

DISCIPLINE CASE STUDY

Rail & Rail Infrastructure

Parkes National Logistics Hub — Parkes, NSW, Australia.

BG
&E
Part of SYSTRA



Murdoch, Bull Creek & Canning Bridge Stations

RAILWAY STATIONS

PERTH, WA, AUSTRALIA

CLIENT: PUBLIC TRANSPORT AUTHORITY

BG&E, alongside sub-consultant GHD, provided structural and civil engineering for the construction of three railway stations at Murdoch, Bull Creek and Canning Bridge as part of the Southern Suburbs Railway rail stations and transport infrastructure project.

Key project features included:

- New bus bridges over the freeway at Bull Creek and Murdoch stations.
- Extensive earthworks for at-grade parking, bus circulation and shared paths.
- A new pedestrian bridge at Bull Creek provides disabled access from adjacent residential areas.
- Conversion of the existing bus transfer facility into an intermodal transit station at Canning Bridge, including new lifts, stairs, platforms and services.
- Reconfigured traffic lanes and updated signal phases at Canning Bridge significantly improved bus efficiency at Curtin University.

All three sites are within the Kwinana Freeway corridor and therefore needed to be constructed with minimum disruption to freeway traffic.

Works at all three sites were required to interface with other railway works, especially Package E (Freeway Works) and Package A (Railway Infrastructure). Associated works included services diversion and modifications to existing bridges.

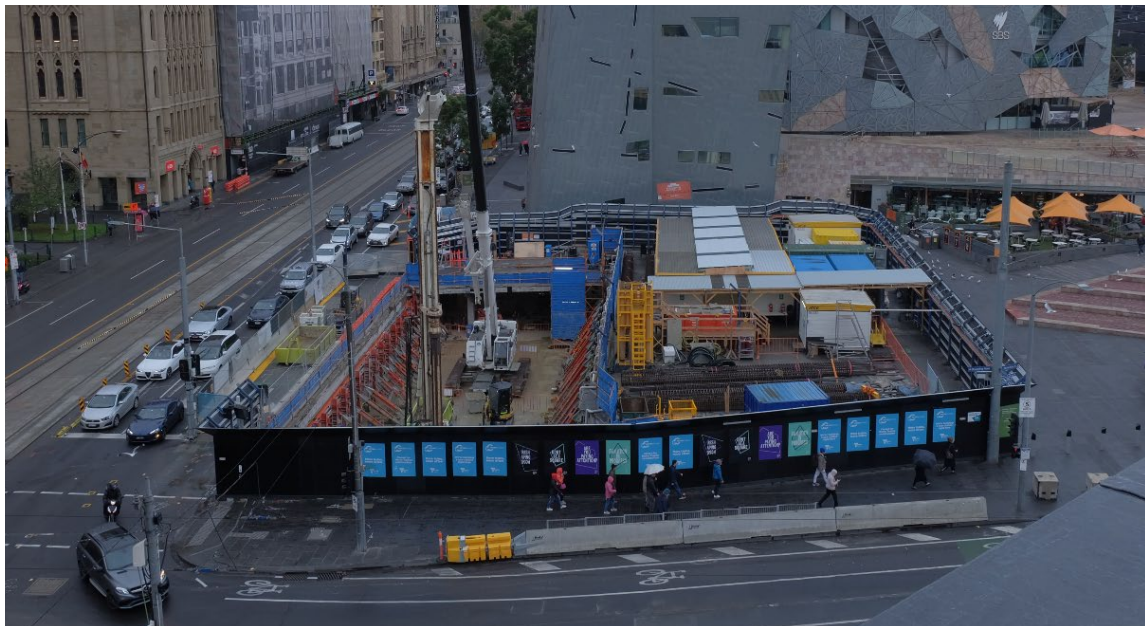
Melbourne Metro

RAILWAY STATIONS

MELBOURNE, VIC, AUSTRALIA

CLIENT: CROSS YARRA PARTNERSHIP

The Melbourne Metro is a city-shaping project featuring a nine kilometre tunnel beneath the CBD, connecting the west and east, with an estimated cost of \$11 billion.



BG&E has secured several important contracts as part of this massive infrastructure project. Specifically, our team is providing the design and documentation for the temporary works to allow evacuation for the new station access shaft, located next to the iconic Federation Square. This design was challenging as it involved maintaining the integrity of the existing Square's suspended slabs during the demolition work.

Other works include design and documentation for:

- Large-scale steel strutting and waler systems for various access shafts in the CBD.
- Retaining walls to allow the construction of new lift shafts in each platform at Flinders Street Station.
- Heavy working decks, tower crane gantries, and complex analysis to assess alternative construction sequencing.



Newcastle Station Stage 2 — Building & Landscape Design

RAILWAY STATIONS

NEWCASTLE, NSW, AUSTRALIA
CLIENT: TRANSPORT FOR NSW

BG&E provided structural condition assessments and engineering advice on the existing masonry structures for the Newcastle Station Stage 2 Building and Landscape Design project.

The project forms part of a broader revitalisation program led by the Hunter and Central Coast Development Corporation (HCCDC), in partnership with Transport for NSW, industry and the local community.



Perth Stadium Station

RAILWAY STATIONS

PERTH, WA, AUSTRALIA

CLIENT: PUBLIC TRANSPORT AUTHORITY

The Perth Stadium Station is a dedicated rail station servicing the stadium and is a key component of the city's public transport network. The station has capacity to facilitate the quick and safe movement of up to 28,000 patrons per hour during major events.

BG&E was involved at various stages of the station's design, including the development of the concept design package for the station and immediate precinct, and working with the Architect during the design development phase for the Public Transport Authority (PTA).

We were also appointed as the civil consultant responsible for the development of the drainage strategy and design of the civil elements for the station concourse and immediate precinct adjacent the rail corridor.

The civil design included the following elements:

- Drainage connections for platform.
- Drainage connections for concourse roof structures.
- Coordination of inground services.
- Retaining wall to perimeter of perway.
- Carparking bays for PTA use.
- Station access from Victoria Park Drive by PTA personnel and emergency vehicles.
- Set out of platform edge angle.
- Assist in the development of construction staging of the works.
- Platform walls.

Perth Station Upgrade

RAILWAY STATIONS

PERTH, WA, AUSTRALIA
CLIENT: WESTRAIL



BG&E was involved with the majority of the structural work associated with the upgrade of Perth Station facilities to meet the demands of an expanding rail network, together with the related Forrest Place Redevelopment.

The work included:

- Construction of the City Station carpark over the operating railway by incrementally launching a transfer deck.
- Modernisation of the station, including the spaceframe.
- Construction of a new platform for the Joondalup line.
- Western extension of the existing station.
- Construction of the Roe Street Bridge.
- Installation of concourse lifts and escalators.
- Pedestrian overpasses linking the station to the bus terminal.

Thornlie Station

RAILWAY STATIONS

PERTH, WA, AUSTRALIA

CLIENT: PUBLIC TRANSPORT AUTHORITY



BG&E provided structural and civil engineering services for the Thornlie Railway Station, a new station on the spur line to the Armadale passenger rail line.

The scope of works included structural engineering for the station building, civil works for car parking and pedestrian access, and integration of the station design with the Spencer Road overpass, pedestrian facilities and car park.

Thornlie Station consists of a single storey steel framed structure with masonry cladding to the station facilities areas. Cantilevered bus shelter roofs are a feature of the bus drop-off points on each side of the main entry to the station. The roofs cantilever off the face of a sweeping masonry parapet wall with punched openings. Masonry noise walls are provided to offer both noise protection and visual screening for passengers and nearby residents.

Glendalough Station

RAILWAY STATIONS

PERTH, WA, AUSTRALIA

CLIENT: PUBLIC TRANSPORT AUTHORITY



Glendalough Railway Station is constructed on the median of the Freeway embankment, adjacent to the road and rail bridges over Scarborough Beach Road.

The precast concrete platform was constructed as part of the bridges contract, with the station being constructed in a subsequent contract. The entry to the station is at Scarborough Beach Road level with escalator and lift access to the platform level.

The station itself has an elegant, lightweight, steel framed roof structure and glazed curtain walls.

NorthLink Western Australia, Stage 3

RAILWAY BRIDGES

PERTH, WA, AUSTRALIA

CLIENT: CPB CONTRACTORS



The \$175 million NorthLink WA Stage 3 project involves the design and construction of approximately 26 kilometres of new dual carriageway highway between Ellenbrook and Muchea, in the north east of Perth.

This project is the third stage of the overall \$1.12 billion NorthLink WA project, which also included upgrades to the Tonkin Highway to complete a free flowing state-of-the-art transport link connecting Great Northern Highway and regional areas with Malaga, Kewdale and Perth Airport.

In partnership with CPB Contractors, BG&E is the Lead Consultant to deliver the design and construction of the NorthLink Stage 3 project.

The key features of this mega infrastructure project comprise:

- A 26 kilometre freeway, standard dual carriageway highway, fully grade separated.
- Three grade separated roundabout interchanges, each with two bridges to carry the highway over the roundabouts below.
- Two bridges over railways and local roads.
- Two bridge over waterways.
- A four metre wide principal shared path extending the full length of the highway.
- A pedestrian underpass and a pedestrian bridge.
- More than 100 culverts, which require flood modelling to design and optimise.

Some of the elements of BG&E's structural design include:

- An innovative continuous bridge design at the two railway crossings, with precast TeeRoff beams that were made using a simple post-tensioned stressbar joint over the piers.
- Adoption of smaller "winged-plank" precast girders to allow for an improved span-to-depth ratio and easy installation (of the small units).
- Full precast concrete barrier panels, attached to the bridge deck with a small stitch joint.
- Six variable message sign units.

BG&E is also coordinating the other design services including electrical, geotechnical, pavements and landscaping, as well as represented the design team during the community and stakeholder engagement process.

*NorthLink Western Australia, Stage 3 —
Perth, WA, Australia.*



New Avon River Bridge

RAILWAY BRIDGES

STRATFORD, VIC, AUSTRALIA
CLIENT: CPB CONTRACTORS



The trains travel at up to 90 kilometres per hour on the new structure, which is a significant improvement on the former bridge, which had a speed limit of 10 kilometres per hour.

BG&E provided bridge, track, civil structures, geotechnical and pavement design, as well as flood modelling and drainage design, for the new bridge.

A key part of this project was introducing a flood relief structure and culverts in the vast floodplain area.

The new Avon River Bridge provides improved reliability and safety, for passengers users of the surrounding roads.



Tonkin Gap Project

RAILWAY BRIDGES

PERTH, WA, AUSTRALIA

CLIENT: MAIN ROADS WESTERN AUSTRALIA

BG&E undertook the detailed development and design for this critical piece of infrastructure that has transformed the Tonkin Highway into a safe and efficient north-south transport link — relieving the bottleneck where the Great Eastern Highway reduced from three lanes to two in Bayswater and Redcliffe.

The \$500 million Tonkin Gap and Associated Works Project was delivered by the Tonkin Gap Alliance, which includes Main Roads WA, Public Transport Authority (PTA), Georgiou, BMD, WA Limestone, GHD, and BG&E.

The associated works include the design and construction of rail-enabling works, including rail bridges and significant dive structures for the METRONET Morley-Ellenbrook Line on behalf of the PTA, to enable trains to enter the median strip of Tonkin Highway at Bayswater, exiting in Malaga.

The project had complex bridge structures (Tee-Roff concrete, launch bridges, steel footbridge, and arch footbridge), two dive structures, the principal shared path underpasses, noise walls, and mechanically stabilised earth walls.

The delivery of the Morley Station Bus Interchange Bridge over Tonkin Highway involved coordination with Transperth to divert bus routes and provide temporary bus stops to service patrons. In addition, the project had to plan to minimise disruption to the Midland Line during the design and construction of the two new Tonkin Highway bridges spanning the line.

The project spanned two LGAs and required delivery of multiple PTA, Main Roads and local government assets. Given the constrained environment, there was a considerable focus on engagement throughout the design and construction.

The project was highly constrained by existing infrastructure. Due to a narrow corridor, high water table, presence of live traffic, and critical services — the project was highly complex.

To minimise the risk associated with future space-proofing and constructability, design development and conflict identification were undertaken through digital systems such as 12D and Revit. This approach also aided realtime visualisation of the design as it developed and improved collaboration with the client and construction team.

During the project design stage, several development challenges were identified due to design development, groundwater modelling impacts, changes to rail alignment, and operational efficiency audits.

The project team worked closely with the Main Roads WA project director and client to work through these challenges.

