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Effectively delivering microtunneling projects using an alliance approach | A case study from Melbourne Water's Pipeline Alliance

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1. ABSTRACT

Melbourne Water (MW) is an Australian statutory corporation, owned by the Victorian State Government, providing water, sewerage and recycled water services. Over the period (2008/09 – 2012/13) MW was responsible for delivering a multi-million dollar (AUD) program of new and upgraded infrastructure including 3 major microtunneling projects. The magnitude of investment was unprecedented in terms of MW experience in capital works investment and by any measure, the scale, complexity and profile of the projects involved was significant. To meet this challenge the program of work was delivered through a number of Project and Program Alliances.

This paper presents a summary of the Alliance Delivery Model, MW context for adopting an Alliance approach, the Pipelines Alliance commercial and legal framework and risk allocation. In addition the paper highlights the value of the Alliance approach, on the Sandgate Avenue Flood Alleviation Project – Stage 1 microtunneling project.

2. INTRODUCTION

MW is a statutory corporation, fully owned by the Victorian State Government. MW is a water resource manager, providing water, sewerage and recycled water services to Melbourne's retail water businesses and waterways, and regional drainage services to the greater Melbourne community.

MW is Victoria's largest urban water business, providing approximately 60% of the state's urban potable water, and 16% of total water supplied in Victoria for urban and rural purposes. MW currently provides wholesale water services to five retail water businesses. It also currently treats around 270 Giga Liters (GL) of sewage collected by the three metropolitan retail water businesses, of which approximately 23% is recycled for commercial use.

For its just-completed five-year Water Plan (2008-2013), Melbourne Water eschewed the traditional tender process for design and construction, and instead used an alliance model, which was a significant change in delivery strategy for Melbourne Water.

This was motivated in part by the magnitude of investment, which was unprecedented in terms of MW experience in capital works investment. By any measure, the scale, complexity and profile of the projects involved was significant.

The following sections of this paper present a summary of the Alliance Delivery Model, MW context for adopting an Alliance approach, the Pipelines Alliance commercial and legal framework and risk allocation. In addition the paper highlights the value of the Alliance approach on the Sandgate Avenue Flood Alleviation Project – Stage 1 microtunneling project.

3. ALLIANCE DELIVERY MODEL

The following section is an extract from the Australian Governments Department of Infrastructure and Transport “National Alliance Contracting Guidelines July 2011 Guide to Alliance Contracting”.

Alliance contracting is delivering major capital assets, where a public sector agency (the Owner) works collaboratively with private sector parties (NonOwner Participants or NOPs). All Participants are required to work together in good faith, acting with integrity and making best-for-project decisions. Working as an integrated, collaborative team, they make unanimous decisions on all key project delivery issues. The alliance structure capitalises on the relationships between the Participants, removes organisational barriers and encourages effective integration with the Owner.

The most significant difference between traditional contracting methods and alliance contracting is that in alliancing, all project risk management and outcomes are collectively shared by the Participants. In more traditional methods of risk allocation, specific risks are allocated to Participants who are individually responsible for best managing the risk and bearing the risk outcome. This concept of collective risk sharing provides the foundation for the characteristics that underpin alliance contracting including collaboration, making best-for-project decisions and innovation. If substantial and significant risk is allocated to individual Participants, then it may not be an alliance.

Alliance agreements are premised on joint management of risk and opportunity for project delivery. All Participants jointly manage that risk within the terms of an ‘alliance agreement’, and share the outcomes of the project (however, the financial outcomes are not always shared equally between the Owner and the NOPs).

Historically, most alliances have been delivered on the basis of a 50:50 sharing of risks (and opportunities) and a capped downside for NOPs. This means that although risks may have been jointly managed by the Participants, potential financial consequences were not equally shared.

