantial energy-consuming activities anticipated to occur over the construction period. Greenhouse gas emissions would predominantly be generated by the following activities:

- combustion of fuel in construction plant, equipment and vehicles (direct emissions occurring on-site)
- vegetation clearing (direct emissions from the decomposition of vegetative material and soil carbon releases)
- electricity used at construction compounds and the worksite (electricity indirect emissions, occurring off-site at the power station)
- disposal of waste from construction staff and site compounds (indirect emissions from the decomposition of waste material, occurring off-site and waste disposal facilities)
- indirect emissions embodied in key construction materials, including cement and steel (i.e. the energy and resources that were consumed to produce a particular construction material).

The volume of greenhouse gas emissions that would be generated during construction would depend on the quantity of construction materials consumed and the types of construction plant and equipment used.

An estimate of the likely volume of directly emitted (scope 1) and indirectly emitted (scope 2 and 3) greenhouse gas emissions associated with the key emission sources is provided in Table 10.19. This estimate has been based on an assumed 4.5 year construction period.

It is noted that the greenhouse gas emissions documented in Table 10.19 are preliminary estimates, which can be refined as further details on the quantity of construction materials, plant and equipment are provided. This information would be determined during detailed design and project procurement.

Table 10.19 Estimated greenhouse gas emissions from the construction of the CSELR

ACTIVITY	ASSUMED QUANTITY USED	GREENHOUSE GAS EMISSIONS (TONNES CO_{2-e})				% OF TOTAL EMISSIONS
		SCOPE 1	SCOPE 2	SCOPE 3	TOTAL	
Diesel fuel consumption in light and heavy vehicles	215.3 kL	841.4	0.0	63.9	905.3	1.3
Diesel fuel consumption in stationary construction equipment	6,018.4 kL	16,145.5	0.0	1,231.2	17,376.8	24.8
Diesel fuel consumption in stationary generators	288.2 kL	773.2	0.0	59.0	832.2	1.2
Electricity supplied to large site compounds	1,118,472.3 kWh	0.0	984.3	212.5	1,196.8	1.7
Wastewater disposed at Municipal plant	210 people	0.0	0.0	50.0	50.0	0.1
Waste from construction workers	210 people	0.0	0.0	252.0	252.0	0.4
Construction materials	Various	0.0	0.0	49,561.0	49,561.0	70.6
Construction worker commute to site	Various	0.0	0.0	8.9	8.9	0.0
Land use change and clearing	Not available	0.0	0.0	0.0	0.0	0.0
Total	—	**17,760.2**	**984.3**	**51,438.5**	**70,182.9**	**100**
Per cent of total	—	**25.3**	**1.4**	**73.3**		

Source: *CSELR Preliminary Greenhouse Gas Assessment Table 4.1, Technical Paper 8.*

As outlined in Table 10.19, the construction of the CSELR proposal is estimated to generate 70,182.9 tonnes of CO_{2-e}, with embodied emissions in construction materials making up 70.6 per cent of these emissions. Direct (scope 1) greenhouse gas emissions associated with clearing of street trees, while not included in Table 10.19, are likely to be minimal, when compared to the total greenhouse gas emissions associated with energy (fuel and electrify) consumption.

Overall, construction related greenhouse gas emissions and energy usage are considered to be manageable through design and the application of standard mitigation measures, as outlined in section 10.9.4.

10.9.4 Management and mitigation

Detailed design

Transport for NSW would undertake a greenhouse gas assessment for the CSELR proposal during the detailed design phase. The purpose of this assessment would be to identify significant sources of greenhouse gas emissions from the proposal, including:

- direct emissions from construction activities, such as the combustion of fuel in construction plant/vehicles and vegetation clearing
- indirect emissions from the use of electricity and the disposal of waste
- embodied energy (and associated greenhouse gas emissions) in construction materials (the energy and resources that were consumed to produce a particular construction material).

The greenhouse gas assessment would identify a range of mitigation measures to reduce the volume of emissions generated during the construction and operational phases of the CSELR proposal. Evaluation and reporting on the feasibility of these mitigation measures would also be undertaken during detailed design as part of the greenhouse gas assessment.

Operation

Opportunities to reduce operational greenhouse gas emissions would be investigated during detailed design. These opportunities could include purchasing electricity derived from a renewable energy source (where available), the use of regenerative braking on rolling stock, promoting the selection of energy efficient rolling stock, the use of photovoltaic powered lighting at stops and undertaking a traction power assessment. The sustainability initiatives documented in Table 7.5 (refer to Chapter 7) would be regularly reviewed, updated and implemented throughout the design development, construction and operational phases.

Construction

While it would not be possible to completely mitigate the generation of greenhouse gas emissions during construction (due to the need to consume energy and resources), the amount of emissions could be reduced by:

- purchasing electrical energy derived from a renewable energy source (where available)
- using low greenhouse gas-intensive construction materials (where a suitable substitute for a high greenhouse gas-intensive material is available)
- adopting energy efficient work practices.

The following management and mitigation measures would be implemented during construction to reduce the amount of greenhouse gas emissions from the proposal:

- Methods for management of emissions would be incorporated into site inductions, training and pre-start talks.
- Activities with the potential to cause substantial emissions (such as material delivery and loading and bulk earthworks) would be identified. Work practices which minimise emissions during these activities would be investigated and applied where reasonable and feasible. These would potentially include:
  - the use of biodiesel and other low carbon fuels in vehicles and equipment
  - the use of fuel-efficient construction equipment with the latest technology.
- Procurement of construction services and materials locally to minimise the distance travelled and therefore emissions of vehicles accessing the site.
- During construction planning, ensure that deliveries are managed in an efficient manner to minimise the number of trips required and therefore reduce the amount of emissions.
- Implementing energy-efficient work practices, such as switching off construction plant, vehicles and equipment when not in use to minimise idling.
- Regularly monitoring, auditing and reporting on energy, resource use and associated greenhouse gas emissions as part of the environmental reporting requirements specified within the CEMP.
- Selection of materials during construction planning to ensure products that reduce embodied carbon are considered and used.

10.10 Hazards and risks

The following sections provide a summary of a desktop review of potential hazards and risks undertaken for the CSELR proposal.

10.10.1 Hazards and risks during operation

Hazards and risks associated with the operation of the proposal would primarily be due to:

- the movement of LRVs through highly pedestrianised areas such as the George Street pedestrian zone, resulting in the potential for collisions/accidents
- potential collisions between road vehicles and LRVs at signalised crossings (for example, at South Dowling Street) and locations where road traffic would be maintained adjacent to the CSELR proposal (for example, High Street and Anzac Parade)
- accidental interactions with the overhead wiring (including during maintenance of CSELR infrastructure)

- the handling, storage, use and disposal of chemicals and other potentially hazardous materials at the Rozelle maintenance depot, Randwick stabling facility and at other locations along the CSELR alignment (e.g. use of herbicides on landscaping)
- injury to maintenance staff from activities occurring within the proposed Rozelle maintenance depot and the Randwick stabling facility, or at other locations along the CSELR alignment (e.g. collision with motor vehicles while undertaking maintenance work adjacent to traffic)
- damage to CSELR infrastructure caused by falling tree branches (particularly overhead wiring)
- utility failure (power or communication system failure)
- electromagnetic fields (EMF) from proposed electricity substations, overhead wiring and LRV charging stations at stops situated within the proposed wirefree zone
- external events (i.e. events occurring at adjacent facilities)
- natural events (including flooding and extreme weather events)
- impacts of climate change (changed frequency of natural events).

The above hazards and risks are considered to be manageable during operations through design (e.g. incorporating adequate safety provisions into the design of CSELR infrastructure), the application of community education programs (e.g. advertisement of potential project related safety risks — such as the risk of injury due to pedestrian movements within the defined CSELR corridor — to build community awareness and resilience of such risks), and standard mitigation measures and plans (e.g. emergency response plans). Further discussion on potential hazards/risks associated with collisions and EMFs from electricity infrastructure is provided in the following sections.