Two BG&E employees were members of the Alliance Management Team and presented to the Board, Steering Committee, external reference groups, ONRSR, community reference groups, and community members.

The success of this project can be attributed to the effective communication of management and governance to the wider project team so that all parties were aware of decisions and outcomes to prevent abortive work.

*Tonkin Gap Project —
Perth, WA, Australia.*



Etihad Rail Network Viaducts, Stage 2

RAILWAY BRIDGES

ABU DHABI, UNITED ARAB EMIRATES
CLIENT: WSP (FOR ETIHAD RAIL)

Etihad Rail's 1,200 kilometre network will extend across the United Arab Emirates (UAE), from the border of Saudi Arabia to the border of Oman.



Engaged as a subconsultant to WSP, BG&E provided structural engineering services for Stage Two C of Etihad Rail's major national railway project, which links the Saudi Arabian and Gulf Cooperation Council (GCC) rail networks in the West to the Oman border and GCC rail network in the East.

The new infrastructure promotes growth in the UAE's industrial and services sectors and enables increased mobility of freight and passengers between cities in the UAE, ports and manufacturing hubs.

BG&E provided the detailed design for approximately 1.8 kilometres of railway bridges for the Desert Main Line C (DMC) and Jebel Ali Branch Line (JBL) line. The bridges mainly consist of post-tensioned cast-in-place box girders supported on concrete piers and piled foundations, and steel through or semi-through materials were deployed where the bridges crossed roads.

The 1.3 kilometre JBL railway bridge includes 36 supported spans, ranging between 17 metres and 72 metres. The 550 metre DMC railway bridge includes 15 spans, either with a simply supported or continuous deck.

In addition to enhancing sustainable economic development, the Etihad Rail Stage Two construction project supports the wellbeing and quality of life of residents and tourists. This project is viewed by government as integral to supporting the UAE's Centennial 2071 as well as strategically enhancing the region's leadership.

*Etihad Rail Network Viaducts, Stage 2 —
Abu Dhabi, United Arab Emirates.*





Sydney Yard Access Rail Bridge

RAILWAY BRIDGES

SYDNEY, NSW, AUSTRALIA

CLIENT: LAING O'ROURKE

The Sydney Yard Access Bridge was one of the early and enabling package of works for the Sydney Metro City and Southwest projects — it runs over the New South Wales (NSW) country rail lines and has allowed for construction of the new Central Station.

The bridge crosses five inter-city rail lines that had never been closed under a single possession. During full closure, the main girders and cross girders were installed within the 54 hour possession window.

BG&E provided the detailed design of the Sydney Yard Access Bridge and the associated civil works and drainage design. The access bridge stretches across Regent Street in Surry Hills and is 140 metres long and eight metres wide with complex vertical and horizontal geometry.

Due to the fixed start and end points of the structure and the need to clear the overhead wires while maintaining a maximum grade, our team developed a box girder solution which enabled the grade to be achieved and the structural design to be carried by a two metre deep steel box through girder solution.

The tracks below meant the location of the piers was highly constrained. Minimum offsets from rail centre lines further restricted their physical location. The final position resulted in skews of 66 degrees to the deck. BG&E recommended a ladder deck system to ensure the cross members of the deck could remain perpendicular to the main girders, which mitigated any issues commonly associated with high skews.

*Sydney Yard Access Rail Bridge —
Sydney, NSW, Australia.*



Roy Hill Mine Railway Bridges

RAILWAY BRIDGES

PILBARA REGION, WA, AUSTRALIA
CLIENT: CALIBRE GLOBAL

BG&E supported the major greenfield Roy Hill Railway Bridges project from early stages through to detailed design and delivery.

Located in the East Pilbara Region, the Roy Hill Mine is designed to produce 55 million tonnes of iron ore annually, featuring one of the world's largest iron ore mines, a port facility at Boodarie Industrial Estate, and a 350 kilometre heavy haul rail line connecting the mine to the port.

BG&E provided bridge design, civil and structural engineering services, and hydrological analyses for the Roy Hill Mine and associated infrastructure to the port.



The scope of works included the following key elements:

- Waterways analysis, including hydrological analysis, hydraulic analysis, scour estimation, and design of scour protection for major river crossings in the Pilbara Region.
- Detailed design of eight rail-over-water bridges (steel-concrete composite), with bridges of up to 10 spans.
- Detailed design of three rail-over-rail overpass bridges (steel through-girder), with spans of up to 45 metres.
- Stakeholder liaison to agree designs for grade separated rail-over-rail crossings, where the Roy Hill crossed over FMG, BHPBIO and BC Iron assets.
- Detailed design of one road-over-rail bridge over the port rail loop.
- Civil roadworks design of Great Northern Highway intersection, level crossing, port access road and intersection, and rail construction yard — including the earthworks.
- Management of geotechnical investigation, including fieldwork, testing, interpretive reporting, and design for bridges.
- Design of pavement and surfacing for access roads and Great Northern Highway.
- Safety and constructability reviews and workshops.
- Liaison with stakeholders.
- Technical specifications to comply with Roy Hill and Main Roads WA requirements.
- Construction support.

*Roy Hill Railway Bridges —
Pilbara Region, WA, Australia.*



Great Eastern Highway Bypass Interchanges

RAILWAY BRIDGES

PERTH, WA, AUSTRALIA

CLIENT: MAIN ROADS WESTERN AUSTRALIA



The Great Eastern Highway Bypass Interchanges project involves the \$80 million upgrade of two major highways at Roe Highway and Abernathy Road, extending Lloyd Street and constructing a new bridge over Helena River in the heart of one of the busiest commercial zones in Perth.

Prior to the implementation of this project the highways had traffic bottlenecks and accident black spots while handling approximately 60,000 vehicle movements, including 6000 heavy vehicles per day.

BG&E provided bridge design and civil engineering services for the 2.1 kilometre project, which included grade-separation of the Roe Highway over Great Eastern Highway, on two bridges, with one carrying the Roe Highway and the other a separate loop ramp.

The interchange solution comprised three unique concrete underpasses, taking shared paths under the interchange ramps. Five metre wide precast beams were used to minimise the overall number of elements and lifting operations. On the bridge over Great Eastern Highway this enabled the number of precast beams forming the 30 metre wide deck to be reduced to six. Precast elements were also extensively used for noise walls, mechanically stabilised earth walls and underpasses.

Also included in this project were duplications of bridges over the east-to-west freight railway and Clayton Street, and modifications to the adjacent existing bridges. The scope of work required the new bridge over the railway to be matched with the existing haunched bridge for aesthetic reasons. An in-situ construction method was deployed, over operating rail tracks.

As the entry to Perth from the eastern states, the Great Eastern Highway and Roe Highway Interchange features a vibrant public art, which represents local wildflowers.

*Great Eastern Highway Bypass Interchanges —
Perth, WA, Australia.*



Graham Farmer Freeway, Stage 2

RAILWAY BRIDGES

PERTH, WA, AUSTRALIA

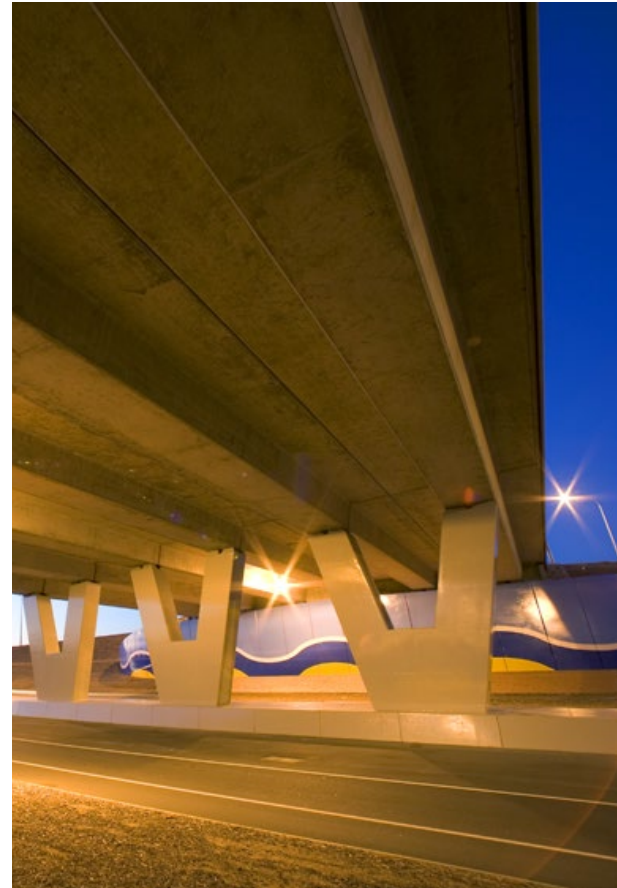
CLIENT: MAIN ROADS WESTERN AUSTRALIA

Graham Farmer Freeway is a 6.5 kilometre link connecting Rivervale and Burswood with West Perth and Leederville, providing a bypass of the CBD.

Stage 2 of the Graham Farmer Freeway includes:

- Four kilometre dual three lane carriageways.
- Three interchanges and nine bridges, including the 406 metre Windan Bridge across the Swan River.
- Relocation of the Perth-Armadale railway line.
- A new station and footbridge at Belmont Park.
- Shared paths and an underpass under the East Parade.

The name of this inner-city freeway is in honour of the Australian rules footballer, Graham “Polly” Farmer, who played between 1953 and 1971 in both the West Australian and Victorian Football Leagues.





Forest Hill Timber Bridge Replacement

RAILWAY BRIDGES

FOREST HILL, QLD, AUSTRALIA

CLIENT: QUEENSLAND RAIL

Queensland Rail replaced 18 rail bridges between Ipswich and Chinchilla with more durable steel structures, improving the safety and reliability of the network.

One of the bridges included in this package is the bridge west of Forest Hill. The original 7.7 metre three span bridge was replaced with a 45 metre three span bridge to enable larger hydraulic flows.

The original timber bridge was demolished and replaced with the new bridge, which was constructed within a 40 hour shutdown of the rail line.

BG&E provided the design, documentation, temporary design and construction support for the new larger span precast girder bridge for the rail main line at Forest Hill. Relevant design detailing and construction methodologies have been incorporated to achieve the construction in such a short timeframe.

The primary elements of the replacement bridge include:

- Bored piles (installed prior to shutdown).
- Precast headstock.
- Pile to headstock connection to suit restricted construction timeframe.
- Precast deck girders.
- Precast relieving slab.
- Prefabricated handrails.

BHP Iron Ore RGP5 Mainline Rail Upgrade

RAILWAY BRIDGES

PILBARA REGION, WA, AUSTRALIA
CLIENT: CALIBRE RAIL (FOR BHP)

BHP Iron Ore (BHPBIO) operates an integrated system of four processing hubs and five mines which are connected by more than 1,000 kilometres of rail infrastructure and port facilities in the Pilbara region of WA.

BG&E provided the detailed design and documentation for 10 new dual-track rail bridges over major waterways, as part of BHPBIO's RGP5 Mainline Rail Upgrade, between Newman and Port Hedland.

The project included installation of 216 piles, 13,000 cubic metres of reinforced concrete and 5,500 tonnes of structural steelwork.

Our team developed a modular steel bridge system, consisting of common steel-concrete composite deck units, steel headstocks, steel pier trestles supported on standardised concrete pile caps and footings throughout the bridges. The use of modular, offsite fabrication and standardised construction provided a cost-effective solution, which streamlined the construction process and allowed for rapid and safe installation.



Rail Capacity Enhancement Project

RAILWAY BRIDGES

PILBARA REGION, WA, AUSTRALIA
CLIENT: CALIBRE GLOBAL

The Rail Capacity Enhancement (RCE) Project was one of the largest railway expansion projects undertaken in Australia, enabling Rio Tinto to increase production of iron ore handled by the Pilbara Iron Rail Network to 353 metric tons per annum.

The project consisted of the duplication of 70 kilometres of track, and construction of four new major bridges and three major arch culverts. BG&E was engaged as a sub-consultant to Calibre Rail to provide bridge design services for the project. This included structural design of the bridges and arches, waterways analysis and the management of geotechnical and quantity surveying services.

We also continued our involvement in the later stages of the project, providing construction support services to the contractor.

The three arch culverts comprised of semi-circular steel multi-plate arches with reinforced concrete headwalls and wingwalls. The culvert invert was lined with a concrete slab with concrete cut-off walls at the ends.



