Review of Central Business District Rail Link Construction Costs by NZTA

Workstream Report

25 March 2011
# Table of contents

1 Executive Summary ........................................................................................................... 1

2 Summary of Business Case ............................................................................................... 2
2.1 Summary of Business Case content relating to workstream ....................................... 2
2.2 Summary of methodology used in Business Case ....................................................... 2

3 Approach to review .......................................................................................................... 4
3.1 Review of Business Case material ............................................................................... 4
3.2 Additional work ........................................................................................................... 4

4 Findings ............................................................................................................................ 6
4.1 Review of Business Case material ............................................................................... 6
4.2 Additional work ........................................................................................................... 7

5 Conclusion ....................................................................................................................... 8

6 Appendices ...................................................................................................................... 9
1 Executive Summary

The NZ Transport Agency (NZTA) has reviewed the APB&B CBD Rail Link (CBDRL) Concept Design and Cost Estimate reports using in-house staff who are experienced with road and rail tunnel design and construction, both in NZ and overseas, including Europe.

These documents had already been peer reviewed by a team of three experienced international consultants, whose findings had provided significant input into refining the proposals.

Our reviewers raised more than two dozen points ranging from major concept suggestions to relatively minor cost queries and opinions, which were referred to the APB&B Study team and Auckland Transport for their views. Most of these suggestions were countered, giving confidence that the original concept and costs had been considered in a robust manner. Some of our suggestions will be carried forward to the detailed design stage, when that is approved.

Both our reviewers were very interested in the benefits to the concept design and construction methods that might be gained through having contractors input to the project. Contractors’ knowledge of techniques and technology could potentially be used to save time and money by optimal design, staging, and construction. Our reviewers are of the opinion that it is conceivable that, given contractor input, it may be possible to reduce the costs if other innovative ways of working could be achieved, and this forms one of our conclusions.

They both agreed with the peer reviewers that the project could be carried out for the estimated cost (excluding property costs) of between $1.9b and $2.2b. Thus they confirm that the estimated construction costs are realistic.

We recommend that when the project is procured, a “competitive early contractor involvement” model is considered, which would maximise innovative design, intellectual property, and the deployment of the latest tunnel technology. This finding in no way denigrates the APB&B work which has been extensively thought through by a range of experienced designers and engineers, challenged by a peer review process, resulting in a credible, fully-costed proposal.
2 Summary of Business Case

2.1 Summary of Business Case content relating to workstream

An Options Evaluation study, including preliminary engineering and spatial planning work to define typical station arrangements and tunnel configuration, was carried out for a range of alignments. All options were evaluated and a preferred option, broadly following an alignment from Britomart Transport Centre, under Queen Elizabeth 2 square, Albert Street, Mayoral Drive, Howe Street, Central Motorway Junction and Symonds Street to emerge near Mt Eden Station to join the North Auckland Rail Line, was chosen. This alignment, which includes three stations at Aotea, Karangahape Road, and Newton, gained support at a local and regional political level.

The Preferred Option was developed with the objective of building a robust Business Case and preparing documentation for the future lodgement of the Notice of Requirement. This work will form phase 3 of the study.

Scope and cost outputs were based upon the engineering inputs required to complete the construction of the project in accordance with technical reports – the Concept Design Report volumes 1 and 2.

To counter gaps or uncertainties in the design team’s project knowledge it has focussed on three overseas metro projects which it believes have similarities to the CBDRL. These are the Copenhagen Metro, Sydney North West Metro, and the Dublin Metro North.

The focus of our review has been on the project construction costs.

It should be noted that we have not given attention to the property costs, which were assessed by The Property Group. The results of its investigations are commercially sensitive and we have not sought to review them. Their estimate of gross property costs are $230m, of which $120m would be able to be realised after the relevant project element is completed, giving a net cost of $110m.

