IECA AWARD FOR ENVIRONMENTAL EXCELLENCE

THE TRANSMISSION GULLY MOTORWAY PROJECT

JUNE 2018

CPB HEB Joint Venture

Index

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SUMMARY

The NZ$850 million Transmission Gully project is being delivered as a Public Private Partnership (PPP) between New Zealand Transport Agency (NZTA) and the Wellington Gateway Partnership. A key part of the new Wellington Northern Corridor, the project is one of the most significant pieces of new road construction in the lower North Island.

A key component of the project is the diversion of the Horokiri and Te Puka streams. Approximately 4.1km of stream is to be diverted into a pipe system, while bulk earthworks are undertaken to lift the streambed by up to 20m.

The Transmission Gully team has implemented an innovative and environmentally responsible method to manage the challenges associated with constructing a 4-lane motorway through the middle of a valley containing streams with high ecological value. The project has utilised subsoil pipes as a temporary diversion, thereby moving the streams offline while construction occurs. The implementation of this method has been refined to minimise sediment released to the receiving environment while also managing the impacts on construction timeframes and costs.

Further, the refinements undertaken while recreating the stream environment have achieved outstanding results within all areas of consideration including:

- Ecological outcome
- Environmental outcomes
- Costs
- Timeframes
- Quality
- Constructability.

The world-leading methods utilised by the CPB HEB JV have ensured the success of these stream diversions. As commented on by a competitor's National Environmental Manager following an IECA study tour undertaken at the project: "I am very envious of your waterway diversions. They look great and they will certainly be a 'showcase' once the landscaping elements are complete."

Industry-wide improvement of practices can be achieved through the implementation of these methods and approaches in similar situations.

Figure 1: The new permanent Te Puka Stream channel under construction.

- 2.4 kilometres of Horokiri Stream and 1.7 kilometres of Te Puka Stream will be diverted.
- 700 metres of the permanent stream channel for Te Puka has been constructed, with 1 kilometre left to go.
- 1.15 kilometres of the permanent stream channel for Horokiri has been constructed, with around 1.25 kilometres left to go.
- One section of Te Puka Stream needs to be raised 20 metres above its current level.
- Around 130,000 tonnes of boulders are being used to construct the permanent Te Puka and Horokiri stream channels. 58,000 tonnes have been placed so far.
- More than 26,000 fish and crayfish were relocated from the Project streams in one of the biggest fish relocation exercises in New Zealand.
- Once the new channels for Te Puka and Horokiri streams are complete (with water flowing), fish including Koaro, Redfin Bully, and Banded Kokopu, will be transported back to repopulate them.

PROJECT OVERVIEW

The Transmission Gully motorway is scheduled to be open for traffic in 2020. A key component of the 110 kilometre Wellington Northern Corridor, the 27 kilometre 4-lane motorway will run from Mackays Crossing (where it will connect to the already completed Kapiti Expressway) through Transmission Gully, to Linden where it will reconnect with State Highway 1.

Twenty six structures, four interchanges and new link roads will connect the motorway to Paekakariki, State Highway 58, Whitby, Waitangirua and Kenepuru. The route runs through the two regional parks of Battle Hill Farm Park and Belmont Regional Park and crosses a number of streams that flow into the ecologically sensitive Pauatahanui Inlet - the largest remaining estuarine wetland in the Lower North Island. The terrain is varied and challenging including peat wetlands, very steep narrow gullies, and flood plains, as well as following a known seismic fault line.

The contract for the design and build of the project was awarded to the CPB HEB Joint Venture in July 2014 with enabling works commencing in January 2016 following the relevant Council approvals being awarded. Earthworks commenced on the project in May of the same year, following establishment of access into the project.

The project is subject to stringent resource consent requirements and management of environmental effects during construction is of the highest priority. A key component of the project is the stream diversions of the Horokiri and Te Puka streams.