The multi-span bridge superstructures at Miller Creek and Western Creek comprised of fabricated steel girders made composite with an in-situ reinforced concrete deck slab to accommodate a single rail track. The girders contained transverse and plan bracing and supported steel ballast panels and walkways as required.

The abutments consisted of in-situ reinforced concrete walls above reinforced concrete pile caps supported on bored piles founding on the rock level.

The piers consisted of a steel column and headstock supported on a reinforced concrete spread footing anchored into the rock or a reinforced concrete pile cap and bored piles where the ground conditions did not contain rock at the higher level.

The road over rail bridge constructed on the North West Coastal Highway consisted of single span bridge containing precast prestressed concrete trough beams supporting an in-situ reinforced concrete deck. The substructure for the bridge was supported on a reinforced concrete cap-beam, concrete columns and pad footing with MSE wall facing panels.

*Rail Capacity Enhancement Project —
Pilbara Region, WA, Australia.*



Mining Area C Railway, BHP Upgrade

RAILWAY BRIDGES

PILBARA REGION, WA, AUSTRALIA
CLIENT: BHP BILLITON

Our team provided concept design, review and independent engineering verification for four bridges on the BHP Billiton Mining Area C to Yandi Railway project.

These included:

- Yandicoogina Creek Bridge.
- Marillana Creek Bridge.
- Hamersley Iron Crossover.
- Yandi Underpass.

The concept design engineering review report specifically looked at the design and construction aspects of the Yandicoogina Creek Bridge and other bridge structures on the Mining Area C railway. The recommendations made for a sound and cost-effective engineering solution to ensure the operation of the railway would be without disruption.

We also carried out a detailed and independent verification of the four bridges, including comprehensive reporting.





Nebo Train Maintenance Facility

RAILWAY YARDS & MAINTENANCE FACILITIES

BRISBANE, QLD, AUSTRALIA

CLIENT: CALIBRE RAIL (FOR BHP)

After identifying commercial opportunities in QLD for the haulage of coal on the Goonyella rail system to the Port of Hay Point, Pacific National implemented a train provisioning and maintenance facility, approximately 10 kilometres south of Nebo, near Mackay.

The facility enables the provisioning and maintenance of Pacific National trains to ensure reliable and efficient operation, including the refueling of trains, routine train inspections and wagon and locomotive maintenance work.



BG&E provided civil, structural, and flooding and drainage services for the \$180 million facility, including:

- Design of key infrastructure: maintenance and admin buildings, wash-down building, warehouse, wheel lathe building, turntable, two provisioning buildings (with sanding system and fuel farm), gatehouse, water treatment facility, water storage dam and tanks, fire water storage, sticky coal ramp, traction control unit, and locomotive testing facility.
- Design and documentation of seven kilometres of rail, including a rail maintenance yard.
- Design and documentation of six kilometres of service road in compliance with Department of Transport and Main Roads standards.
- Design and documentation of three major corrugated steel pipe culvert crossings.
- A flood study of the three surrounding catchment areas (including 125 hectares) to determine the upstream afflux flooding effects of installing the three major culvert crossings.
- Civil specifications.
- Construction support.
- Involvement in road safety in design audits and reviews.

*Nebo Train Maintenance Facility —
Brisbane, QLD, Australia.*





Liberty Steel Bulk Handling Facility

RAILWAY YARDS & MAINTENANCE FACILITIES

ACACIA RIDGE, VIC, AUSTRALIA
CLIENT: PACIFIC NATIONAL

One of Australia's market leaders in rail freight solutions, Pacific National (PN), is developing a new bulk handling facility for steel at Acacia Ridge in QLD.

BG&E provided civil and structural engineering services for the new facility, specifically, site investigation management, optioneering, concept design and cost estimates, a solution to retain the existing pavement, facility staging and operability optimisation.

Our highly-skilled team provided a design optioneering approach for PN and Liberty Steel which ensured the interests of all stakeholders were exceeded. BG&E also provided input into the detailed cost estimate options and quantities to assist with procurement.

The key components of our solution include:

- A new steel terminal.
- Shunt simulation.
- Rail and road design.
- Formation and civil design.
- Pavement capacity and design.
- Stormwater design.

Upon completion, the state-of-the-art facility will import, handle and load steel onto freight trains for distribution across the nation.

Rail Maintenance Yard Independent Verification

RAILWAY YARDS & MAINTENANCE FACILITIES

BOWEN, QLD, AUSTRALIA

CLIENT: BOWEN RAIL COMPANY

As the independent verifier for the Bowen Rail Company's rail maintenance and provisioning facility, BG&E provided civil engineering services, including review of the yard design for compliance against standards and industry best practice.

The scope of work included identifying areas for optimisation, value adding and reducing costs, in consideration of master planning and future expansion of the facility. Operations and maintenance of the yard were critical in determining the overall suitability and compliance to project requirements.

Our winning technical team have decades of experience in delivering similar facilities and each element of the layout has been interrogated.

The Bowen Rail Company is a leading provider of solutions to transport QLD's resources for export across the globe, using their technologically advanced fleet of locomotives.





Rail Plant Maintenance Facility

RAILWAY YARDS & MAINTENANCE FACILITIES

BATHURST, NSW, AUSTRALIA

CLIENT: JOHN HOLLAND COUNTRY REGIONAL WORK

As the lead consultant, BG&E provided the concept design for a new facility equipped for undertaking a full range of rail plant maintenance activities on Country Rail Network's (CRN) track maintenance plant.

BG&E worked with John Holland's team to provide an "engineering" based functional facility which focused on operational efficiency and constructability.

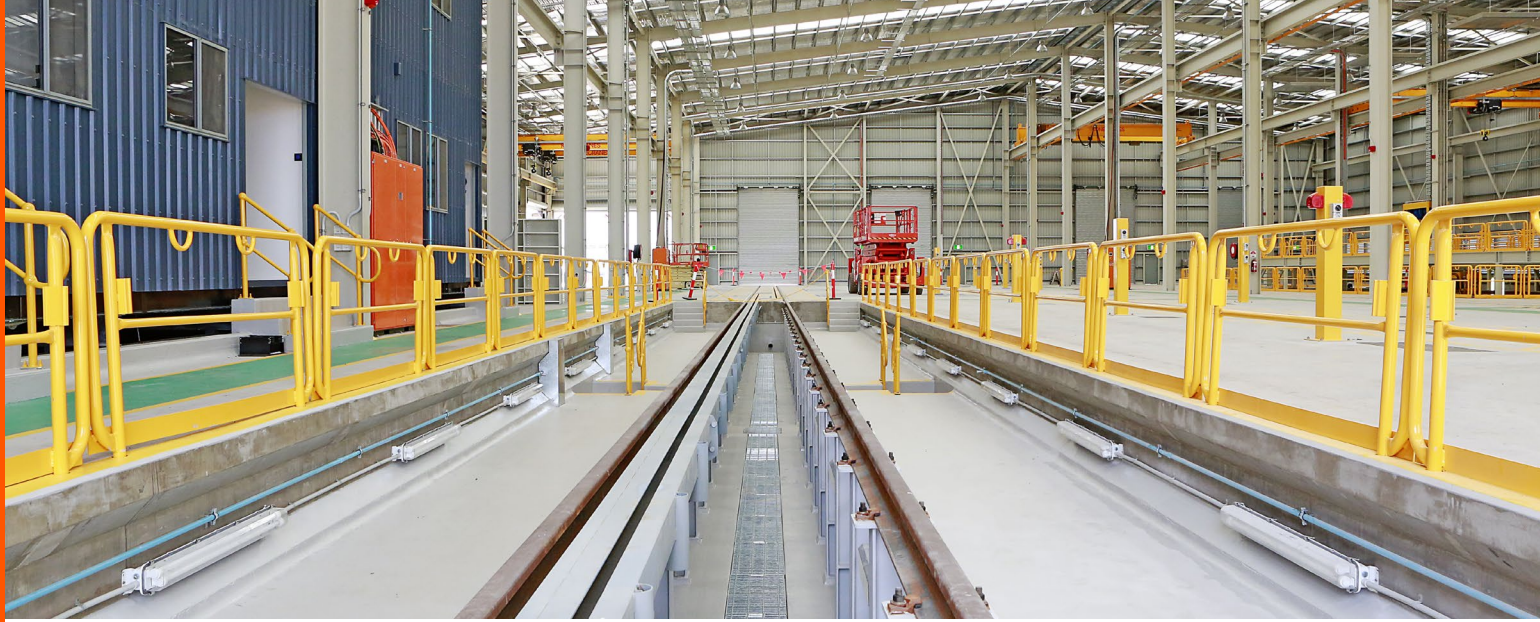
The facility includes:

- Buildings with workshop storage, administration areas and a wash down bay.
- Two new rail sidings, one kilometre in length, adjacent to the existing mainline.
- Connection to mainline.
- Allowance for an additional future mainline connection.
- New turnouts, buffer stops and suspended rail over pits.

The concept design provided by BG&E was driven by listening to our client's needs and providing a functional layout to allow maintenance operations to be carried out safely and effectively.

BG&E worked with John Holland's team to provide an "engineering" based functional facility which focused on operational efficiency and constructability.

This project involved a close working relationship with the client and facility operators, allowing them to maintain a level of input over the design to achieve the most efficient and cost effective outcomes.



Pacific National Rail Maintenance Facility

RAILWAY YARDS & MAINTENANCE FACILITIES

WAITARA, QLD, AUSTRALIA
CLIENT: PACIFIC NATIONAL

In order to support their coal haulage in the Goonyella, Blackwater and Newlands rail networks, Pacific National required a maintenance facility to maintain and operate their locomotives.

A new facility was constructed at Waitara, QLD to satisfy this requirement. The new facility featured a new access road, laydown areas and carparking, including associated pavements and drainage, a maintenance building with a service pit and overhead crane, administration office and amenities building. Water treatment and additional storage facilities were also provided.

BG&E, as part of the Pacific National Infrastructure Alliance (Pacific National, BG&E, Abigroup and QR National), was responsible for designing the facility. As lead consultant, BG&E was responsible for the engagement and management of other design consultant.

Design facets included:

- Civil engineering — including earthworks, rail, roadworks, stormwater and flooding.
- Structural engineering.
- Architectural services — including operational layouts and building fabric.
- Geotechnical engineering.
- Mechanical, electrical, hydraulics and fire systems.
- Track works and rail systems.

BG&E was involved in the planning, design development, construction design, procurement, commissioning and hand over of the facility.

St Mary's Freight Hub

RAILWAY TRACK & CIVIL

SYDNEY, NSW, AUSTRALIA

CLIENT: PACIFIC NATIONAL & ACFS PORT LOGISTICS



St Mary's Freight Hub (St Mary's) is a 10 hectare development that is situated in an industrial zoned area, beside a business park and in between a railway line, in Sydney's west. The hub is being delivered via a joint venture between Pacific National (PN) and ACFS Port Logistics (ACFS).

The new freight hub will service major retail distribution centres and warehouses from industrial estates in Eastern Creek, Marsden Park, Wetherill Park and Erskine Park. Containerised freight will be moved via rail, directly from Port Botany to St Mary's.

BG&E provided civil and structural engineering, and flooding and drainage services, including a terminal reference design, ongoing technical support and Stage 1 Rail construction documentation.

The design included the hardstand staged capacity analysis working with PN and ACFS to optimise capital expenditure and rail head operability. Rail capacity and shunt modelling with animations were also assessed to determine the required shuttle and shunt movements.

By transporting goods via rail and utilising St Mary's, the PN and ACFS will help to reduce the number of trucks on Sydney's roads, ease traffic congestion, improve safety and reduce emissions.

Some of the key features of BG&E's solution are:

- An expansive intermodal terminal.
- Functional design.
- Shunt simulation.
- Rail and road design.
- Formation and civil design.
- Pavement design.
- Flooding analysis.
- Stormwater design.
- Maintenance facilities.
- Traffic engineering.

*St Mary's Freight Hub —
Sydney, NSW, Australia.*



Mitchell Freeway Rail Deviation

RAILWAY TRACK & CIVIL

PERTH, WA, AUSTRALIA

CLIENT: MAIN ROADS WESTERN AUSTRALIA



The Mitchell Freeway Extension is an important expansion of Perth's main northern artery by more than four kilometres, from Hodges Drive to Burns Beach Road, through the rapidly growing city of Joondalup.

In addition to providing greater connectivity, this project set a new benchmark in community engagement and included an environmental strategy which protected the urban bushland and minimised use of the surrounding natural resources.

BG&E provided the design of the three major road bridges, five pedestrian underpasses, rail tunnel (near Moore Drive under Mitchell Freeway southbound carriageway) and the noise walls.