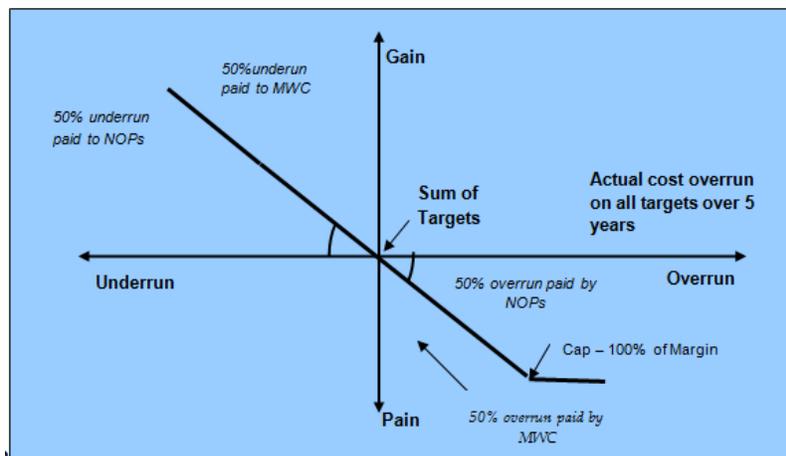


Figure 1 - Historical Risk or Reward Models – Cap on NOPs' Painshare

4. MELBOURNE WATER CONTEXT

Prior to the establishment of Program Alliances, Melbourne Water had traditionally managed project delivery through a “detailed design followed by construction” approach. Following a trend towards more collaborative contracts, and successful delivery of project alliances, Melbourne Water’s drivers to adopt program alliances included:

- **Delivery of an expanded capital plan:** requiring additional management and delivery resources
- **Acceleration of projects:** to meet obligations and demand for services as agreed in the Water Plan
- **Achieving best whole of life outcomes:** implement efficiencies through economies of scale and scope, innovation and value engineering
- **Resourcing and flexibility:** Securing high quality resources and flexibility to speed up and slow down individual projects in response to operational constraints and project risks
- **Managing reputation risk:** Ability to prevent or resolve stakeholder and community issues in a coordinated and cooperative manner
- **Facilitating a collaborative team environment:** Desire for a high performance collaborative team approach to problem solving, project development and delivery
- **Managing risk:** Ability to contribute to the resolution of regulatory / political / permit issues and be flexible in the approach to manage project risks.

Four program alliances were initially established in 2008, which was subsequently consolidated to three. The program alliances commenced at the same time and were co-located, enabling benchmarking and learning's to be transferred between alliances.

5. PIPELINES ALLIANCE

The Pipelines (Sewerage and Drainage) Alliance was a \$154 million (AUD) program consisting of over 30 capital projects with sizes ranging from \$10,000 to \$45 million (AUD). The drivers for the program included drainage and sewerage renewal, flood mitigation; redevelopment growth, odour reduction and wet weather overflow reduction. The projects were combined in a program requiring skills in modelling, civil works, tunnelling and refurbishment.

The alliance partners include Melbourne Water (Owner); GHD (Designer); and Capacity JV, Jaydo Construction and Fulton Hogan (Constructor). As employee / family owned firms each of the non-owner participants (NOP) partners have had a vested interest in a successful alliance and have very similar values to that of Melbourne Water, enabling the goals of the alliance to be easily aligned with those of the parent organisations.

The alliance partners strengths included; understanding of Melbourne Water drivers and internal stakeholders from Melbourne Water; a broad range of planning and design services and depth in experience from GHD; program management controls and systems from Fulton Hogan; and an experienced self-performing team from Jaydo Construction.

Our Purpose: We aim to deliver sewerage and drainage solutions for current and future generations in a safe, efficient, collaborative and innovative way, which will result in a positive legacy for stakeholders, the environment and the partners' reputations.

Our Principles: Safety | Pride | Innovation | Respect | Integrity | Teamwork

Our Behaviours:

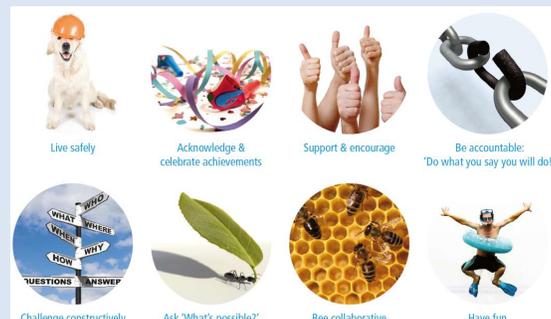


Figure 2 – Pipelines Alliance – Purpose, Principles and Behaviours

The alliance operated like a virtual company with a strong identity and culture of its own that took precedence over the parent companies. The stability of the Leadership and Management teams supported a consistent vision and accountability for achieving what was set out to do at the start of the Alliance.