Collisions with pedestrians and road vehicles

The CSELR proposal would result in the potential risk of collisions between LRVs and pedestrians, or LRVs and road traffic, particularly where the alignment must cross roads carrying vehicular traffic or where pedestrians must cross or interact with the CSELR alignment, such as within the George Street pedestrian zone.

Shared running sections of the CSELR would include the busway along Anzac Parade/Alison Road between Robertson Road and Doncaster Avenue and the alignment between the Kingsford stop and UNSW. In these sections shared running would be with buses only. There would be no shared running with general traffic.

For shared running and pedestrianised sections, LRV drivers would be required to give due consideration to buses and pedestrian movements, assessing LRV speeds and braking requirements against their perceptions of actual or potential hazards. On observing a stop signal stationary obstacle in path of the LRV, the driver should be able to stop the LRV by use of the service brake only.

LRVs are also fitted with warning bells that are used on approach to and departure from each stop, except at night when they are used only where the driver considers there is a danger to public safety. The detailed design of the CSELR would be subject to detailed safety reviews to identify requirements for mitigation to manage and reduce the risk of incidents arising from collisions during operation.

The management of hazards associated with the movement of LRVs through the existing road network and highly pedestrianised areas has been has been reinforced in many major cities (such as Strasbourg, France and Linz, Austria and Melbourne) through widespread and targeted educational programs and detailed design considerations for the vehicles and stops. A similar approach would be applied to managing potential hazards or risks associated with the CSELR proposal.

EMFs and stray current

Potential EMF sources associate with the proposal include 750 Volt overhead contact wires, buried cables and to a lesser extent, running rails. The LRVs themselves are also a source of EMF.

Types of EMF associated with light rail systems like the proposed CSELR include high frequency emissions, and low frequency emissions. High frequency emissions could affect electronic and sensitive equipment. Low frequency EMF is considered a health hazard under long term exposure if the emission levels are high. Users of the CSELR would only be exposed to LRV generated EMFs for short period of time. Consequently, this generally poses no health issue.

The CSELR would be designed to comply with appropriate Australian and international standards, thereby minimising the risk associate with EMF exposure. A clearance of three metres would be adopted between the 750 Volt overhead contact wires to persons or infrastructure to ensure minimal, if any impact to the public from exposure to EMF. The only possible issues which may arise are with very sensitive electronic equipment located in buildings near the system. The LRVs would be required to comply with internationally recognised standards for electromagnetic compatibility, and so should not present any EMF emissions issues. Current is received via pantographs and is utilised within the vehicle traction system within an insulated, enclosed compartment of the vehicles clear of any public access.

Stray leakage of currents from the running rails into surrounding earth would need to be minimised, as this could cause electrolysis corrosion of nearby buried metalwork. The CSELR design proposes the running rails are encased within insulating material, ensuring this issue is mitigated.

10.10.2 Hazards and risks during construction

Hazards and risks associated with the construction phase of the proposal can be broadly categorised into the following:

- *environmental hazards and risks* — including discharge of potentially contaminated and/or hazardous materials to the environment
- *occupational health and safety hazards and risks* — including any activity or outcome that may affect the health and/or safety of construction personnel or the community, due to the failure of health and safety procedures
- *construction hazards and risks* — including operation and maintenance of plant and machinery, and use/stockpiling of materials required for construction.

Further discussion on the above hazards and risks is provided in the following sections.

Environmental hazards and risks

Environmental hazards and risks associated with construction of the proposal could arise during the transport, use and storage of hazardous materials on-site, as well as the discovery of contaminated soils/groundwater and their subsequent disposal.

During construction, potentially hazardous materials would be stored and used on-site at the proposed construction compounds, laydown areas and other ancillary work areas, as shown in Figure 6.2 (refer to Chapter 6). The types of potentially hazardous materials that may be required to be stored on-site during construction of the proposal are listed in Table 6.7 (refer to section 6.4). The refuelling and maintenance of construction plant and equipment would be undertaken within designated areas at these construction sites, and typically using specialised refuelling contractors equipped with appropriate spillage response equipment and training.

Potentially hazardous materials would be transported to and from construction sites on public roads. Spills and leaks during transportation could result in the contamination of land and waterways outside of the proposal area. It is expected that this risk would be manageable through the use of delivery contractors who are certified to transport those potentially hazardous materials and have adequate environmental management procedures to address risks associated with spills and leaks during transportation.

As described in section 10.3, a number of potential sources of contamination existing along the CSELR proposal alignment. Construction activities, if not managed correctly, have the potential to result in the release of these contaminants into the wider environment.

Sensitive environmental receivers that could be affected by spills and leaks of hazardous materials or the unearthing of contaminated soils/groundwater (and their subsequent disposal) include:

- surface waterways, including Sydney Harbour, Kippax Lake, Kensington Ponds, Botany Wetlands, Mill Pond, Botany Bay, and a pond system located within Centennial Park (including Busbys Pond and Randwick Pond). (Further discussion on potential impacts to surface waterways is provided in section 10.2)
- groundwater aquifers and associated sensitive groundwater receptors, including registered bore users and groundwater dependent ecosystems. (Further discussion on potential groundwater impacts is provided in section 10.4)
- public recreation areas (e.g. parkland), including Moore and Centennial Parks, First Fleet Park and Royal Randwick racecourse. (Further discussion on potential impacts to soils and geology (including the contamination of soils) is provided in section 10.3)
- flora and fauna, including existing street trees to be retained along the CSELR alignment and fauna species currently using the area for foraging and/or roosting habitat. (Further discussion on potential impacts to flora and fauna is provided in section 10.6)
- members of the public and construction, operation and maintenance personnel.

Environmental hazards and risks associated with the construction of the CSELR proposal would be manageable through the development and implementation of environmental management measures as part of the CEMP to address the following issues described earlier in this Chapter:

- chemical spills and leaks
- surface water quality
- groundwater quality
- disposal of contaminated materials
- disposal of contaminated groundwater.

Occupational health and safety hazards and risks

Occupational health and safety hazards could arise throughout construction, where inadequate hazard/risk identification, reporting and monitoring systems are not implemented and/or maintained. Hazards and risks that could occur during the construction of the CSELR proposal include:

- undertaking construction works close to publically accessible/highly trafficked areas (e.g. within/adjacent to pedestrian footpaths within Sydney CBD, Royal Randwick racecourse and UNSW)
- undertaking construction works close to sensitive community facilities (e.g. schools, childcare centres and hospitals)
- undertaking construction works within or adjacent to major arterial and regional roads (including Anzac Parade, Alison Road and the Eastern Distributor)
- undertaking construction works in the vicinity of existing services and utilities (e.g. high voltage power lines, gas mains, etc.)
- failure to shut down/isolate services and utilities proposed to be relocated as part of the CSELR proposal (e.g. electricity cables and gas mains)
- undertaking construction works close to existing buildings and vibration sensitive structures
- encountering asbestos, contaminated land and other potentially hazardous materials during construction (e.g. demolition of existing structures) and associated risks associated with the handing, stockpiling, transporting and disposal of such material
- the use and storage of hazardous materials
- the use of heavy machinery
- works which may impact or restrict emergency access from existing building and/or emergency vehicles.

The above hazards and risks are anticipated to be manageable through the development and implementation of standard mitigation measures, which would be developed as part of the CEMP and occupational health and safety plan prior to construction.

Construction traffic management measures would be developed for the construction of the proposal. These would include construction traffic management plans for all phases of the works and to support applications for Road Occupancy Licences. These would detail requirements for lane closures, traffic diversions and permitted site access points in each case.