After first removing over 26000 fish from the natural streams, approximately 4.1km of stream needed to be temporarily diverted into a pipe system, while bulk earthworks were undertaken to lift the stream by up 20m. New permanent channels are being created, with huge emphasis on ensuring that they mimic the natural channel as closely as possible while providing the best habitat for the high number of native – and some endangered, fish species. Additionally, these channels must still meet the hydraulic performance requirements to meet up to a 1 in 1000 year flood event protection specification. Works on these permanent stream diversions commenced in July 2016.

To date 680m of the Te Puka stream diversion and 818m of the Horokiri stream diversion have been completed, with these sections of the stream now running in their permanent alignment. The completion of the stream diversions is planned for January 2019.

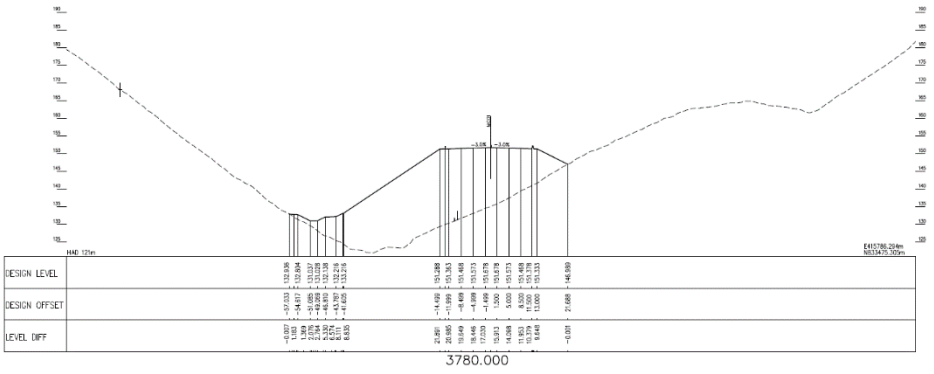


Figure 2: Cross section showing original level and final stream level

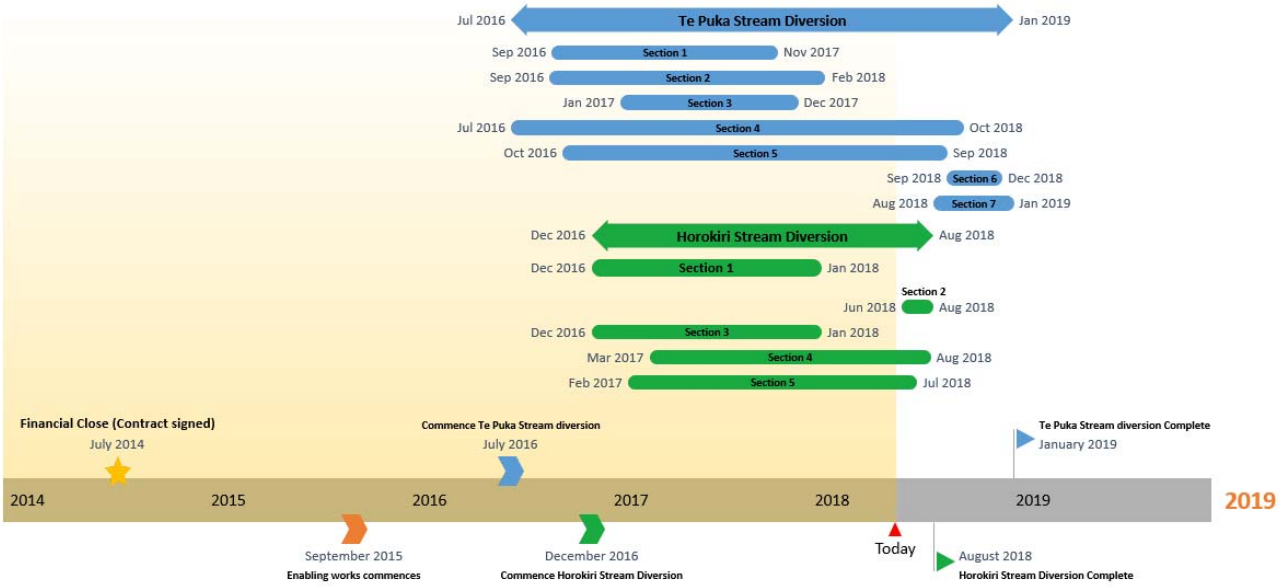


Figure 3: Summary Programme for the Stream Works

The Transmission Gully project is well underway with approximately 60% of the nine million cubic metres of earthworks complete and many sections at subgrade level. Structures are currently 26% complete and drainage is 63% complete. The first sections of paving will commence in the middle of this year in the northern part of the project. Transmission Gully is on track to open in 2020.

