Westgate Tunnel Project

Independent Advisory Committee

Interim Report on :
Groundwater
Ground Movement
Contamination, Waste and Spoil Management

Prepared by Stephen Hancock - Technical Advisor

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Introduction

1. The West Gate Tunnel Project will involve the deep excavation and construction of a sequence of engineering features related to new and expanded road infrastructure both above and below ground surface between the western edge of the CBD and the Kororoit Creek Road intersection with the Westgate Freeway to the south west of Melbourne.

2. This interim report has been prepared at the request of the IAC in accordance with the Terms of Reference issued by the Minister dated 26/5/2017and a brief issued on 29 June 2017 entitled "*West Gate Tunnel Project: Provision of Expert Advice to Inquiry and Advisory Committee*". This document requires at Task 6 -"*Provide an interim report to the IAC to be tabled at the commencement of the Hearing on 14 August 2017 which sets out within your area of expertise:*
   a) *The matters required by the PPV practice note - Expert Evidence including all facts, matters and assumptions upon which you have proceeded*
   b) *The key issues, including whether the key issues you have identified prior to the circulation of have changed and if so how;*
   c) *Your expert view raised by paragraph 13(e)(i0- (Iv) of the Terms of Reference * in so far as they relate to the key issues you have identified;*
   d) *Any areas in which you consider that there is insufficient information having regard to the current and future stages of the project (eg detailed design);*
   e) *Recommended changes to the approval documentation (if any)"*

   *(the TOR requirements under 13(e) (i)-(Iv) requires "*consideration and where relevant investigation of:*
      i. *the magnitude and significance of adverse and beneficial environmental effects,*
      ii. *the adequacy of the proposed environmental management framework including the environmental requirements and environmental management measures contained within the EES, with reference to applicable legislation and policy;*
      iii. *The adequacy of WAA No S0100269 ;*
      iv. *The adequacy of the impact assessment and whether the proposed environmental performance requirements are capable of being met"*

3. Thus this interim report has the objective of informing the IAC of such sensitive issues which may, in the opinion of the Technical advisors arise in respect to the elements named in the title above.

Material Considered

4. EES documentation has been released by the Western Distributor Authority which covers the full scope of the possible environmental effects required by the Minister for Planning to be considered. The full scoping requirements are set out in the document entitled *Scoping Requirements for Western Distributor Project - April 2016 by DEDJTR*. Amongst many others in Table 1 of that document, it requires that " Evaluation Objectives" should include - "Land stability, Hydrology and water quality and Waste Management" issues arising from both the construction and operation of this project.

5. In respect to the elements of relevance to this report, the following EES documents have been read in detail and their findings considered as to completeness and reliability in respect to this preliminary technical report:
   a) West Gate Tunnel Project - Environmental Effects Statement -Main Report - Volume 1 including the Executive Summary; Section 4 -Assessment Framework; Section 5 - Project Description
   b) Volume 3 including Section 19 Effects on Physical Environment.
   c) Technical Reports B Contaminated Soil and Spoil Management
   d) Technical Report. C Groundwater
   e) Technical Report. D-E Ground movement and Surface Water

6. In addition, the EES Map Book and the Development and Urban Plans and the "*EPA Submission on the West Gate Tunnel Project environmental effects statement " dated10 July 2017"* have been considered including various reference documents such as "Engineering Geology of Melbourne". A wide variety of EPA documents, including State Environment Protection policies and Guidelines relating to Major Construction Sites; Land (pub.no.854), Potentially Contaminated Land, Acid Sulphate Soil and Rock (pub.no 655.1, Soil hazard categorisation and management have been considered along with authoritative references on Acid Sulphate Soils - Laboratory Methods Guidelines.