Construction hazards and risks

The uncovering of contaminated materials has the potential to result in health impacts to construction workers, the environment and members of the community that come into contact with such materials. Without adequate management, the contamination of land and waterways outside of the CSELR proposal area could result from runoff, dust generation, or spills or accidents during the transportation of contaminated materials within or from the construction site. Contamination issues are discussed further in section 10.3.

Overhead wires and subsurface utilities could also pose construction hazards to site workers and the environment. As outlined in section 10.9, a number of underground electricity and gas mains have been identified in the vicinity of the proposed works, a number of which would require protection or relocation as part of the CSELR proposal. Damage to services and utilities during construction could result in injury to site workers and members of the community. For example, damage to underground electricity cables could result in the transmission of large electrical currents through the ground surface (known as earth potential rise), which has the potential to injure construction workers and members of the community standing close to the damaged power utility. The management of utilities and services are discussed further in section 10.9.

The demolition of the Olivia Gardens apartment complex would pose construction risks to site workers and the community, if inadequate demolition technique and/or working clearances are adopted. The demolition of existing buildings and structures could also involve the removal of asbestos. This activity would be undertaken by a licenced contractor who has current WorkCover NSW accreditation in asbestos removal and would be undertaken in accordance with relevant guidelines, including OEH's *Waste Classification Guidelines* (DECCW 2009). A hazardous materials survey would also be undertaken during detailed design to determine the presence of contaminated materials on-site.

A number of underground structures have been identified as being crossed by, or located near the CSELR alignment, including:

- Eastern suburbs rail (ESR) station box below Chalmers Street
- Town Hall station box below George Street
- pedestrian walkway from Town Hall station to Queen Victoria Building
- pedestrian walkway from Town Hall station to Galleries Victoria.

Each of these underground structures are currently subject to structural loading from heavy traffic on the roads above. Given that the track slab associated with the CSELR would serve to spread the load of LRVs running above, it is not currently anticipated that the risk of structural instability, damage or failure would be increased from the proposal. Nevertheless further structural assessment would be undertaken for all structures to inform the development of the detailed design and address any risks identified.

In many cases the design would also reduce the depth of cover to the structure, which in the situation of the rail station boxes above is relatively shallow (i.e. the maximum depth for the ESR box is under half a metre, and the maximum depth for the Town Hall station box, around one metre). The detailed design of the CSELR would specifically address these issues.

10.10.3 Management and mitigation

Operation

Operational hazards and risks would be addressed through design, the application of community education programs, and standard mitigation measures and plans (where required). These measures would include the following:

- Targeted road safety campaigns to raise awareness around the operation of LRVs would be used in the lead up to the opening of the CSELR and during operation to promote the safe operation of the proposal. This would focus on raising awareness and promoting safe behaviours in shared zones and at key crossings.
- Targeted consultation with identified sensitive receivers for EMF (e.g. UNSW and Prince of Wales Hospital) would be undertaken to inform the detailed design. Any issues identified would be resolved on a case by case basis with solutions such as monitoring and, if necessary, protective screening at the site of the sensitive equipment.
- All cables would be buried within ducts and would adhere to all International and Australian electrical standards in terms of distances from surrounding cables (i.e. adjacent high voltage cables require minimum separation in accordance with industry standards).
- Storage of chemicals associated with the operation and maintenance of the LRVs would be designed in line with the appropriate EPA guidelines and legislative requirements.
- Hazardous material procedures (including procedures for managing spills, and the refuelling and maintenance of vehicles/equipment) would be developed and implemented during the operation of the CSELR proposal to minimise potential for impacts associated with chemical spills and leaks. These procedures would adequately address activities at the proposed Rozelle maintenance depot and Randwick stabling facility, as well as other general maintenance facilities that would occur along the CSELR alignment.

Construction

Construction hazards and risks would be addressed through the development and implementation of standard mitigation measures, which would be developed as part of the CEMP and occupational health and safety plan prior to construction. These measures would include the following:

- Hazards and risks associated with construction activities would be identified prior to construction. Management measures for each identified hazard/risk would also be developed. A process for regularly reviewing work practices/procedures would be implemented throughout construction to identify, report and respond to any new environmental hazards/risks.
- Environmental management measures would be developed and implemented as part of the CEMP to address the following issues:
  - chemical spills and leaks (as documented in section 10.2, 10.3 and 10.4 of this EIS)
  - surface water quality (as documented in section 10.2 of this EIS)
  - groundwater quality (as documented in section 10.4 of this EIS)
  - disposal of contaminated materials (as documented in section 10.3 of this EIS)
  - disposal of contaminated groundwater (as documented in section 10.4 of this EIS)
  - traffic, transport and access (as documented in sections 12.3, 13.3, 14.3, 15.3, 16.3 and 17.3 of this EIS)
  - the management of services and utilities (as document in section 10.9 of this EIS).
- Construction worksites located adjacent to public areas would be screened (where required) to minimise risks of injury as a result of unsecured debris, tools and other objects.

10.11 Privacy impacts

10.11.1 Privacy impacts during operation

Potential privacy impacts may be experienced by some sensitive receivers (including residential properties, schools, businesses, hospitals) that adjoin the CSELR alignment during the proposal's operation. These would include:

- passengers overlooking adjoining properties while travelling on the light rail
- potential privacy concerns for those in the immediate vicinity of the proposed stops, which is likely to be more of a concern where the stops are planned for areas currently experiencing relatively low levels of pedestrian activity, including the:
  - Surry Hills stop
  - Wansey Road stop
  - UNSW High Street stop
  - Randwick stop
  - Carlton Street stop
  - Todman Avenue stop
  - Strachan Street stop
- increased light spill into adjoining properties as a result of additional lighting for safety and security purposes along the CSELR alignment and required vegetation clearance.

At a number of locations along the proposal corridor, existing vegetation would continue to provide some screening between the CSELR proposal and adjoining sensitive receivers. In addition, the alignment of the CSELR would be on road and follow the existing alignment already followed by buses (such as along Devonshire Street or along Anzac Parade). In these locations, the impacts to existing privacy are not anticipated to be substantial.

However, in areas along the proposal corridor where vegetation would be cleared to construct stops or the light rail alignment, or where the light rail alignment would pass through areas where an existing transport corridor does not exist (such as within the vicinity of the existing Olivia Gardens apartment complex), the existing screening of some adjacent land uses may be reduced, with associated privacy impacts. Proposed areas of tree removal are described in detail in sections 12.6, 13.6, 14.6, 15.6 and 16.6. These areas include Devonshire Street and Wansey Road where residents are located adjacent to the areas of proposed tree removal.

Light spill impacts during operation are discussed in more detail in sections 12.7, 13.7, 14.7, 15.7, 16.7 and 17.6

10.11.2 Privacy impacts during construction

The construction of the CSELR proposal may temporarily reduce privacy for surrounding residents and adjacent businesses due to:

- general construction activities within the construction footprint, such as vegetation clearing, and the general presence of construction workers along the proposal corridor
- use of temporary construction access points to access the site at construction compounds and other temporary construction access points
- construction vehicle movements, both within the construction footprint and along nominated haulage routes
- potential vehicle, pedestrian or cyclist diversions along routes during construction that do not currently have high levels of use
- increased light spill into adjoining properties during night works.

The proposal's impact on individual sensitive receivers would depend on the construction stage, the receiver location and the design and location of construction hoardings (which would generally minimise privacy impacts but may have other impacts such as visual amenity impacts). Privacy impacts during the CSELR proposal's construction would be greatest at locations where residential or other sensitive receivers have an unscreened view of the construction corridor or work sites, or where vegetation clearing provides a clear view of construction activities and therefore increased views towards these sensitive receivers.

Light spill impacts during construction are discussed in more detail in sections 12.7, 13.7, 14.7, 15.7, 16.7 and 17.6.