The Mitchell Freeway alignment was altered adjacent to the Hodges Drive Bridge to enable the bridge to be shortened and resulted in similarities with the other major bridges. This also provided savings in earth works costs, as well as economies of scale.

At the Currambine Station underpasses, the design loads from traffic barriers were carried independently to the proprietary precast units. This approach enabled utilisation of precast box units that are not generally designed for barrier loading.

The northern suburbs rail system was constructed in advance of the freeway extension, which required the realignment of approximately one and a half kilometres of rail track to the south of Currambine Station (located within the freeway median).

Our team also designed the bridges with common format, to ensure consistency and harmony in appearance and public art was incorporated in the precast panels of the road bridge abutments.

*Mitchell Freeway Rail Deviation —
Perth, WA, Australia.*



Graham Farmer Rail Realignment

RAILWAY TRACK & CIVIL

PERTH, WA, AUSTRALIA

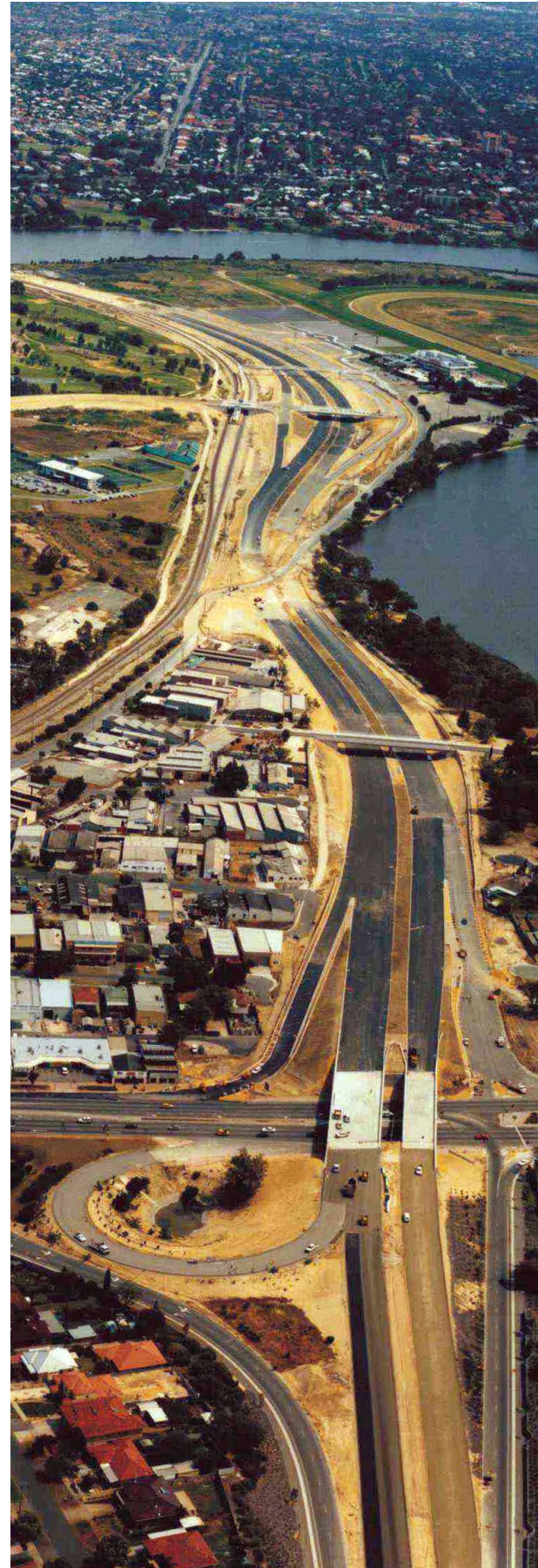
CLIENT: MAIN ROADS WESTERN AUSTRALIA

Graham Farmer Freeway is a 6.5 kilometre link, connecting Rivervale and Burswood with West Perth and Leederville, and providing a bypass of the CBD.

The name of this inner-city freeway is in honour of the Australian rules footballer, Graham “Polly” Farmer, who played between 1953 and 1971 in both the West Australian and Victorian Football Leagues.

Stage 2 of the Graham Farmer Freeway includes:

- Dual three lane carriageways nearly four kilometres long.
- Three interchanges.
- Nine bridges — including the 406 metre Windan Bridge across the Swan River.
- Relocation of the Perth-Armadale railway line.
- A new station and footbridge at Belmont Park.
- Shared paths and an underpass under East Parade.



Jurong Regional Line (JRL) 105 & 106 Rail Viaduct

RAILWAY TRACK & CIVIL

CHOA CHU KANG, JURONG PIER, PANDAN RESERVOIR AND PENG KANG HILL,
SINGAPORE

CLIENT: LAND TRANSPORT AUTHORITY

The Jurong Regional Line (JRL) is an elevated future Mass Rapid Transit (MRT) line that will serve the Jurong area and the western part of Singapore.

The JRL will serve 24 stations, reaching north to Choa Chu Kang, south to Jurong Pier, west to Peng Kang Hill and east to Pandan Reservoir. This is the seventh MRT line in Singapore and will feature fully automated CJ151 trains and a moving block signalling system for the line.

BG&E is working with a partner to fulfil the Enhanced Accredited Checking Role for the JRL. This includes viaduct packages and working collectively with the LTA and the design and construct teams.

The LTA tendered the works in 13 design and build packages. The scope of works include providing accredited checking services of the two (J105 and J106) design and build civil contracts. This includes being fully conversant about the civil works, specifically, the viaducts, stabilising structures, retaining walls, buildings and other associated permanent structures, as well as undertaking a detailed review and providing a report.

The key features of this important package are set out below.

- Performing analysis and design reviews with independent calculations on the structural and geotechnical works including but not limited to major and minor structures and elements, connections, deck furniture, all fixings, parapets, railings, permanent noise barriers, claddings and fascia, to confirm the adequacy, stability and integrity of the structural system under various construction sequence and loading conditions, meet the serviceability requirements and comply with the LTA' specifications.
- Performing a review with independent calculations on the proposed demolition sequence at existing structures or stations, checking the adequacy of the existing structures and the proposed protective and strengthening design works to the existing structures.
- Conducting analysis with independent calculations on the rail viaduct bearing articulation, design loading and movement ranges at movement joints.
- Undertaking serviceability checks, including but not limited to deformation analysis, vibration, with independent calculations for the rail viaduct, retaining walls, buildings and other associated permanent structures where appropriate.
- Reviewing the design on structural detailing, connection details including detailing of reinforcement bars and strengthening details.
- Conduct design review on drainage design, durability performance of the structures including fire protection, waterproofing, accessibility and maintainability, ease of future structural inspections and ease of future bearing maintenance and replacement works.
- Reviewing the method and construction sequence particularly in the aspect of impact to public safety, check the effects of construction load on the permanent structures and construction safety risks, and checking pre-cambering of box girder for balanced cantilever segmental construction.

*JRL 105 & 106 Rail Viaduct —
Singapore, South East Asia.*



Emerald Hill Track Rehabilitation & Track Slew

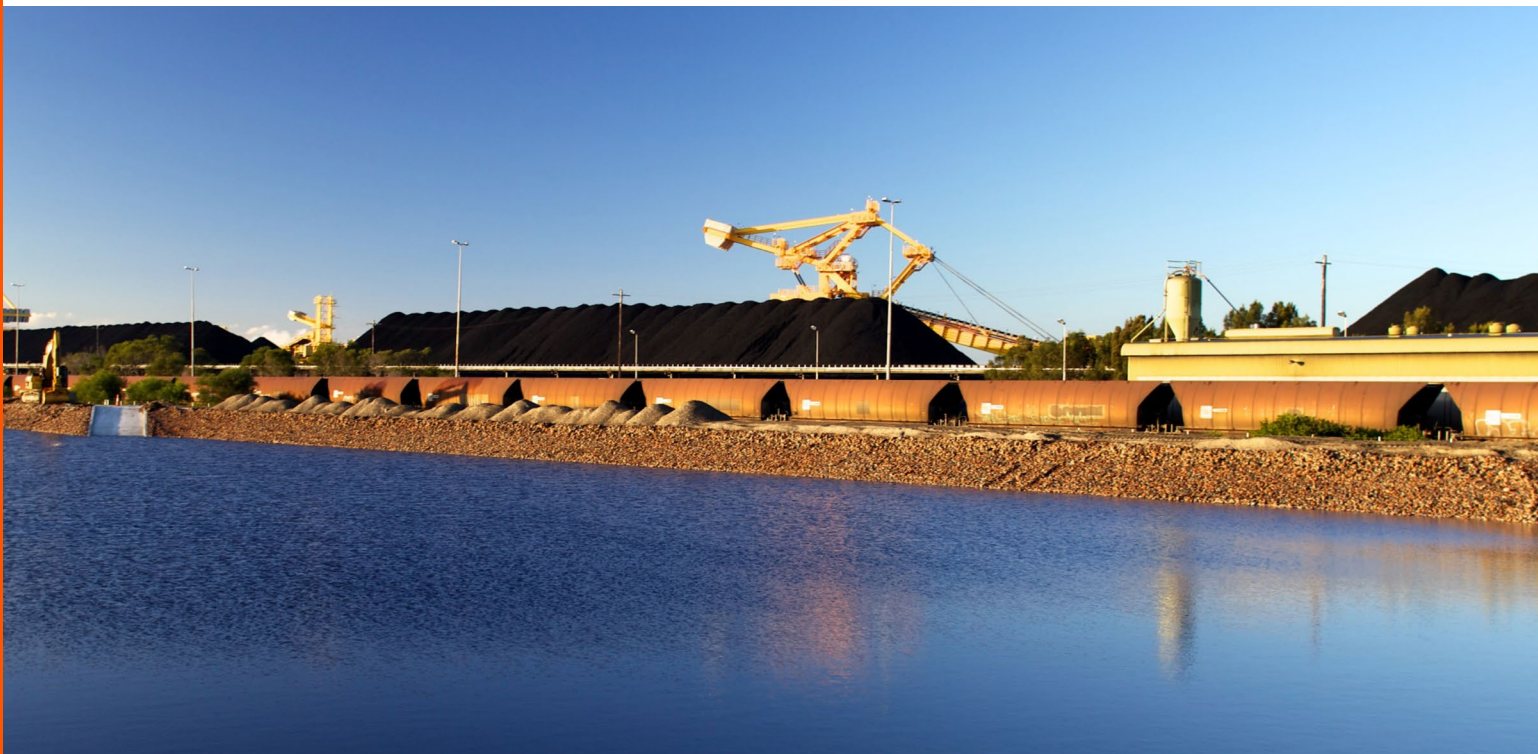
RAILWAY TRACK & CIVIL

EMERALD HILL, NSW, AUSTRALIA
CLIENT: ATRC

The project includes the construction of a 4500 metre track slew, four new culverts and the relocation of three existing signals in Emerald Hill in rural NSW.

BG&E prepared design documentation for the construction contract for the section of rail track exhibiting longterm formation failure due to poor soils. The design included the rail alignment, earthworks and drainage crossings for two segments of track rehabilitation and a 3.6 kilometre track slew. The track slew was designed as an offline construction to the existing main line.

Our team worked with the geotechnical consultant to complete formation design, address safety and project environmental risks for construction, including formation slope stability assessment where excavation works were parallel to poorly performing highly reactive clay soils.



BG&E also addressed flooding concerns for the project and worked with signalling consultants to optimise the design to minimise signalling impacts.

The key aspects of the structural design included pre-cast uniform (foursided), box culvert design for 350LA railway loading, associated headwalls, handrails and elevated stair/platforms for drainage crossings.

The civil design considered optimisation of horizontal and vertical alignment of rail design to address constructability, staging, cover requirements for the drainage culverts and to minimise earthworks/ pavement volumes. We utilised the in-built features of 12d software pavement design manager and trimeshes for generation of pavement design, subgrade surfaces for volume estimation.

Part of BG&E's scope of works also included undertaking waterways investigation to determine the performance of the existing culverts and to perform comparisons for proposed drainage structures and the long-term performance during design storm events.

Some of the key constraints included constructability and staging, addressing off-line construction of the drainage culverts adjacent the existing mainline. Constructability and staging were considered for the project slew start and end points, which required optimisation of the alignment and earthworks.