DISTINCTIVE FEATURES, ACCOMPLISHMENTS & CHALLENGES

Considered a feat of environmental engineering, the stream diversion work required sections of the Te Puka and Horokiri Streams to be shifted sideways and raised as much as 20 metres above its original position to allow for the new motorway route.

CPB HEB JV Project Director Boyd Knights pointed out that 1.7 kilometres of Te Puka Stream had to be raised because the valley floor needed to be higher for the motorway: “It’s a one of a kind design and very difficult, not least because access for workers is narrow and steep, temporary diversions are required to protect the stream during construction, rip-rap rock had to be barged in from the South Island and Taranaki and the finished waterway needs to meander as streams do.”

These stream diversions follow this methodology:

- Install fish exclusion fences
- De-fish stream, transferring fish to appropriate habitats
- Salvage stream bed material
- Install pipes into stream bed
- Liven pipes
- Place fill
- Rebuild stream to side of valley in approved design location
- Liven stream
- Remove fish fences
- Monitor Success.

Native fish were relocated from the streams prior to the commencement of construction, in one of the largest fish relocation exercises ever undertaken in the country. After the new streambeds are constructed, the streams will be restocked with native fish and will follow a natural course, with banks densely planted in native shrubs and trees. It is expected that with this revegetation and restocking process valleys such as Te Puka will eventually be richer in wildlife than before the project started.

Figure 4: Defishing of streams

Given that there are over 4.1km of stream diversions to be installed it was imperative to have a robust method to undertake the stream diversion works. It is unusual to build a road through the middle of a valley given the likelihood of encountering a stream and the subsequent impact- management constraints.

Pipes used as subsoils and diversions

Erosion and Sediment Control (ESC) measures for diverting or working within the vicinity of streams typically require the construction of a temporary diversion to move the stream outside of the area of works. Given the Transmission Gully project is being built in the middle of a valley this was not a

practicable solution. During the tender phase, environmental professionals, ecologists and the Transmission Gully team of engineers developed the innovative approach of diverting the streams through pipework under the final construction platform while the replacement stream was built. After flows are diverted back into the new stream, the pipe remains in place to provide long-term subsoil drainage for the earth fill above.

Significant time was spent during the tender process to ensure that utilising subsoil pipe as a stream diversion during construction was robust enough and would meet both environmental standards and construction requirements.

The overall holistic approach adopted for the drainage management was to provide a simple, self-sufficient and sustainable solution that satisfied the particular challenging demands and requirements of the project. Particular areas of focus included:

- Providing a safe road by draining the road surface adequately and ensuring a safe roadside environment.
- Embracing environmental and sustainable principles.
- Utilising natural processes and materials wherever possible to reduce reliance on hard engineering solutions.
- Minimisation of underground drainage infrastructure to enhance seismic and settlement resilience.
- Minimising operational maintenance requirements.
- Minimising impacts for the surrounding environment.
- Replication of the natural environment in stream diversions (form, shape, gradient, etc.) to promote fish passage and retain ecological habitat value.

The approach of utilising subsoil pipes minimised the costs and impacts of attempting to divert a stream in challenging terrain and geology. To minimise ecological impacts it was necessary to de-fish the 4.1km of stream to be diverted. In total over 26,000 fish and crayfish were captured and relocated from the Project catchments.

Figure 5: Inlet of temporary stream diversion pipe

Given that it was not practical to create a typical open channel stream diversion, a methodology to create a piped stream diversion was created and approval sought from the Regional Council. Commencement of the first piped section of stream diversion occurred early July 2016.