10.11.3 Management of impacts

Maintaining privacy of residences and other sensitive receivers along the CSELR corridor and around the proposed stops is an important urban design consideration.

The following mitigation measures would be implemented to reduce and manage potential adverse privacy impacts of the CSELR.

Landscaping and privacy screening – during operation

Detailed design would consider measures to minimise removal of existing vegetation where possible. Where the CSELR corridor is located close to residential dwellings or other receivers sensitive to privacy impacts, the detailed landscape design would consider how planting and other landscaping options can be used to create or maintain privacy.

Further discussion regarding the proposed landscaping along the CSELR alignment is provided in Chapters 12-16 of this EIS and in the CSELR Landscape Strategy (Appendix F).

Where landscaping is not able to mitigate privacy impacts, additional urban design elements, such as fencing or other screening features, would be considered to improve the privacy of existing sensitive receivers. These measures would be considered, as required, during the detailed design of the proposal in consultation with the relevant landowner(s). The design of landscaping or privacy screening would also need to consider safety issues such as sightlines for LRVs and crime prevention through environmental design (CPTED) principles.

Operational lighting

Lighting within the CSELR corridor would be required to address safety and environmental considerations. Detailed design would need to consider the potential privacy impacts of light spill to adjoining properties, especially where these are residential properties or other potentially sensitive receivers.

The lighting design for the proposal would use fixtures that prevent light within the light rail corridor from spilling upwards and/or beyond the required area to be lit and into adjacent residences or sensitive environmental areas. Lighting would be designed by a specialist lighting consultant and would comply with relevant Australian Standards, including *AS4282-1997 (Control of the obtrusive effects of outdoor lighting)*.

Construction lighting

As described in sections 12.7, 13.7, 14.7, 15.7 and 16.7, light spill from the light rail construction corridor into adjacent visually sensitive properties would be minimised by directing construction lighting into the construction areas and ensuring the site is not over-lit. This would include the sensitive placement and specification of lighting to minimise any potential increase in light pollution.

Construction hoardings

In addition to safety and visual amenity considerations, the design and placement of construction hoardings would consider opportunities to minimise privacy impacts on adjacent residents or other adjacent land uses sensitive to privacy concerns.

11. Regional cumulative impacts

Chapter 11 provides an assessment of potential cumulative impacts and benefits associated with operation and construction of the CBD and South East Light Rail Project (‘the CSELR proposal’ or ‘the CSELR’) and other major proposed developments along the CSELR corridor.

11.1 Purpose and approach

When considered in isolation, the environmental impacts and benefits of an individual project may not be large. However, when combined with the effects of other developments, the resultant cumulative effects may result in a greater extent, magnitude or duration of impact. Identifying potential cumulative impacts assists in developing appropriate management measures and provides a basis for coordinated regional planning and environmental monitoring.

Proposed developments with the potential for cumulative impacts with the CSELR were identified through:

- consultation with stakeholders, councils and the CSELR project team
- a search of the Department of Planning and Infrastructure’s (DP&I’s) major projects register on 25 July 2013
- a search of the NSW Planning Assessment Commission’s project register for Sydney City and Randwick local government areas on 30 July 2013
- a search of City of Sydney, Randwick City Council, Transport for NSW and Roads and Maritime Services websites
- a review of background documents including planning strategies and major facility master plans.

The assessment focused on proposed developments that are:

- in close proximity to the CSELR
- likely to be under construction and/or operation concurrent with the CSELR
- large and of the type that may have cumulative impacts with CSELR
- likely to be developed considering their approval status and/or support from relevant government planning strategies and local environmental plans.

In regard to the last point, this cumulative assessment does not focus on possible projects that are very early in the planning process and/or have no current government commitment. In this regard, it is assumed that projects that are behind the CSELR in the planning approval process would be required to integrate with the CSELR (where appropriate), and consider the potential for cumulative impacts.

Key potential impacts of each development with the potential for cumulative impacts with the CSELR were identified based on consultation, current knowledge and professional judgment. This included review of publicly available details of developments and environmental impact assessments.

The cumulative assessment was mostly qualitative. However, the construction and operational road network performance modelling undertaken for the CSELR proposal (refer Technical Papers 1 and 2) incorporated likely traffic generation from a number of major developments along the CSELR alignment. The operational modelling also incorporated the bus network changes that are proposed for the CBD and South East as part of the NSW Government’s *Sydney City Centre Access Strategy* (SCCAS). The inclusion of some of the bus network changes in the modelling, however, makes it possible to make some quantitative assessment of potential cumulative traffic and transport impacts of these projects with the CSELR.

11.2 Potential cumulative impacts

11.2.1 Overview

The following subsections provide an overview of the types of cumulative impacts that may occur during the construction and operation of the CSELR and other major developments. Proposal-specific impacts are discussed in sections 11.2.2 and 11.2.3.

Construction-specific cumulative effects

Construction-specific cumulative effects are most likely to occur where construction works overlap in terms of timing and/or location. Cumulative effects from construction activities usually relate to noise and vibration, traffic and access, visual amenity and air quality impacts. The scale of the impacts largely depends on the type of work, its duration, and the sensitivity of surrounding land uses. Cumulative construction impacts may include:

- cumulative increases in construction vehicle traffic on public roads causing noise/vibration and air quality impacts on sensitive receivers
- cumulative noise impacts associated with multiple construction works, especially at night
- disturbance to existing and future land uses and access
- cumulative heritage impacts
- cumulative impacts on utilities and services
- cumulative changes to water quality of nearby waterways or groundwater from multiple construction sites
- cumulative visual amenity impacts.

Projects do not have to overlap in terms of construction timing to have cumulative impacts. If various projects follow progressively and are concentrated in a general locality, there may also be a cumulative effect associated with an overall increased duration of disturbance on sensitive receivers, particularly residents. This effect is often termed ‘construction fatigue’. This is potentially a key issue for the CSELR proposal due to the length of the construction program and the concentration of a number of major development projects in close proximity, particularly in the CBD.

Operational-specific cumulative effects

Cumulative operational impacts and benefits of the CSELR and other major developments may be associated with:

- changes to the distribution of traffic and access arrangements, and associated changes in amenity, including noise
- changes to the visual amenity of an area
- property and land use impacts and urban renewal.

11.2.2 Cumulative impacts with other transport and road projects

Other major transport and road projects and plans/strategies with the potential for cumulative impacts with the CSELR are detailed in Table 11.1, including the status and indicative timing of these projects, and their likely impacts based on current knowledge.

As well as the projects listed in Table 11.1, a number of other potential transport projects have been identified by the NSW Government through the *NSW Long Term Transport Master Plan* (December 2012a) and the associated *Sydney’s Light Rail Future* (December 2012b) and *Sydney’s Ferry Future – Modernising Sydney’s Ferries* (May 2013) documents. Examples in the vicinity of the CSELR proposal include:

- a potential ferry hub at Barangaroo – timing unconfirmed
- a comprehensive upgrade to the Circular Quay ferry interchange to improve interchange with trains, buses and the CSELR proposal – timing unconfirmed
- a second harbour crossing and a new CBD line for rail – identified as long-term priorities in the Master Plan (10–20 year timeframes)
- a cycling network connection to the Sydney CBD from the east – identified as a medium term priority in the Master Plan (5–10 year timeframe)
- possible future light rail extensions to Malabar, Walsh Bay and Barangaroo North.

If these projects proceed, they would all be required to integrate with the CSELR proposal. If they overlap with construction of the CSELR, they would also need to consider potential cumulative effects. As these possible projects are only in the very early planning stages, they have not been discussed further in this cumulative assessment.

Potential cumulative impacts between the transport projects listed in Table 11.2 and the CSELR proposal are discussed in Table 11.3.