*Emerald Hill Track Rehabilitation & Track Slew —
Emerald Hill, NSW, Australia.*





Mitchell Freeway Extension

RAILWAY TRACK & CIVIL

PERTH, WA, AUSTRALIA

CLIENT: MAIN ROADS WESTERN AUSTRALIA
& PTA

BG&E designed and documented the track and civil works for the realignment of 1.5 kilometres of dual track electrified railway on the Perth-Clarkson railway, including construction staging at the tie-ins.

As lead consultant, BG&E coordinated the location of all other aspects of the design, including traction overhead power mast locations, signals and communications ducting and pits, signal location boxes and tunnel services.

The track was successfully opened to traffic in a single 48 hour shutdown in which tie-in earthworks and track works, traction overhead wiring, signals and communications were installed, commissioned and validated.

BG&E supported the design and construct contractor, Macmahon, in the design of construction staging and temporary works.

Penola Rail Upgrade

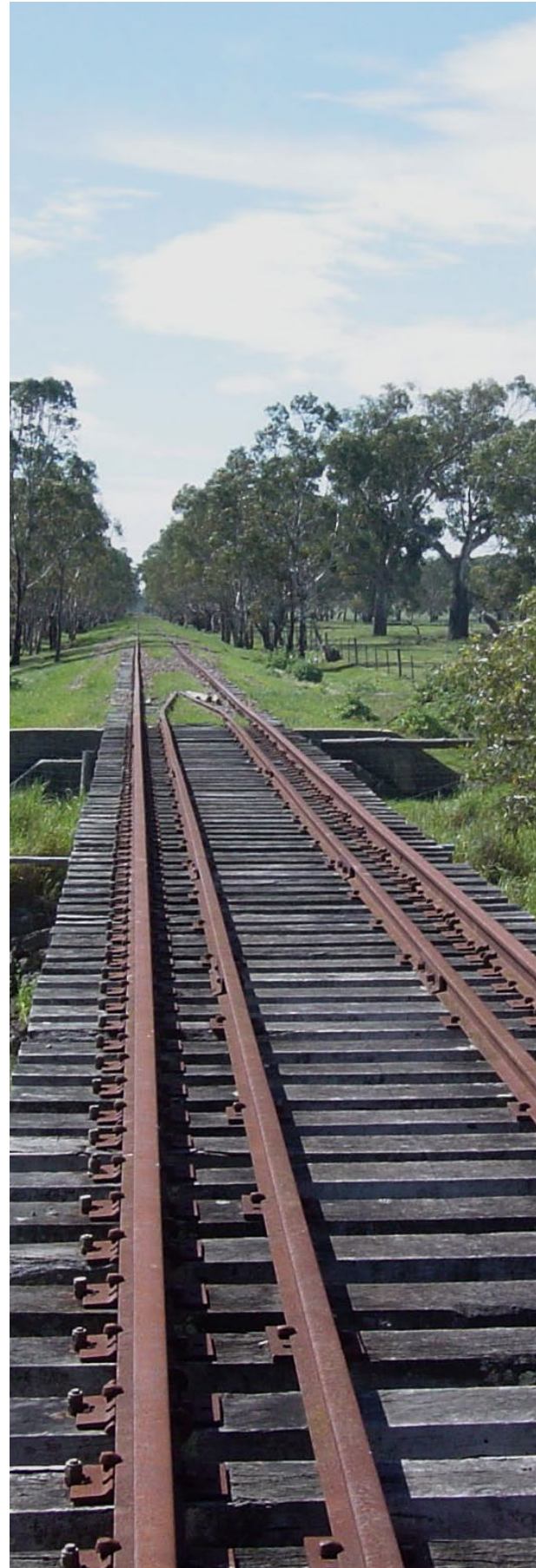
RAILWAY TRACK & CIVIL

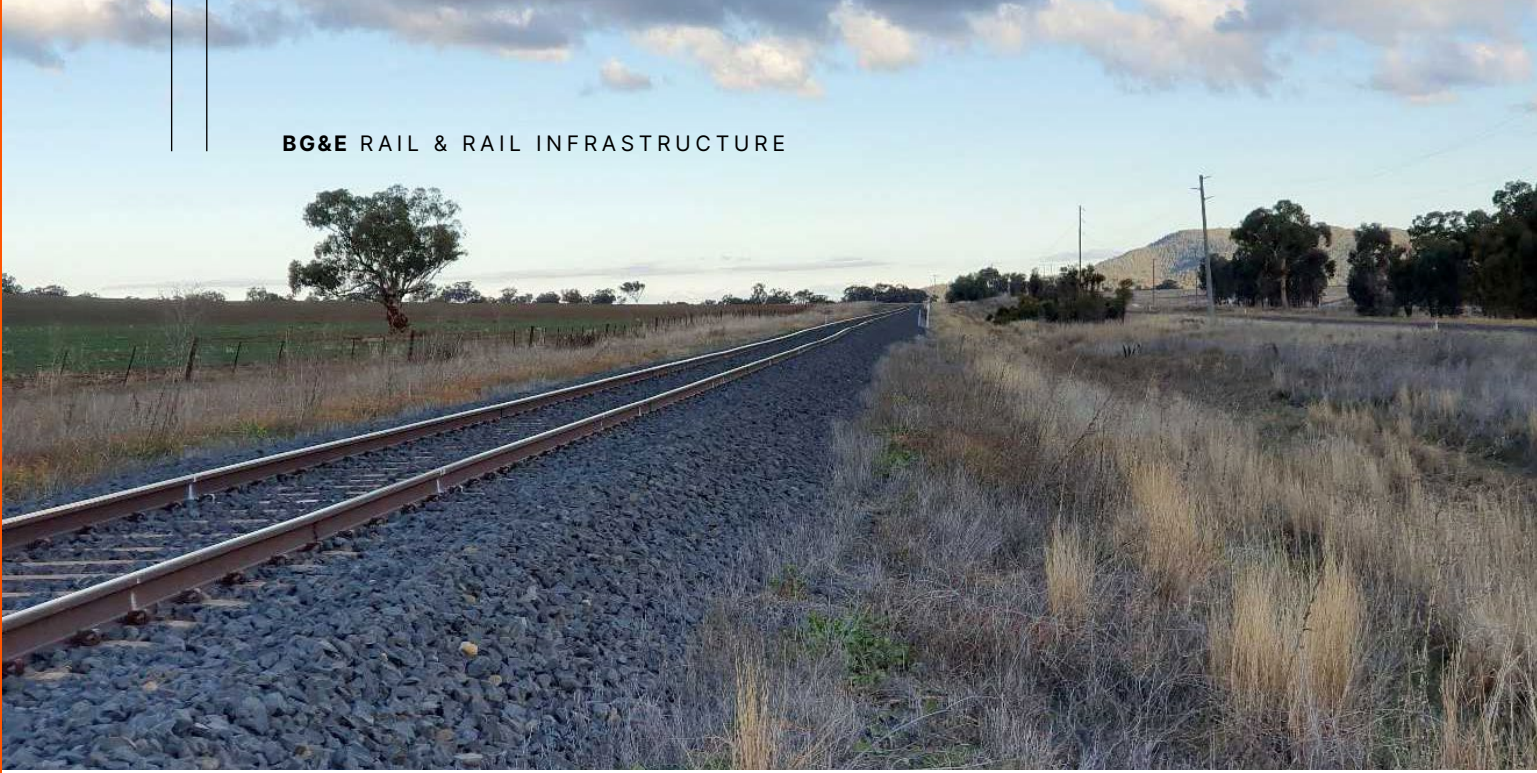
PENOLA, SA, AUSTRALIA

CLIENT: GENESSE & WYOMING AUSTRALIA

BG&E completed a condition assessment of the entire 151 kilometre Wolesley–Kalangadoo railway line, including tracks, sleepers, ballast, bridges and culverts. This section forms part of the main line between Wolesley and Mount Gambier in SA.

Originally constructed in the 1880s, the line operated until its closure in 1995 and has remained disused since.





Polona Rail Loop

RAILWAY TRACK & CIVIL

MARYVALE, NSW, AUSTRALIA

CLIENT: JOHN HOLLAND COUNTRY REGIONAL NETWORK

Construction is underway on a rail passing loop at Maryvale, which will deliver time savings of up to an hour and reduce congestion along the Main West Rail Line for freight and passenger services between Orange and Dubbo in regional NSW.

The \$13 million project, which includes construction of a new loop, extension of minor bridges and an upgrade of the remotely operated motorised points and signalling, will allow modern and longer freight trains to pass each other and create additional capacity on the busy Main West Rail Line, as well as provide more flexibility with timetables.

As the lead consultant, BG&E provided the functional specification report, concept, preliminary, detailed and construction design, for the Polona Rail Loop extension which upon completion will allow for crossing of 1800 metre trains. The loop extension features include new turnouts and additional track. Our team also provided civil engineering services, including rail and track formation, earthworks, drainage, and worked closely with sub-consultants to deliver the associated with environmental, geotechnical and survey elements of the project.

Jimblebar Rail Duplication

RAILWAY TRACK & CIVIL

PILBARA REGION, WA, AUSTRALIA
CLIENT: BHP BILLITON



BG&E undertook engineering investigations and detailed design for the upgrade of a sealed mine access road to BHP's Orebody 18 site in the Pilbara region of WA, approximately 40 kilometres east of Newman.

In addition to design of the access road, we undertook the design of the duplication of the existing BHP Jimblebar spur rail line, which runs parallel to the access road. The route crosses a number of existing waterways, which required hydrology analysis and hydraulic and structural design.

We also provided assistance in the preparation of tender drawings, quantities and contract documents for the construction of 20 kilometres of access road and 13 kilometres of rail duplication.

The civil design included design of box culverts, pipes and reinforced concrete drainage structures designed for heavy haul rail (iron ore wagons) and mining vehicle loadings at crossovers.



Perth-to-Mandurah New Metro Rail Project — Package A Verification

RAILWAY TRACK & CIVIL

PERTH, WA, AUSTRALIA

CLIENT: PUBLIC TRANSPORT AUTHORITY

Implemented by the Public Transport Authority of WA, the City Metro Rail project — linking Perth with Mandurah — was a major infrastructure project for the state.

BG&E provided civil and structural engineering services for the project, which involved construction of:

- 72 kilometres of electrified double-track railway.
- 774 metres of twin-bored tunnels under the city.
- 20 bridges and structures.
- Roads and civil works.
- Associated infrastructure.

The structural design component of the project was very diverse, including the twin-bored tunnels in Perth city, decline structures, numerous railway and traffic bridges, railway stations and temporary structures.

The project provided considerable benefits for the respective communities, specifically, improving access to public transport and opportunities for growth. It also provided a platform for future expansion and development of the CBD and the southern suburbs in Perth.



Main West Rail Line Capacity Enhancement Program

RAILWAY TRACK & CIVIL

SYDNEY, NSW, AUSTRALIA

CLIENT: JOHN HOLLAND COUNTRY REGIONAL NETWORK

The \$21.5 million Main West Rail Line Capacity Enhancement Program by Transport for NSW provides a more efficient track corridor for rail services with two new passing loops to help this critical route be able to meet expected growth in the NSW regional freight task.

Rail loops are located at Kerrs Creek, Polona, Bumberry, Pinecliff, Rydal and Georges Plains, easing congestion for both passenger and freight trains. The project entailed around 1.8 kilometres of new track being laid, and new signalling infrastructure.

The project ensures the Main Western line can efficiently support freight services, which use the line to transport around nine million tonnes of freight each year, while providing a more reliable service for local passengers.

BG&E provided civil engineering services for John Holland, including the detailed design of several new passing loops and loop extensions, which included rail alignment and associated earthworks, track structure and drainage. The design reduced fill requirements and construction costs through use of recycled materials.



GrainCorp's Project Regeneration

RAILWAY TRACK & CIVIL

VICTORIA, NSW, AUSTRALIA
CLIENT: GRAINCORP

GrainCorp's network of facilities provides an important link between Australia's growers and the export market. Project Regeneration was launched to create a more efficient network of storage sites across the country's eastern grain belt.

The sites reduce freight costs and deliver better silo prices for growers via:

- Higher volumes to maximise efficiency (inload and outload).
- More efficient turnaround times and more loads per hour for growers.
- Quicker train cycle times.

BG&E provided civil and structural engineering services to deliver yard upgrades and new rail infrastructure. Our team led the design of multiple sites to help meet the rising grain transport demands on the ARTC and Aurizon networks and the John Holland Country Regional Network. This comprised all of the rail and civil works at Cunningar, Bellata, Milvale, Redbend, Coonamble, Condobolin, Calleen, Yarrawonga, Burren Junction, Hillston, Barellan, Ardlethan, Yamala and Nevertire.