The Pipelines Alliance was responsible for the design and construction of Sandgate Avenue Flood Alleviation Project – Stage 1.

6. TEAM STRUCTURE

The Pipelines Alliance was a self-performing alliance. The majority of program works were completed by personnel and teams directly employed by the Alliance partners, which means a consistent alliance culture and core values could be delivered to all levels of the program. This also meant the Alliance could be flexible and adaptive, responding to needs and priorities as they changed within Melbourne Water over the duration of the capital delivery program.

During the 5 years of the Pipeline Alliance, more than 200 people from the four parent organizations were involved – at its peak 160 people were part of it. The management structure and size of the alliance enabled a hands on approach to the management of the projects within the program of works. This ensured the impacts associated with streamlined management systems could be mitigated.

The alliance was led by a Program Leadership Team (PLT) composed of 5 people from the 3 partners plus Melbourne Water, who provided consistent commitment from the beginning to end. This team set the tone and carried the mantra of “best for Alliance” through their decision-making, and they were responsible for providing internal resources and removing roadblocks. The PLT left most operational decisions to the Project Management Team (PMT), which was led by a Program Manager. The core PMT during the delivery phase consisted of a Design Manager, a Construction Manager, and a Business Services Manager, but in the start-up phase there were 6 additional members responsible for championing the key result areas (refer Section 7 for details). The streamlined project management team (PMT) led to reduced costs through efficiencies, reduced start-up costs, and improved collaboration through the ability to transfer learnings between projects due to team consistency.

The structure of the Alliance Program Team was established to integrate the design and construction teams throughout all phases of the project. This structure led to several benefits. The integration of design and construction teams through early contractor involvement in design meant that projects transitioned smoothly from design to construction delivery, the construction project manager was aware of the design intent, as well as the risks, and the involvement of constructors in the design and costing processes led to improved designs and reduced rework. This integrated, collaborative evaluation and decision-making processes also helped to generate innovative thinking on complex projects and challenges.

By self-performing the majority of program works, risk allowances were also not compounded through subcontracted work, further delivering value for money on all projects.

7. COMMERCIAL FRAMEWORK

The legal and commercial framework was documented within the Program Alliance Agreement (PAA). The agreement was a summary of what was agreed to through the relationship and commercial workshops. It is a non-adversarial contract that is based on the principles of equity, trust, respect, openness, no dispute and no blame. The nature of the alliance is defined in the agreement through the founding purpose, principles and behaviours. The legal and commercial framework enables open communication to occur between all parties, the joint management and mitigation of risk. The Agreement also contains provisions that eliminate the need or ability of the parties to resort to claim and counter claim behaviours. The commercial framework is structured in a way that assigns collective financial responsibility and liabilities to the parties.

The Program Alliance Agreement is an important legal document, but it was really the process of creating and committing to the Pipelines Alliance purpose, principles and behaviours that formed the intended alliance culture that has stood the test of time – adopting the ‘best for program’ approach from the start was key in successfully

avoiding disputes, and the true measure of success was that the alliance did not need to refer to any of the contractual terms in the agreement once it was executed.

The purpose of the commercial framework was to align the Non Owner Participants (NOPs) commercial drivers with MW's Best for Program requirements and to equitably share gainshare and painshare with the NOPs on the basis that Performance = Value = Reward.

The commercial framework is structured around the following key Program Alliance concepts that are presented in Figure 2:

- **Direct Costs (Limb 1)** - Any cost or expense incurred by the Participants in performing work under the PAA, including all Program specific overheads, on the basis that no one participant shall derive any profit or unreasonable advantage from the utilisation of their resources or personnel for the works under the PAA.
- **Margin (Limb 2)** - The margin is comprised of Corporate Overhead and the Minimum Conditions of Satisfaction (MCOS) Profit. The actual value of Margin for each participant was negotiated during the commercial alignment process. The actual figure was required to withstand public scrutiny. Melbourne Water has an expectation that the “aligned” margin was a discount from the historical mathematical average of the NOPs financial performance.
 - Corporate Overhead - A percentage of the Participant’s actual direct costs, reflecting the actual corporate overhead structure of an individual Participant;
 - MCOS Profit - A percentage of the Participant’s actual direct costs, which reflect an equitable return to an individual alliance participant in the context of an Alliance Delivery Framework in a situation where the Alliance Participants achieve, but do not exceed, the MCOS.
- **Gainshare / Painshare Regime (Limb 3)** - A performance based payment paid to or by the NOPs to reflect the NOPs' equitable share of the improvement or diminution in the value to Melbourne Water of Program outcomes resulting from the Alliance’s performance in specific Key Result Areas (KRAs.). Note, painshare is capped at the Participants direct costs (Limb 1).