Table 11.1 Major transport and road projects and plans/strategies with potential for cumulative impacts with the CSELR

PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	ASSUMED KEY IMPACTS OF THIS PROJECT BASED ON CURRENT KNOWLEDGE
SCCAS (NSW Government)	Integrated transport and access strategy for the Sydney CBD that incorporates integrated modal delivery plans and projects for light rail (including the CSELR), as well as: • city centre bus network redesign and implementation • traffic bypass and priority routes for the city centre • interchange precincts within the city centre • pedestrian improvements and integration with the CSELR pedestrianisation works in George Street • a strategic cycleway network for the city centre • integration of the proposed Barangaroo ferry hub • interchange and access improvements for city centre rail stations. • a second harbour crossing and new CBD rail line • improvements to city centre rail stations make passenger movement easier and reduce congestion • reallocation of on-street parking to provide for new and expanded taxi zones, more loading zones and to complement other transport improvements (refer sections 1.1 and 3.2.3 of this EIS for further details)	SCCAS was released for public comment in September 2013. Initiatives to be progressively implemented from late 2013.	• Major benefits anticipated for accessibility through and to the city centre, including the unlocking of capacity on Sydney's transport network • Major changes to traffic and transport arrangements would also have associated access, noise, visual and socio-economic impacts associated with transport mode shifts, changes in travel time and redistribution of trips. In some areas, this would lead to environmental and amenity benefits; however impacts would be felt in other areas where vehicles (private and buses) are redistributed *Source: Sydney City Centre Access Strategy, NSW Government, September 2013*
Sydney City Centre Bus Infrastructure Project (NSW Roads and Maritime Services)	Proposed physical infrastructure changes required to implement the redesign of the city centre bus network	Proposed to be constructed and operational prior to mid-2014 (prior to CSELR construction commencement)	Key environmental issues/impacts during construction include: • Potential disruption to traffic flows • Noise and vibration impacts • Potential disruption to pedestrian access and operation of businesses adjacent to work sites • Potential for encountering archaeology for areas requiring excavation • Temporary visual impacts and impacts to general amenity

Table 11.1 cont.

PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	ASSUMED KEY IMPACTS OF THIS PROJECT BASED ON CURRENT KNOWLEDGE
Wynyard Walk (Transport for NSW)	New, underground pedestrian link from Wynyard Station to the intersection of Kent and Napoleon Streets, including: • a new plaza (Napolean Plaza) over the entrance • a new Sussex Street pedestrian bridge • designed to have capacity for 20,000 pedestrians per hour and to cater for pedestrian movements between Barangaroo and Wynyard Station *Source: http://www.transport.nsw.gov.au/tags/wynyard-walk, accessed 25/07/13*	Under development due for completion in 2015	Key environmental issues/impacts include: • significant benefits for pedestrian access, public transport connections and socio-economic factors • construction impacts on traffic and transport, heritage items and archaeology, noise and vibration, and socio-economics • operational impacts in relation to the road network, visual impacts and urban design *Source: Wynyard Walk, Review of Environmental Factors, Transport for NSW, April 2012*
Inner West Light Rail Extension (Transport for NSW)	• Construction and operation of 5.6 kilometres light rail extension from Lilyfield to Dulwich Hill	Under construction and due for completion in early 2014	• Anticipated to have significant benefits for transport and access within and from/to the Inner West of Sydney, as well as wider social, economic and environmental benefits • Key environmental issues/impacts include: general construction impacts, land use and transport integration, operational noise and vibration, historic heritage, ecology and design, sustainability and amenity *Source: Sydney Light Rail Extension Stage 1 – Inner West Extension, Environmental Assessment (Transport for NSW 2010)*
WestConnex (Roads and Maritime Services NSW)	• Major infrastructure project that will include a 33 km link between Sydney's west and the Port Botany precinct • The project includes: widening of the M4 east of Parramatta, an extension of the M4 east at North Strathfield to Taverners Hill in Petersham, and duplication of the M5 East to King Georges Road • A Sydney Airport Access Link between the St Peters area and the M5 East portals would complete the missing link between the two motorways and provide better connections to the airport terminals, Port Botany and surrounding industrial areas *Source: <http://www.rta.nsw.gov.au/roadprojects/projects/building_sydney_motorways/westconnex/index.html>, accessed 26/07/13*	Yet to be approved; however project has strong government commitment. Stage 1 is due to commence construction in early 2015 (subject to planning approval). Planned for completion by 2025 (in stages).	Environmental impact assessments are yet to be prepared; however key environmental issues/impacts are likely to include: • major benefits for the regional economy associated with traffic, transport and access improvements, including freight transport • other benefits for urban renewal in areas such as Parramatta Road • construction impacts in relation to traffic generation, other traffic and transport access disruptions, heritage, noise, dust, water and amenity impacts • operational impacts from changes in traffic, transport and access impacts and associated changes in amenity (noise, air and visual impacts)

Table 11.2 Potential cumulative impacts: the CSELR and other major transport projects

PROJECT (PROPONENT)	POTENTIAL CUMULATIVE IMPACTS WITH CSELR
SCCAS (NSW Government)	The SCCAS has been prepared as an integrated package of transport and access improvements within the Sydney CBD, which includes the CSELR proposal. This integration should ensure that operational cumulative impacts are largely positive in relation to transport and access, urban renewal, global competitiveness and economics – which are the key drivers for the SCCAS and the CSELR. The SCCAS projects and the CSELR proposal would both be associated with substantial changes to CBD traffic and transport distribution and access, and associated changes in amenity (noise, air quality, visual impacts) and land use. Components of the SCCAS that follow the CSELR through the planning process would also be required to consider and manage cumulative impacts. Cumulative construction impacts cannot be confirmed until the timing of the various SCCAS projects is known. However, even if the various projects do not directly overlap in terms of timing, their concentration within the CBD indicates that affected receivers and communities would be subject to a degree of 'construction fatigue'.
Sydney's Bus Future – CBD Bus Plan and other changes in South East (NSW Government)	As noted above, the road network performance modelling undertaken for the purposes of the CSELR EIS (refer Technical Papers 1 and 2) provides a cumulative assessment of impacts of the CSELR and the likely CBD and South East bus plan changes. In conjunction with the CSELR, the bus changes are expected to deliver a 12 to 25% increase to bus speeds on the network in the morning peak, which is substantially higher than the traffic speed benefits expected from the CSELR alone (refer to Table 11.1). When combined, the projects would also encourage a greater public transport mode share and would maximise efficiency of the transport network. These benefits would be expected to also lead to operational cumulative benefits for the economy, urban renewal, access and connectivity, and amenity – particularly in the CBD where many buses would be removed. Cumulative operational impacts of the bus changes and the CSELR are likely to be concentrated around the stops where bus interchange facilities are proposed (Randwick, Kingsford, Town Hall, Queen Victoria Building, Rawson Place and Central Station stops). This may include land use change, noise and visual impacts, as well as access impacts such as mode shifts between buses and light rail. The CBD Bus Plan and South East bus changes would comprise operational changes only – so no cumulative construction impacts would be expected. (See project below for impacts of bus infrastructure changes in the CBD).
Sydney City Centre Bus Infrastructure Project (Roads and Maritime Services)	The bus infrastructure upgrade work would need to be completed prior to implementing the changes to bus routes within the city centre. As the bus route changes would be implemented prior to commencement of early work construction for CSELR, there is no overlap of construction works from the two projects and therefore no cumulative impacts.
Wynyard Walk (Transport for NSW)	Wynyard Walk and the CSELR proposal are integrated projects, which should have cumulative operational benefits in terms of transport and access, urban renewal and integration with the Barangaroo development. Wynyard Walk is in close proximity to the CBD section of the CSELR (separated only by Wynyard Station) and the projects may overlap by approximately 6 months in regard to construction. Therefore there is potential for cumulative construction traffic, economic, water and amenity impacts. In particular, if the CSELR early works in George Street overlap with the cut-and-cover tunnel under Kent Street for Wynyard Walk, there is potential for impacts on traffic and access – particularly for exit from the city to the north. If construction of the CSELR early works commences at the Randwick and Kingsford ends of the CSELR and progress towards the CBD; the risk of cumulative construction impacts may largely be avoided.
Inner West Light Rail Extension (Transport for NSW)	The Inner West Light Rail Extension project is expected to be operational in 2014 and would be integrated with the CSELR proposal. Hence no, or minimal, cumulative construction impacts of the two projects are expected. In regard to cumulative operational impacts, no major cumulative impacts are expected as the projects are separated geographically. The only exception is within the area of the proposed Rozelle maintenance depot, which abuts the western end of the Inner West Light Rail Extension. In this regard, the CSELR has the potential for some cumulative operational noise and visual impacts with the Inner West project.
WestConnex (Roads and Maritime Services)	Motorway connections to the arterial road network in the vicinity of the CBD are planned for WestConnex at the City West Link at Haberfield and Parramatta Road at Camperdown. This would lead to changes in traffic flows along these major arterials. Potential cumulative impacts relate to overlap of the CSELR and WestConnex construction timeframes, which may lead to additional traffic congestion along Parramatta Road/Broadway and City West Link/Western Distributor corridor and consequential amenity impacts in relation to noise, access and air quality.

