AWARD FOR ENVIRONMENTAL EXCELLENCE

HIGHLY COMMENDED 2018

IECA

NorthConnex

2018 IECA Environmental Excellence Award

lendlease | BOUYGUES CONSTRUCTION AUSTRALIA | Australian Government BUILDING OUR FUTURE | NSW GOVERNMENT | Transurban

Table of Contents

Glossary / Abbreviations

CWMS	Construction Work Method Statement
EWMS	Environmental Work Method Statement
FRP Works	Formwork, reinforcement and pour, generally referring to capping beam for retaining wall construction
MTBM	Micro-Tunnel Boring Machine, used to install gravity flow pipelines that require precise line and grade in poor soil
PESCP	Progressive Erosion and Sedimentation Control Plan
Pile trimming	Method to remove and expose poured piles, generally undertaken with a jackhammer
RW	Retaining Wall
Soil anchors	Anchor designed to provide permanent support to ground

Project Overview

The $3 billion NorthConnex project will deliver significant benefits to road users across Sydney, with the opening of the twin nine-kilometre tunnels expected in 2020. NorthConnex is the longest road tunnel project in Australia, and will link the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills. The tunnel will remove around 5,000 trucks daily from Pennant Hills Road, helping to improve safety, local air quality and reduce existing traffic noise. The project is being delivered by Lendlease Bouygues Joint Venture on behalf of the proponents Transurban and Roads and Maritime Services with the tunnel to be operated and maintained by NorthConnex Company Pty Ltd (consisting of Transurban and the Westlink M7 shareholders).

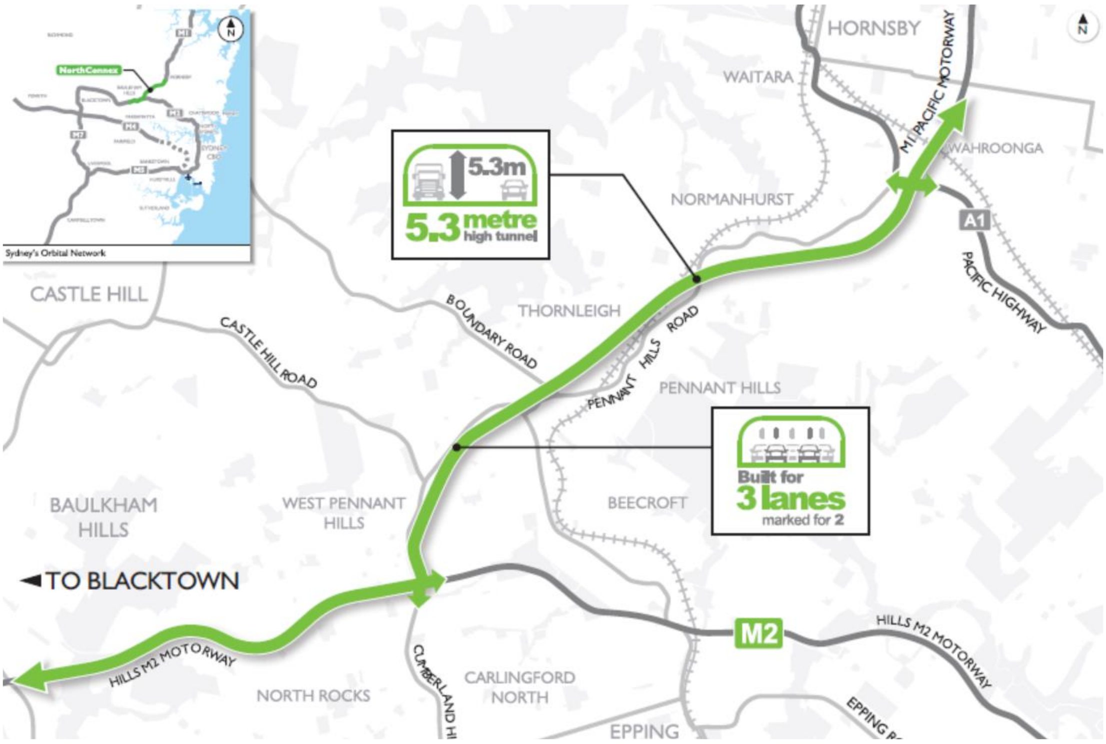


Figure 1: NorthConnex project tunnel alignment linking the Hills M2 Motorway to the M1 Pacific Motorway

The project presented several environmental challenges, particularly within the northern civil package of works at Wahroonga, where the realignment of a 395 metre stretch of a live creek (Cockle Creek) was required to facilitate site establishment and the construction of the M1 Motorway southbound tunnel dive structure. As a result, the project adopted innovative design and construction methodologies to deliver the required engineering scope in conjunction with best practice erosion and sediment control outcomes. The construction methodology took into consideration multiple stages of creek relocations, in order to enable earthworks and the construction of the tunnel dive structure footings and walls. This ensured an extremely high level of environmental protection, with all personnel working on the project understanding the importance of protecting this local waterway.

Project Summary

While the 9 kilometre NorthConnex project is being delivered in a highway urbanised area, local green corridors of significant ecological value are present within the project footprint. The northern civil area on the project contains the most environmentally sensitive features and riparian topographies within the project footprint.

The key environmental challenge within the northern project footprint was to protect the water quality of Cockle Creek during multiple temporary creek relocations which were required to facilitate the construction of the southbound tunnel dive structure along the M1 Pacific Motorway. North of the site, Cockle Creek flows through the Ku-ring-gai Chase National Park. In addition to the complexity of the scope of works to be executed, the project team was challenged with high rainfall events at the peak of construction in 2016 and 2017, which exceeded the mean rainfall of Sydney in over 10 years. This was a particular challenge, due to the upstream catchment area of Cockle Creek is highly urbanised and resulting in an extreme volume and velocity of flows during rainfall events.

The package of works to successfully relocate the creek took 28 months from commencement to completion. During this time more than 14 events occurred where emergency erosion and sedimentation control measures had to be implemented to ensure Cockle Creek had adequate protection, and there was no risk of flooding the surrounding community.

The initiatives adopted on the project to ensure a robust and effective erosion and sedimentation control approach included:

» Selection of the appropriate team committed to developing the construction method to ensure environmental protection of the natural hydrological conditions and surrounding community;

» Development of complex engineering staging to enable more than 10 temporary creek realignment in various sections during the southbound dive structure construction;

» Identification of management measures to mitigate direct and indirect impacts during detailed design and construction phase, and ensure the permanent structures are designed for a 1 in 100 year ARI storm event;

» Selection of careful and cost effective engineering practices and environmental management to avoid sediment, nutrient or hydrological changes to downstream environments;

» In-depth emergency planning strategy developed, implemented in the event of a high rainfall events or flooding;

» Detailed progressive plans established throughout the different stages of construction developed with the project's soil conservationist, to ensure appropriate environmental and erosion and sedimentation controls were adopted as the works progressed, site conditions changed and high rainfall events were experienced; and

» Extensive forward planning to ensure high quality temporary controls were implemented along the environmentally sensitive corridor throughout the construction phase.

Involvement and collaboration with the environmental and sustainability team, engineers, the greater construction team, designers, independent soil conservationist, NSW Department of Primary Industries Fisheries, the EPA, RMS representatives, NSW Department of Planning, Transurban and NSW Office of Water, was essential to ensure the outcome of a successful delivery of the creek relocation to a high environmental standard. The project in turn has achieved an outstanding outcome, which is of particular credit to the personnel involved due to the challenging environment and weather conditions experienced throughout construction. Ultimately, the success was achieved through refined planning, extensive collaboration of teams, environmental risk management, engagement with relevant authorities and a driven and dedicated team.

NorthConnex Project Information

Location

The NorthConnex project is located north-west of Sydney, with the 9 kilometre tunnel linking the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills. Largely, civil construction is based at the northern and southern ends of the project where integration works along the motorways are required to facilitate the tunnel portal construction and entrance to the northbound and southbound dive structures (on and off ramps). The topography of the northern interchange area transitions from other areas of the project and it has steeper slopes and a more rugged Hawkesbury landscape. Cockle Creek is located along the southbound side of the M1 Pacific Motorway, and is upstream of the Ku-ring-gai Chase National Park.

Figure 2: NorthConnex project main tunnel alignment from West Pennant Hills to Wahroonga

Figure 3: Close up of the northern civils package at Wahroonga, highlighting Cockle Creek along the southbound alignment of the M1 Pacific Motorway, and the realignment work area

Key Dates

A timeline of the key dates for the project are outlined below:

- February 2016 – Site establishment and early works at Cockle Creek
- June 2016 – Commencement of Cockle Creek realignment works
- November 2016 – Permanent construction commencement at Cockle Creek
- June 2018 – Cockle Creek realignment completion

Major Parties Involved

The NSW Government, Transurban and the M7 Westlink Shareholders (the Project Sponsors) are building an underground tolled motorway linking the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills.

The $3 billion project consists of a construction budget of $2.65 billion in addition to land and project delivery costs. The project is funded through toll charges with a contribution from the NSW and Federal Government of up to $405 million each.

Project Description: Features, Accomplishments & Challenges

Features of Cockle Creek

Environmental Features

Cockle Creek is an environmentally valuable feature of the Ku-ring-gai Chase National Park and surrounding residential areas, providing a natural space for recreation including hiking. This is the major riparian corridor contained within the project footprint, and is imperative as a green corridor leading to the top of the catchment within Ku-ring-gai Chase National Park.

The flow of Cockle Creek originates in the urban area of Wahroonga and leads into Ku-ring-gai Chase National Park. Due to the urban area the creek's flow volume and velocity changes within minutes following an upstream rainfall event. The creek bed is dominated by cobble and generally flow is of a medium velocity, which is identified as a first and second Strahler stream order. The topography transitions from rolling steep slopes in the southern area of the project, to a steeper and more rugged Hawkesbury landscape when moving northwards towards the northern interchange area. Flora communities are characteristic of those that were present to European occupation, namely Hinterland Sandstone Gully Forest.

Habitat availability varies along the length of the creek with complexity increasing downstream along with the quality of fish, frog and bird habitats. The area is largely pristine by the time it enters the national park. One threatened fauna species identified as potentially occurring in the area, the Red-crowned Toadlet (*Pseudophryne australis*). Breeding and foraging habitat was not identified to occur within the construction footprint or study area, however there are 314 records for the Red-crowned Toadlet within 10 kilometres of the project's footprint. A small area of potential habitat exists north of the M1 Pacific Motorway within the upper tributaries of Cockle Creek, which would not be directly impacted by the project, however all downstream flows from the project lead into the habitat. Figure 4 below identifies the location of CCA and CCB along the Cockle Creek alignment, referring to the study area, in reference to Tables 4.1 and 4.2 on the following pages.

Figure 4: Rapid assessment of area CCA and CCB along the Cockle Creek alignment.

Table 4.1 and 4.2 below outlines the rapid assessment of aquatic and riparian habitat of Cockle Creek, undertaken prior to the commencement of construction works.

Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation
CCA[1]	Creek 1st Order stream (Strahler). No barriers to fish passage.	Bank slope = >70 ° Sheet erosion = <1% Gully erosion = <1% Slump erosion = <1% Undercut erosion = <1%	Average wetted channel width = 1-3m Velocity = slow (<0.1 m/s) Turbidity is clear Riffle = 20% Run = 50% Pool = 30% Dominant substrate = bedrock Subdominant substrate = cobble Native aquatic vegetation abundance = rare Fish habitat = class 3 Riparian bird habitat = moderate Frog habitat = moderate	About 50% of the native vegetation remains, either in strips or patches. Most strata dominated by exotic species, high impact species abundant. More than one stratum completely altered from reference (lost or <10% remaining). Reduced cover (<50%) of dominant strata, and only one age class present.



Reach CCA is in the vicinity of the Junction Road Compound (left), at Bareena Avenue (middle), and a steep rock drop-off downstream of Junction Road Compound (right).

[1] Refer to CCA on Figure 4 for the location along the Cockle Creek alignment

Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation
CCB[2]	Creek 1st Order steam (Strahler). Minor barriers with fish passage during all flows.	Bank slope = >70 ° Sheet erosion = <1% Gully erosion = <1% Slump erosion = <1% Undercut erosion = <1%	Average wetted channel width = 3-5m Velocity = medium (0.1-0.3 m/s) Turbidity is clear Riffle = 40% Run = 30% Pool = 30% Dominant substrate = bedrock Subdominant substrate = boulder Native aquatic vegetation abundance = absent Fish habitat = class 3 Riparian bird habitat = good Frog habitat = moderate	No or little evidence of broad-scale loss of native vegetation. Exotic species present but not dominating any strata, high impact species rare. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present.
	 Reach CCB has boulders dominating the landscape downstream of Junction Road Compound (above).			

[2] Refer to CCB on Figure 4 for the location along the Cockle Creek alignment

Cockle Creek Hydrology

Hydrological studies were undertaken to inform and test the design for the creek realignment. The overall design approach for pavement drainage along the Cockle Creek area was to provide a system that intercepts and controls surface water within the project footprint, to an appropriate drainage outlet that safely discharges stormwater and does not adversely impact the downstream receiving environment or flood adjacent properties. In relation to the permanent realignment of Cockle Creek, environmental design specifications were taken into consideration to ensure features such as fish passages and rock pools were included.