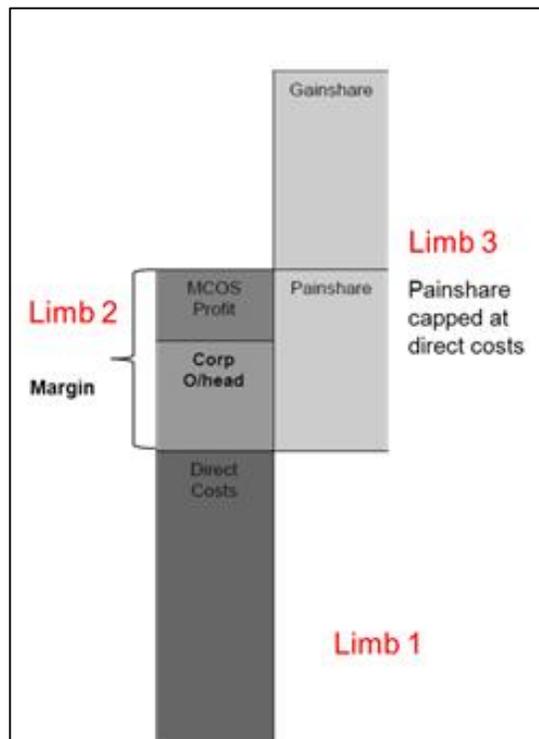


Figure 3 – Commercial Framework

8. KEY RESULT AREAS

The Key Result Areas (KRAs) and outcomes defined by Melbourne Water for the Alliance provided a clear framework for achieving Melbourne Water’s vision, which were aligned to Key Performance Indicators (KPIs) at a project and program level and commercial incentives through the painshare / gainshare mechanisms.

Table 1 – Key Result Area Outcomes

Key Result Areas	Outcomes	Weighting
Health and Safety	No one gets harmed	0% Modifier
Sustainability & Environment	We always comply with regulations, apply sustainability principles when making decisions and seek to have no impact on the environment	15% Modifier
Delivery	We will complete our projects on time to a high standard of workmanship with full functionality	25%
Value	We will reduce whole of life costs, find innovative solutions and transfer knowledge while achieving project objectives	25%
Stakeholder Engagement	We will show leadership and work collaboratively with stakeholders and the community to achieve shared goals and achieve the best possible results	25%
People & Culture	Our team culture will be constructive and collaborative: we will learn from each other and provide development opportunities for our people.	10%

KRA working groups established KPIs to provide a transparent, measurable and objective measure of performance against KRA outcomes. The KPIs are measured at an individual project level, weighted and accumulated to represent an overall Outturn Performance Score, which is used to determine painshare and gainshare payments to alliance participants.

In traditional contracts the focus is typically on time and cost. Having measures of performance across six KRAs has been one of the major advantages of an alliance model. It drives different behaviours and a more balanced approach to project outcomes. There can be tension between some KRAs, however this has driven healthy debates within the Alliance and with Melbourne Water stakeholders to ensure the priorities were clear for each project.

9. SANDGATE AVENUE FLOOD ALLEVIATION PROJECT – STAGE 1 | CASE STUDY

9.1 Background

Stage 1 of the Sandgate Avenue Flood Alleviation project consists of constructing approximately 1,550m long, 2.5m internal diameter tunnel, commencing upstream at the Monash University Peninsula Campus and traversing approximately west to the outlet located at Kananook Creek.