11.2.3 Cumulative impacts with other major developments in the vicinity of the CSELR

Other major developments with the potential for cumulative impacts with the CSELR are identified in Table 11.3, including the status and indicative timing of these developments, and their likely impacts based on current knowledge. Potential cumulative impacts with the CSELR proposal are discussed following the table.

As well as the projects listed in Table 11.3, a number of other potential development projects in the vicinity of the CSELR proposal have been announced, but are only in the early planning phases. This includes:

- major new public squares at Town Hall, Railway Square/Central Station and Circular Quay – proposed by City of Sydney in its *Sustainable Sydney 2030* strategy
- NSW Government's Central to Eveleigh Global Precinct opportunity – a major strategy to extend the Sydney CBD beyond its southern boundary with proposals to renew the Central to Eveleigh rail corridor, including greenspace, high density housing, hotels and tertiary education facilities (expressions of interests to be put to the market in late 2013)
- development of the Randwick Urban Activation Precinct – a major strategy to increase urban densities within the Randwick and Kensington/Kingsford region, including potential concentration of potential urban consolidation and renewal around improved public transport options including the proposed CSELR stops
- implementation of the Kingsford Town Centre Strategy proposed by Randwick City Council – including improving retail strips along Anzac Parade and Gardeners Road in Kingsford.

If these projects proceed, they would all be required to integrate with the CSELR proposal. If they overlap with construction of the CSELR, they would also need to consider potential cumulative effects. As these possible projects are only in the very early planning stages, they have not been discussed further in this cumulative assessment.

Table 11.3 Major developments with potential for cumulative impacts with the CSELR

LOCATION (REFER FIGURE 9.15)	PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	LIKELY KEY IMPACTS OF PROJECT
01	Barangaroo Concept Plan development	Large-scale urban development of the former Darling Harbour east area between King Street Wharf and Walsh Bay. Development includes: • Barangaroo South – a 7.5 hectare extension of the Sydney CBD, including high rise retail, corporate offices, a hotel and apartments) • Barangaroo central – master plan under development, but likely to include low-rise residential, commercial and civic buildings) • Barangaroo north – a 6 hectare parkland called Headland Park with a cultural centre and underground car parking. 23,000 people will live and work in the precinct, with 33,000 expected to visit each day. Approximately 380 people will be working on-site during construction. The project includes a fully integrated public transport system – 96% are expected to use public transport, walk or cycle.	Under development. Barangaroo South – first two towers due to be completed along with Headland Park in July 2015 and rest of development by 2020. Barangaroo Central – planning has commenced, construction timing yet to be confirmed. Barangaroo north – due to be completed in 2015.	• Significant economic and employment generation – during and post-construction • Traffic, transport and access impacts during construction including increased truck and other vehicle movements, and/or road closures • Operational traffic and transport impacts – although impacts are proposed to be managed through integration with public transport network, and other measures such as restrictive parking supply and underground parking provision • Direct impacts to heritage items and archaeology and indirect impacts on heritage viewsheds • Visual and overshadowing impacts during construction and operation • Social and community impacts – minimised through incorporation of community facilities and parkland as part of development • Noise and vibration impacts from demolition and construction activities • Significant contamination on-site (soils and groundwater) – major remediation process required • Water, drainage and stormwater management – construction and operation • Waste management • Infrastructure and utility impacts *Sources: http://www.barangaroo.com/news-media/fact-sheets.aspx>, accessed 22/07/13* *NSW Government (2006) East Darling harbour, State Significant Site Proposal, Concept Plan and Environmental Assessment*
02	APDG Site commercial redevelopment (various developers)	Commercial redevelopment of block bounded by Alfred, Pitt, Dalley and George Streets at Circular Quay. Includes demolition of existing buildings and rebuild of new commercial, residential and retail towers with improved connections through the site and public domain improvements.	Part under development. Timing of remaining development unknown.	• Expected to have benefits in terms of urban design, public domain and connectivity, as well as economic benefits • Key environmental impacts/issues likely to include: – Construction traffic, access, noise, dust and amenity impacts – Visual and overshadowing impacts during operation

Table 11.3 cont.

LOCATION (REFER FIGURE 9.15)	PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	LIKELY KEY IMPACTS OF PROJECT
Wynyard Station	CityOne redevelopment at Wynyard Station (Thakral Holdings)	• Upgrade of Wynyard Station, including upgrade to eastern access ways to station, a new five-level retail area and new 29 storey office building • Demolition of Menzies Hotel on-site	Major project concept plan approved in 2012. Timing of construction unknown (anticipated 4-year construction period)	• Built form, urban design, privacy and overshadowing impacts • Rail and bus infrastructure and access impacts • Heritage impacts • Noise and vibration impacts during construction • Traffic impacts (construction and operation) • Parking impacts • Drainage and utilities impacts • Contamination *Source: Environmental Assessment Report, CityOne Concept Plan, JBA holdings, January 2011*
383 George Street	383 George Street (Fife Capital)	• Proposed demolition of existing buildings • New multi-storey mixed use development – commercial and retail	DA lodged. Construction proposed from second quarter 2014 for 2.5 years.	Likely to include: • Traffic impacts (construction and operation) • Built form, urban design, privacy and overshadowing issues • Noise and vibration impacts during construction
03	Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP Project) (Darling Harbour Live consortium)	• Demolition of the existing Sydney Convention Centre and Sydney Exhibition Centre and replacement with a new exhibition, convention and entertainment facility; a hotel complex; and an outdoor event space (at an expanded Tumbalong Park) • 'The Haymarket' student accommodation development providing approximately 2,360 dwellings • Public domain improvements and improved pedestrian connections with Ultimo and the City • Realignment of Darling Drive	Approved project. Core cultural facilities due for completion in 2016. Remaining retail, commercial, hotel and residential development due for completion by 2021. The Haymarket proposed for development from 2014–2021.	• Urban design, visual and amenity impacts • Transport and accessibility impacts during construction and operation • Social and economic impacts • Heritage and archaeology impacts • Water cycle management, water quality and drainage/hydrology impacts • Noise and vibration impacts during demolition, construction and operation • Impacts on utilities • Environmental and construction management • Significant benefits for the economy, public domain improvements, and provision of community facilities *Source: State Significant Infrastructure Application, Environmental Impact Statement, Sydney International Convention, Exhibition and Entertainment Precinct, Public Private Partnership Component, JBA, March 2013*

Table 11.3 cont.