The key components of BG&E's yard upgrade solution include:

- Improved grain loading terminals.
- Functional design.
- Shunt simulation.
- Rail and road design.
- Formation and civil design.
- Pavement design.
- Stormwater design.
- Traffic engineering.

Our technical experts finalised the scope of work within an accelerated delivery programme to enable construction, prior to the pending grain harvesting season.

*GrainCorp's Project Regeneration —
Victoria, NSW, Australia.*



Nevertire Siding Extension

RAILWAY TRACK & CIVIL

NSW, AUSTRALIA

CLIENT: JOHN HOLLAND COUNTRY REGIONAL NETWORK

BG&E completed the design and documentation of all track and civil works associated with extending the existing Nevertire Loop to achieve additional loop standing room.

Located at the city end of Nevertire Yard, the loop services a GrainCorp Silo. The existing configuration made it difficult for train operations to efficiently load at Nevertire without fouling the public level crossing.

The loop extension allows 730 metre train consists to load at Nevertire without fouling the public level crossing. The proposed construction timeframes were met opening the loop before the end of September 2015 to facilitate movement of grain throughout the 2015 season. This timeframe was exceptionally tight as the design contract wasn't awarded until late May 2015.

The scope of works incorporated:

- Survey.
- Geotechnical investigation.
- Review of environmental effects.
- Civil infrastructure design.
- Rail geometric design.





Tarago Rail Siding

RAILWAY TRACK & CIVIL

TARAGO, NSW, AUSTRALIA
CLIENT: PACIFIC NATIONAL

Pacific National and Veolia have made representations to extend the multi-user rail siding at Tarago in regional NSW to permit 1000 metre long trains to be stowed or crossed at this location without the need to break trains across multiple rail sidings.

The outcome is for BG&E to produce an investigation report including a preliminary design that will be used to form the basis of the construction scope and be used in consideration for further progression of this project.

This includes preliminary design documentation of all track and civil works associated with the preferred design option, as well as the preliminary design of the associated signal infrastructure that will be required to achieve the desired functionality.

This also includes ensuring safe working requirements and operating network rules and procedures are adhered to in accordance with the track, civil and signal standards, when determining the final infrastructure configuration to achieve the functional requirement of permitting 1000 metre trains to be stowed or crossed at the facility.



Sydney Metro City & Southwest (SMCSW)

RAILWAY TUNNELS

SYDNEY, NSW, AUSTRALIA

CLIENT: JOHN HOLLAND, CPB CONTRACTORS & GHELLA JV

The Sydney Metro City & Southwest (SMCSW) project will extend the metro rail between Chatswood and Marrickville and will include a new tunnel beneath Sydney Harbour.

Arcadis and BG&E in a joint venture (ABJV) were engaged to do the tunnel station excavations, surface civil works and selected permanent and temporary works structures. In addition to the original scope of work, BG&E's team of engineers have provided construction engineering assistance and temporary work design.

The SMCSW is a 15.5 kilometre project, spanning from Chatswood to the Marrickville area, including a crossing beneath Sydney Harbour.



*Sydney Metro City & Southwest (SMCSW) —
Sydney, NSW, Australia.*

The project includes:

- Constructing running tunnels with waterproofing using tunnel boring machines (TBMs) for dry tunnels, mined cross passages, a cavern for a rail crossover at Barangaroo, tunnelling below Central Station, and creating mined station caverns with adits for new stations at Victoria Cross, Martin Place, and Pitt Street, including a connection to the existing Martin Place Station on the Sydney Trains Eastern Suburbs Line.
- Demolition, excavation, and concrete structures for dives in Chatswood and Marrickville, as well as for new stations in Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, and Waterloo.
- Installing a permanent concrete lining in all tunnels, caverns, adits, cross passages, and underground openings to accommodate future track bed and rail and station services. It also includes constructing the primary concrete structure at the new Barangaroo station and ensuring safe personnel access to underground spaces with temporary support services, including maintaining site facilities for handover to Follow-on Contractors upon completion.
- Removal of all temporary work and site facilities not otherwise required for handover to Follow-on Contractors.

The ABJV are responsible for following scope of works for the TSE design:

- Design of temporary and permanent civil works (roadworks, drainage, temporary and permanent storm water diversion, flood modelling, utility coordination, road safety audit, traffic modelling, traffic staging, temporary works etc.).
- Design of temporary and permanent structures for all open box, shaft and dive sites (bored and CFA piling, shoring, steel platforms, deep excavation over 40m, drained and undrained structures, etc.).
- Building effects assessment.
- Project wide durability assessment.
- Earthing and Electrolysis assessment
- Project wide flooding assessment.
- Project wide CAD and BIM management.

Perth Busport

RAILWAY TUNNELS

PERTH, WA, AUSTRALIA

CLIENT: PUBLIC TRANSPORT AUTHORITY



The Perth Busport development is an underground structure with three above ground entry portals access.

The facility will act as structural foundations for the future Perth City Link Project which will provide new roads for vehicular access between the CBD and Northbridge, as well as a new 20 storey residential, retail and commercial development.

BG&E, as member of the City Busport Alliance with Brookfield Multiplex and the Public Transport Authority, was engaged to design and construct the Perth City Link Project which comprises a new underground Bus station with a footprint of approximately 10,000 square metres. The project also includes fit out of a 250 metre bus entry tunnel, a new bus tunnel connecting the Busport to nearby Wellington Street and the diversion of major in ground services.

The perimeter of the structure is bounded by a diaphragm wall on three sides with an active underground rail tunnel forming the fourth perimeter wall.

The internal columns have been located on a fixed grid to facilitate bus movements and door positions; this same grid will be used for the future development above ground.

The structure was designed as a top-down construction to meet the stringent requirements to limit the movement of the adjacent rail tunnels and the existing infrastructure and heritage building in the vicinity.

The design incorporated bored piles extending up to 50 metres below ground level.

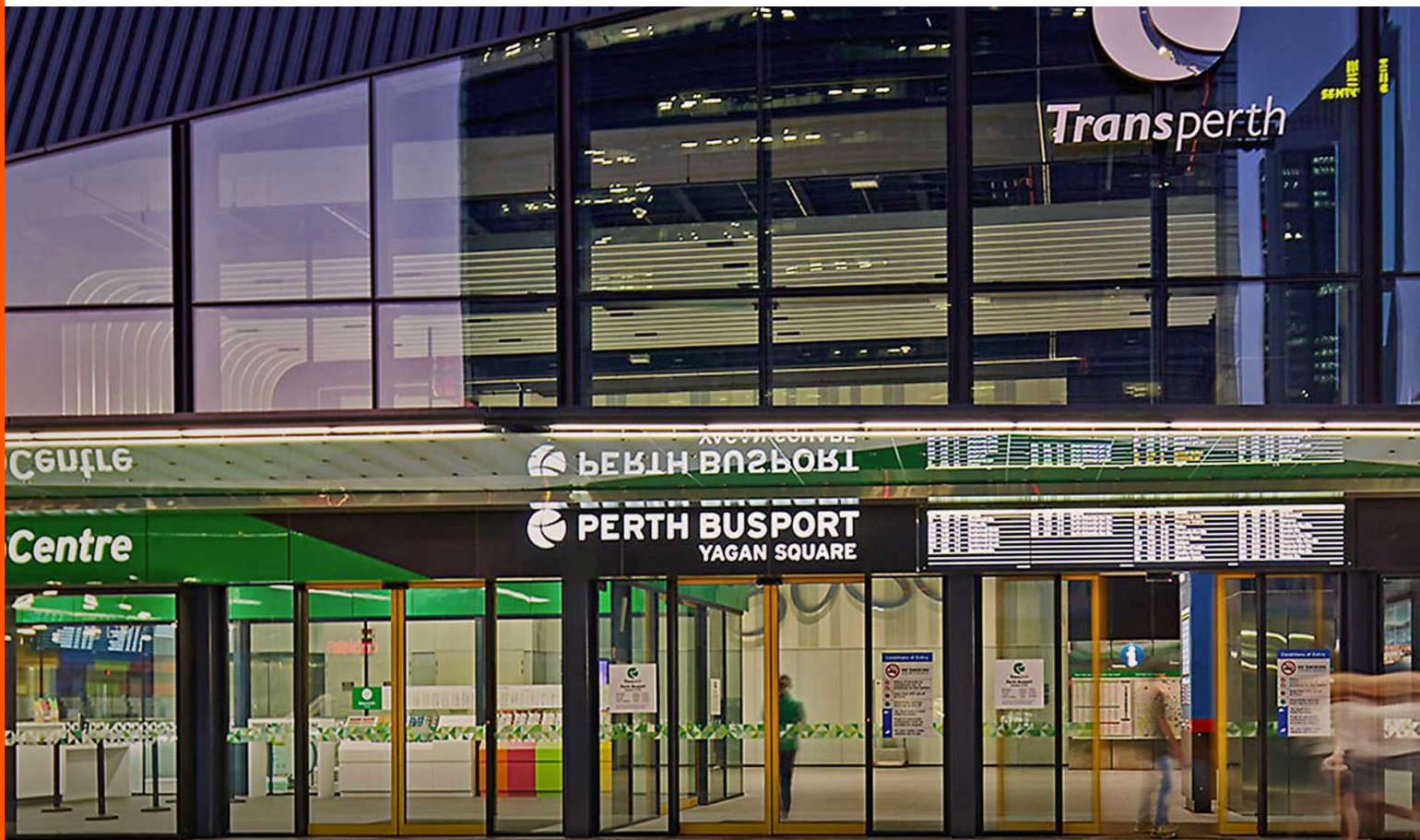
The 750 millimetre thick basement slab is seven metres below the water table. BG&E adopted an innovative combined fibre reinforced concrete solution in combination with waterproofing membranes to ensure a watertight solution was achieved.

To achieve the required long spans the roof was design as an 800 millimetre thick in-situ multi strand posttensioned slab.

Our proactive team undertook research to assess the risk of an uncontained hydrocarbon fire and additional passive measures were incorporated to minimise the risk of partial collapse of the busport.

Busport documentation was completed using BIM, with BG&E assuming the lead coordination role between the structural, architectural and services consultants.

*Perth Busport —
Perth, WA, Australia.*



Sydney Metro Northwest

RAILWAY TUNNELS

SYDNEY, NSW, AUSTRALIA

CLIENT: SMEC AUSTRALIA & NORTHWEST RAPID TRANSIT



The Sydney Metro Northwest project will be the first fully-automated metro rail system in Australia and will deliver eight new railway stations, 4000 commuter car parks and a new high frequency single deck train system to support Sydney's growing North West.

Trains will operate every four minutes in the peak with at least 15 trains per hour. John Holland has been awarded two packages of work for the Sydney Metro Northwest.

BG&E's was engaged by SMEC to provide investigation and assessment services to assist with the certification of the four kilometre viaduct structure on the Northwest line. This work became necessary after the failure of some spans on the viaduct, during post-tension strand stressing.

Our multi-disciplinary team of materials and structural engineers assessed all installed spans, precast segments awaiting installation, and constructed piers and crossheads. This involved working closely with other consultants, as well as with the construction consortium to facilitate access and to undertake testing and inspection works.

The elements were inspected and reported on within a six week period, which enabled certification by Transport for NSW. Any necessary rectification works could be undertaken thereafter.

Following the completion of the testing and assessments, BG&E was reengaged to provide a broader range of testing and durability services, including:

- Supervision of site works associated with key structural elements, and inspection of activities in association with the design engineer.
- Testing of concrete in tunnel invert for conformance verification.
- Assistance in the optimisation of precast element design to improve production program.
- Inspection of precast production to verify conformance to project specifications.
- Provision of shop drawing drafting capability to assist with precast production.
- Other materials advisory services as issues arose during construction.

*Sydney Metro Northwest —
Sydney, NSW, Australia.*





Forrestfield-Airport Link

RAILWAY TUNNELS

PERTH, WA, AUSTRALIA

CLIENT: PUBLIC TRANSPORT AUTHORITY

The Forrestfield-Airport Link will deliver a new rail service to the eastern suburbs of Perth — with three new stations at Redcliffe, Airport Central and Forrestfield. It involves the construction of eight kilometre underground twin-bored rail tunnels.

BG&E worked alongside Jacobs and Golder Associates in a JV — “ALERT” (which stands for the Airport Link Engineering Review Team).

Our scope of works includes the provision of technical input into RFIs and NCRs, and risk assessments for the major project stakeholders, including Airservices Australia, Arc Infrastructure and Perth Airport.