7. Finally, the statements of evidence of the following experts were read and contributed valuable material. These included:
   a) Jonathan Medd - Golder Associates on Groundwater
   b) Trevor O'Shannessy - Golder Associates on Ground Movement
   c) Andrew Kalitsis - Golder Associates on Contaminated soil and spoil management
   d) John Heilig- Heilig and Partners Pty Ltd on Vibration and regenerated noise(tunnel)

8. All these documents have been used to identify and evaluate the key issues arising from the West Gate Tunnel Project in relation to groundwater, ground movement and contaminant waste and spoil management . The comments that derive from these analyses has also included consideration of past deep excavation programs in which the writer had direct first hand experience. These have included the Brooklyn Trunk Sewer tunnel; the Brooklyn Pumping Station dewatering; the South West Trunk Sewer (SWTS) tunnel from Brooklyn Pumping Station to the Hopper Crossing Pumping Station; the City Link tunnels and the Arts Centre (Hamer Hall) Construction and the planning for the Metro Rail project. All of the latter involved excavations in some or all of the materials which will be intersected by the various engineering excavations involved in the West Gate Tunnel Project. Finally, the land surrounding the project for industrial uses and for concomitant waste disposal over at least the past 100 years is recognised.

9. Thus, comments presented herewith on the risk profiles and management approaches put forward in the EES documents and in the statements of evidence by the experts from the WDA are informed by the writers long experience of groundwater management and of industrial waste clean up and contaminant management and on the fate and movement of contamination in the natural environment. It should be noted however that the writer has not had access at the time of preparing this Interim Report to the primary data sets. These include the bore logs and the test procedures , records and individual test results which gave rise to the statistical data on Groundwater Hydrology

and the geotechnical parameters which are at the bases of risk assessments and modelling the modelling involved in Ground Movement assessments.

Risk identification, assessment and mitigation

10. The development of the West Gate Tunnel Project as presented within the project documentation and the evidence submitted has been pursued through an iterative and inclusive process of route and risk identification, physical parameter assessment and evaluation. This process was guided by an initial Environmental Management Framework (EMF) which led on the identification of Environmental Performance Requirements (EPR) and thence to identifying mitigation measures to be included in Construction Environmental Management Plan (CEMP) to be implemented through the final design and construction procedures. This latter process is stated in the project documentation as being ongoing.

11. These procedures are seen by the writer as having been thoroughly pursued and to have been consistent with the policies and legal responsibilities applying to any such development proposal as the West Gate Tunnel Project. Specifically the risk identification processes pursued are seen to have been thorough in the investigations undertaken, as have been the assessment and modelling exercises. Similarly, the mitigation approaches outlined to date are appropriate and the intention to use active and ongoing monitoring including repeated model verification to ensure the ability to foresee the outcome of monitoring trends is applauded. It is to be expected that present risk levels are likely to be conservatively estimated and that more serious risks are only likely to emerge from instances where the statistically evaluated risk parameters do not apply or where unforeseen limitations give rise to the impacts mitigation actions being less than is expected.

12. The writer is conscious of the impacts which can occur due to departures from statistically evaluated risk scenarios and hence has focussed on these in considering the project documentation. It should be added that despite the potential for such unforeseen conditions to arise, the writer is confident that mitigation measures are available which can at a cost and with time ensure that such occurrences can be mitigated to meet the project EPRs.

Groundwater

13. It is inevitable that excavations for the West Gate Tunnel project, be they the 15.6m diameter road tunnels; the 3.0m diameter cross drives between the road tunnels; the dive and portal structures associated with entry and exit engineering; the necessary realignment of the North Yarra Main Sewer or the drilling of bored piles for the bridges and overhead structures and even the construction of earth embankments will impact upon the shallow groundwater regimes. This is because the water table (the upper level of saturation within the underlying geological sequence) is mostly at quite shallow depths below the surface and indeed is at the surface near such features as the Stony Creek Backwash Swamp , at Moonee Ponds Creek and along Kororoit Creek to the west.

14. The EES documents present a rigorous evaluation of the hydrogeology of the project area and of the contiguous land surrounding the project. The investigation program has been comprehensive in defining the geology, the hydrological conditions and parameters of the geological units potentially impacted by the construction and or operation of the project. It has been equally diligent in identifying the potential sources and range of contamination risks which could be encountered. Risk assessment (RA) evaluations allowed the definition of the EPRs necessary to meet EPA policy and guidelines and the identification of environmental management techniques which could be used to mitigate the magnitude of any impacts to achieve acceptable outcomes within the overall Environmental Management Framework (EMF) for the project.