LOCATION (REFER FIGURE 9.15)	PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	LIKELY KEY IMPACTS OF PROJECT
04	University of Technology (UTS) City Campus Master Plan	Creation of a series of new buildings, major upgrades to existing campus buildings and improved pedestrian connections and open spaces. Projects in progress include: • new Broadway Building to house the Faculty of Engineering and Information Technology • new Dr Chau Chak Wing Building • Building 1 upgrade • Thomas Street project, including new building and revitalised Alumni Green. Future projects in planning include Building 1 and 2 podium extension, refurbishment of Buildings 1, 3, 4 and 5 and relocation of library to Building 2.	Under development – commenced in 2008 with other new buildings due to be completed by August 2014. Planning for final phases has commenced and due for completion in late 2018–early 2019.	• Noise and vibration during construction • Impacts on university operations during construction • Dust generation during construction • Traffic and access impacts during construction • Traffic, transport and access considerations during operation • Urban design and visual impacts • Significant benefits anticipated in regard to: – Visual amenity of the streetscape – Economic benefits *Source: http://www.uts.edu.au/partners-and-community/initiatives/city-campus-master-plan/ accessed 22/07/13*
05	Central Park mixed use development (Frasers Property)	• Redevelopment of approx. 6 hectares of the former Carlton and United Brewery site on Broadway for a range of residential accommodation, retail, commercial office facilities, a 6,400 m^2 park and community facilities. • First stage is for two residential towers, 600 apartments and 14,000 m^2 of retail space.	First stage under development due for completion late 2013. Final stages due to be completed late 2013 to mid-2014.	• Urban design and visual impacts • Transport and access during construction and operation • Heritage impacts (although key heritage items retained and restored) • Noise, vibration and dust generation during construction • Contamination and remediation issues • Utilities infrastructure and stormwater management • Waste management • ESD considerations Anticipated benefits include: – Public domain and urban design improvements – Economic benefits – Allowance for affordable housing *Sources: http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=190 accessed 22/07/13* *Frasers Broadway, 27 Broadway, Chippendale NSW 2008, Concept Plan Modification, JBA, July 2008*

Table 11.3 cont.

LOCATION (REFER FIGURE 9.15)	PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	LIKELY KEY IMPACTS OF PROJECT
07	Redfern–Waterloo Authority Built Environment Plan – Stage 2 (Urban Growth Development Corporation)	• Plan for a series of urban renewal projects designed to stimulate economic and social progress in the Redfern, Waterloo, Eveleigh and Darlington region. • Stage 1 of the Plan seeks to create up to 18,000 jobs and 2,000 new dwellings, including a new town centre, through Redfern and Waterloo. • The draft plan for Stage 2 seeks to provide a mix of private, affordable and social housing.	Stage 1 – completed Stage 2 – 20–25 year timeframe.	• Urban design, public domain and built form issues • Social impacts • Traffic, transport and accessibility (construction and operation) • Built and Aboriginal heritage considerations • Amenity impacts during construction and operation • Anticipated benefits include: – Economic benefits – Urban renewal and social development benefits, including affordable housing *Sources: <http://www.smda.nsw.gov.au/precincts/redfern-waterloo-precincts, accessed 22/07/13*
09	Green Square redevelopment area and town centre (City of Sydney, Green Square Consortium and Landcom)	• $8 billion development 2 km west of the Royal Randwick racecourse, covering approximately 278 ha in Beaconsfield, Zetland, Rosebery, Alexandria and Waterloo. • The Green Square town centre includes planned construction of residential and commercial buildings, and community facilities including a community hall. exhibition galleries, multi-purpose recreation area and aquatic centre, in addition to a 6,500 m^2 park. • Expected to attract up to 40,000 new residents and 22,000 new workers to the Green Square precinct.	Under development. First residential components to be completed in 2015–2016. Overall development to be completed by 2030.	Key environmental impacts/issues comprise: • Land use change from primarily industrial and manufacturing use to mixed use commercial and residential precinct • Traffic, transport and access – the project will significantly alter transport patterns and increase travel demand to and from the precinct • Flooding and stormwater management • Urban design and visual impacts • Landscaping and open space • Infrastructure and utilities • Heritage impacts Anticipated benefits include: • Social benefits including affordable housing and urban renewal • Economic benefits *Sources: <http://www.cityofsydney.nsw.gov.au/development/major-developments/green-square>, accessed 22/07/13* *Green Square Town Centre Development Control Plan 2012 (City of Sydney)*

Table 11.3 cont.

LOCATION (REFER FIGURE 9.15)	PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	LIKELY KEY IMPACTS OF PROJECT
Moore Park	Entertainment Quarter Concept Plan, Moore Park	• Six additional buildings within Entertainment Quarter precinct of Moore Park Showground • Demolition of two existing buildings	Concept Plan approved in November 2011. Timing of construction unknown.	• Built form and urban design • Heritage • Transport and parking • Environmental and residential amenity • Demolition impacts • Hazards and potential land use conflicts *Source: Planning Assessment Commission, Determination of Entertainment Quartier Concept Plan, Moore Park, Sydney LGA, 25 November 2011*
10	Royal Randwick Racecourse Master Plan (Australian Turf Club)	• Includes redevelopment of the existing spectator precinct, a new stabling complex, and convention facilities • Also provides for construction of a new eight-storey, 170-room hotel and associated restaurant, bar, restaurant, conference facilities and basement parking • The proposed new facilities are expected to enhance the experience of racegoers and expand the scope of events held at the Royal Randwick racecourse *Source: <http:/royalrandwickracecourse.com.au/>, accessed 23/07/13*	Master plan was integrated into the Randwick DCP in June 2013. Hotel due to be constructed by early 2015. Other facilities – timing unknown.	Key environmental impacts/issues comprise: • Landscape and open space impacts including significant trees • ESD • Environmental and residential amenity and visual impacts • Noise • Traffic, transport and accessibility • European and Aboriginal heritage • Flooding, drainage and surface water management • Land contamination • Odour (from new stabling) • Sediment, erosion and dust control during construction Anticipated benefits include: • Social and economic benefits through encouragement of tourism accommodation in the region and broader Sydney catchment • Supporting facilities of other major land uses including Randwick hospitals, UNSW, Moore and Centennial Parks *Sources: Royal Randwick Racecourse – Hotel, Environmental Impact Statement, Urbis, June 2012* *Determination of Project Application, New Stables at Royal Randwick Racecourse, Planning Assessment Commission, February 2011*

Table 11.3 cont.

LOCATION (REFER FIGURE 9.15)	PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	LIKELY KEY IMPACTS OF PROJECT
11	UNSW Campus Master Plan	Three major projects proposed at the Kensington campus: • Kensington Colleges development - construction of five new colleges with housing for up to 920 students • Wallace Wurth building redevelopment - redevelopment of the existing building to modernise facilities and expand floor space from 13,000 to 21,000 m2 to house the Kirby institute; expected to accommodate over 1,250 students and 750 research personnel • Materials Science and Engineering building construction of a new 10-storey building with approximately 20,000 m^2 of floor space	Under development. Kensington colleges development (due for completion in early 2014). Wallace Wurth building redevelopment (due for completion in March 2014). Materials Science and Engineering building (due for completion in June 2015).	Environmental impact assessments are not available for these developments; however key issues/impacts are likely to include: • Traffic, transport and access during construction and operation • Noise, dust and amenity impacts during construction • Disruption of campus operations during construction • Visual and urban design considerations *Sources: <http://www.facilities.unsw.edu.au/node/74>, accessed 22/07/13*
12	Randwick Hospitals Campus Master Plan	• A major site within the wider Randwick education and health specialised centre • The Randwick Health Campus comprises four major hospitals: the Prince of Wales Hospital, Sydney Children's Hospital, Royal Women's Hospital and Prince of Wales Private Hospital • Single land parcel of approximately 13.26 hectares, bordered by High Street, Avoca Street, Barker Street and Hospital Road in Randwick • The master plan aims to consolidate incremental development that has occurred within the hospital campus, whilst providing the opportunity for expansion to accommodate short, medium and long term needs	Master Plan commenced in 2008 and is integrated into the *Randwick Comprehensive Development Control Plan 2013.*	Environmental impact assessments are not available for these developments; however key issues/impacts are likely to include: • Access and circulation • Heritage conservation • Landscape and open space • Urban design and visual amenity • Safety and security *Source: Randwick Comprehensive Development Control Plan 2013*

Table 11.3 cont.