The JV ALERT team is also providing project engineering roles, specifically, assisting Public Transport Authority with the technical lead, project coordinator, project control and document control roles.

Our role is to conduct a technical review of:

- Underground and above structures for the new stations.
- Portal and dive structures.
- Structural aspects of bored tunnel segmental lining.
- Structural aspects of all cross passages and emergency egress shafts.
- Structural aspects of all associated temporary works.
- Civil design aspects of all new stations.
- Durability documentation.
- Waterproofing.
- Pile and D-wall testing methodology and results.
- Flooding analyses.



Cross River Rail

RAILWAY TUNNELS

BRISBANE, QLD, AUSTRALIA

CLIENT: DEPARTMENT OF TRANSPORT & MAIN ROADS QLD

As Brisbane's population swells to more than 2.5 million, the Cross River Rail project will help unlock a bottleneck at the core of the city's transport network and transform the way the public travels across south east QLD.

The Cross River Rail is a new 10.2 kilometre rail line from Dutton Park to Bowen Hills, which includes nearly six kilometres of twin tunnels under the Brisbane River and CBD.

The current rail network is nearing capacity and is constrained by a single river crossing and four inner-city stations, which causes the bottleneck and limits the ability to run more trains. The Cross River Rail unlocks this bottleneck by delivering a second river crossing, allowing more trains to run, more frequently, as well as integrating with new roads and bus services, to enable a "turn-up-and-go" public transport system across SEQ.

BG&E undertook proof engineering of the structural, durability, geotechnical (using specialist sub-consultants) and tunnelling engineering services for the Cross River Rail.

This transformational project is providing thousands of jobs across the region and is helping to activate increasing urban development.

Roe Street Railway Tunnel

RAILWAY TUNNELS

PERTH, WA, AUSTRALIA
CLIENT: WESTRAIL



As part of the construction of the northern suburbs rail link on the median of the Mitchell Freeway, a tunnel beneath Roe Street was required from the existing and operating Perth-Fremantle railway reserve.

The extremely tight radius, 450 metre tunnel, including approaches, was constructed adjacent to the foundations of the existing Mitchell Freeway bridges over Wellington and Roe Streets which placed headroom limitations on operating equipment.

During the construction of the tunnel, the existing Perth-Fremantle track was electrified and secant pile retaining walls were used to ensure minimal disturbance to the adjacent bridge footings. We undertook the design of the tunnel slab track floor and the 130 metre precast concrete roof.



Kwinana Freeway Interchanges & Extension Tunnels

RAILWAY TUNNELS

PERTH, WA, AUSTRALIA

CLIENT: MAIN ROADS WESTERN AUSTRALIA & PTA

BG&E set new standards in design and construction solutions with the Kwinana Freeway extension that involved bridges, tunnels, underpasses and associated works. The multi-million-dollar project transformed the state's freeway network, reducing traffic congestion and improving operational efficiency.

This included the design of 12 bridges with varying widths and spans, ranging from 26 to 48 metres, as well as three pinned precast concrete arched structures at Glen Iris, Anketell and Safety Bay Road with provisions for future rail tunnels.

For the first two structures, in-situ concrete retaining walls were incorporated along the entrance and exit ramps. At Safety Bay Road, mechanically stabilised earth walls have been employed at both ends of the tunnel.

BG&E also designed seven DUP underpasses as in situ reinforced concrete structures incorporating a central light well.

The Glen Iris Tunnel, a key part of the freeway extension, is now earmarked to be used as part of Perth's first East-West rail link.

The Glen Iris Tunnel, a key part of the freeway extension, is now slated for use in Perth's first East-West rail link, the Thornlie-Cockburn Link. This inaugural cross-city train line will provide flexible travel and improved public transport for southern suburbs.

Mitchell Freeway Tunnel

RAILWAY TUNNELS

PERTH, WA, AUSTRALIA

CLIENT: MAIN ROADS WESTERN AUSTRALIA & PTA

BG&E provided the design of the three major road bridges, five pedestrian underpasses, a rail tunnel near Moore Drive under Mitchell Freeway's southbound carriageway, and the noise walls for the Mitchell Freeway Extension project.

For the Mitchell Freeway rail tunnel, a new cut and cover tunnel was designed under the southbound carriageway to accommodate grade separation of the rail and freeway crossing. A decline structure was included in the median on the approach to the tunnel portal. The design and construction of these elements were coordinated to minimise disruption to rail traffic during track cut-over operations.

The Mitchell Freeway Extension adds over four kilometres to Perth's key northern corridor, stretching from Hodges Drive to Burns Beach Road through the fast-growing City of Joondalup.



Geraldton Southern Transport Corridor

RAILWAY TUNNELS

PERTH, WA, AUSTRALIA

CLIENT: THEISS (FOR MAIN ROADS WESTERN AUSTRALIA & PTA)

BG&E provided bridge design and civil and structural engineering for the Geraldton Southern Transport Corridor, including the two tunnel structures.



One rail tunnel accommodates the crossing of local roads over the railway and highway and utilises a three-pinned precast concrete arch structure supported on spread footings. The other tunnel structure allows the railway to pass under the new highway. Foundation analysis of the tunnels considered liquefaction of the sands and called for consolidation at the port's tunnel site.

This project has enabled Geraldton to redefine its future economic and social prosperity by providing an efficient freight connection to the Port of Geraldton and removing the railway from the foreshore of the city.

The key elements of the project include:

- 11 kilometres of single rail line from the Narngulu industrial area to the Geraldton Port, with provision for future duplication.
- 13.5 kilometres of a new east-to-west Highway between the Geraldton Airport and the Geraldton Port, linking to Mt Magnet Road.
- Four bridges, two tunnel structures and preliminary design of two future bridges.
- Two major interchanges between the highway and connections to the local road network.
- Construction of an eastern breakwater to the port and town beach improvement works, utilising spoil from the works.
- Service relocations associated with the works.

*Geraldton Southern Transport Corridor —
Perth, WA, Australia.*



Kwinana Freeway Interchanges & Extension — Berrigan Drive-to-Safety Bay Road

RAILWAY TUNNELS

FREMANTLE & ROCKINGHAM, WA, AUSTRALIA
CLIENT: MAIN ROADS WESTERN AUSTRALIA & PTA



This multi-million dollar extension of the Kwinana Freeway helped to transform WA's freeway network by significantly reducing traffic congestion and improving the operational efficiency of the network.

BG&E set new standards in design and construct solutions with the bridge, tunnels, underpasses and associated works for this project.

This included designing 12 bridges with varying requirements for width and span. A combination of single and two-span structures, with the freeway bridges having spans from 26 metres up to 48 metres.



*Kwinana Freeway Interchanges & Extension —
Berrigan Drive-to-Safety Bay Road —
Freemantle & Rockingham, WA, Australia.*

Specific architectural and engineering requirements by Main Roads Western Australia were addressed in our solution of wide pre-tensioned precast concrete trough beams acting compositely with insitu concrete decks and supported on bifurcated columns. Semi spill-through reinforced earth abutments employing full height concrete panels, curve shaped in plan, maintain a uniformity in construction theme with earlier structures provided on the freeway. Insitu concrete columns formed in precast voided sections associated with the reinforced earth facing panels transfer loads from the superstructure to the foundations below.

Our team also designed three pinned precast concrete arched structures at Glen Iris, Anketell and Safety Bay Road (rail tunnels planned for future use). For the first two structures, insitu concrete retaining walls are incorporated along the entrance and exit ramps. At Safety Bay Road, mechanically stabilised earth walls have been employed at both ends of the tunnel structure.

BG&E also designed seven DUP underpasses as insitu reinforced concrete structures incorporating a central light well. Fast forward to 2021 and the Glen Iris Tunnel, which is key part of the freeway extension, is now earmarked to be used as part of Perth's first EastWest rail link.

The Thornlie-Cockburn Link will be the city's inaugural East-West cross line connection, making travelling around the city by train more flexible and providing improved public transport for the communities in the southern suburbs. BG&E is contributing to this project.

Parkes National Logistics Hub

HEAVY HAUL RAIL

PARKES, NSW, AUSTRALIA

CLIENT: COLEMAN RAIL & PACIFIC RAIL

BG&E provided civil and structural engineering, and flooding and drainage services for the Parkes National Logistics Hub, which included serving as the lead design consultant for the new freight facility which comprised container storage, rail sidings, heavy vehicle access roads and direct interface to the first stage of ARTC's Inland Rail.

Partnering with Coleman Rail in a design and construct contract, our collective team drew on a preliminary design and recommended several value engineered options which were incorporated to the final detailed design.

Uniquely positioned between the East West rail line, the North South Newell Highway and the incoming \$10 billion Melbourne-to-Brisbane Inland Rail, Parkes is set to become the epicenter for major logistics, manufacturing, warehousing and distribution opportunities.



BG&E also worked closely with our clients to produce a cost effective, fit for purpose design that achieved all the functional requirements set forth within a constrained environment. The project directly interfaces with the Inland Rail, at numerous rail and pavement interfaces. These were engineered in collaboration with ARTC and will provide a suitable and cost effective outcome for all parties.

The key features of the solution include:

- A state-of-the art intermodal terminal.
- Functional design.
- Shunt simulation.
- Rail and road design.
- Formation and civil design.
- Pavement design.
- Flooding analysis.
- Stormwater design.
- Maintenance facilities.
- Traffic engineering.

*Parkes National Logistics Hub —
Parkes, NSW, Australia.*



Carmichael Rail Project Independent Verification

HEAVY HAUL RAIL

NORTH GALILEE BASIN, QLD, AUSTRALIA
CLIENT: CARMICHAEL RAIL

The Carmichael Coal Mine is located in QLD's North Galilee Basin. The project involves the development of a thermal coal mine and supporting new narrow-gauge railway and related infrastructure delivering a transportation link to a connection with an existing rail network.

This infrastructure will support both the Carmichael Mine operation and future developments throughout the Galilee Basin. The Carmichael Rail Project is a greenfield 200 kilometre heavy haul narrow gauge single line railway with an initial capacity to transport 40 million tonnes per annum of coal.

The single line railway includes a mine loop to facilitate loading trains and strategically located passing loops and associated bad order sidings. On behalf of the QLD Government, BG&E is independently reviewing and certifying the design by others for compliance with the state and federal government approval conditions.

Moranbah North Mine Rail Diversion Feasibility Study

HEAVY HAUL RAIL

MORANBAH, QLD, AUSTRALIA

CLIENT: ANGLO AMERICAN METALLURGICAL COAL

The Moranbah North Mine Rail Diversion project aims to realign the existing Aurizon Main Line in the Goonyella System to maximise the product coal from the Moranbah North Mine.



The existing electrified main line is located within the existing Moranbah North and Grosvenor mine lease and requires relocation to allow for the underground mining operation to continue.

Understanding of the rail asset owner's requirements and standards as well as operations of the existing main line is critical to provide the greatest chance of approval for this fast-tracked project.



Great Northern Highway Fortescue Metals Group Solomon Road Over Rail Bridge

HEAVY HAUL RAIL

PILBARA REGION, WA, AUSTRALIA

CLIENT: FORTESCUE METALS GROUP & CALIBRE GLOBAL

The Great Northern Highway (GNH) Fortescue Metals Group (FMG) Solomon Road over rail bridge, is a single span arch bridge carrying the GNH over the existing Solomon Railway Works and includes realigning associated sections of existing road.

This infrastructure is critical as it helps to facilitate FMG's T155 expansion project in the region.

BG&E provided civil engineering services, including the detailed design and documentation of the following:

- Three railway bridges over waterways in concrete composite girders and concrete substructure designed for extreme flood events.
- One rail-over-rail overpass consisting of a steel through-girder superstructure with an in-situ concrete substructure, designed to resist the impact loads from heavy haulage rail trains.
- One road-over-rail overpass on the GNH, designed as precast and prestressed concrete beams with a composite in-situ deck.



Great Northern Highway Fortescue Metals Group Solomon Road Over Rail Bridge — Pilbara Region, WA, Australia.

The rail bridge design featured modular steel-concrete composite girders on piled foundation for the river bridges, including design for heavy haul rail loads and for significant scour depths. The river bridges comprised two, four and five spans with a common modular span length of 25.6 metres. The rail overpass bridge featured a steel through-girder bridge with deep fabricated plate girders and fabricated cross girders supporting a longitudinal in-situ deck slab.