Hydrologic models have the ability to simulate rainfall-runoff processes within catchments, and were used to estimate catchment flows generated from design storm events and historical rainfall records. Design Intensity Frequency Duration (IFD)[3] data and storm temporal patterns have been derived in accordance with Australian Rainfall and Runoff (AR&R) and the Bureau of Meteorology (BoM). The IFD data was then used to derive design rainfall events for use in the hydrological analysis for the pavement drainage design along the southbound dive structure and Cockle Creek alignment. Hydrologic models represent catchments as a series of sub-catchment areas, based on watershed boundaries, which are linked together to replicate the run-off characteristics of the total catchment area. The model input data included parameters to represent factors such as rainfall patterns (temporal and spatial), catchment size, drainage features, surface roughness, surface storage, and variations for surface water infiltration potential.

A pre and post construction comparison was undertaken for the total catchment area at the outlet to Cockle Creek. The waterway has a significantly sized catchment from the Wahroonga area, and also comprises of the drainage from the alignment of the eastern and eastern side of the M1 Pacific Motorway. In total, this area calculates to a catchment size of 153.2ha. Table 4.1.2, outlines the catchment area for Wahroonga and flows into Cockle Creek prior to the commencement of the project construction works, and following the completion of the project.

Table 4.1.2 noting the total catchment area of Cockle Creek

Cockle Creek Footprint Outlet	Pre-construction (ha)	Post-construction (ha)
Total catchment	153.20	153.20
M1 Impervious area	8.55	8.38
% of M1 area	5.58%	5.51%

There were existing piped outputs leading to Cockle Creek within the project footprint, which required careful management during the construction works. At the southern end of Cockle Creek, there is an 1800mm pipe outlet leading directly into Cockle Creek which has a significantly sized catchment area, capturing stormwater flows from the western side the M1 Pacific Motorway. In

[3] Design Intensity Frequency Duration (IFD) rainfall curves range from 5 minutes to 72 hours in duration and ARI from 1 year to 100 years. For the purpose of the study on the project, a 1 in 100 ARI storm event was analysed.

addition, there were multiple outlets along Cockle Creek and the project's footprint, capturing water from the eastern side of the M1 Pacific Motorway. All pipe outlets leading into Cockle Creek are noted in Table 4.1.3 below.

Table 4.1.3 noting the pipe outlet locations along Cockle Creek

Pipe Outlet Size (mm)	Pipe Outlet Location
2no. 900	Woniora Avenue
1800	Pipe channel from the M1 Motorway, Woniora Avenue
750	Burns Road
450	Pipe channel from M1 Motorway, near Burns Road
450	Pipe channel from M1 Motorway, near Bareena Avenue
375	Bareena Avenue
875	Pipe channel from M1 Motorway, near Bareena Avenue
750	Pipe channel from M1 Motorway, at Lochville Street
1500	Underbore from M1 Motorway, at Junction Road Compound

A stormwater mapping exercise was undertaken with the construction team to communicate the design specifications and environmental risks associated with the hydrology of the area, and potential impacts to Cockle Creeks whilst construction works were underway. The Foreman, Engineering team and Environmental Coordinator of the area worked closely to review the design drawings and ensure the construction work methodology was appropriate considering the potential environmental impacts. Additional unexpected stormwater outlets were discovered during the clearing stage of the construction works, which were managed accordingly with construction methodologies altered to take the outlets into consideration.

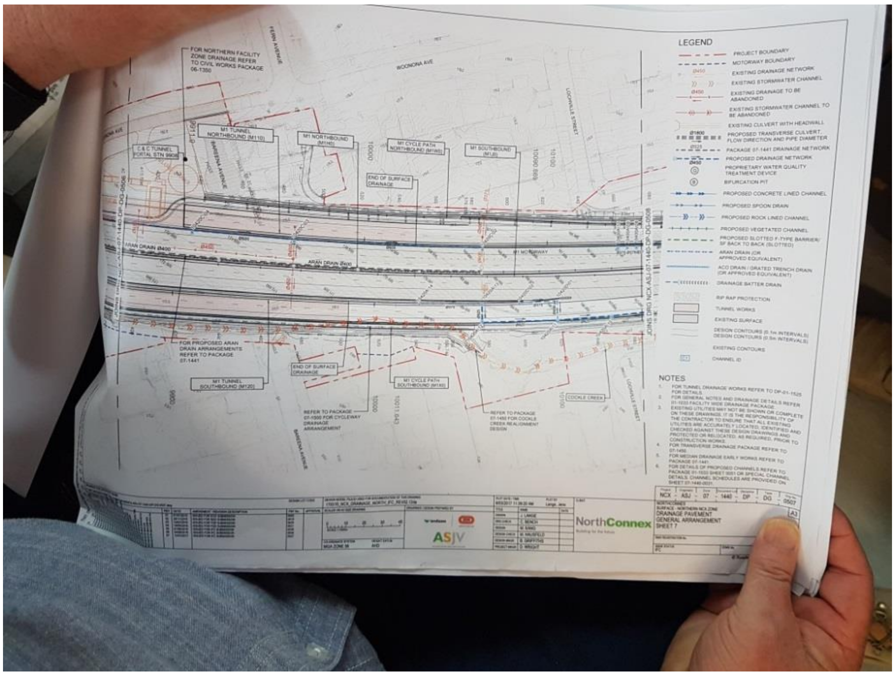


Figure 4: Foreman reviewing the Northern Surface Drainage Pavement Design, in relation to works along Cockle Creek

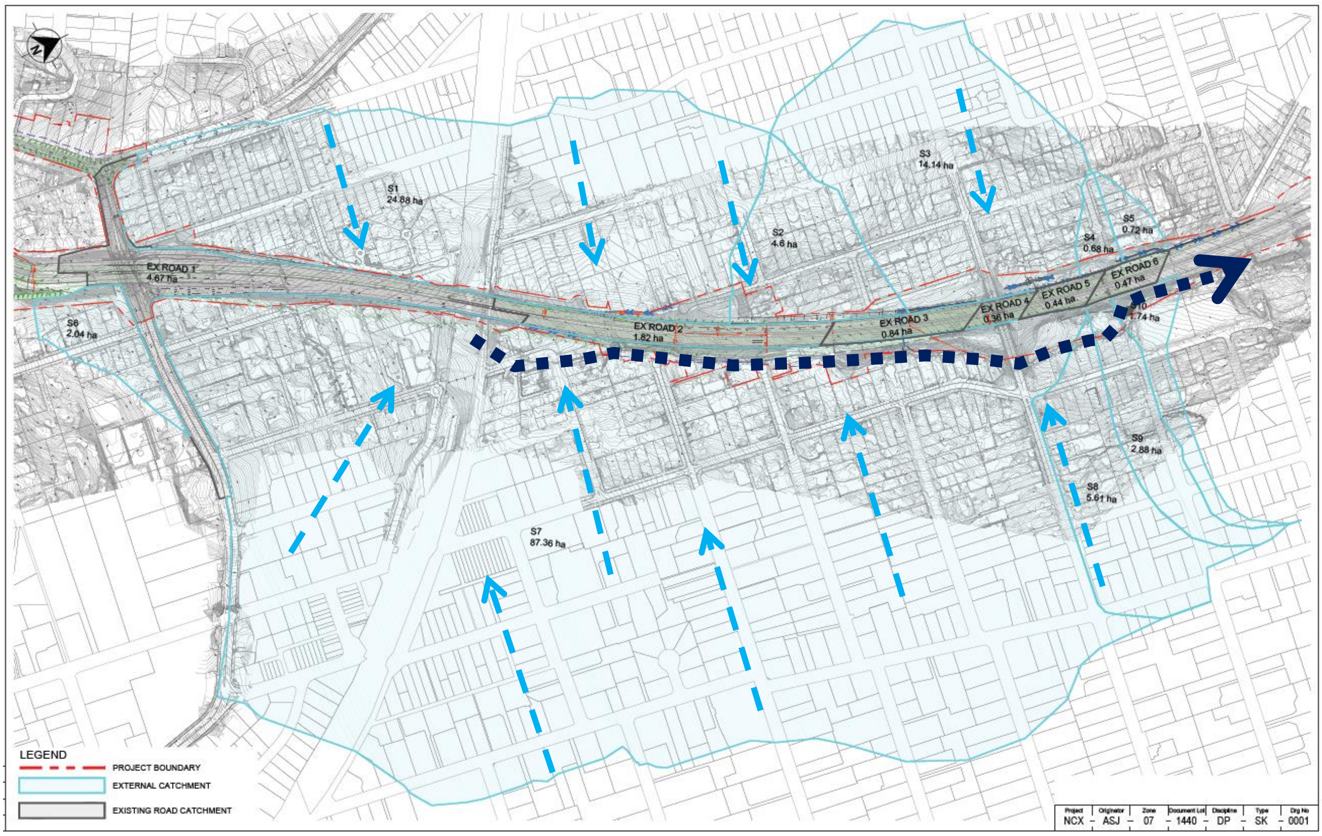


Figure 5: Catchment plan for the road and external Wahroonga area, inclusive of Cockle Creek. The blue arrows note the direction of clean water flows, and the dark blue arrow notes Cockle Creek

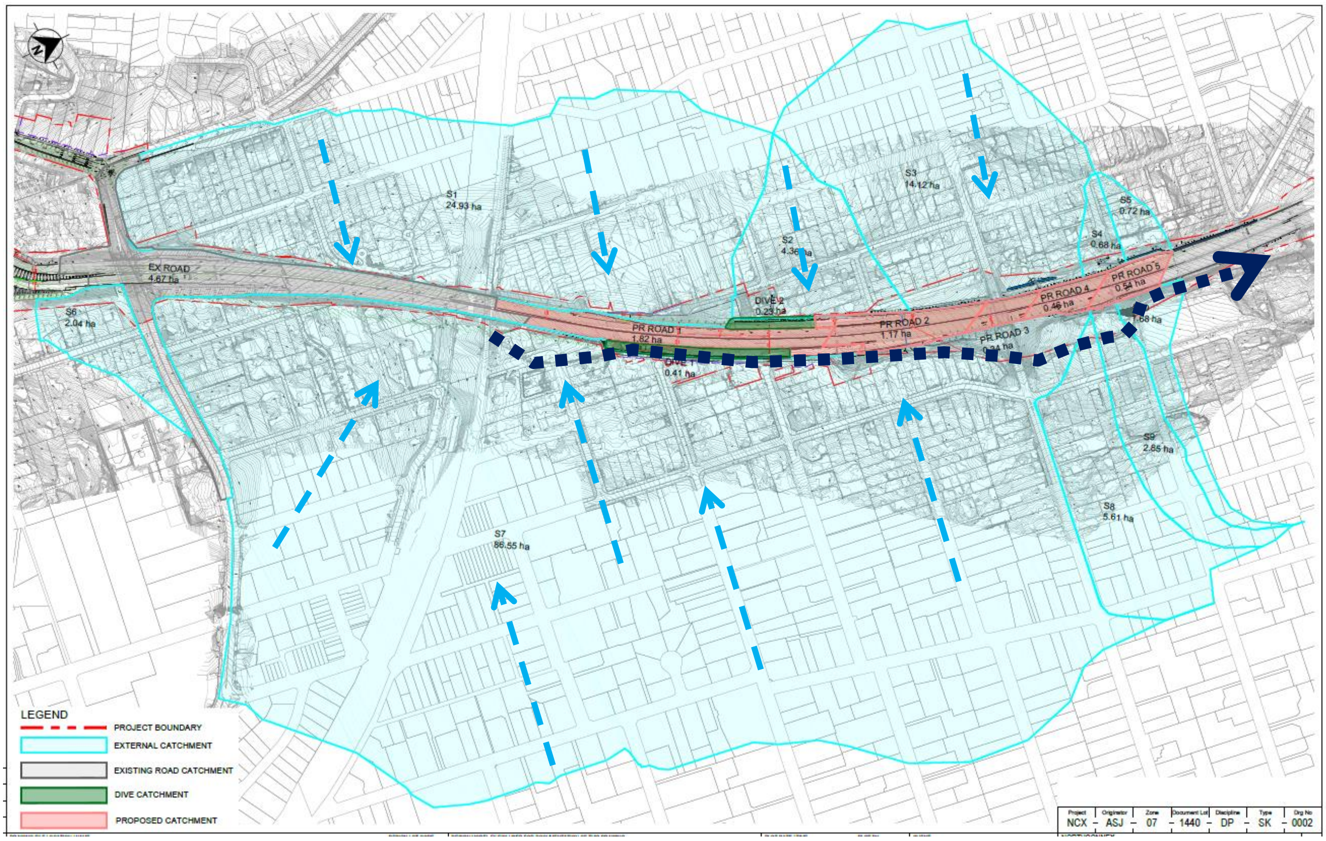


Figure 6: Catchment plan for the road, dive, Wahroonga area and proposed catchment area, inclusive of Cockle Creek. The blue arrows note the direction of clean water flows, and the dark blue arrow notes Cockle Creek

Meteorological Conditions:

As a result of the large catchment area, during small rain events of around 10mm, the creek experiences high velocity flows in a very short time. In anticipation, the construction works were significantly modified in order to appropriately set up the construction site and ensure clean water flows along the corridor. The shutdown procedure followed for rain events is outlined in section 4.2.3.

During project construction, seasonal high intensity and capacity rainfall events were experienced. Table 4.1.3 below outlines the significant rainfall events experienced during the construction and realignment of Cockle Creek.