2.2 Summary of methodology used in Business Case

The methodology used by the project team has been to zero base the estimated costs of all inputs involved in the construction of twin 4km tunnels, including stations, property purchase, contingencies and funding risks, to develop an estimated project cost and a 95th percentile project cost in 2010 dollars. In estimating input costs, unit rates, best practice, and information from other local and overseas projects has been used where relevant. As an example, the Victoria Park Tunnel project being undertaken by the NZTA has provided some real time comparator information, especially for the cut and cover portions of the CBDRL. This work has resulted in the Cost Estimate report.
In developing the *Cost Estimate* the APB&B Study Team has undertaken a comprehensive analysis of risks, grouped by type, likelihood, probability, best case, worst case and most likely. These scenarios were costed and a risk register has been developed. Using this information in a Monte Carlo style analysis informed the Contingency / Funding risk dollar amount that was adopted in the report, and modified following input from the peer reviewers.

The *Cost Estimate* report was peer reviewed by three experienced industry experts, Ian Bond of BondCM Auckland (a peer reviewer frequently used by the NZTA for its roading projects), Edwin Rogers of AECOM Sydney (an experienced industry director) and Hiroshi Yamazaki of Leighton Contractors (a tunnel construction expert).

The peer reviewers each raised detailed issues in writing which were further discussed at a workshop with the project team. As a result of the approximately 100 issues raised, the project team made 47 changes which had cost impacts. Interestingly, the impact of the peer review on the total project has been a $99m reduction in the cost estimate. A summary table showing the original cost estimate and the adjustments as a result of the peer review is attached at Appendix 1. A high level summary of the distribution of issues by subject area is attached at Appendix 2.

Following this, the final *Cost Estimate* was prepared by the project team in December 2010, incorporating the changes made as a result of the peer review.

The peer reviewers have signed off on the statement “Our conclusion is, for the scope of works defined in the *Concept Design Report*, we are comfortable that it can be completed for an estimated construction cost (excluding land and property acquisition,) in the range of NZ$1.9 to NZ$2.2 billion. These costs include the estimated design, planning and PM/CM costs associated with the delivery of the project over an assumed 10 year timeframe and are expressed in a 2nd quarter 2010.”
3 Approach to review

3.1 Review of Business Case material

The Concept Design and Cost Estimate documents, together with the Peer Review have been further reviewed by two experienced NZTA Highways and Network Operations staff - a tunnel engineer and a state highways manager with tunnel experience. These reviews were not as “in depth” as those carried out by the peer reviewers, but rather overview assessments to provide further confidence that other options had been considered and that risks around “big ticket” items had been appropriately dealt with. Our reviewers also considered whether contingencies and risks had been estimated and accounted for in an appropriate manner.

In addition, to gain some background about metro rail tunnel projects overseas, an internet search was carried out.

Our reviewers were both impressed at the level of detail that had been worked through at this stage in the CBDRL’s development. The level of detail in the cost estimate is somewhat higher than might be expected for a large state highway project at the Business Case stage. This has also been noted by Ian Bond. This additional level of detail should provide more confidence around project cost.

Our comments were referred in draft form via Auckland Transport to APB&B, whose project director responded to the points raised. These responses are shown verbatim at Appendix 3, and were taken into account before we finalised our findings.

3.2 Additional work

An internet search by NZTA has revealed that suburban underground metro systems are well-established in many of the world’s cities, there being at least 110 relevant examples whose details can be reviewed in the literature. There exists a body of technical understanding of railway tunnelling methods that is well over 100 years old. Cut and cover, mined, shielded tunnels and tunnel boring machine (TBM)-constructed tunnels are all mainstream techniques which can be utilised in a wide range of geographic locations and geological conditions.

Project challenges which have been experienced overseas have included unexpected geotechnical issues; maintenance of soil pressures and groundwater management; building subsidence; and, rarely, flooding and tunnel collapse. Construction delays, funding problems, and cost over-runs are also issues that some jurisdictions have had to address. All of these factors can have an impact (usually negative) on the construction cost.
Four suggestions are made in the areas of project best practice, procurement, and risk management in order to extract the maximum from current underground railway tunnel techniques, to help drive down construction costs, and to manage risks:

- When procuring the design and construction elements of the CBDRL, ensure that the bidders indicate how they will use the findings of other international subway projects to inform the CBDRL, especially as regards what went right, what went wrong, and lessons learnt. The APB&B Study Team considers that the Copenhagen, Sydney North West, and Dublin metro projects are similar to CBDRL. We suggest that other relevant recent and current projects that could be interrogated are – Amsterdam metro, Salvador metro, Mumbai metro, Palma de Mallorca metro, Sofia metro, and Thessaloniki metro.