LOCATION (REFER FIGURE 9.15)	PROJECT (PROPONENT)	DESCRIPTION	STATUS AND INDICATIVE TIMING	LIKELY KEY IMPACTS OF PROJECT
13	Sydney Interim Exhibition Centre at Glebe Island (Infrastructure NSW)	Interim exhibition centre for use during construction of SICEEP project (an approx. 4 year period) Includes temporary pavilion-style exhibition space of approximately 20,000 m^2, with the option for an additional 5,000 m^2 for temporary expansion for larger public exhibitions and trade shows. Temporary wharf at Glebe Island	Early works for the facility were due to commence in July 2013. Proposed to be finalised for the 2014 exhibition season (starting in February 2014).	• Built form and urban design • Transport, traffic and accessibility impacts • Noise and vibration impacts • Visitor access and associated works • Marine and water transport impacts • Water, drainage, stormwater and groundwater impacts • View sharing • Economic impacts • Heritage impacts • Infrastructure and services provision • Remediation and contamination impacts *Sources: http://www.infrastructure.nsw.gov.au/home/glebe-island-facility.aspx, accessed 22/07/13* *http://www.glebeislandexpo.com/, accessed 22/07/13* *Glebe Island Expo, Glebe Island and White Bay – Environmental Impact Statement, APP Corporation, November 2012*

City Centre Precinct

A number of major developments are proposed and/or under construction within the City Centre Precinct, between Circular Quay and Central Station. Of these the following have the potential to overlap with the CSELR construction:

- the Barangaroo Concept Plan development
- the APDG site commercial redevelopment
- CityOne development at Wynyard Station
- 383 George Street development
- the SICEEP Project
- UTS City Campus Master Plan development
- Central Park mixed use development.

The closest of these developments in terms of location are the APDG, CityOne and 383 George Street developments, which are adjacent to the proposed CSELR works on George Street and/or at Circular Quay. If the CSELR works in these areas overlap with the timing of these developments, there would be potential for cumulative construction impacts in relation to noise, traffic and access, dust and amenity. There is also potential for cumulative traffic impacts with the other major developments. Construction fatigue is also likely to be a concern to those residing, staying in hotels and working in the CBD, due to the intensity of development proposed in the City Centre before and over the course of the CSELR construction.

All of the major developments proposed in the City Centre are potential patronage generators for the CSELR proposal. In turn, the CSELR would provide an alternative public transport service within the city, and out to the South East, thereby enhancing accessibility and promoting a shift to public transport. Road network performance modelling undertaken for the CSELR proposal (refer Technical Papers 1 and 2) has incorporated additional demand and changes in the road network associated with these developments. Therefore, the traffic and transport operational impacts described in Chapters 9 and 12 of this EIS are a cumulative assessment of impacts of these projects.

Together the CSELR and these developments would also be expected to have cumulative benefits in relation to economic and employment generation (construction and operation), public domain improvements and urban renewal. Cumulative operational impacts may include operational noise impacts associated with road traffic noise changes and operation of the CSELR.

Surry Hills Precinct

No major developments were identified within the Surry Hills Precinct with the potential for cumulative impacts with the CSELR. The Redfern–Waterloo Built Environment development Stage 2 extends into the suburb of Surry Hills; however, this is discussed in the context of broader regional developments in section 11.2.3

Moore Park Precinct

The proposed Entertainment Quarter Concept Plan development has the potential for cumulative impacts with the CSELR if the construction timing overlaps with the CSELR development. Traffic and transport and amenity impacts during construction are likely to be the key cumulative issues. The Centennial and Moore Parks Trust has also released a Centennial Parklands Strategic Vision and Master Plan, which proposes a Strategy for the future management of Centennial Parklands, including Moore Park and the Entertainment Quarter. However, projects under the Strategy are mostly in the early planning stages; other than the new Northern Stand at the SCG and an upgrade to Moore Park Golf Course which should both be completed prior to construction of the CSELR.

Randwick Precinct

The Randwick Precinct includes part of the Centennial Parklands, which is subject to the Centennial Parklands Strategic Vision and Master Plan discussed above. Projects under this plan are only in the very early planning stages. The Strategy also incorporates and integrates with the CSELR, which should ensure that operational cumulative impacts are largely positive.

The Randwick Hospitals Campus Master Plan, UNSW Master Plan and the Royal Randwick racecourse developments all have the potential for cumulative construction impacts with the CSELR within the Randwick Precinct. Cumulative traffic, transport and access and amenity impacts (such as noise and dust) during construction would be a key concern for these land uses, which are all destinations for visitors from the broader Sydney region. There is potential for cumulative visual impacts of the proposed Randwick stabling redevelopment (corner of Wansey and Alison Roads) and the CSELR on adjacent residents in Wansey Road and Alison Road; however, the proposed stabling redevelopment is located within a ‘sunken’ corner of the racecourse, which would reduce potential impacts.

Disruptions in access to the hospital emergency departments are a particular concern for the hospitals; however, both the CSELR and the hospital development would have detailed management strategies to avoid impacts on hospital visitor safety. As the proponents of these developments are all key stakeholders for the CSELR, they have been closely involved in construction planning and would continue to be consulted as the project develops.

As outlined previously in section 9.3 and further in Chapter 15, the future development of the Randwick Urban Activation Precincts (UAP) program would substantially increase travel demand as a result of the proposed development within this area. While still in the early stages of planning, the NSW Government has recognised that the construction of the CSELR proposal in the precinct would provide a catalyst for urban renewal and consolidation. The delivery of a high-capacity and reliable mode of transport through the area would support the additional social and community infrastructure being delivered through the UAP program.

The developments should all have benefits in relation to potential patronage for the CSELR, and the CSELR would in turn provide an alternative public transport service for visitors to these sites. Although the various developments would lead to a major change in the visual environment, the various master plans have been carefully planned to minimise tree removal and visual impacts. Overall, no major cumulative operational impacts would be expected with development of these projects and the CSELR.

Kensington/Kingsford Precinct

This precinct also incorporates the UNSW Master Plan development discussed in section 11.2.3.4. No other major developments were identified within the Kensington/Kingsford Precinct with the potential for cumulative impacts with the CSELR.

Developments in the broader region

The proposed Green Square Redevelopment and Town Centre and the Redfern–Waterloo Built Environment Plan (Stage 2) developments are major mixed use urban developments proposed within the broader region surrounding the CSELR. Due to their geographic separation from the CSELR alignment, neither development is likely to have major cumulative impacts with the CSELR during operation.

In terms of construction, the Green Square development has the potential to overlap in terms of timing with CSELR, and potentially transport routes. The Redfern–Waterloo Stage 2 development has a 20–25 year timeframe so is unlikely to overlap.

11.3 Management and mitigation

The potential cumulative construction impacts associated with the CSELR and other major transport and other developments would be further considered as the detailed design and detailed construction planning are developed. Transport for NSW would coordinate activities with the proponents of these other major project to minimise potential cumulative impacts.

As a minimum, the following construction management plans would incorporate measures, where required, to manage cumulative construction impacts:

- construction traffic management plan
- construction noise and vibration management plan
- air quality and dust management plan
- construction compounds and ancillary facilities management plan
- earthworks management plan – which would include measures to manage water quality.