Table 4.1.3 noting the total rainfall within the area of Cockle Creek

Year	Month	Rainfall (mm)[4]	Comments
2015	November	**142.8**	
2016	January	88.4	
2016	March	98.0	
2016	June	**318.0**	Double the mean rainfall for the month of June (BOM, 2018)
2016	July	**94.6**	
2016	August	71.8	
2016	December	65.2	
2017	February	**189.0**	
2017	March	**291.8**	Highest rain received was on 18 March 2017, receiving 71.8mm in less than 24hours
2017	May	**63.0**	
2017	June	147.8	Highest rain received was on 8 June 2017, receiving 74.4mm in less than 24 hours
2017	November	59.4	
2018	February	115.4	
2018	March	**149.2**	

Local Community:

In order to facilitate the permanent realignment of Cockle Creek, multiple temporary relocations were carried out and creek crossing structures were installed in order to provide enough space to enable the construction of the southbound tunnel dive structure and widen the M1 Pacific Motorway. A section of the creek approximately 395 metres long required realignment. The narrow corridor along Cockle Creek was a constraint to the project due to scope of construction activity required, and the machinery needed to undertake the works. This area was within a densely populated, affluent area within Sydney, with residences

[4] Bold rainfall notes the rainfall was above the mean rainfall for years 2004 to 2018 in the area (BoM, 2018).

having some European heritage value, being located as close as 5 metres from the works. Hence, the project was faced with a high level of public scrutiny and interest.

Various community events including school Fetes were undertaken to liaise and update the local community members of the progress of construction, highlighted in Figure 7 below.

Figure 7: The community held this Wahroonga School Fete, providing information on the Cockle Creek realignment and environmental protection measures in place

Project Accomplishments and challenges

Construction Commencement & Team Focus

In order to achieve a shared understanding and awareness of the importance of environmental protection required at Cockle Creek, a framework was developed to assist the construction and environment teams collaborate and work together. This assisted in opening up a dialogue between all personnel involved on the creek realignment works, including the civil labour team working on-site and facilitated involvement in the construction methodology development and implementation of environment mitigation measures along Cockle Creek. The framework, noted in Figure 8 below, was adopted for each new construction activity to be carried out along Cockle Creek. As a result, innovative and cost-effective solutions were developed to successfully undertake and achieve the works.

Framework:

Stage 1

- **Planning and breakdown of scope** of new construction works/activities within the Cockle Creek M120 package
- Planning documentation includes the development of:
  - Environmental Work Method Statement
  - Construction Work Method Statement
  - Erosion and Sedimentation Plan
  - Engagement with relevant environmental authorities, independent soil conservationist and local community

Stage 2

- **Environmental Risk Workshop** with the inclusion of the construction and safety teams

Stage 3

- **Brief and educate** the construction and on-site labour team of the works to be undertaken, and environmental controls and protection required

Stage 4

- **Monitor and inspect** the site on a daily basis
- Generate an environmental action list for the team on a weekly basis

Figure 8: framework to work with the construction team and successfully implement

Photo eft to right: Soil conservationist discussing the next phase of the realignment with Environmental Coordinator, as a part of Stage 1 of the Framework in Figure 8. Members of the engineering team planning upcoming construction works

Construction Methodology:

The realignment of Cockle Creek was completed in multiple stages to ensure adequate protection of the creek environment, reduce the requirement for low flow diversions to be set up during construction works (to keep the creek free flowing), and take into consideration any wet weather events forecast during the duration of construction.

The realignment works were broken into specific areas to allow works to occur concurrently due to the spatial restrictions of the area, identified in Figure 9 below. With reference to each area within the erosion and sedimentation control plans are specific road access names, listed below:

- Area 1: M120 portal / Woniora Avenue
- Area 2: Burns Road
- Area 3: 2B Burns Road
- Area 4 Bareena Avenue
- Area 5: Lochville Street

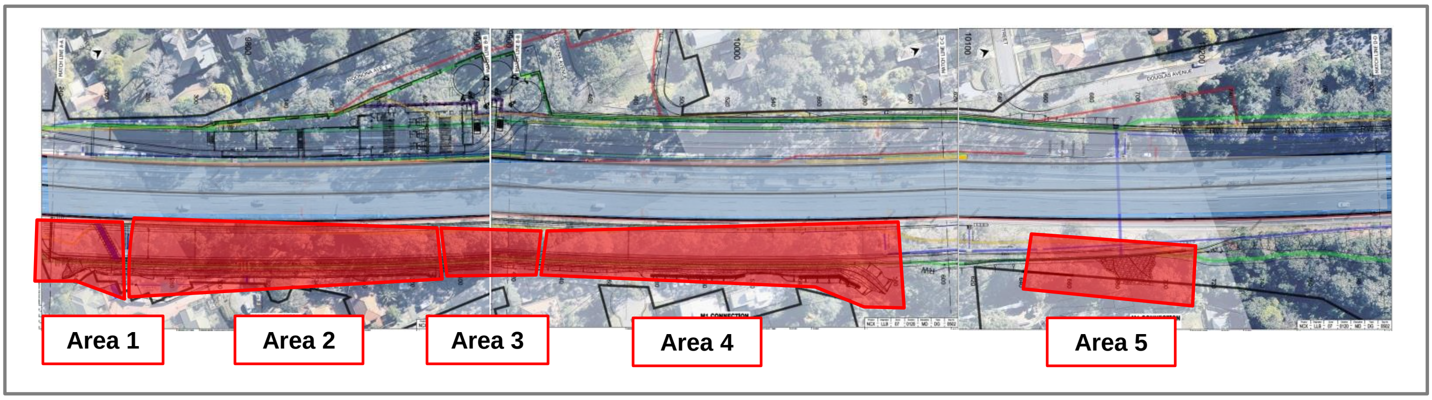


Figure 9: Staging of Cockle Creek realignment works along the M1 Pacific Motorway, noting the different work areas

The scope of works to enable Cockle Creek to be realigned, and facilitate the construction of the southbound tunnel dive structure are detailed in stages, in chronological order below.

- Stage 1: Clear along the Cockle Creek alignment, including demolition of existing houses. Realign and underbore the sewer line adjacent to the alignment of Cockle Creek from area 5 to area 1;
- Stage 2: Installation of temporary crossing at area 4 and area 3 to provide access to the western side along Cockle Creek, for clearing activity to continue;
- Stage 3: Temporary realignment of Cockle Creek at area 2 and 3 with bulka bags (as a temporary flood defence), and installation of an additional temporary crossing at area 3;
- Stage 4: Earthworks to allow for the construction of a piling pad (cut and fill). Piling along Cockle Creek for retaining wall 1 (RW1) and retaining wall 2 (RW2). Installation of additional temporary crossing (at area 5). Earthworks along the piled retaining walls, pile trimming, FRP works (formwork, reinforcement and pour) for capping beams and retaining walls, and concrete pours for RW1 and RW2 from area 2 to area 4;
- Stage 5: Temporary realignment of Cockle Creek at area 4, including construction of mass block wall and moving the position of the existing temporary crossing;
- Stage 6: Underbore at area 5 (micro tunnelling and pipe jacking);
- Stage 7: Removal of 2B Burns Road temporary crossing (area 3) and small section of Cockle Creek realigned, to facilitate the remaining retaining wall FRP works and concrete pours to commence;
- Stage 8: Commencement of works in area 1, M120 portal works; temporary creek realignment, 1800 pipe temporary extension, installation of remaining piles and installation of soil anchors.
- Stage 9: Temporary realignment of Cockle Creek behind retaining wall 1 at area 2, to allow works within the permanent channel;
- Stage 10: Backfill behind retaining wall 2, excavate between the retaining wall 1 and retaining wall 2 for the final creek alignment along areas 1, 2, 3 and 4. Install Bailey Bridge for access to backfill area behind retaining wall 1 at area 2. Piling and pile trimming along the M1 on the western side of Cockle Creek, for the remaining wall of the dive structure; and
- Stage 11: Existing creek bed modifications along Cockle Creek and placement of creek bedding and rip rap in Cockle Creek for permanent realignment from area 1 to area 4.

It is important to note that the installation of environmental erosion and sedimentation controls were progressively installed as works progressed, in all areas along the creek alignment, in conjunction with onsite inspections with the project's soil conservationist. Generally there was an overlap of construction activity along Cockle Creek in different areas (i.e. pile trimming is occurred concurrently with FRP works in different areas along Cockle Creek).

Stage 1 – Clearing along Cockle Creek: *Area 1 to 5*
– Commencement of Sewer Underbore: *Area 1 to 5*

All clearing was undertaken at a time when the creek had low flows and no rain was forecast, to ensure safe work practices and prevent any erosion and sedimentation during the construction. In order to gain access to the site and along Cockle Creek, the area required extensive clearing. Access was required on the eastern and western side of Cockle Creek, and therefore three temporary creek crossings at different locations along the creek alignment were constructed during the clearing process.

As clearing was being undertaken directly adjacent to Cockle Creek, specific environmental controls and measures were put in place to ensure no debris or saw dust would enter the live flow of water. Wood posts fitted with geo-fabric were installed along Cockle Creek within the active clearing area for that particular day (photos 1 and 2). The control was designed to capture all debris and saw dust generated from the clearing, preventing any foreign material from entering the clean water flows. This was a cost-effective approach, as all materials used were recycled from on-site and could be reused a third time following the clearing works. Where the wood frame could not be installed, a temporary diversion of the creek flow was set up, to redirect the water flow around the work area ensuring no debris would enter the live creek flow (temporary diversion described in detail in Stage 2).

The batters leading to the M1 Pacific Motorway on the western side of Cockle Creek were not grubbed during this stage of works, to ensure ground cover and stabilisation remained. The creek bed had some vegetation trimmed to allow access for detailed survey and geotechnical analysis, however was not grubbed to ensure no erosion or sedimentation potential (photos 3 to 10).

Following clearing within the area, earth bunds or mulch bunds (mulch used from the clearing activity) secured with geo-fabric were installed along the alignment of Cockle Creek. Sediment fences were installed next to the bunds as a secondary ERSED defence (photo 8, 10).

Photo 1 & 2: Timber frame with geo-fabric, to capture any debris during clearing activity

Photo 3 & 4: Clearing tape and sensitive area fencing delineating the vegetation area to be cleared, and the boom installed as secondary protection in the event of an environmental spill or additional debris

Photo 5 & 6: Area cleared, with the tree stumps and root zone remaining in place on the batters. Note the proximity of the noise wall of the M1 Motorway adjacent to the creek

Photo 7: Commencement of installation of geo-fabric bunded batter along the western side of Cockle Creek, with marine boom installed as a precaution measure. Photo 8: Temporary crossing at Bareena Avenue installed, with completed geo-fabric bund and sedimentation fence

Photo 9 & 10: Clearing progressing on the western side of Cockle Creek, with ERSED controls being progressively installed

Stage 2 – Temporary Access along Cockle Creek: *Area 3, 4 and 5*

Three temporary crossings were required along the creek alignment as a result of space constraints caused by the location of the M1 Motorway and the location of an existing house adjacent to Cockle Creek within area 3 at 2B Burns Road. The construction of each temporary crossing enabled vehicular and plant access to the western side of Cockle Creek. The location of the three temporary crossings required in areas 3, 4 and 5 are outlined in Figure 10 below.

Figure 10: Green marking the location of each temporary crossing along Cockle Creek marked in blue

In order to successfully construct each temporary crossing, a temporary creek diversion was set up along the creek bed to maintain the clean water flows and prevent any clean water from entering the work area. This entailed setting up a sandbag dam on the upstream side of the works within the creek bed, and pumping the clean water around the work area and further downstream. The pump was installed in an area within the creek upstream where the water naturally pools within the rock formations, and was manned at all times to monitor the ingress of clean water flows from the creek and ensure the pump did not stir up the water and generate sedimentation. The positioning of the pipe outlet from the pump downstream was critical to ensure no scouring of the creek bed would occur, and the flow remained consistent with the natural flow of the creek water. Generally, two pumps were used during the diversion to maintain the natural flow of water. A marine boom (silt curtain) was installed on the downstream side of the works as a precautionary measure to capture any potential spills or debris.

The creek diversion area was cleaned prior to releasing the natural creek water flow from the dam upstream at the end of each day, or the disturbed ground was covered and secured with geo-fabric or similar. Figure 11 below visualises how the temporary creek diversion was installed when works were occurring in the creek, in accordance with an approved Dewatering Permit.