- To extract maximum innovation and minimise construction costs, consider a design procurement of the “competitive early contractor involvement” type, including provisions whereby intellectual property is owned by Auckland Transport / KiwiRail.

- Ensure that considerably more investigation of the sub-surface along the route is carried out at an early stage in the design, since the investigation phase has identified this as a risk, and the literature review confirms that it is. Old services such as sewers are a feature of tunnelling in developed cities.

- If the possibility of cost over-runs is considered to be a major affordability and political risk, and in any case as part of the procurement choice, consider an alliance-type contract whereby risk is shared between the project owners and the contractor(s).
4 Findings

4.1 Review of Business Case material

Our reviewers raised a total of 32 issues some of which were very “big picture” (for example could a single track with passing loops at stations be considered? Could a station be delayed – rather than removed?); some were focussed around getting the most benefit from the TBM(s) and minimising disruption to surface traffic (for example considering the deployment of two TBMs and constructing the deep stations from the tunnels rather than mining them); and some were fairly detailed (for example questioning whether adequate budget had been provided for environmental mitigation).

Both our reviewers were very interested in the benefits to the concept design and construction methods that might be gained through having contractors input to the project. Their knowledge of techniques and technology could potentially be used to save time and money by optimal design, staging, and construction. While it is not known to what extent this would alter the Concept Design and Cost Estimate reports which have been produced by APB&B, this forms one of our conclusions and we strongly believe that the procurement methodology should utilise innovative industry input to the largest extent possible, without locking in one contractor at too early a stage.

Some of our suggestions potentially added cost to the project and some we consider could possibly reduce costs. The net effect however is insignificant. Similarly we believe that some of the timeframes for project elements are generous, while several (for example redeploying the TBM, and commissioning the tunnels) are too tight. Once again, the net effect is no change to the anticipated time for completion.

Our draft suggestions were referred via Auckland Transport to APB&B for comment, which was received in early March. The project team has generally commented on our points with a well-reasoned counter as to why the original design was chosen, and why in its opinion the suggestions made would not be satisfactory. This is reassuring, and shows that a great deal of effort has gone into preparing the design and cost estimates. It adds weight to the robustness of the methodology and cost estimating. This information is attached at Appendix 3.

Some of the issues we raised have been taken on board by the project team and will be further explored at the time of detailed design, when the project is approved for further work.

In terms of the project footprint for the purposes of moving to Notice of Requirement phase, we believe that the Concept Design report is adequate.

Both our reviewers were of the opinion that it is conceivable that given contractor input it may be possible to reduce the costs if more innovative ways...
of working could be achieved. They both agreed with the peer reviewers that the project could be carried out for the estimated cost (excluding property costs) of between $1.9b and $2.2b. Thus they confirm that the estimated construction costs are realistic.

4.2 Additional work

We do not consider that additional work is required to provide a robust assessment of the construction costs.

As noted in Section 2.1 since we have not had the opportunity to review The Property Group’s report on property-related costs, we recommend that this be peer reviewed prior to final acceptance.
The NZTA’s conclusions having reviewed the project reports are:

1. The design and cost estimates for CBDRL have been prepared to a level of detail that is greater than that for equivalent large roading projects, which gives an added measure of confidence
2. The formal peer review carried out by three eminent industry representatives – a cost estimator, project director and tunnel expert - raised a large number of points which were workshopped with the APB&B Study Team, and which resulted in 47 changes to the project
3. The peer review process reduced the cost estimate by $99m
4. Our reviewers raised 32 issues which were referred to APB&B, who responded promptly with well-reasoned opinions (shown in Appendix 3)
5. Most of our issues were countered by the project team, giving additional confidence that the Concept Design and Cost Estimate reports are robust
6. More work needs to be carried out into the sub-surface along the route, however this should not affect the next phase of the project, NOR lodgement
7. A number of our suggestions will be taken further into the detailed design stage
8. Our reviewers were very interested in the benefits to the concept design and construction methods that might be gained through having contractors input to the project. Contractors’ knowledge of techniques and technology could potentially be used to save time and money by optimal design, staging, and construction
9. Both our reviewers were of the opinion that it is conceivable that given contractor input it may be possible to reduce the costs if more innovative ways of working could be achieved.
10. Procurement using the “competitive early contractor involvement” model, and possibly an alliance for delivery, should be considered to maximise innovation, the use of technology, intellectual property, and to minimise risk and cost over-runs
11. Overseas experience with recent rail tunnels should be utilised to examine and address project risk, not just in the engineering discipline
12. Our reviewers agreed with the Peer Reviewers that the project could be carried out for the estimated cost (excluding property costs) of between $1.9b and $2.2b.
13. Thus they confirm that the estimated construction costs are realistic
14. The NZTA thanks the reviewers, Auckland Transport and APB&B for their co-operation in this review
6 Appendices

Appendix 1

Cost Adjustments Subsequent to Formal Peer Review, as presented in APB&B Phase 2 Concept Design

<table>
<thead>
<tr>
<th>Project Area</th>
<th>Initial Mean August $m</th>
<th>Phase 2 Mean Sept 2010 $m</th>
<th>Difference $m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Cost</td>
<td>1,403.1</td>
<td>1,376.2</td>
<td>(26.9)</td>
</tr>
<tr>
<td>Overheads</td>
<td>267.4</td>
<td>214.0</td>
<td>(53.4)</td>
</tr>
<tr>
<td>Contingency / escalation</td>
<td>341.7</td>
<td>270.3</td>
<td>(71.4)</td>
</tr>
<tr>
<td>Property (net including risk)</td>
<td>76.7</td>
<td>128.7</td>
<td>52.0</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>2,089.0</strong></td>
<td><strong>1,989.3</strong></td>
<td><strong>(99.7)</strong></td>
</tr>
</tbody>
</table>

Appendix 2

Formal Peer Review (Bond, Rogers, Yamazaki) - Issues by Topic Area

<table>
<thead>
<tr>
<th>Issue relates to:</th>
<th>Number of issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stations – location, design, construction etc</td>
<td>21</td>
</tr>
<tr>
<td>Tunnel design</td>
<td>5</td>
</tr>
<tr>
<td>Tunnel construction, timing etc</td>
<td>31</td>
</tr>
<tr>
<td>Costs / contingencies etc</td>
<td>28</td>
</tr>
<tr>
<td>Risk analysis</td>
<td>9</td>
</tr>
<tr>
<td>Traffic control, property, consentability</td>
<td>4</td>
</tr>
<tr>
<td>Rolling stock, NAL connection</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Appendix 3
CBD Rail Link Business Case Review
Comments from NZTA’s Tunnel Engineer

APB&B Response March 2011 – Comments in blue numbered a through z to kk

Introduction

NZTA’s tunnel engineer has worked on rail and road tunnel projects around the world, including as a contractor. He is currently engaged on the Waterview project working for the client (NZTA). He has had the opportunity to review the APB&B documentation and provide comments based on his previous experience, best practice, and recent experience on Victoria Park Tunnel and Waterview.

Conclusion

Overall, he agrees with the peer reviewers that the project can be delivered for the estimated construction cost in the range NZ$1.9 to $2.2b. He believes that there are some significant savings to be made in some areas, however some of these would be negated by additional costs in other areas. He also believes that the time for construction is probably correct, although he believes that the construction approach and sequencing could be carried out differently. There are some opportunities for savings to be made on the estimate if alternative methods and sequencing were adopted, an opportunity that might be realised under a “competitive early contractor engagement” procurement model.

a. Noted: From our comments below, whilst we believe there are and should be opportunities for improved construction methods and hence savings and that there will be areas where cost increases will occur, we would caution against the word “significant”. At concept level the methods chosen must be conservative but realistic which we believe is the case. We would note that the phase Waterview is in now is 2 design stages further advanced than we are. The key to determining the optimum construction sequence will be involving the expertise and experience of constructors at an early stage in whatever procurement model is followed.