Figure 4 – General Arrangement Plan

The alignment traverses through a well-developed urban environment, with the alignment passing under roadways, parkland, sporting facilities and a railway reserve. Third party assets along the alignment included residential and commercial structures, sporting clubs, car parks, roads, railway, and service pipelines. The proposed alignment is presented in Figure 4 – General Arrangement Plan.

The tunnel was excavated by a dual slurry-earth pressure balance TBM, with the depth to tunnel crown ranging from 0.7m to 14m below the natural surface level. The TBM completed three drives and navigated two 500m-radius curves, with a maximum drive length of 608m. The tunnel lining consists of 2.5m internal diameter, 250mm thick reinforced concrete jacking pipe.

The key works for the project were:

- Design and construction of 1,550 m of 2.5 m diameter tunnel from the Monash University Peninsula Campus to Kananook Creek, using microtunneling and pipe jacking techniques
- Design and construction of four temporary works, launch/receiving shafts and an additional temporary works shaft for the Kananook Creek outlet works
- Design and construction of four permanent access manholes
- Design and construction of two permanent connection manholes to connect existing drainage infrastructure to the main tunnel
- The Nepean Highway crossing

9.2 Nepean Highway Crossing

9.2.1 General

A key challenge for the project was the Nepean Highway crossing. The vertical alignment of the pipeline at the outlet was dictated by the water level in Kananook Creek. The aim was to design the outlet level as high as possible to minimize creek deposits back flowing into the pipeline, this created significant challenges by reducing the available cover under the Nepean Highway. The design provided as little as 700mm of cover over the pipe across the north bound lanes of the highway.

The Nepean Highway crossing was a significant project risk. It was important that the Alliance recognize and mitigate this risk. Risk management was undertaken in a series of workshops that commenced during concept design

and continued through to construction. Designers, geotechnical engineers, construction engineers and TBM operators were all involved in the workshops and the planning of this activity.

The workshops aimed to discuss and develop risk mitigation strategies for the following key issues:

- The geological profile at the crossing
- Constructability / options for construction of the crossing
- Traffic management
- Temporary support / kentledge
- Monitoring settlement and ground loss
- TBM operational requirements

The alliance delivery model provided an environment where the client, consultant and contractor came together to assess various design and construction options in good faith, acting with integrity and making best for project decisions.

9.2.2 Geological Profile

The Geological Profile is presented in Figure 5. The regional geology of the project area consists primarily of weathered Tertiary volcanics and terrestrial sediments, overlain by younger superficial formations of Quaternary age.

A number of site investigations were undertaken in a staged approach to assess the ground conditions for tunnelling. Investigations included targeted exploratory borehole drilling, cone penetrometer testing and seismic geophysical surveys. Sub-surface conditions encountered generally consisted of soil materials, which were generally quite variable in both composition and spatial distribution along the alignment.

Two major geological units were identified within the tunnel horizon at the Nepean Highway crossing:

Dune and Sheet Sands (Quaternary) - The sand is comprised of clear, colourless quartz, in the fine to medium ranges, with some surface iron oxide staining giving the unleached sand a yellow colouration. Density of the sands is usually low, with 'typical' SPT N blow count being below 15 (loose to medium density). The sand is typically poorly graded to uniform, with a grading uniformity co-efficient (D60/D10) commonly less than 3, indicative of potentially unstable 'flowing' ground conditions below the water table.

Brighton Group (Tertiary) - The deposit consists of poorly sorted, mainly coarse sands with variable amounts of gravel, finer sands and clay. Within the tunnelling horizon this unit is present predominantly as a clay soil, with frequent lenses of sand. The clay component is typically very stiff and of intermediate to high plasticity (PI% 17 to 47). Sand lenses occur intermittently, interbedded with the clay soil and vary in grading from fine clayey sand through to clean coarse quartz sand. Occasional fine gravels are also present in this unit. Grading uniformity co-efficient (D60/D10) of the sandy material is quite variable but can be as low as 1.75, indicative of potentially unstable 'flowing' ground conditions below the water table.

Groundwater levels were approximately 5m below ground surface level. The water chemistry was typically fresh with Total Dissolved Solids varying between approximately 450 mg/L to 1,700 mg/L

It was identified that a fault (slip) zone occurred between the southbound and northbound lanes of the Nepean Highway and provided the transition between the Brighton Group material and the Dune and Sheet Sands. Additional targeted boreholes were drilled to further understand the exact location and dipping angle of this fault as this dramatic change in material directly affected the TBM operational requirements..