Numerous challenges were faced as the method was installed within sections one to three of the Te Puka diversions. Not least was the need to install a stabilised spillway whenever 50mm of rainfall was forecast to ensure transference of the flows if the pipes were to overtop.

As works progressed other methodology changes were developed to better manage the system including:

- Installation of a dual inlet headwall to better ensure flows entering the pipe system
- Refinement of the trash screens to prevent blocking
- Improvements in the Pipe installation method.

Figure 6: Double inlet structure

Pipe Installation Method Improvements

The construction methodology for the Te Puka stream diversion followed the general principle of minimising construction within the flowing stream, when practicable, to limit the creation of sediment. Each distinct section of stream was diverted using different methods. Following the installation of the initial Te Puka pipe a review was conducted to identify any improvements that could be made for subsequent sections in the Horokiri and Te Puka diversions.

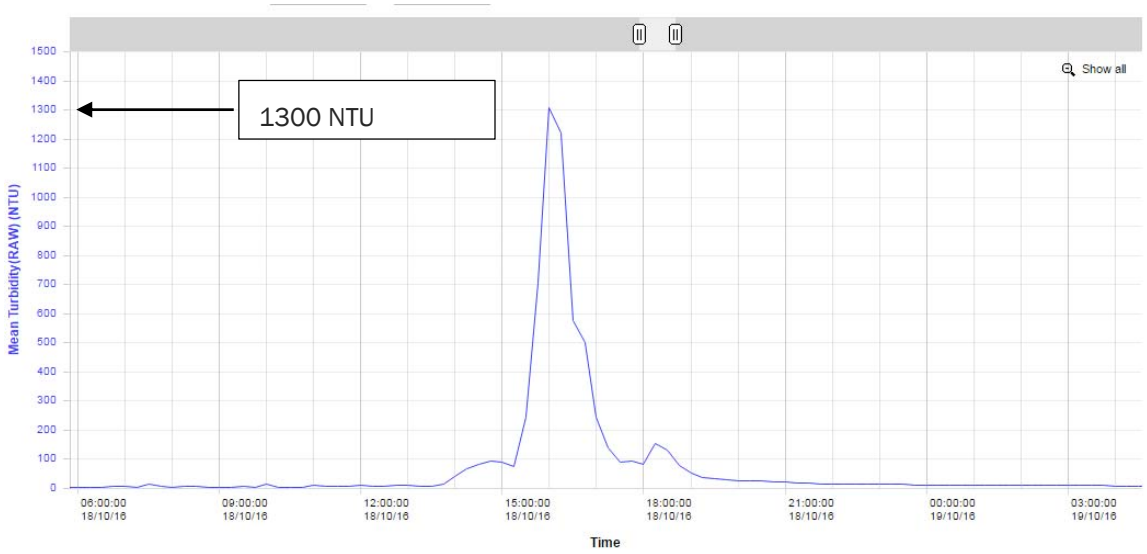
Following the review, it was decided that the bedding rock would be placed directly into the stream bed while an overpump was being conducted. Once work was completed for the day the stream would be livened with half the water being overpumped. The portion of the flows through the area where the rock had been laid would then be captured by a dirty water pump and sent to the Sediment Retention Pond for treatment. This would allow downstream flows to continue while minimising the turbidity impact on the stream. The same process was then used for the pipe installation.

The implementation of this method had the following positive impacts:

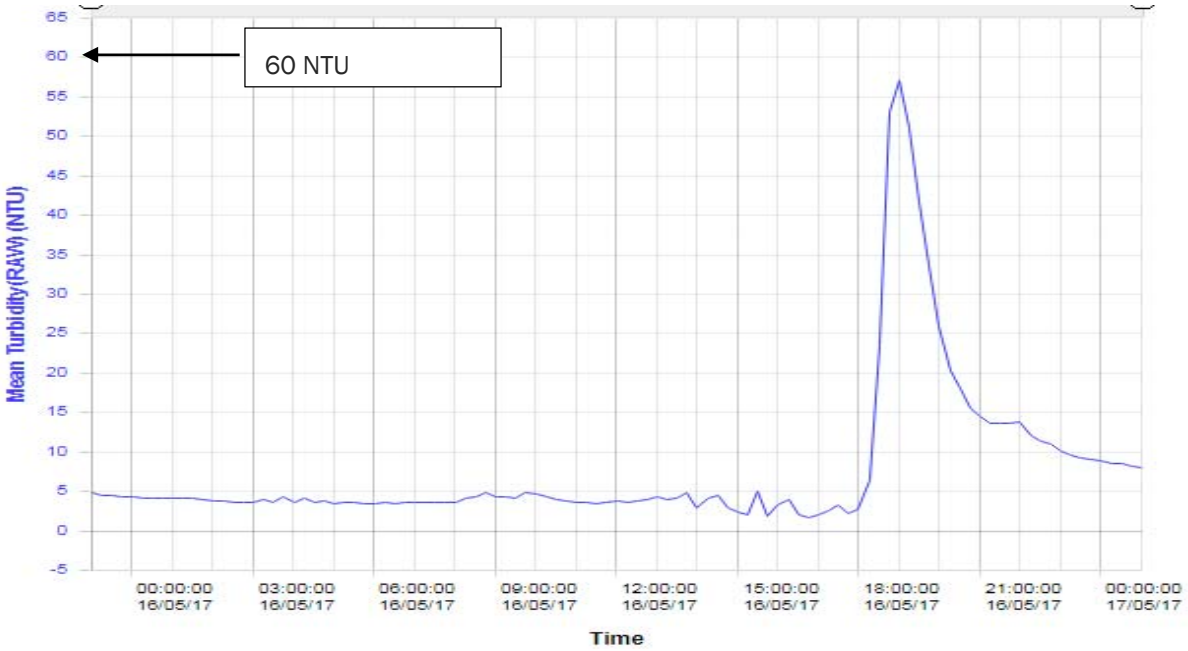
Figure 8: Bedding Rock placed in stream

- Less time working within the stream bed
- Less turbidity upon pipe livening and thus less sediment load in the streams
- Reduced risk of sediment loading during heavy rainfall events
- Increased productivity.

The graphs below show the turbidity levels and durations for a typical livening utilising both the initial approved method and the revised method. As can be seen the level of impact is markedly reduced. In addition to the environmental benefits, the refined method also reduced the time for installation by approximately two months, thereby reducing costs by approximately $300,000.



Graph 1: Turbidity using approved method for livening of subsoil diversions



Graph 2: Turbidity using refined method for livening subsoil diversions

The streams in pipes – so what next?

On 17 February 2018 the final section of the Te Puka stream was diverted into the piped system and commencement of the permanent stream diversions could occur. At their new location up to 20m above the previous elevation of the stream, a number of challenges had to be overcome for the installation of the stream diversions including:

- Installing a stream diversion on a fill site
- Ensuring protection from a 1:1000 year ARI event
- Recreating the habitat
- Minimising turbidity released on livening
- Creating surface flows on rip rap sized at up to 1.2m diameter.

Figure 9: Horokiri permanent diversion

The Transmission Gully team approached each of these challenges with its usual tenacity and professionalism. The final design included a Geosynthetic Clay Liner to ensure the fills were protected and the streams were maintained within the stream channel. The largest potential issue was to ensure surface flows and habitats were recreated allowing fish passage through the new stream diversion.

The rip rap sizing to protect the motorway from up to a 1:1000 year ARI was between 0.1 and 1.5m. A proposal was developed to infill between these rocks with sand to fill the voids and allow a better chance of surface water occurring. On top of this an Ecological layer was constructed from the material salvaged from the stream bed during pipe installation. This ecological layer was developed based on stream surveys undertaken prior to construction to recreate the percentage of pools, riffles and runs at the same velocity as the original stream profile.

Figure 10: Washing in of stream salvage prior to livening to promote surface flow

Some example designs from the Horokiri stream are provided below.