Opportunities

- More cost effective station design and layout. The three stations represent about 43% of the project cost, which is high. Maximising use of the station volumes could be advantageous (see also next bullet).
- We agree that maximizing use of Station volume is paramount but disagree that we haven’t achieved it. As outlined in our CDR the circulation, FLS and plant approach in the stations has significantly reduced space from typical underground stations when all design, functional and other drivers are taken into account. For example the fire egress and ventilation approach is quite innovative with a single surface connection point which has realized substantial volumetric savings. Aotea Stn is relatively shallow and has to be cut and cover. At 100,000m3 the increase over the minimum volume is a factor of having to access sites across the intersections from the main box a situation driven by available property. Newton and K Road a deep stations driven unavoidably by the alignment and hence the depths we are dealing with. These points are dealt with in the CDR.
- Reconsider mix of escalators and stairs, from practicality, usability, and Fire, Life and Safety (FLS) perspectives.
- The objective of the current work has been to provide a viable scheme in support of the designation process and project costing. At Aotea some escalators could be converted to stairs but this would not change excavation volume and have minimal cost impact and would not be as amenable. The current configuration has been a balance between ease of circulation and amenity, regulation requirements and following international best practice.
- At Newton and K Rd the vertical distances make stairs impractical, reduce amenity and as above make little cost impact. FLS issues with all escalators have been dealt with.
- Construction technique – consider using the TBM to its maximum effect from the southern portal (which could be further south than planned) driving the two tunnels to lower Albert Street and constructing the stations from the tunnel(s), rather than mining two stations and using cut and cover for the other. Mining seen as slow, risky and expensive, also problems getting TBM through the station boxes.
- We consider that based on current geotech, which is light, we have maximized the TBM length at both ends. At the south end the primary reason is geometric constraints and where the cross...
over has to occur which is on the ‘cliff’ face, where the ground drops away to the NAL, shallow at one end deep at the other. WE also seek to avoid TBM drives on the tight curves, allowing a cross over to be constructed in cut and cover in the area which would require very large spans if mined. To the north of this box the ground conditions are weak and fractured rock which would require either creation of a break in box (expensive and slow) or a mined section as we have done to get to better rock conditions. Further geotech will hopefully allow some improvement on this but we are only talking 30m. With the cross over box being built by cut and cover, we then make use of the void above the rail box by putting vent plant in it thereby releasing land at the surface for commercial purposes. We consider this an economic approach. At the north the TBM break out at 390m has been selected where the ECBF cliff face is believed to be and this is where the horizontal curve starts to tighten to beyond that capable of the type of TBM that would be used.

f. Generally cut and cover stations are a lower cost than mined, this and the ground profile at Aotearoa drive it towards a cut and cover solution as cover is only 6-7m. More risky and more costly than cut and cover however, K Road and Newton the stations are too deep to be fully excavated by cut and cover cost effectively. A hybrid solution is proposed with a central shaft providing the space for escalators, stairs and plant and then mining the station platform caverns from that access. This reduces the dependency between the TBM drives and the station excavations. For shallow depths (say up to 20m) I would agree that mining is slower. Also programatically we are making use of the time prior to arrival of the TBM to excavate and hence gaining programme time.

- From lower Albert St to Britomart, consider jacking a culvert through under Queen Elizabeth square, Queen Street and Britomart, a slow method but worth considering as the project spans four years. This would remove the need for the major cut and cover operation planned. Westfield would still be purchased to aid construction and reduce risk.

- A jacked box solution is possible and would reduce the impact on Queen Street bus stands, however the cut and cover solution requiring temporary and staged relocation of the bus stands is selected because it is expected to be lower cost whilst not imposing unacceptable disruption to Queen Street. A cut and cover box is required through the Westfield site and switching to a different approach under Queen Street will add cost. It is also necessary to do considerable work on the under pining of the GPO buildings which will also require access from street level on Queen Street which would not be removed by using a jacked box solution.

- Bring the tunnel portal as far south as possible, to maximise use of the TBM (which is around half the cost of cut and cover method).