Each of the rail bridge spans were designed to be delivered to site almost fully complete, with only the handrails and reinforcement to be placed on site, on the ground prior to lifting. The only site work once the beams were lifted into place was pouring the deck slab and place ballast mats. This approach to modular design highlights BG&E's consideration of constructability and our understanding of optimal construction techniques in remote locations.

The waterways investigations included detailed hydrological analysis such as application of regional methods, runoff routing, flood frequency studies of gauged study and assessment of rainfall runoff on 2D models.

The hydraulic modelling also included 1D and 2D models for the bridges. BG&E designed culverts for a 40 kilometre section of rail where the railway crosses the Fortescue River Valley, west of GNH. We deployed a variety of 1D and 2D models on broad and local scales to assess the interconnected behaviour of the streams and culverts. Our team also designed multiple culvert banks in the central part of the valley to cater for the total flow across the wide floodplain and to achieve minimal water shadow and environmental impact.

The GNH overpass part of the project included designing the overpass bridge, realignment to GNH and associated local access roads and intersections. The bridge was designed to AS5100 with reference to relevant Main Roads Western Australia (MRWA) SES Circulars, contract specifications and guidelines. The bridge consists of tee off precast prestressed beams with an in-situ composite deck. The bridge supports are subject to rail impact loads from the FMGL heavy haulage railway below. The pier and abutment consist of in-situ concrete walls on piled foundations and are designed for rail impact loads.

BG&E worked with MRWA and FMG to determine the appropriate bridge width, clearance and span length, allowing for future expansion of the rail network and access tracks. The GNH roadworks were designed in accordance with MRWA standards and guidelines for geometry, signage, lines, drainage and barriers.

The geotechnical investigation was undertaken by Golder Associates (Golder), including boreholes and test pits at the rail bridges, supplementary investigations for the GNH overpass bridge, and detailed sampling and testing of earthworks and pavement materials for the GNH roadworks. Golder provided complete factual and interpretive geotechnical reports and undertook the relevant phases of the investigation in accordance with MRWA guidelines. Our team worked with the regional office to confirm the most suitable surfacing treatments and to assist the client and contractor in applying these on site.

The project was completed within the design and construction budget. The bridge and roadworks were opened to traffic on the required date to suit the road traffic and FMG rail traffic requirements.

*Great Northern Highway Fortescue Metals
Group Solomon Road Over Rail Bridge —
Pilbara Region, WA, Australia.*





Tunkawanna-to-Rosella Railway Duplication

HEAVY HAUL RAIL

PILBARA REGION, WA, AUSTRALIA
CLIENT: RIO TINTO IRON ORE

The Tunkawanna-to-Rosella Railway Duplication project involved the construction of seven heavy haul rail bridges that provide a dual-rail track at this critical section of Rio Tinto's rail system through rugged terrain in the Pilbara region of WA.

BG&E provided bridge design and structural and civil engineering services for this project. Specifically, designing bridges that comprised precast prestressed concrete girders to maximise off-site construction, robustness and durability.

The bridge foundations are subject to very large railway and flood forces, and ground anchors were used to resist overturning forces, while minimising in-situ works.

Simple and repetitive concrete shapes were adopted to allow re-use of forms and economies of scale. The overall design provided a robust and highly constructible solution, in a harsh and remote environment.

Warrnambool Stabling Yard

RAILWAY YARDS & MAINTENANCE FACILITIES

WARRNAMBOOL, VIC, AUSTRALIA
CLIENT: DT INFRASTRUCTURE



Part of the wider Warrnambool Line Upgrade and Regional Rail Revival Initiative delivered by Rail Projects Victoria, the Warrnambool Stabling Yard enabled VLocity trains to operate through to Warrnambool — increasing capacity and reliability along the corridor.

The new facility consists of two stabling roads adjacent to the main line, both able to accommodate a six-car VLocity train.

BG&E delivered all non-signalling design services, working closely with DT Infrastructure's signalling team to provide a fully coordinated design. Scope encompassed track, drainage, pedestrian and vehicle crossings, civil and roads, buildings, architecture and site services.



Somerton Intermodal Terminal

RAILWAY YARDS & MAINTENANCE FACILITIES

SOMERTON, VIC, AUSTRALIA
CLIENT: ACCIONA RAIL

BG&E was engaged from project conceptualisation as the lead design consultant for the Somerton Intermodal Terminal — Australia's largest open-access terminal, located north of the Port of Melbourne. Working in a collaborative D&C environment, BG&E managed and delivered over 45 design packages from concept through to commissioning.

The terminal has a capacity exceeding one million TEU, utilising rail-mounted gantries and electric reach stackers, with container stacking capacity of over two million TEU. It accommodates 1800 metre double-stacked interstate trains, multiple 1500 metre services, and broad and standard gauge shuttles across 13.6 kilometres of track, with direct links to the adjacent industrial precinct.

BG&E worked with the client to understand operational requirements and incorporated future-proof systems for automated terminal train movements, with the terminal enabled to become operational in stages.

Terminal layout was developed collaboratively with ITC, with movement, safety, efficiency and operational interaction central to the design approach.



Image courtesy of Victoria's Big Build.

SRL East — Tunnels South (Work Package C)

RAILWAY TUNNELS

MELBOURNE, VIC, AUSTRALIA
CLIENT: SUBURBAN CONNECT

The \$3.6 billion Suburban Rail Loop East project involves construction of a new 26 kilometre underground rail line from Cheltenham to Box Hill, with four intermediate stations.

BG&E delivered integrated structural, civil, geotechnical, flooding, durability and construction phase services across multiple packages for Work Package C of the SRL, which covers the twin tunnels between Cheltenham and Glen Waverley, two portal structures, and station boxes at Clayton and Monash.

All project sites were located in highly developed urban areas, presenting a complex set of constraints throughout design and delivery. Interfaces with existing sensitive structures, contaminated ground conditions from adjacent landfill sites, high groundwater levels, compressed construction schedules and the need to maintain road, rail and pedestrian operations throughout required continuous coordination across disciplines and stakeholders.

Key achievements included:

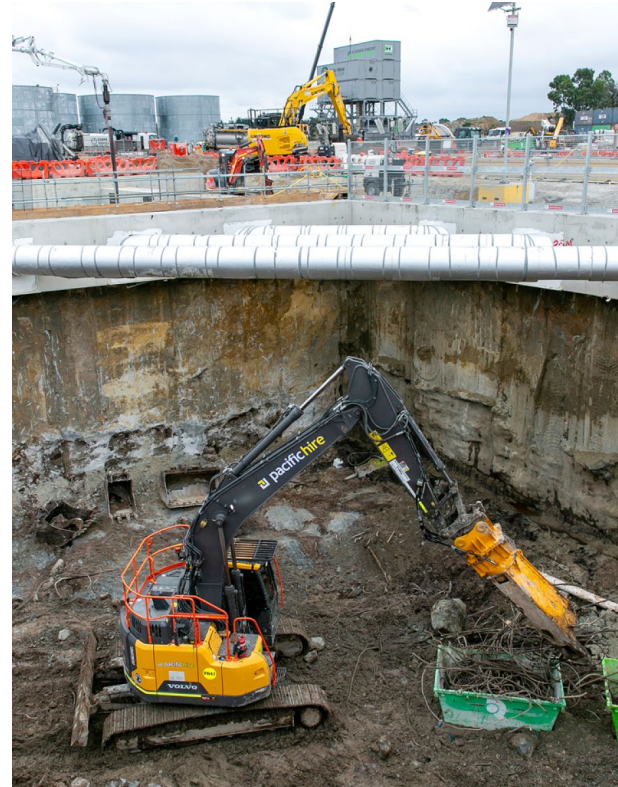
- Clarinda TBM Launch Site delivered on a complex landfill site, generating significant programme savings by reducing the number of TBMs required.
- Flooding approvals and no-objection notices secured across all sites through extensive optioneering.
- Three arterial road intersection upgrades delivered with DTP approval, including accelerated traffic signal changes.
- 3D digital twins and BIM used to eliminate clashes and coordinate complex multidisciplinary interfaces in constrained brownfield conditions.
- Several major post-IFC design changes managed without programme impact, including revision of the Clarinda road network and Southern Adit updates reflecting revised geotechnical parameters.

UNDERPINNING

Permanent underpinning to Clayton Viaduct Pier 4 was required due to tunnelling impact on existing piles. BG&E delivered permanent underpinning design, including temporary works for the construction sequence, alongside a detailed structural assessment of the existing viaduct encompassing condition assessment, load rating and settlement analysis under project-induced impacts.

SOUTHERN INTERCHANGE ADIT

The Clayton Southern Interchange Adit is a single-volume basement structure at the junction of Clayton Road and Carinish Road, providing access to the southern end of the future SRL station. The design accommodates pedestrian access via escalator and lift, future adit openings to the east and south, permanent ground anchors to resist groundwater buoyancy, and a structural interface with the station box formed through large openings in the diaphragm walls.



SRL East — Tunnels South
(Work Package C) —
Melbourne, VIC, Australia.

Image courtesy of Victoria's Big Build.



SRL East — Tunnels South (Work Package C) — Melbourne, VIC, Australia.

CLAYTON STATION BOX

The Clayton Station Box is an excavation approximately 200 metres wide, designed to enable the follow-on contractor to construct the permanent station. Key design elements include watertight interfaces with the Southern Interchange Adit and a future eastern adit, glass-reinforced polymer soft eyes in the diaphragm walls to allow TBM arrival and relaunch, and base slab design accounting for TBM traverse and associated temporary works.

CIVIL — SITE ESTABLISHMENT

BG&E delivered site establishment design for both Clayton Station and the Clarinda TBM Launch Site.

At Clayton, a steeply graded site was regraded into construction platforms with robust drainage infrastructure, an internal road network and detailed pavement design.

At Clarinda, an existing landfill and recycling facility was transformed into a large operational compound accommodating heavy vehicle movements, storage areas and construction buildings, with drainage and sediment basin design developed to address existing flooding issues and significant sediment loading.

FLOODING

BG&E provided flooding assessments and mitigation design across all project sites — including Clayton, Monash and Cheltenham station establishments, the Clarinda TBM Launch Site, the Heatherton Train Stabling Facility and a tunnel-wide probable maximum flood assessment. Detailed modelling and mitigation design managed impacts on surrounding communities, with flooding approvals and no-objection notices secured across all sites.

CIVIL — LOCAL AREA WORKS

Permanent modifications to the Clayton Station precinct included road truncation, realignment of the Djerring Trail cycling route around the viaduct construction site, and upgrade of the Clayton Road and Shandean Avenue intersection to provide an alternate traffic route. Works involved traffic signal phasing modifications, pavement and drainage design to DTP, council and MTM standards, and utility coordination. All packages required DTP and council approval, including road safety and disability audits.



*SRL East — Tunnels South
(Work Package C) —
Melbourne, VIC, Australia.*

Image courtesy of Victoria's Big Build.

GEOTECHNICAL

Geotechnical services at the Clayton site included numerical modelling of adit excavation impacts on the existing viaduct, underpinning design at Pier 4, permanent retaining system design for the Southern Interchange Adit, temporary retaining system design for the Clayton Station Box, and development of an instrumentation and monitoring plan for existing and new structures during construction.

DURABILITY

BG&E undertook project-wide durability assessments across all design elements, integrating durability requirements into the core design solution to balance capital efficiency with lifecycle performance. A detailed assessment report covering concrete, steel and polymer material requirements was developed, with particular consideration of variable ground conditions and proximity of the tunnel alignment to ammonium leachate from adjacent landfill sites.

CONSTRUCTION PHASE SERVICES (CPS)

BG&E provided ongoing construction phase support across all packages — responding to design RFIs, reviewing contractor shop drawings, assessing design changes and conducting site inspections. Several significant post-IFC changes were managed, including revision of the Clarinda TBM Launch Site internal road network following tunnel layout finalisation, and amendments to the Southern Adit and Clayton Station Box reflecting revised geotechnical parameters, updated panel layout and revised reinforcement detailing.

TEMPORARY WORKS

As the permanent works designer for the Clayton site, our team possesses detailed knowledge of site constraints, structural interfaces and project requirements, allowing us to leverage existing models and design data to optimise temporary works outcomes. This integrated approach has enhanced efficiency and coordination across packages.

At BG&E, we are united by a common purpose — we believe that truly great engineering takes curiosity, bravery and trust, and is the key to creating extraordinary built environments.

Our team of more than 800 highly skilled people, in offices across Australia, New Zealand, Singapore, the United Kingdom and Middle East, design and deliver engineering solutions for clients in the Property, Transport, Ports and Marine, Water, Defence, Energy and Resources sectors.