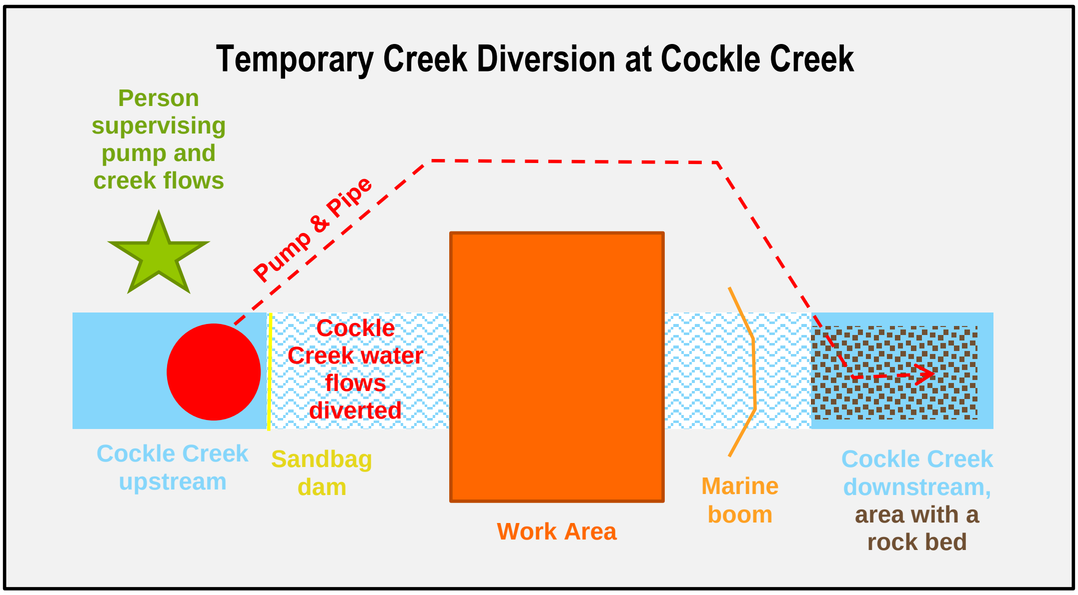


Figure 11: typical set up of a temporary creek diversion along Cockle Creek

The temporary crossings were specifically designed for various locations along the creek, taking into account variation in the creek bed geology and different space constraints. The temporary crossings were designed for a storm so the water could overtop the steel plates and continue the flow path along the creek. Up to four 600mm to 800mm HDPE pipes were used for the crossing constructions, however the construction methodology remained constant for each of the installations. Concrete barriers were fixed at each side of the crossing to prohibit movement of sediment during vehicle traffic. These barriers were removed, or a gap between the barriers was created when a rain event was forecast to allow the crossings to overtop and follow the path of the creek flow. Figure 12 below outlines the structure of the crossing and how it was positioned in the creek bed.

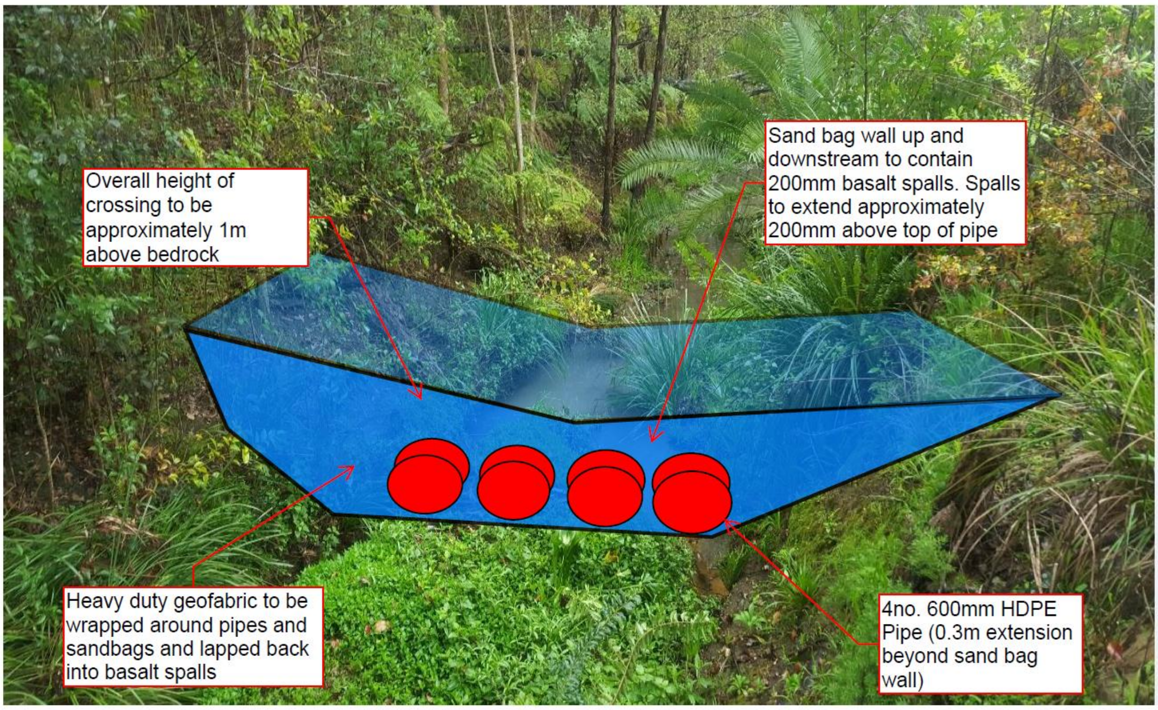


Figure 12: temporary crossing design at Bareena Avenue

Each design was incorporated into the progressive ERSED Plan, which outlined the specific methodology to follow when installing the crossings in Cockle Creek. The weather forecast was monitored prior to works commencing to ensure the installation could be completed in one day, in addition to ensuring the creek had a low flow. An additional pump was available onsite to over pump any water, if there was an unforeseen risk of water rising during the works caused by an influx of water from a pipe outlet located upstream of the construction works.

The specific methodology for installation was as follows:

1. Set up temporary creek diversion in dry weather;
2. Line creek bed with heavy duty geo-fabric, ensuring the low flow channel of the creek is correctly positioned;
3. Install 4x 600mm/750mm diameter HDPE pipes;
4. Install sandbags and bulka bags filled with clean sand between and around the pipes on both sides of the crossing, to ensure the flowing water is diverted into the pipes. The sandbags will be placed on top of the pipe up to a height to suit creek invert levels;
5. Backfill pipes with 75mm to 200mm clean rock to be level with the top of the sandbags;
6. Wrap the ends of the geo-fabric up around the ends of the pipes up to the top of the sandbag wall, and tie in with the steel plates (40/70mm rock around the pipes, for compaction purposes). This will ensure any breaking of the sandbags does not lead to a spillage of the 20mm aggregate;
7. Cut holes in the geo-fabric at the ends of the pipe to ensure water can freely pass through; and
8. Create access on either side of the crossing with stabilised 75mm to 200mm clean rock.

Photos 11 to 16 below outline the process used to install a temporary creek crossing along the alignment of Cockle Creek. In this case, this crossing was installed at 2B Burns Road. This was installed for one week, prior to removing to allow the bulka bag realignment channel to be installed. This crossing was therefore considered very temporary, and hence sandbag walls within the temporary crossing were not installed.

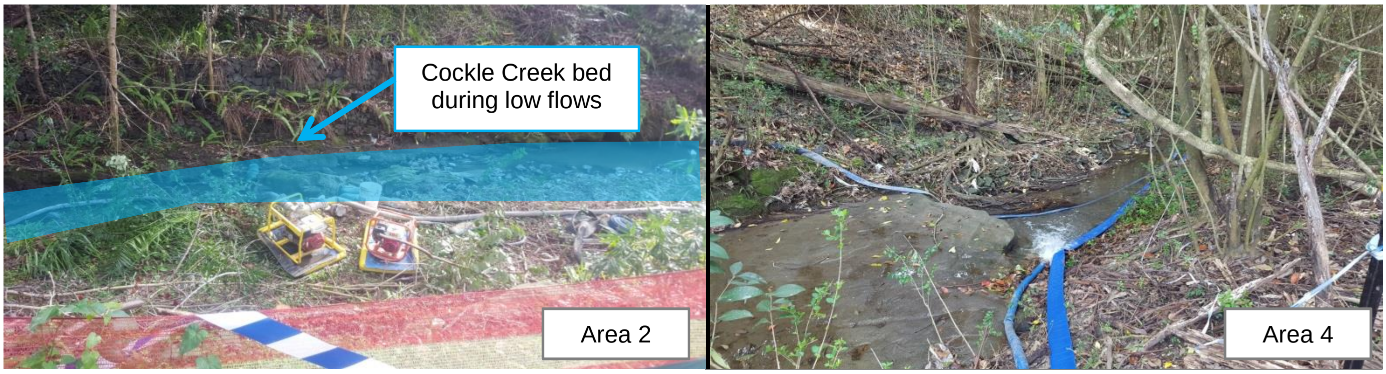


Photo 11 and 12: Set up of temporary creek diversion upstream and downstream respectively. The pipe outlet is positioned on existing bedrock to prevent scouring of the natural creek bed, and the generators are bunded with plant nappies

Photo 13: Temporary creek diversion in place whilst clearing the creek bed, placing geo-fabric, clean rock and pipes. Photo 14: Clean basalt rock placed on top of the temporary crossing and an additional layer of geo-fabric to secure the rock

Photo 15: Steel plates removed over the crossing whilst plant travel across the crossing. Photo 16: ERSED controls set up around temporary crossing including a sediment fence, stabilised access on either side of the crossing and sandbag bunding

Photo 17: Temporary crossing installation. Photo 18: Installation of temporary crossing at Lochville Street, to attain access on the western side of Cockle Creek

Photos 19 to 21 show the completed temporary crossings at each location along Cockle Creek.

Photo 19: Temporary crossing at 2B Burns Road

Photo 20: Temporary crossing at Bareena Avenue

Photo 21: Temporary crossing at Lochville Street

Stage 3 – Temporary Realignment of Cockle Creek: *Area 2 to 4*

There were multiple sections of the creek in areas 1 to 4 required realignment, to allow piling, FRP works of the permanent creek channel, and construction of the M120 dive structure adjacent to Cockle Creek. Retaining wall 1 is a one metre high wall, which was designed to be backfilled up to the existing surface levels along the creek. Retaining wall 2 is a three to four metre high flood wall, designed to prevent any water from the creek flowing into the new southbound dive structure constructed in the location of the existing creek alignment.

Similar to all construction activities in close proximity to the creek, the weather will be checked daily to ensure dry weather flows and no forecast rain. Where works are directly on the creek bed or require additional working area, a temporary creek diversion for the day will be set up. The creek diversion work area is cleaned prior to releasing the natural creek water flow from the dam upstream at the end of each day, to ensure no sedimentation.

Figure 13 shows the first section of Cockle Creek that was realigned within areas 2 and 3, including the reconstruction and relocation of a temporary crossing at 2B Burns Road, previously noted in Stage 2 of the construction methodology.

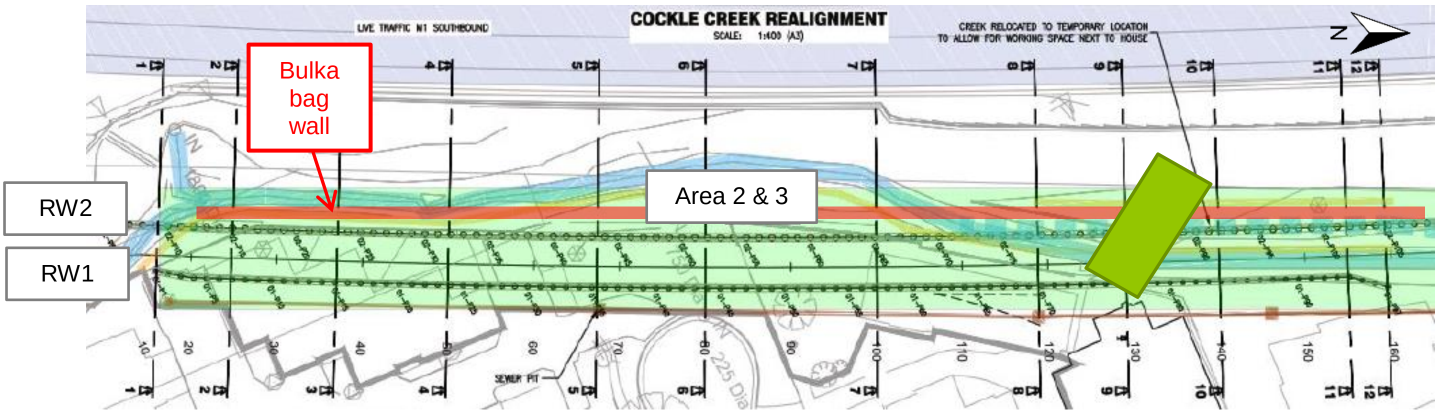


Figure 13, first section of Cockle creek to be realigned, to enable piling and FRP works to commence, noting RW01, RW02, the temporary crossing and the bulka bag wall adjacent to the piles

Following the relocation and temporary installation of the temporary crossing at 2B Burns Road, outlined previously in Stage 2, access and works was enabled on the western side of the existing creek. An excavator was used to widen the creek, commencing work on the western side from downstream to upstream. The exposed batter and western diversion wall was shotcreted, to stabilise the surface and prevent dirty water runoff into Cockle Creek. In areas along the batter where hard sandstone rock was present, the surface remained natural. During establishment of the batter and prior to shotcreting (for ERSED purposes), the exposed excavated daces were treated with geo-fabric at the completion of each shift to avoid scouring during rainfall, or in the event of a flow. The tie-in of the temporary diversion to the temporary crossing on the western side of the creek had bulka bags installed, to prevent any scouring and potential erosion.

The construction of the eastern side of the diversion was completed with an excavator, using fine-free quarry materials and natural sand filled, durable bulka bags wrapped in plastic and heavy duty geo-fabric. Bulka bags were progressively installed along the eastern side of the creek diversion and fixed into position with star pickets and timber. The eastern side of the diversion wall formed part of the piling pad, which was progressively back-filled in conjunction with the bulka bag installation. Geo-fabric and clean rock lined the diversion channel, with a low flow channel with large basalt rock present beneath this. In areas within the channel where hard sandstone rock was present, the surface remained natural. The temporary crossing was removed during low flow creek flows at the completion of the eastern and western diversion walls and channel. The creek was sandbagged upstream and pumped around the work area further downstream. An excavator removed the material from the creek bed and connected the temporary diversion with the live creek flow.