A trial of this methodology was implemented in a smaller section of stream under Bridge 6. It was a resounding success with up to 70% of the flow on the surface within three hours. After three months it was estimated that 87% of the flow was present on the surface.

Figure 11. Bridge 6 Stream diversion immediately post livening

To minimise the turbidity within the natural stream upon livening and to better ensure surface flows were achieved, a methodology was adapted which included "washing in" of the stream salvage material. This washing in activity was captured at the base of the stream diversion behind a coffer dam allowing recirculation of the water until the process was finished. The dirty water was then transferred to an SRP for treatment.

Figure 12: Bridge 6 Stream Diversion 3 months post livening

The first livening on the Bridge 6 diversion within the Horokiri stream occurred on the 29th of November 2017 in a 200m long section. Ecologists who inspected the stream on the 22/20/2017 concluded that adequate fish passage had been achieved including refuge and resting points. A member of the Wellington Regional Council commented "*the channel looks really good, and it's great to see the turbidity so low*". The project now had proof that the diversion methodology worked and set about implementing this on a larger scale.

Bigger and better

Following the success of the Bridge 6 trial diversion of the Horokiri Stream, the project commenced works required to divert larger sections of the Horokiri and Te Puka Streams. The first of these was an 818m diversion within the lower sections of the Horokiri Stream. Because of the length of channel to be diverted there were concerns that flows downstream may reduce to the extent of having an ecological impact. To mitigate this risk two 6-inch pumps were set up and 1600m of hose channelled some of the flow around the diversion.

Figure 13: Te Puka diversion under construction

Unfortunately, this livening didn't go as well as planned with water flows becoming subsurface in approximately 80m of the diversion thereby restricting fish passage. Works were undertaken to further wash the stream salvage into the rock armour to assist in re-establishing and maintaining surface flows. Reviews were undertaken to determine the cause of substandard performance of this section. These reviews determined the necessary consideration and adjustment of:

- Amount of material placed in the section
- Time spent washing in
- Material placement on the sides of the diversion.

Adequate surface flows were achieved following the implementation of remedial actions based on the considerations above. These were assessed and were reported on by the ecologist:

Figure 14: Subsurface flow in Horokiri section 3

"I can confirm that at livening and after the first rain event the aquatic habitat present at the flows assessed (60-70 L/s on the surface) reflects the original and represents suitable aquatic habitat with the variation in flows and substrates that is suitable and was found in the Horokiri." Vaughan Keesing Project Ecologist

Turbidity readings from the livening process are found below:

Turbidity Sampling Horokiri S3	Upstream (CH7170)	Downstream (CH7950)
Pre-Livening 11:00 25/01/2018	2.49	2.02
Post Livening 07:30 26/01/2018	1.89	5.61

Turbidity rose very little, well below any trigger value and little higher than a minor rain event. Flows ran clear within hours.

These lessons were taken on board for the following stream diversion in the Te Puka.

The final stream diversion undertaken to date was within the Te Puka stream where 680m was livened on the 17th of February. The lessons learnt in the Horokiri diversion were taken on board and surface flows along the entire diversion length were achieved almost immediately.

Turbidity levels were measured as follows:

1st February 2018	
INLET NTU:	11.82 at 'headwater' at livening (1715hrs)
OUTLET NTU:	3190 when water first left the stream bed (~1830hrs)
OUTLET NTU:	205 at 2015hrs (3hrs later)
2nd February 2018	
INLET NTU:	5.22 at 'headwater' (0700hrs)
OUTLET NTU:	10.98 (0746hrs)

Figure 15: Horokiri Stream after livening

Figure 16: Te Puka Stream diversion post livening

Where to from here?

The project has currently livened approximately 1.5kms of the 4.1kms of main stem diversions. Stream diversions within the Te Puka and Horokiri catchments are planned to be completed by January 2019, with the project opening in 2020.