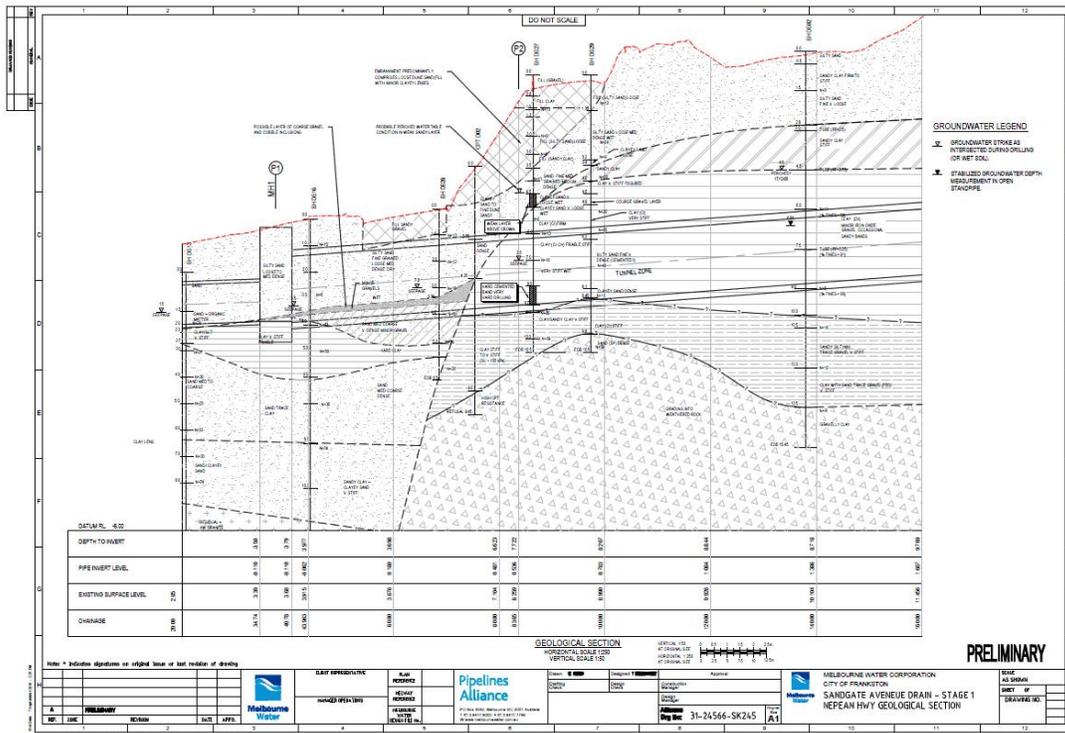


Figure 5 – Geological Profile at Nepean Highway

9.2.3 Constructability / options for construction of the crossing

Whilst the project was constructed via tunneling, it was identified that tunneling in itself was not a feasible option for the Nepean Highway crossing given the limited cover. A number of alternative construction methods were considered including:

- Open cut – The dramatic change in surface grade along the alignment, from 0.7m to 8m of cover within 40 metres of pipeline construction, provided an opportunity to construct the crossing of the north bound lanes via open cut methods. However in order to achieve this a TBM retrieval shaft was required to be constructed within the median strip of the highway.
- Tunneling and construction of a temporary bridge to maintain traffic.
- Tunneling and ground improvement (soil mixing, soil replacement)
- Tunneling and construction of temporary support / kentledge to provide additional overburden to above the crown of pipe.

9.2.4 Traffic Management

The Nepean Highway is an arterial route to Melbourne from the Mornington Peninsula. VicRoads required that 3 trafficable lanes in each direction were to be maintained during peak flows. It was agreed that a weekend closure of the north bound lanes was possible, allowing a window from 11am Friday to 5am Monday. This requirement to maintain 3 trafficable lanes and the timeframe for a weekend closure dictated the construction method. A retrieval shaft within the median strip and a temporary bridge for traffic could not be constructed to satisfy these requirements. The adopted construction method consisted of tunnelling and construction of temporary support / kentledge to provide additional overburden to above the crown of pipe

9.2.5 Temporary support / kentledge

Additional overburden pressure equivalent to one pipe diameter or 3m of cover was required to restrain the possible ground heave, and enable water jets to be used intermittently to clean the cutter head, providing the maximum jetting pressure was restricted to 4 bar.