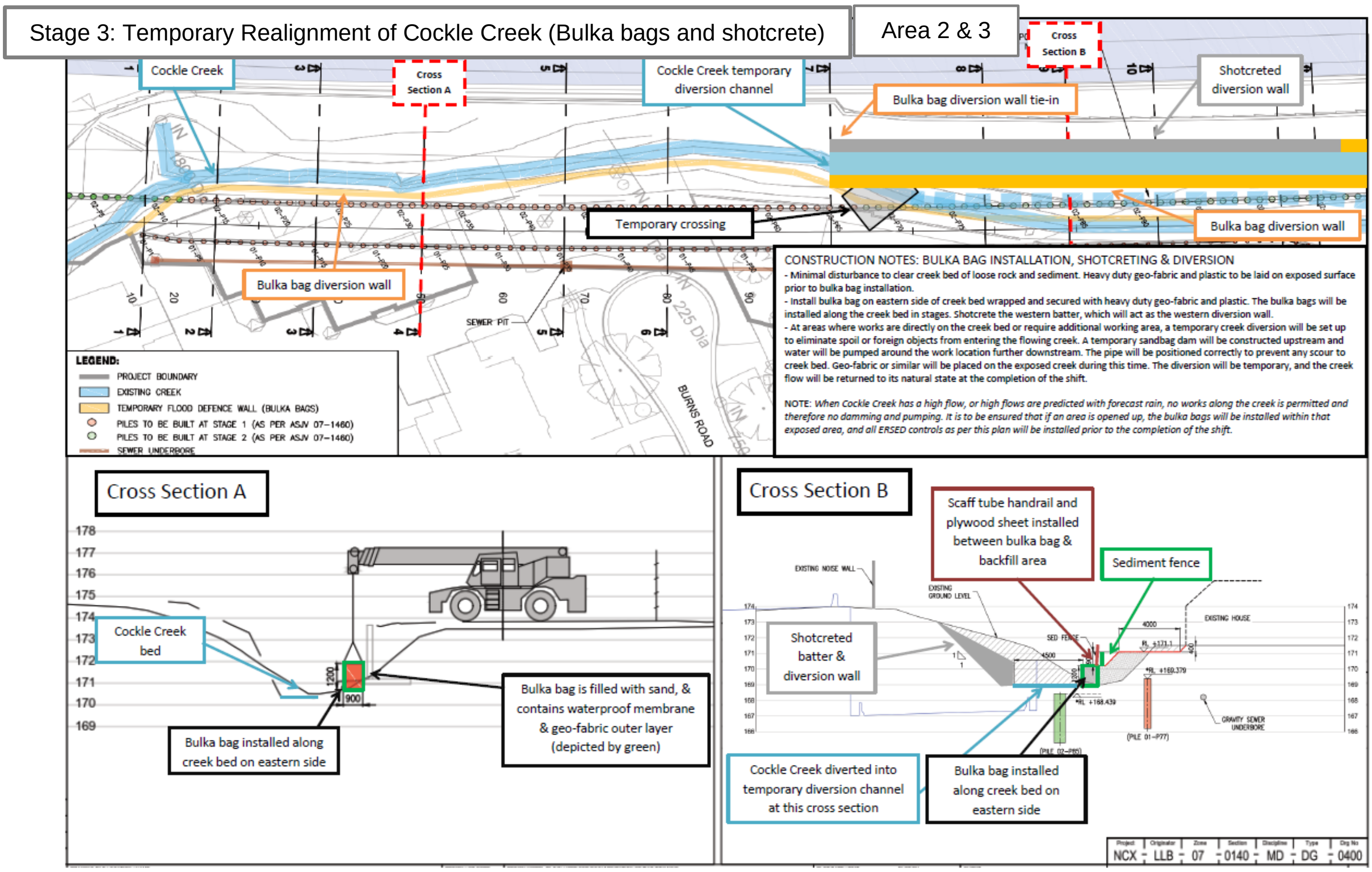


Figure 14: Extraction of ERSED Plan relation to the installation of the bulka bags along Cockle Creek, and shotcreting the batter. Note the sediment fence was replaced with the installation of concrete poured behind the plywood fence to ensure no seepage through to the creek.

Following the installation of the bulka bags wrapped in plastic and geo-fabric positioned along the creek bed, scaff tube handrails and plywood sheets were installed. The plywood fencing along the bulka bags was backfilled with concrete to ensure no seepage of construction water, concrete runoff of chemical spills, into the live creek. The pouring of concrete along the plywood fencing was undertaken during a temporary creek diversion to ensure all protective measures were implemented during the environmentally high risk activity. The plywood fencing was designed as a primary environmental protection control, to ensure all erosion and sedimentation was controlled and captured within the site and there was no runoff into Cockle Creek. In addition, if there was a flood event, the bulka bag and plywood wall were designed to withstand a significant storm event, providing additional protection and capacity to the creek. The design was discussed and identified during the initial risk workshop for Cockle Creek realignment, with Figure 15 below detailing the design.

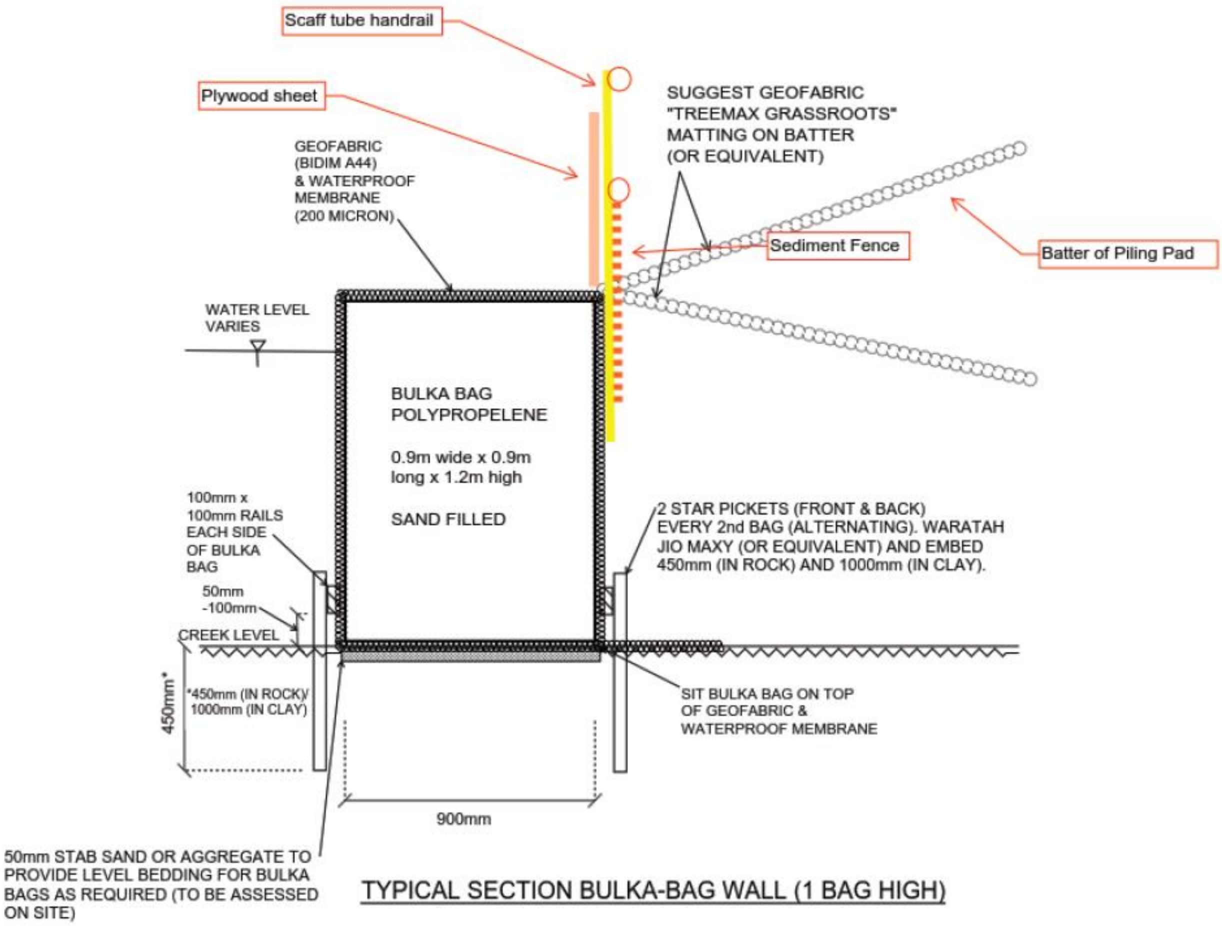


Figure 15: Typical cross section of a bulka bag wall, designed specifically to Cockle Creek. Note there was a double plywood layer for the fencing, and the area was concreted to ensure no leeching into the creek environment

The following photos detail how the bulka bag and plywood fencing is installed, along various sections of Cockle Creek.

Photo 22 and 23: Temporary creek diversion is in place, whilst the creek bed has been excavated and the bulka bags are being installed, firstly wrapped in plastic and secondly with heavy duty geo-fabric. Note a small section of the creek bed has been excavated to ensure the construction activity is complete at the end of the shift, and to return natural the creek flows with no disturbance

Photo 24 and 25: Small section of the creek bed at Bareena Avenue, with the bulka bags being installed progressively

Photo 26: Section of the creek bed at Burns Road looking towards 2B Burns Road (north), where the creek bed has been excavated and bulka bags have been installed. A temporary creek diversion is in place (see the blue pipe), due to the excavation works being in close proximity. The batter has been shotcreted to limit the disturbance to the western side of the creek, and reduce maintenance (refixing/replacing geo-fabric).

Photo 27: Section at 2B Burns Road, with the progressive installation of the plywood fencing

Photo 28: The existing creek bed is being backfilled in preparation for the installation of the plywood fencing. Photo 29: Installation of the plywood fencing.

Photo 30 and 31: Completed plywood fencing with concrete backfill along the creek realignment, in preparation for the piling pad

Photo 32: Completed plywood fencing and backfill for the piling pad, noting the sandbag breaks in place along the alignment to prevent potential erosion. Photo 33: View from 2B Burns Road looking southwards towards the completed temporary creek realignment

Photo 34 and 35: Installation of bulka bags in section of the creek between 2B Burns Road and Bareena Avenue, where the natural creek bed is unstable. Plywood fencing with concrete was installed as a protective measure for the creek, in preparation for the piling activity

Photo 36: Shotcreted batter along the temporary creek alignment. Photo 37: Concrete poured behind the plywood fencing, with sandbag breaks installed along the alignment to capture any runoff from the piling pad

Photo 38: Section at Bareena Avenue realigned with bulka bag and plywood fencing installed. Photo 39: Temporary crossing at 2B Burns Road

Stage 4 – Earthworks and piling along Cockle Creek: *Area 1 to 5*

– Installation of temporary crossing at Lochville Street: *Area 5*

The installation of more than 500 bored piles was required along the alignment of Cockle Creek, with multiple rows of piles extending from areas 1 to 5. When piling adjacent to Cockle Creek, additional controls measures were implemented, to ensure the waterway had adequate protection. This included the installation of plywood fencing, correctly managing the material from the bored piles and concrete pours, and setting up sedimentation tanks to pump any drill runoff into. Figure 16 below captures the piling activity and location along Cockle Creek.

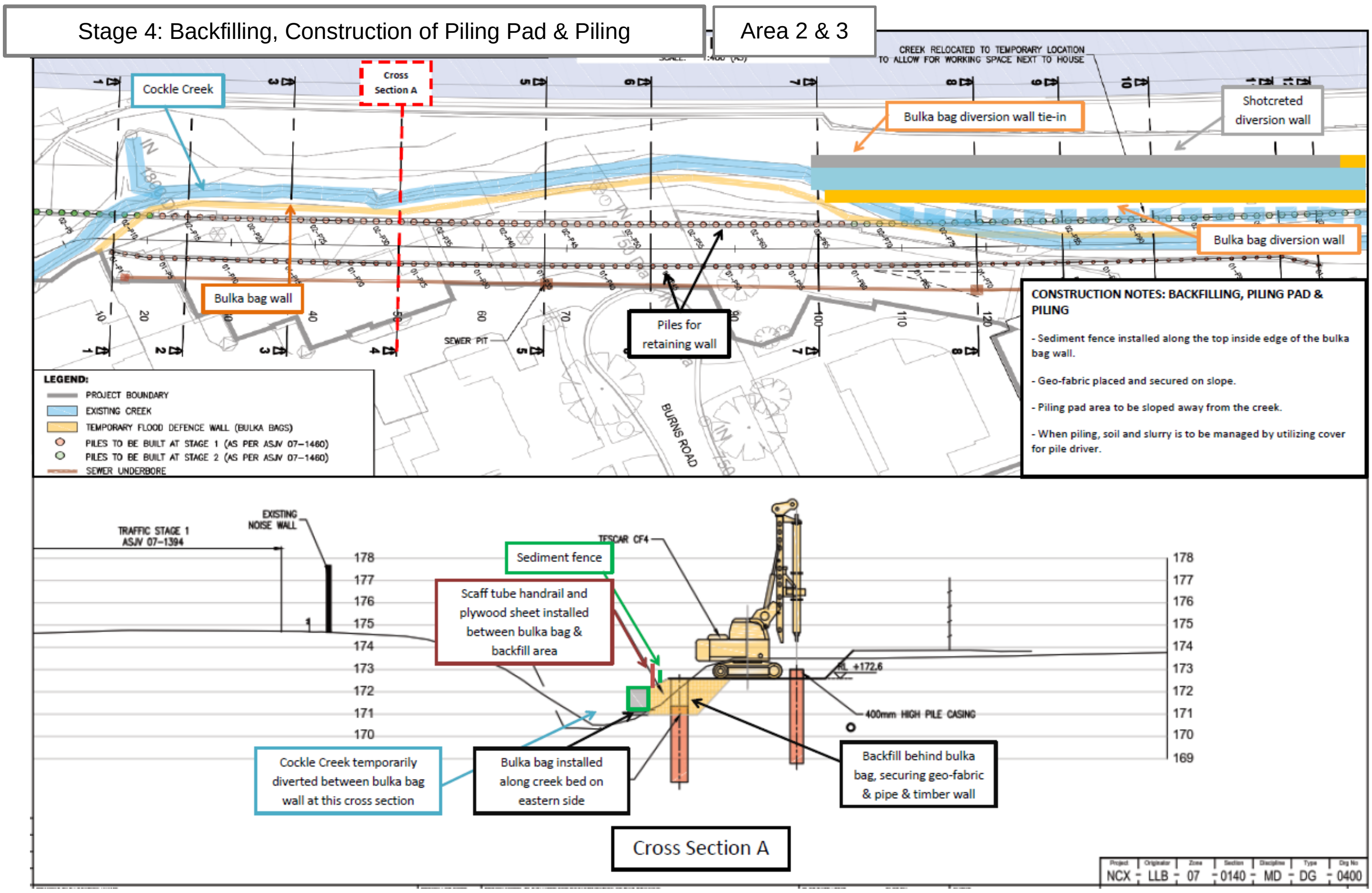


Figure 16: Extraction of ERSED Plan relation piling along Cockle Creek. Note the sediment fence was replaced with the installation of concrete poured behind the plywood fence to ensure no seepage through to the creek