KEY BENEFITS

By incorporating and expanding on earlier planning, and a drive to improve productivities, this has resulted in innovation and the achievement of substantial benefits including:

Environment

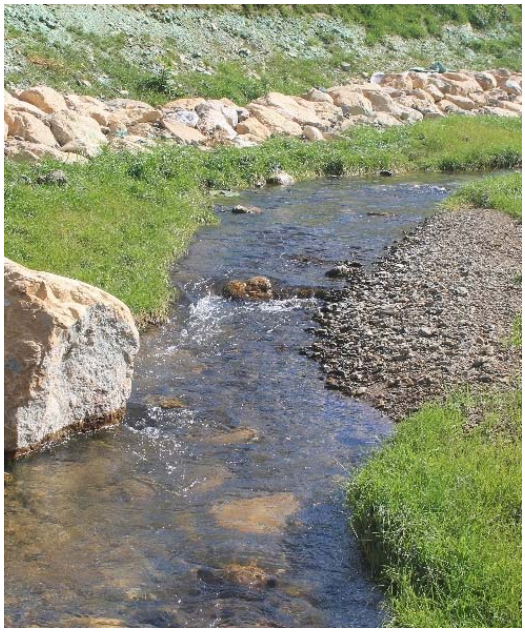
- Upfront planning during the tender phase has ensured that the method for diversion of the Horokiri and Te Puka permanent streams was well understood at the time of implementation allowing appropriate planning to be undertaken and minimising the potential for environmental incidents.
- Critical review of the initial implementation methodology has significantly reduced the environmental impacts on the stream environments.
- The change in methodology used to install the subsoil piping has resulted in a significant improvement to the levels of turbidity seen within the receiving environments upon livening. The initial consented implementation method resulted in impacts of up to 37kg of sediment per linear metre of pipe installation. If continued for the 4500m of pipe installation this method would potentially have resulted in 167 tonnes of sediment being released into the receiving streams. The revised method improved the sediment release by almost 30kg per linear metre - with a reduction from 37kg to 7.8kg of sediment. This method, if utilised for the 4500m of pipe installation, will have resulted in a potential saving of 132 tonnes of sediment release.
- Avoidance of unnecessary risks by diverting the streams completely offline through the subsoil pipes protects the water quality during the earthworks staging allowing construction works to progress essentially offline in some incredibly steep and challenging terrains.

Community

- The Horokiri Stream runs to the nationally significant Pauatahanui inlet - the largest remaining estuarine wetland in the Lower North Island. Reducing the turbidity of the stream works protects this important wetland.
- A broader community concern is the protection of the fish populations within the Horokiri and Te Puka streams. The relocation of over 26,000 fish and crayfish has protected these populations whilst the works are performed.
- The reconstruction of the streams to a similar state as pre construction minimises the projects impacts on a holistic scale reducing mitigation requirements and maintaining habitats in these critical environments.

Comparison of Stream Diversion Pre- and Post-Construction

Pre-construction



Post-construction

Industry Contribution

Using subsoil pipes as a temporary stream diversion revolutionises the construction of permanent stream diversions in steep and challenging terrains. While the concept itself isn't new, in this particular case the design and scale have been adapted to achieve the desired project outcomes. This allowed the team to incorporate the existing environment into the temporary design to allow for the construction of the permanent works while maintaining the preferential flow path, a considerable achievement.

Utilising a sub-soil pipe as the stream diversion was originally proposed during the tender process to manage a difficult and challenging situation whereby a 4-lane motorway was being constructed through the middle of a narrow valley. It was identified in the early stages that conventional approaches to stream diversion were not suitable in such a challenging environment. Employing a piped system in this environment has presented several quantifiable benefits, including:

- Reducing the impact of sedimentation to the stream environment
- Reducing the number of instances a stream is required to be moved during construction, particularly when the stream is being lifted by 20m
- Reduced likelihood of discharges as pipes are sized appropriately for stream flows.

Implementing stream diversions through sub-soil pipes effectively allows the stream to be completely offline and protected during construction. This allows ease of construction with resulting increases in productivity and efficiency while minimising environmental impact.

Method change

The revised method for pipe installation has saved the project approximately 2 months in installation time and over $300,000 of costs, not including overheads.