This additional loading was achieved by installing large steel plates over the alignment on a thin layer of crushed rock. A row of concrete road barriers was then placed on the steel plates, and the voids filled with crushed rock. On top of this a second layer of concrete barriers were placed. These barriers were in place prior to tunneling commencing and extended to the TBM retrieval shaft.



Figure 6 - Temporary works associated with the Nepean Highway Crossing

9.2.6 Monitoring settlement and ground loss

It was important to demonstrate that there was no settlement or ground loss between the asphalt surface and the tunnel prior to re-opening it to the public. A theoretical settlement “trough” was calculated to estimate the expected settlement. A number of settlement pin arrays were installed on the verge and across the carriageway, which were frequently surveyed and monitored against theoretical levels. The results of monitoring showed a direct correlation to theoretical levels and provided an initial level of confidence that no ground loss had occurred. In addition to monitoring the following “tests” were carried out prior to reopening the crossing to traffic:

- 50mm holes were cored through the asphalt acting as inspection holes to ensure the tarmac was not “bridging” any voids in the pavement below.
- A load test of the pavement was undertaken by driving a water cart repeatedly over the alignment.

9.2.7 TBM operational requirements

The required tunnelling operation received particular scrutiny in the lead up to the crossing, given the performance requirements in varying geology and minimal ground cover. The stiff clays encountered required the use of water jets to draw the material through the head and crusher gap. As greater sand and gravel content was encountered, it was imperative to stop using the water jets and change to EPB mode to support the face, and reduce the risk of slurry blowout. The location of the necessary change from jet to EPB mode was set by interpretation of the geological maps and investigation.

9.2.8 Outcome

The Nepean Highway Crossing was successfully completed over a weekend closure of the north bound lanes from 11am Friday to 5am Monday. At the completion of the drive the pavement on the northbound carriageway was inspected using a series of core holes above the tunnel crown, which did not show any subsidence below the asphalt. In addition a load test of the pavement was undertaken by driving a water cart repeatedly over the alignment before the roadway was re-opened it to the public.

The early breakthrough ensured that the annulus of the tunnel could be grouted prior to the highway being re-opened to traffic on Monday morning. The asphalt was profiled and replaced after a few days once the area had time to settle.

This crossing was an extremely high risk activity, and the Alliance framework created a proactive environment in which all parties were able to work together to actively plan and complete the works -- the final innovative solution enabled the works to be completed efficiently, at minimal cost, and mitigated community criticism.

10. CONCLUSION

The alliance delivery model is premised on the principle of making best-for-project decisions, and uses the concept of shared risk and opportunity as the foundation for an integrated, collaborative culture. This culture actually serves to reduce the risks that the alliance needs to manage, because the fluid involvement of various teams between each stage of the work results in superior designs, better communication, smooth transitions, and transferable learnings – all of which leads better performance and outcomes.

As shown earlier, the legal and commercial framework and the structure of the team carry through the principles of collaboration and cohesion, so that decisions on high-risk project components like the Nepean Highway crossing were made with full consideration of all stakeholder input on potential solutions. This comprehensive decision-making approach set the team up for success, enabling them to complete the technically challenging crossing on time while effectively managing the environmental conditions, community concerns, and traffic constraints.

The major benefit of the alliance model is that the incentives around better performance align with and reinforce the ability to better manage and reduce project risks, which is perhaps the key different between this model and other models for project delivery. By sharing all risks and opportunities and by having the owner and alliance partners equally invested in the outcomes, each group finds that its own interests are indeed best served by the “best for project” basis. The resulting further reductions in risk serve to bolster the virtuous cycle, and strengthen the demonstrable benefits of this approach.

11. REFERENCES

Department of Infrastructure and Transport, Australian Government (July 2011) – National Alliance Contracting Guideline, Guide to Alliance Contracting, 9-10.

Weeks, M. and Banks, A. (2013) – Sandgate Avenue Flood Alleviation Project, Stage 1 Design and Construction, NASTT.