Piling and pile trimming is undertaken with the use of piling rigs, concrete pumps, excavators, bogie trucks, light vehicles, jack hammers, hand held hoses and various hand tools. A typical sequence for piling and pile trimming when work was carried out along Cockle Creek was as follows:

1. Clearly delineate piling zone, waterway and sensitive areas, and locate any utility services;
2. Provide protection between the waterway and the piling works (bulka bag and plywood fencing has been installed
3. Mark location of bored piles and set up the piling rig and ancillary equipment onsite;
4. Piling rig to excavate insitu material using standard rotary drilling techniques and air drill techniques at marked pile locations;
5. Set up and manage sediment tanks in the work area to capture any drill runoff;

6. Stockpile excavated material away from the creek before loading offsite with bogie trucks;
7. Install steel casings in bored pile holes, where necessary, in loose ground to avoid the material falling into the excavated pile hole;
8. Where necessary, use bentonite slurry to ensure pile hole stability during pile excavation operations;
9. Installs steel reinforcement pile cage;
10. Concrete delivery to site via agitators, reversing to the point of discharge at the concrete pump or pile hole;
11. Installation of concrete (wet pile); pouring undertaken via concrete pump and tremie pipe lowered to the base of the pile hole and extracted as the concrete is poured to ensure ground water is pushed to the top of the pile where it is pimped to a detention tank;
12. Installation of concrete (dry pile); pouring undertaken via concrete pump and a layflat hose lowered to the base of the pile hole;
13. Piles to be over-poured 400mm minimum above design finish level. In the case of concrete being over-poured above the top of the piling pad, excess concrete to be transferred into the designated concrete washout bin (refer to Figure 17);
14. On completion of concreting each day, all equipment to be washed down at the designated concrete washout bin.
15. Concrete curing to be commenced on completion of concreting; and
16. Pile trimming to top of pile ready for pile cap/abutment works.

The correct management of concrete and spoil material from the bored piles was considered environmentally high risk due to the activity being in close proximity to Cockle Creek (within three metres). A sediment tank with a baffle was used to capture and redirect any construction and drill runoff, as the site was too restricted in size to have a basin. Connected to the sediment tank was a PR Power unit (Siltbuster), which acted as an additional baffle settling the sediment in order to discharge under the correct approval. A trade waste licence with Sydney Water was set up to allow discharge of the water. Figure 17 below shows the set up and management of concrete and construction water whilst piling.

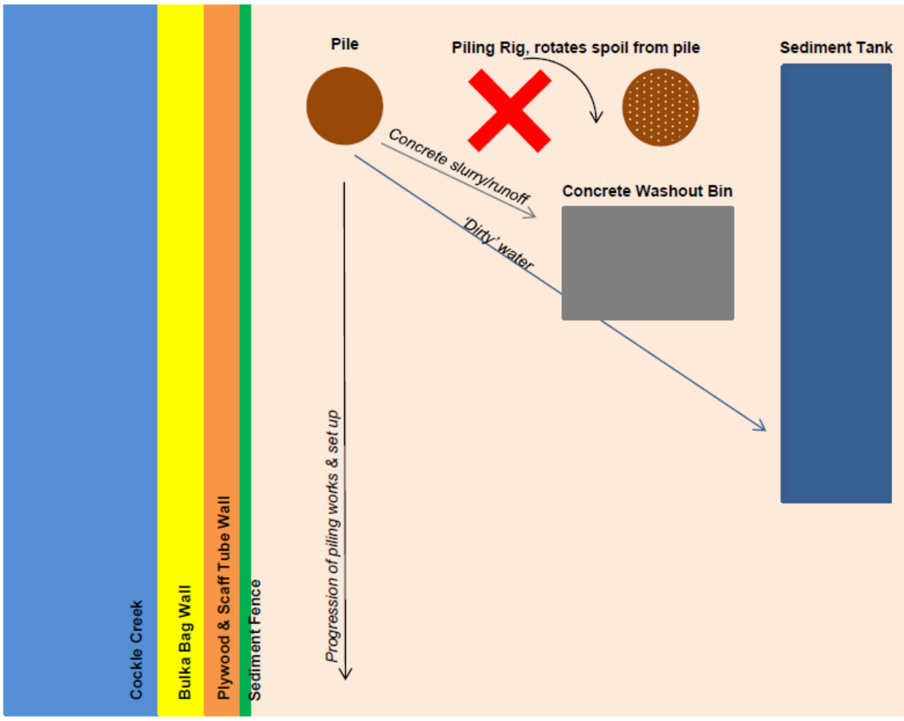


Figure 17: Typical piling set up along the plywood fencing of Cockle Creek (construction of retaining wall 2, the closest set up to Cockle Creek). Note the sediment fence was replaced with concrete backfill to ensure no spillage to seep through to the creek

Photo 40: Piling along Cockle Creek

Photo 41: Concrete washout set up and positioned away from Cockle Creek, with sandbag bunding and plastic lining

Photo 42: Pile trimming near Cockle Creek, with noise blankets set up

Stage 5 – Construction of mass block wall along Cockle Creek: *Area 4*
– Continued temporary realignment of Cockle Creek: *Area 4*

The mass block wall construction at Bareena Avenue formed part of the permanent realignment channel for Cockle Creek. In order to successfully install the mass block wall, a temporary creek realignment channel around the works to allow space to place the mass blocks and time for concrete curing was required. The location of the existing temporary crossing at Bareena Avenue was also altered for the mass block installation.

Similar to the installation of the bulka bag and plywood fencing in previous stages, the installation was continued from area 3 and along area 4 and part of area 5. The bulka bag and plywood fencing structure allowed the row of piles to continue along the alignment in areas 4 and 5, forming the permanent creek alignment and dive structure entrance.

The following photos show the progression of works along Cockle Creek.

Photo 43: Clearing of tree stumps within the creek bed for the mass block wall installation. Photo 44: Heavy duty geo-fabric used as a temporary measure to stabilise the cleared creek banks, prior to the installation of the bulka bag and plywood fencing

Photo 45: Excavation of the creek bed, for the installation of the mass block wall, noting a temporary creek diversion is in place to divert water around the work area. Photo 46: Commencement of installation of mass blocks

Photo 47: Area 4 during a rain event, with the site team installing heavy duty geo-fabric along the creek bank and around the mass block wall area. Photo 48: Section of mass block wall completed, with geo-fabric lined batter and installation of clean basalt rock in the creek channel

Photo 49: Commencement of installation of bulka bag wall for the creek realignment, following a rain event. Photo 50: Installation of bulka bag and plywood fencing along area 4, during a temporary creek diversion around the works (the 3 pipes along the rock)

Photo 51 & 52: Continued installation of the bulka bags and plywood fencing, in preparation for the piling pad and piling works

Photo 53: Extension of mass block wall, and piling pad preparation. Photo 54: Piling commencement following the installation of bulka bags and plywood fencing. Photo 55: Concrete management during the installation of the plywood fencing and mass block wall

Stage 6 – Underbore beneath M1 Motorway: *Area 5*

Underboring was required under the M1 Pacific Motorway to install a drainage line connecting the M1 northbound drainage into Cockle Creek on the southbound side, as per Figures 18 and 19 below. Underboring was undertaken with a Micro-Tunnel Boring Machine (MTBM), which was pushed from a launching pit into a receiving pit, by means of hydraulic jacking cylinders. The boring machine was equipped with a waterproof drilling shield, enabling the boring to take place in any type of ground condition. When underboring adjacent to a waterway, additional control measures needed to be implemented for underboring and associated activities, to ensure the waterway and any adjacent sensitive areas had adequate protection when the MTBM broke through into the creek bed area.

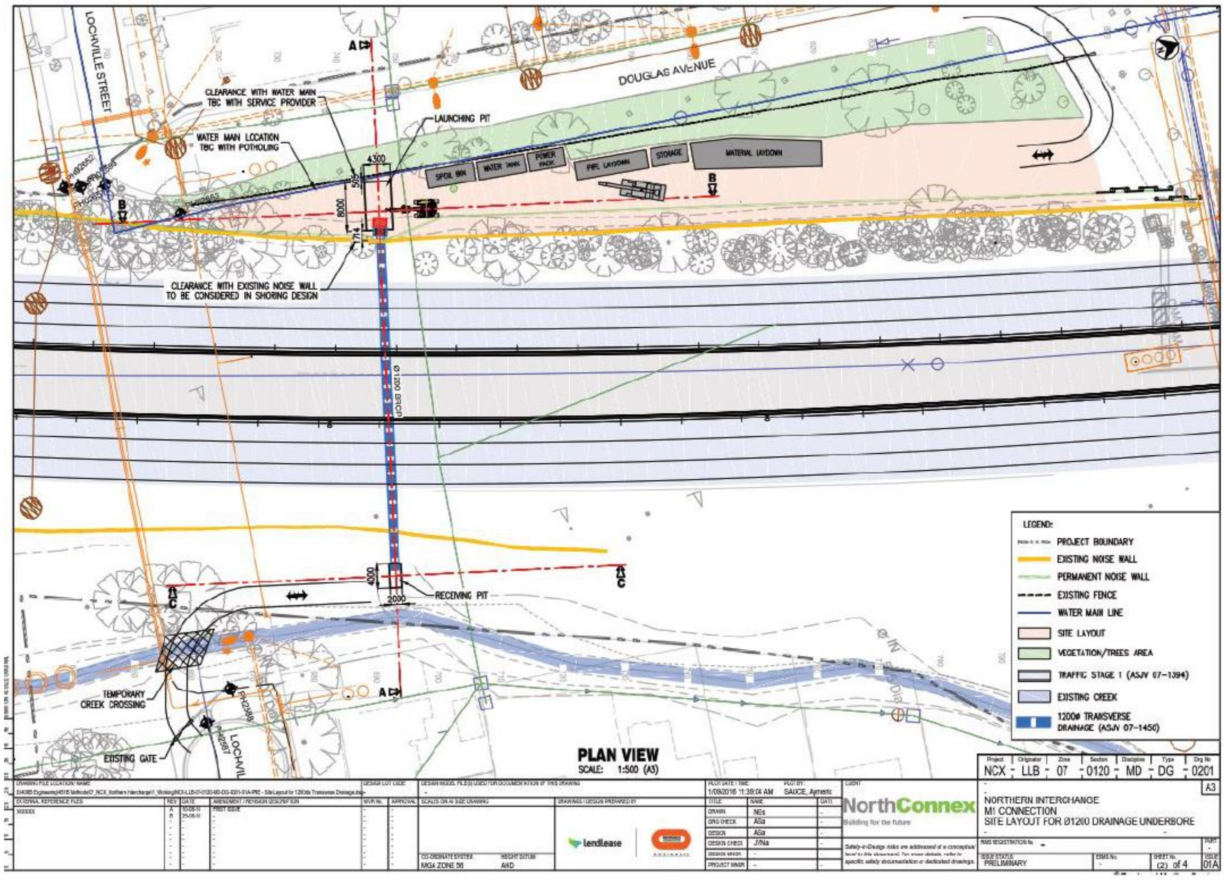


Figure 18: Location of the underboring required from the northbound side of the M1 Pacific Motorway, leading to Cockle Creek on the southbound side

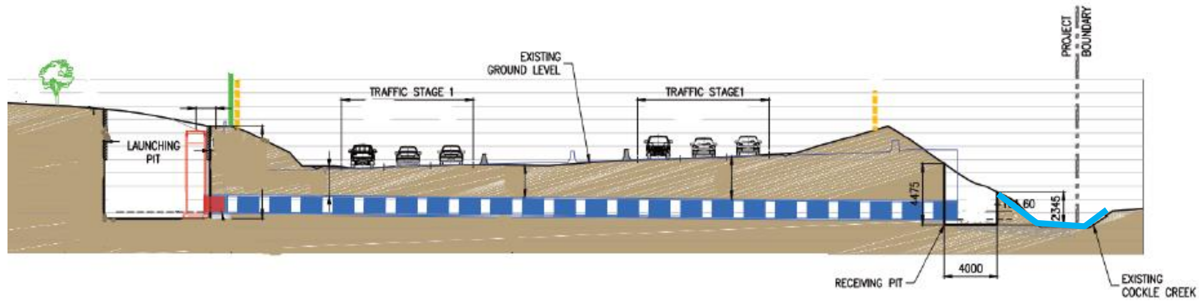


Figure 19: Cross section of the underbore beneath the M1 Pacific Motorway

The typical sequence for underboring and launching into the receiving pit near Cockle Creek is outlined below:

- Prepare the launch pit located on the northbound side of M1 Pacific Motorway;
- Construct access to receiving pit (on the southbound side of M1 Pacific Motorway, adjacent to Cockle Creek);
  - Excavate and construct access track from the Lochville Street temporary crossing, leading to the receiving pit;
  - Ensure the batter is stabilised and bunding and a sediment fence is installed along Cockle Creek;
- Underboring and pipe jacking;
  - Commence micro-tunnelling at the launch pit, installing reinforced concrete jacking pipes;
  - Once crushed, the rock will be passed back through the pipes to the launch pit via a screw conveyor system and removed by the excavator and loaded into bogies for removal;
  - The day when the MTBM reaches the receiving pit, a low flow diversion will be put in place and rip rap will be placed in the creek bed with a steel plate put on top. The MTBM will be pushed through the batter directly adjacent to the creek and will land on the steel plate, leaving the outlet of the pipe exposed through the batter. Following this, an excavator will remove the MTBM and the steel plate; and
  - Rip rap will be placed and shaped around the pipe and in the creek bed as necessary to prevent any potential scouring, once the drainage line is connected and live.
- Demobilising all equipment

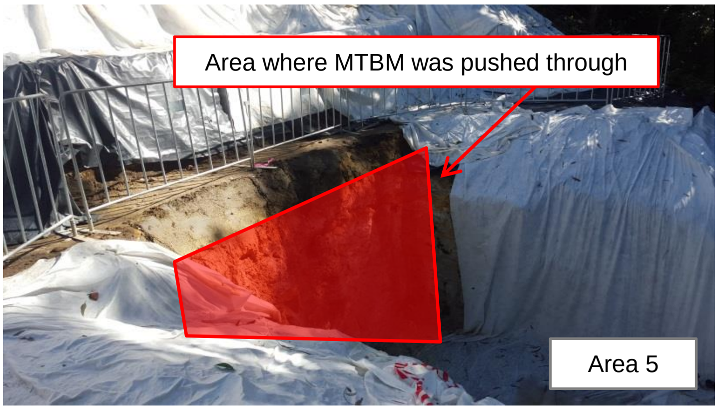


Photo 56 and 57: Proximity of the underbore receiving pit to Cockle Creek

Photo 58: Additional geo-fabric and basalt rock placed in preparation for the connection

Stage 7 – Removal of 2B Burns Road crossing: *Area 3*
– Concrete pours for retaining walls: *Area 2 to 4*

The temporary crossing installed at 2B Burns Road needed to be removed in order to enable pouring the retaining wall adjacent to the temporary creek realignment. Once removed, concrete pours for sections of the retaining wall were undertaken, measuring 15m^3 to 20m^3 in size (size of each pour required).

As the concrete pours were considered large, and multiple deliveries were required, careful planning was required to ensure the appropriate environmental controls were in place. Upon delivery of the concrete, the concrete agitator was set up on the eastern side of the creek where protection from the bulka bag and plywood fencing was located, and temporary bunding was provided between the pump and agitator truck (using material such as geo-fabric or left over plastic from the bulka bag wall installation). The concrete pour was undertaken on retaining wall 1, where the cycleway and noise walls were erected. When pouring concrete, it was ensured that there was a designated concrete washout area with adequate environmental controls protecting the area in the event of a spill or rain. The below photos capture the typical concrete delivery and washout setup. Any potential ground water pushed to the top of the surface during the pour was pumped into the detention tank, which was checked for adequate capacity prior to pouring the wall. Any excess concrete over-poured above the designed finish level was transferred into the designated concrete washout bin. This process was repeated for each pour for each section of the retaining wall.


Photo 59 and 60: Concrete pour with a concrete pump into various sections of retaining wall 2

Photo 61 and 62: Concrete delivery and washout set up along Cockle Creek for the retaining wall pours

Photo 63: Temporary diversion set up directing the clean water flows of Cockle Creek around the area to be poured. Plastic lining is placed over the creek to ensure any spills or overpours are captured. Photo 64: Concrete washout and chemical bunding in preparation for a concrete pour

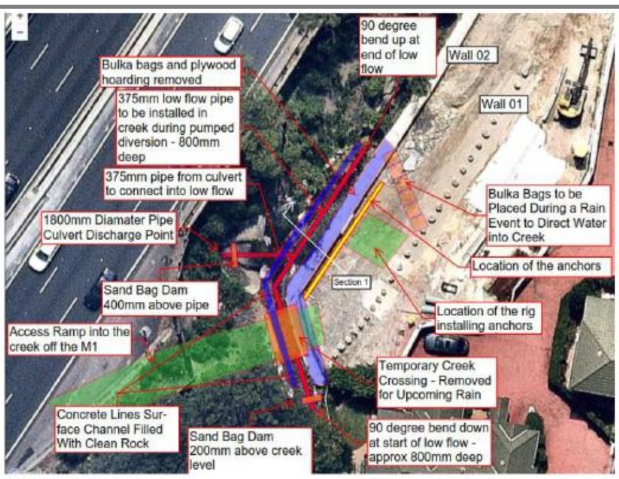
Stage 8 – M120 portal works: *Area 1*

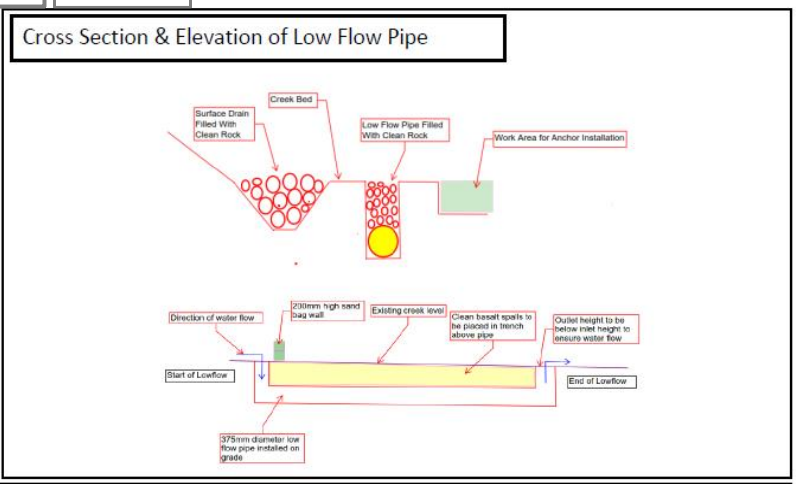
– Temporary Creek realignment: *Area 1*

The installation of 10m long soil anchors underneath the new creek alignment was required at the southern end of Cockle Creek, in the area of the M120 portal. Due to the restriction in location and proximity to the creek, the existing bulka bag and plywood fencing between the existing creek alignment and the new creek alignment was removed to allow the installation. The ground level that the anchors needed to be installed from was below the adjacent existing creek level and needed to be excavated out. In order to maintain clean water flows along the creek, and prevent any water from entering the work area, a low flow pipe system and diversion channel was installed.

A 375mm diameter low flow pipe from the start of the creek realignment to the location of the most northern anchor, approximately 25 metres, was installed at a depth of approximately 800mm. The pipe was installed on a grade to ensure the water was continually flowing and backflow was prevented. A surface channel was shaped in the creek bed towards the western side of the channel, to direct all other creek flows away from the work area. Similar to previous stages, Stage 8 involved the installation of bulka bags along Cockle Creek to act as the temporary flood defence and maintain the clean water flows. The installation methodology and environmental controls installed are outlined in Figure 20 below.

Stage 8: Installation of Low Flow Pipe for Soil Anchors | Area 1





CONSTRUCTION NOTES: INSTALLATION OF PIPING, PILING & ANCHOR INSTALLATION

In order to maintain the creek flow at the southern end of Cockle Creek between the piles on RW02, whilst drilling and installing 10m long anchors, the following methodlolgy is proposed:

- Excavate a ramp from the M1 portal area down the existing creek level, to gain access to the work area.
- Install 375mm diameter low flow pipe, approximately 25m long from the southern end of Cockle Creek, during a pump diversion in the creek. The pipe will be installed in the creek with an excavator at a depth of approximately 800mm. There will be a 90 degree bend down at the start of the alignment and a 90 degree bend up at the end of the low flow pipe.
- Build a sand bag dam wall 200mm high above the creek level just past the entry to the low flow pipe, to ensure the water is diverted into the low flow piping system.
- Installation of a 375mm pipe into the existing 1800mm culvert which will be connected to the low flow pipe. A sand bag wall will be built in the outlet of the culvert 200mm above the 375mm pipe to ensure the water is directed into the low flow pipe.
- The trench containing the low flow piping will be backfilled lined with geo-fabric, and filled with 70-150mm clean basalt spalls.
- A surface channel will be shaped in the creek bed towards the western side of the channel, to direct any small amount of surface water to the western side of the creek and away from the work area. The channel will be filled with clean basalt rock.

NOTE: *The system is intended to keep the creek water below the adjacent work area during dry flows. All construction activities to occur in dry weather where Cockle Creek has a low flow.*

WET WEATHER NOTE: *Check the weather forecast on a daily basis. No works to commence in the creek when there are signs of upcoming heavy or consistent rain. During any rainfall it is intended that the creek will be allowed to flow over the sand bag walls down the existing creek channel. In this case, the work area will be protected with sand bags and geofabric and no*

Figure 20: Environmental controls and work method for the installation of low flow pipe in Cockle Creek, in preparation for soil anchor installation

Photo 65: Cockle creek temporarily realigned around the piling and soil anchor works. Photo 66: Cockle Creek following a rain event

Photo 67: Section of cockle creek with piled retaining wall 01 in the background. Photo 68: Soil anchors installed in the creek area

Stage 9 – M120 portal works: *Area 1*

– Temporary Creek realignment: *Area 1, 2 and 3*

Following the installation of the soil anchors within the M120 portal area, the final piles for the portal structure were poured, retaining wall 2 was poured and an additional realignment of Cockle Creek was required to enable further access around the creek area, for further concrete pours, and work to build the permanent channel between the two retaining walls. The temporary realignment of Cockle Creek was directed on the western side of retaining wall 02, in a geo-fabric and clean basalt rock low flow channel, and surface water concrete channel. The 1800 pipe outlet within the portal area was temporarily extended over the work area and into the creek.

Figure 21 below outlines where the creek was realigned, and the controls required to ensure clean water flows were maintained and protected from the construction activity in the surrounding areas. The photos visualise the temporary realignment behind the retaining wall.

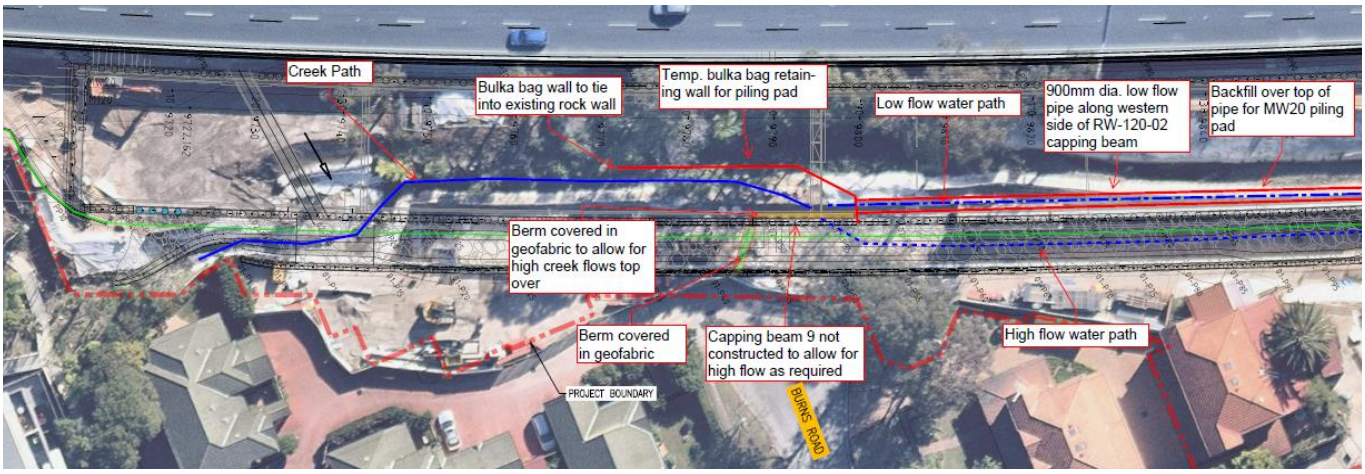


Figure 21: Environmental controls and work method for realignment of Cockle Creek behind retaining wall 2

Photo 69: Excavation behind the piles for retaining wall 2, in preparation for the temporary realignment of Cockle Creek. Note the temporary diversion in place directing the clean water flows of Cockle Creek around the work area. Photo 70: Extension of the 1800 pipe outlet at the portal, and the bulka bags acting as the protective barrier for the creek

Photo 71: Temporary realignment of Cockle Creek around the piling works at the M120 portal. Photo 72: Temporary realignment of Cockle Creek behind the retaining wall, with the surface water channel being concreted and the low flow channel in place

Photo 73 & 74: Temporary realignment of Cockle Creek behind retaining wall 02, with geo-fabric and clean basalt rock lining. Note the pipe is set up but not in use for a temporary diversion

Photo 75: Permanent works occurring along the channel between retaining walls one and two. Photo 76: Temporary realignment of Cockle Creek

Photo 77: Permanent channel works, including regrading and construction of a low flow channel, geo-fabric and plastic lining, and gabion basalt rock baskets. Photo 78: Outlet of the temporary realignment channel at 2B Burns Road. The section had to be piped due to the construction of a piling pad

Photo 79 & 80: Dust suppression during various construction activities along Cockle Creek

Stage 10 – Backfill behind retaining wall 2 for pilling & pile trimming: *Area 1, 2, 3 and 4*

– Install Bailey Bridge: *Area 2*

Following the installation of the temporary creek realignment channel behind retaining wall 2, the commencement of the piling pad construction occurred to form the final retaining wall for the entrance to the tunnel. This entailed backfilling an area of approximately 0.91ha to the level of the retaining wall to enable piling and associated piling activities to occur. A high degree of care was taken as the works remained in close proximity to the creek, with all batters covered and secured with geo-fabric or sprayed with Vital Chemicals soil binder. Various oil binder types were utilised depending on the area such as spraying heavy duty haul roads or batters.