- Please refer to our answer in e. above. The cost comparison is true where there is reasonable cover on the tunnels. In this area there may be some opportunity to move the portal south but the low cover and poor ground is a constraint and would require extensive ground treatment to allow tunnelling by TBM for many more meters to the south. The rail grade constraints prevent the lowering of the alignment to increase cover. This opportunity will need to be further investigated but the current location is selected as a reasonable conservative position allowing the potential impacts on the street and adjacent buildings to be accounted for in the designation process.

- Consider two TBM’s to reduce construction time, could save 6-9 months (but see timing risk below).

- The use of two TBM’s has been considered and dismissed for the reasons described in the Concept Design Report section 8.5.1. In particular the timing of station construction and critical path does not give sufficient benefit in overall programme, only a net 4 months not the 6-9 mths suggested above, to justify the additional cost of a second TBM and associated support.

- Review the FLS requirements which may be over-stated.

- The FLS requirements have been developed based on the designers’ experience, international standards, international practice, in the context of NZ regulations and in discussion with the NZ Fire Service. Further development of these initial concepts will be required as the design is progressed and we would be happy to explore specific areas where you believe them to be overly conservative for underground rail and underground stations.

- Reconsider the need for cross passages between tunnels – European standards understood to allow a 1km walk to safety for emergencies rather than the 240m proposed. Fire in a stationary train considered unlikely for a range of reasons.

- The current EU technical Specification for Interoperability for Safety in Railway Tunnels requires a minimum cross passage spacing of 500m. Exit to the surface (not to just a point of safety) are required at a minimum spacing of 1000m. We agree that there may be some opportunity in detailed design to increase the spacing of cross passages following a risk.
assessment and focused consultation with New Zealand Fire Service; however there is no
certainty that a wider spacing will be agreed to given the absence of NZ standards and
precedence for such a design. We therefore believe that the current arrangement is
appropriate for a designation and cost estimate at this time and follows currently what has been
agreed in similar projects in Australia and Asia.

1. Any train fire in a tunnel is considered unlikely given that the new rolling
stock to use the
system will be designed to resist ignition and fire spread. However, if a fire did develop on a
train (especially on a train with no intercar separations), there is a small possibility that the fire
could disable the vehicle in a tunnel. Cross passages are provided also to facilitate
maintenance and NZFS intervention.

Risks

- Tunnel diameter may be insufficient at 6m. Distance from live rail to tunnel ceiling less
than 550mm, 1m would be more usual. May need 6.5m diameter tunnels

m. The current diameter is adequate for the proposed solid traction power rail rather than
overhead lines and in line with similar gauge underground rail facilities. This has also been
reviewed by KiwiRail’s Auckland Electrification Project Team.

- Kinematic envelope of new EMUs not known, will be by time CBDRL is built, and may
impact on bullet 1 above (yaw and slew may affect space requirement)

n. I agree this remains a significant risk to be managed going forward and is on our risk register.
The future trains and tunnel configuration must match. The current cross sections as noted
above have been reviewed By KRN’s AEL project and we believe has been provided in the
train procurement for suppliers to consider. A 6.5m tunnel can be accommodated in the
proposed designation.

- Lay down areas at southern end may be insufficient, which would be exacerbated by
slewing the NAL 8 metres to the north. The spoil stockpile area may be too small – need at
least enough concrete ring segments for two shifts / one day’s construction. Spoil coming
out from tunnel will be wet, contaminated, and will not have time to dry, making removal
more difficult. Solution would be to purchase additional properties.

o. These issues have been considered in the layout of the southern construction yards. Refer
section 8. The space for spoil and segments and tunnel logistics have been sized to allow
some redundancy on the impacts of the shift structure, ability to truck out and in and we believe
is reasonable with the property take largely based on taking most of the useable flat area. We
agree that this will place some constraints on the construction, however we consider the space
sufficient and appropriate for designation.

- System testing and commissioning considered to take 12 months not 6 as stated (offsets
the 6 months gained in bullet 5 in “opportunities”).

p. The commissioning can be staged to some extent, 6 months is considered to be sufficient for
commissioning that cannot be carried out in parallel with other activities and consistent with
similar projects we have experience of.