As the temporary crossing at 2B Burns Road were removed, access was created to the work area along Burns Road by a Bailey Bridge installed across the two retaining walls to facilitate the delivery of material for the piling pad and access for all piling associated activities.

Photo 81 and 82: Batters from the piling pad covered in geo-fabric

Photo 83: Bailey Bridge with environmental controls installed at Burns Road. Photo 84: Piling the remaining retaining wall adjacent to the M1 Pacific Motorway. Photo 85: Batters along the piling pad sprayed with Vital Chemicals soil binder

Stage 11 – Creek Bed Modifications & Permanent Placement of Rip Rap: *Area 1, 2, 3 and 4*

Prior to switching the natural flow of Cockle Creek to along the permanent channel and between the two retaining walls in areas 1 and 2, works were undertaken to ensure the channel was clean and there were no opportunities for contamination.

The rehabilitation of Cockle Creek involved a number of areas to be treated with rip rap ranging in size from 300mm to 750mm diameter, due to the variation on the existing creek bed conditions. There are four rock pools along the length of the creek alignment, which were treated on a location by location basis depending on the creek bed conditions. The eastern side of the realigned creek was rehabilitated with a diverse range of native vegetation in accordance with DPI water guidelines.

Photo 86 and 87: Sections of Cockle Creek realigned into the permanent channel, with both natural bedrock and basalt rock

Photo 88 and 89: Sections of Cockle Creek realigned into the permanent channel, with both natural bedrock and basalt rock

Photo 90: The realigned channel flowing during a rain event. Photo 91: Seed planted behind the newly installed noise wall adjacent to Cockle Creek

Shutdown and rain preparation procedure

As a part of all construction works and under the environmental work method statement for each activity, a review of the weather forecast was critical to ensure the correct planning of works and set up of environmental controls. The following points were undertaken:

- Review upcoming weather forecast daily and plan works accordingly;
- Undertake a one week look ahead of weather conditions at the end of each week, and ensure upcoming works are planned accordingly. When significant rain over 10mm is forecast for the coming week, works to be altered and cancelled ahead of schedule, as there are strictly no earthworks to occur adjacent to Cockle Creek during a rain event;
- The commencement of works is determined by the foreman, superintendent and environmental coordinator as a result of reviewing the suitability of weather conditions in conjunction with the proposed works;
- Prior to forecast rain, prepare the work area and ensure all ERSED controls as per the PESCP are implemented. An Environmental Coordinator will inspect the site prior to the rain event to ensure appropriate controls are set up;
- When Cockle Creek has a high flow following rain, no works along the creek are permitted; and
- A post rain inspection including a review of all ERSED controls is undertaken, with any ERSED maintenance actioned as soon as possible.

When rain was forecast, or there was a shutdown period of three days or greater, a robust, detailed and very specific shutdown procedure was implemented along the Cockle Creek site to ensure all erosion and sedimentation controls were installed and there was adequate protection in the event of a flood. A specific checklist for the shutdown along the site was developed by the environmental coordinator and project soil conservationist for the site personnel and foreman, to note the high priority actions and controls to be installed. Throughout the progression of works, the shutdown checklist was altered to be most applicable to the site at that time.

The following areas were of high importance to ensure the correct set up of environmental protection in specific relation to Cockle Creek and proximity to the live flow of water. Specific controls were undertaken at these areas prior to rainfall, or daily as noted.

- Temporary creek crossing preparation;
- Access and egress points on-site;
- Batters, access tracks and stockpiles; and
- Temporary and permanent realignment channel preparation.

The following photos capture the environmental controls installed at each of these locations respectively.

Temporary creek crossing preparation:

The following erosion and sedimentation controls were installed prior to rainfall, or daily as noted.

- Ensure steel plates on the temporary crossings are cleaned daily;
- Sandbags and geo-fabric to be placed on either side of the access track at the temporary crossings, at the end of each day;
- Barriers across the temporary crossing to be moved, to allow the natural flow of the creek to overtop in the event of high rainfall;
- Bulka bag barrier is installed at Lochville Crossing, to act as a sump, to capture any runoff from the steep access track and protect Cockle Creek; and
- Ensure the temporary crossing pipes are free from debris or rubbish.

Photo 92 and 93: Progressively installing bulka bags wrapped and secured with geo-fabric at Lochville Street temporary crossing, prior to a rain event

Photo 94: Sandbag bund directing any dirty water runoff from the access track to the rumble grid, which was specifically designed to have the capacity of a small sump due to the access location being next to the creek. Photo 95: Post rain showing the sediment captured with the bunding, preventing any dirty water runoff into Cockle Creek

Access and egress points on-site:

The following erosion and sedimentation controls were installed prior to rainfall, or daily as noted.

- Sandbag bunding and geo-fabric is positioned at the access points from Burns Road, Bareena Avenue and Lochville Street.


Photo 96 & 97: Shutdown controls at the access points to site.

Batters, access tracks & stockpiles:

The following erosion and sedimentation controls were installed prior to rainfall, or daily as noted.

- Batters are stabilised and secured with geo-fabric, or sprayed with soil binder;
- Any piling pads to be sprayed with soil binder;
- Stockpiles sprayed with soil binder or secured with geo-fabric; and
- Sandbag breaks installed along access tracks.

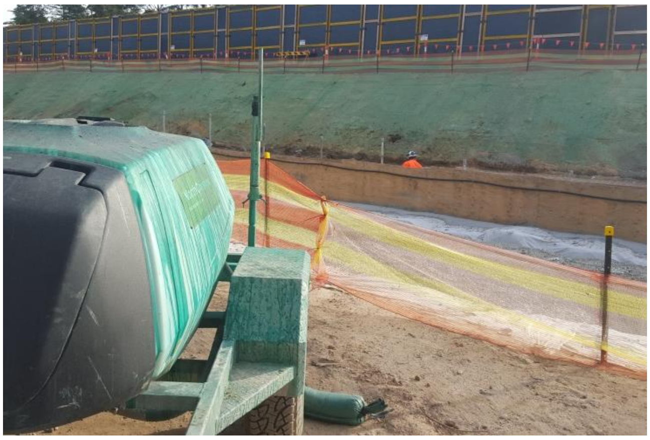



Photo 98: Area stabilised with soil binder and batters secured with geo-fabric along Cockle Creek. Photo 99: Soil binder unit utilising Vital Chemical soil binder products, and sprayed batter in the background

Temporary and permanent realignment channel preparation:

The following erosion and sedimentation controls were installed prior to rainfall, or daily as noted.

- Remove materials and plant from the permanent alignment channel, and line and secure with geo-fabric (refer to photos 100 to 102 below); and
- Ensure all areas around the creek are stabilised and secured with geo-fabric.


Photo 100 and 101: Area at 2B Burns Road stabilised and secured with geo-fabric, and the excavated channel lined with geo-fabric


Photo 102: Permanent alignment channel secured with geo-fabric prior to a rain event. Photo 103: Permanent alignment channel following a rain event

Figure 22: Cockle Creek rain preparation checklist

Challenges

The challenge presented to the team in mid-2015 was the relocation of Cockle Creek which was in direct conflict with the southbound dive structure. The final design and staging of works along Cockle Creek was complex and challenging, due to the construction methodology requiring multiple relocations to enable access on the eastern and western side of the creek respectively, whilst associated construction works proceeded. The area featured complex geology as a result of the creek, which added an additional layer of complexity to manage during construction. The location of Cockle Creek and its proximity to the construction of the dive structure was extremely confined and restricted by housing and the existing M1 Pacific Motorway. To overcome these limitations, the construction methodology required multiple temporary creek locations to enable various stages of construction works.

The key environmental challenge on the project was the management of water quality at Cockle Creek. During times of rainfall, works are restricted and the site along the alignment of Cockle Creek is shut down, hence being dependant on weather forecasts. The project team was challenged with high rainfall events at the peak of construction in 2016 and 2017, which exceeded the mean rainfall of Sydney in over 10 years. Permanent works were built within the footprint of existing creek, which ultimately led to complex realignments and diversions in a very restricted work space, and the requirement of all activities being controlled and constantly monitored. Environmentally high risk activities such as wet piling were undertaken within metres of the creek.

Uniqueness of Project

Despite this section of the project being faced with an extremely complex and environmentally high risk area, the culture and support between the teams to ensure protection of the environment was a priority and was very positive. This led to innovations in environmental controls and a high standard of general ERSED on site. The foreman for the site led this culture, and was the reasoning behind many of the successes and innovations. The foreman ensured the site team had backup emergency measures at all times, to mitigate contamination events and correctly manage the water quality of Cockle Creek.

The erosion and sedimentation controls implemented on-site were of a high standard, and arose from detailed and extensive forward planning to ensure the work methods proposed had adequate environmental protection noted for implementation. Daily site inspections were undertaken at key times of the construction stages during temporary creek realignments and temporary crossing installation. Following the inspections, detailed action lists and checklists were presented and actioned by the foreman and other site personnel. The key to the success of the installation of environmental controls was the collaboration of the environmental coordinator, foreman and labourers to explain and work through the problems collectively, and address each action onsite.

The high quality of environmental controls installed had benefits beyond the protection of the creek. Repairs following rain events were minimised, enabling construction works to proceed promptly. The multiple temporary realignment channels were set up correctly and with care on the first instance, and therefore maintenance and repairs following high flowing creek events was also minimal. Spoil on-site was reused for the multiple piling pads.

From an ecological perspective, the quality of the creek water and management of water quality was critical to ensure there were no downstream effects. A range of surface water quality monitoring was conducted throughout the duration of construction measuring upstream and downstream parameters at a NATA accredited laboratory. In addition, visual checks of the creek were undertaken on a daily basis to ensure the water remained of a high quality.

Contribution to Environment, Community & Industry

The construction and environmental work methods utilised to successfully permanently realign Cockle Creek and construct the southbound dive structure have generated sustainable benefits beyond the project requirements and within the local community and wider construction industry. The following points have been achieved:

- High degree of environmental protection, with the implementation of innovative and detailed erosion and sedimentation controls along the alignment of the creek, during all stages of the creek realignment;
- Cost-effective protection of the natural flowing Cockle Creek, and management of dirty construction water. The cost effective engineering and environmental management avoided sediment, nutrient or hydrological changes to downstream environments;
- The design of the permanent realignment creek channel provides a higher quality area of riparian and aquatic habitat than the existing creek, and guaranteed flooding mitigation for a 1 in 100 year ARI storm event;
- The design initiatives incorporated sustainability objectives for the project in designing waterways to improve the existing water quality outcomes, benefiting the local community for future generations;
- A reduction in risk to the local community of inundating and flooding roads and residences in the area, with the added capacity of Cockle Creek;
- Consideration of sustainability within the approach of procurement of materials, reuse of materials and beneficial reuse of spoil onsite;
- Performed well during client and stakeholder visits, providing great benefit to the project in relation to environmental performance and ongoing compliance;
- 63 green light inspections were received out of 75 inspections by the Environmental Representative, RMS and Transurban, highlighting the successful environmental management onsite;
- Knowledge shared environmental and sustainability benefits generated during the construction of the creek realignment, with the construction team, local community and wider support teams;
- Training delivered to the construction and labour team to correctly install environmental controls during the realignment of Cockle Creek, highlighting the understanding of the environmental importance when working in an environmentally high risk area will be acknowledged, and will be carried on as a knowledge legacy for future projects;
- Installing the environmental controls correctly and designed to withhold storm events once, ensured that there was reduced maintenance required throughout the duration of works along Cockle Creek;
- Detailed progressive plans established throughout the different stages of construction, to ensure appropriate environmental and erosion and sedimentation controls were adopted as the works progress, site conditions change and high rainfall events were experienced. This has brought benefit to the construction team when forward planning the program and extent of environmental protection required;

- Developed and trained a team committed to sustainably developing the construction method and works to ensure environmental protection of the natural hydrological conditions and surrounding community
- Cost efficient choice of materials and construction methodology during Cockle Creek realignment: Bulka bag installation rather than a temporary retaining wall of mass block calculating to a saving of up to 80%; and
- Innovative measures implemented to ensure the water quality of the creek was maintained, including temporary diversion set up during the day to avoid permanent low flow pipes installed along the creek.