- NOR consenting fees considered too light at $1.5m.

q. Our planners who also are advising on Waterview have reviewed the specifics and consider
this a reasonable budget when the specifics of this project is considered. It maybe that the
definition of what is included is unclear.

| NOR Consent Fees (as advised) | $1,500,000 |
| Building Consent Fees       | $6,872,000 |
| Planning Fees               | $3,950,000 |
| Client Management (Planning Management) | $2,500,000 |
| **Total**                   | **$14,822,000** |

- Environmental compliance costs not found in report – budget needed to ameliorate
problems from construction sites, noise provisions, contaminated sites, temporary
settlement ponds etc. Budget $5-7.5m, note Waterview approximately $15m (larger
project, more above ground)

r. We note that Environmental Compliance is a typical stand-alone NZTA cost centre. We have
dispersed this cost amongst the demolition and enabling works section of our measured works
the value of which across the whole estimate totals $7.40m excluding.

- No allowance found for Central Train Systems and train detection – consider $10-20m
s. Signalling and train control systems assumed to be an add on to the new systems currently being installed under Electrification project so assumed that train control systems will only need modification and expansion rather than replacement to accommodate CBD RL. WE have allowed significant sums for SCADA

- Automatic Fare Collection – may be too light at $6m, consider $12m but more accuracy known when AIFS is commissioned

t. Estimate is benchmark assessed. Perhaps on top of our already established contingency allowances we could include LS values for scope uncertainty.

- Services may need reconsidering – the gravity sewer is old, fragile, and at a very shallow grade. Victoria Park Tunnel experience shows pumping stations and added funding may be required – add $2-3m.

u. Services relocations such as stormwater, wastewater, gas, water, telecommunications, electrical, transportation, etc have been assessed on a principal location basis (i.e. station or alignment). The cost allowances for these locations have been derived and weighted on the anticipated complexity of the construction zone (e.g. Albert St/Customs St), the expected number of services running through the construction zone, and any other known infrastructure that requires relocation/diversion. The scope of work required for services diversions has not yet been fully defined however, the assumed scope generally includes for work such as locating and protecting existing services, building major and minor temporary services diversion(s) while construction proceeds, building new infrastructure and disconnecting temporary on completion.

The phase 2 cost estimate typically includes services relocations as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Services Relocations</th>
<th>Drainage Services Relocations (Included in Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aotea Station – Includes $3m for WW/SW and strengthening works to the Orakei sewer main</td>
<td>$7,460,000</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>K Road Station</td>
<td>$4,500,000</td>
<td>$1,000,000</td>
</tr>
<tr>
<td>Newton Station</td>
<td>$4,500,000</td>
<td>$1,000,000</td>
</tr>
<tr>
<td>Britomart Connection</td>
<td>$9,600,000</td>
<td>$1,300,000</td>
</tr>
<tr>
<td>NAL West Connection</td>
<td>$2,850,000</td>
<td>$450,000</td>
</tr>
<tr>
<td>NAL East Connection</td>
<td>$2,050,000</td>
<td>$300,000</td>
</tr>
<tr>
<td><strong>Total (Net Cost)</strong></td>
<td><strong>$30,960,000</strong></td>
<td><strong>$6,050,000</strong></td>
</tr>
</tbody>
</table>

Note: Above figures exclude P&G/OH&P, Contingency and Funding Risk.

Whilst pump stations have not been specifically noted in our estimate, we are reasonably comfortable that the above cost allowances provided (and the project risk contingency allowances) will cover such a requirement should it eventuate.

- Signalling costs of $10m may be insufficient – add $5m

v. See above comment on r. Signalling costs provided by KiwiRail Electrification project team based upon expansion of systems being installed as part of electrification.

- Air handling – can be a difficult problem to address, perhaps need confirmation of approach from a specialist

w. We have had tunnel ventilation experts in rail who have designed the concept and are confident the system chosen is a sound approach

**Issues**

- In EMU procurement, need to ensure that EMUs can handle the gradient, from a slow tight corner (exiting Britomart) into a “steep” upgrade of 3.2%.
x. Agreed this data has been passed to the Electrification team
   - Catenary around 145m radius curve exiting Britomart is very tight for long units – fixed overhead rail might assist but needs consideration

y. The tightest curve currently on the Akl network is 95m. Fixed overhead rail is the current referred solution, refer 7.3.2 in the CDR.
   - Transitions between fixed overhead rail and wire catenary, and vice versa, are difficult

z. Agreed
   - The requirement for no signalling between stations seems unusual – may be necessary to control trains in emergencies.

aa. This is a misunderstanding. The signalling for the base option only permits one train to be in each section of line between stations at a time. The more sophisticated option allows for two trains to be in an inter station section at any time, thus providing more capacity.
   - Peer review issue 11 – agree there is a conflict between rock bolting and canopy tubes that was not resolved by the workshop and notes

bb. Incorrect, from the Peer review record design alteration was made.
   - Peer review issue 61 – disagree that the TBM relocation / changeover could be effected in 2 weeks. Three months would be more realistic

c. Henry is a tunnelling expert from Leightons and he stated a 4 week lag between drives. We agreed to a 6 week minimum and that is what is on the programme and is based on the pull back method. In fact the current critical path runs through Newton Stn Cavern and effectively there is also an 8 week hold up at present beyond this 6 week period before the 2nd drive can start.
   - The vertical curvature expected of the TBM / tunnels should not be less than 3,000m radius. Need to avoid purpose – cast concrete rings as too complex and risky

dd. Advice from TBM suppliers and offshore experience has been sought in the design development and confirmed that the current vertical curves can be accommodated without special segments.

Comments from a meeting with one of NZTA’s State Highway Managers (who has international experience with road and rail tunnels)

Big Picture
   - Whole of life costs very important for Rail, especially in design and build environment, cheap capital cost can involve very expensive maintenance and renewal costs

ee. Agreed these are in our objectives.
   - Thinking about incremental costs and benefits, eg has a single tunnel with passing ability at stations, or a one way tidal flow operation been modelled (Interfleet work may inform)?

ff. Neither option has been modelled as instinctively if one of the reasons for the scheme is to relieve capacity constraints on a rail system which is already double tracked, then a single track line with passing loops is unlikely to be effective. In addition given the relatively short distance between stations, it is unclear what if any saving in capital cost would be achieved, when the space required and cost of providing room for single to double track turnouts at each end of each station is worked out. Potentially these may also have an impact on the maximum gradients between the stations. Similarly a tidal flow operation implies that there is a predominant direction of travel in each peak rather than in both directions.
   - Could a station be delayed (noted that the incremental BCRs of dropping stations has been included)?

gg. Yes this has been considered in the CDR, tabulated in the cost estimate and was addressed in the business case research.
   - Important to consider early contractor involvement to maximise opportunity for the use of specialised plant, for example latest TBM technology.

hh. Agreed and is mentioned in the procurement approach in the cost estimate and will be reflected in the procurement strategy yet to be developed.
Would like to see innovative deployment of TBM(s) with contractors suggesting ways to shorten construction time and construct stations more efficiently (eg from the tunnels)

ii. Agreed, this is very much the intent going forward

Think about ways of minimising disruption to surface traffic – a major cost to the project which needs to be included in the economics

jj. These have been considered and will clearly need ongoing development to investigate the trade off of traffic disruption and costs. Traffic consideration is included in the CDR, very much a part of our construction methodology and included in the AEE and these effects considered in the business case.

Use of spoil – is it cut to waste or can it be utilised elsewhere – any impact on the design or programme? Have the costings accounted for contaminated material, either from the downtown reclamations or the material from the TMB which will have additives in it?

kk. Estimate assumes cut to waste as the worst case scenario. This is prudent at this stage until the timing of the project is clear and any synergy with other govt. projects could be achieved and the delivery method is chosen.

At present, our estimate assumes that 95% of the excavated material is clean and 5% contaminated. This allows for some contamination in the lower area noting that we have allowances in the risk contingency as well with the excavation at that end around 10% of the total. We don’t expect contamination elsewhere, so covered at 50% and if all contaminated the extra over out of contingency, $3-4m

With regards to spoil arising from the bored tunnelling work, this would be clean as the additives used would be Eco friendly to allow safe disposal. Eg the foams used degrade and disappear.

No disagreement with the $2.2b estimated cost