15. The above evaluation processes are stated in the project EES documentation to be ongoing as detailed designs are generated and as Construction Environmental Management Plans are developed

for each stage of the project. It is to be expected that the mitigation measures outlined will be implemented within the CEMP based on needs identified by further investigations where necessary and by trigger monitoring as bases for initiating or intensifying the application of the various mitigating measures.

Hydrogeology

16. The extensive investigations throughout the project area have revealed that the Maribyrnong River is a stream which has been displaced to the eastern edge of its original valley by the outpouring of Newer Volcanic lava flows from the north. The original valley was centred on a stream course about 2 - 2.3km to the west at an elevation of about - 35mahd. The geological sequence which was exposed by the original valley of the river included the poorly sorted silty sands and gravels of the Brighton Group. This erosion also exposed the silty clay marls of the upper sequence of the Fyansford Formation which is underlain by the upper deeply weathered Older Volcanics (Tvo1) on the eastern side with the fresh deeper Older Volcanics (Tvo2) to the west below the Fyansford Fm. Some Werribee Fm (Tew) remnants are recorded in the Geological Section (Figure 14 of Technical Report D-E) but this is stated to be stiff to very stiff clays and lignite.

17. The consequence of this sequence is that the road tunnels will penetrate initially the deeply weathered upper Older Volcanic (Tvo1) sequence south west of the the Northern Portal and then as it traverses south west it will traverse into the Fyansford Fm (Tmn)in the floor and the Brighton Group (Tpb) in the roof before traversing into some Sub Basaltic alluvium within the palaeovalley of the Maribyrnong River and thence through the extremely altered palagonite (lower) sequence of the Newer Volcanics (Tvn2) with both tunnels then passing through the slightly weathered to fresh basalt of the upper Newer Volcanic (Tvn1) sequence to arrive at the southern portals.

Risk profiles and Risk Mitigation

18. The risks to groundwater within the project area relate to the groundwater extractions that may be involved in the project engineering. In particular, it is the risk that the impacts could have on groundwater availability and it's quality to meet such beneficial uses as apply. In addition there are potentially risks relating to the mobilisation of existing contaminated groundwater and/ or the generation of new sources of contamination such as through the oxidation of potentially acid sulphate soils.

19. These risks are all assessed within the project documentation and are rated in the risk matrices presented. Those assessments are, as they stand, agreed by the writer. The means of mitigating those risks are also seen to be comprehensive and well considered. The probability of actual occurrence of material risks is however uncertain and, whilst they will be provided for in the groundwater management plan being presently prepared as part of the CEMP, the need for mitigation is to be triggered by monitoring results and model predictions.

20. Thus it must be accepted that the mitigation of any risks to the groundwater environment will depend upon:
    a) The time taken to implement mitigation procedures,
    b) The intensity of implementing mitigation procedures , and
    c) Complexity of implementing effective procedures.

    These aspects are not presented in any of the project documentation or within the expert witness statements presented to date.

21. The risk profiles relating to groundwater all ultimately come back to a consideration of the specific geology and hydrogeology of the materials to be intersected and traversed and in respect to contamination - the degree to which contaminated groundwater sources are located such that contamination is likely to be mobilised to points of extraction within the times available for such travel either during construction or operation. These aspects are considered below.

22. The engineering involved in the project development to the east of the Northern Portals of the road tunnels will in relation to groundwater environmental issues involve minor short term risks .

23. Pile construction for the bridges across the Maribyrnong River and Moonee Ponds Creek and for the elevated road and Veloway structures are only likely to involve the removal of minor volumes of saturated Yarra Delta sediments as poured in-situ piles are established to depth within steel subsurface formwork. The engineering processes involved are well established and the need for the use of construction materials resistant to saline water and other electrolytically inducible corrosion processes should be well understood and covered by the CEMP.

ROAD TUNNELS, PORTALS AND THE HYDE STREET OFF RAMPS
GEOLOGICAL ENVIRONMENTS

24. The geology of this segment of the project includes, close to the Maribyrnong River and the Stony Creek Backwash Swamp, some fill and Yarra Delta sediments. The latter will include include:
    a) Fill and made ground including a wide range of material mostly above or close to the water table;
    b) Alluvium - silty and clayey especially along Stony Creek deriving from Newer Volcanics erosion, close to the water table;
    c) Coode Island Silt (Qhi) - clayey silt with sands towards the edges and at depth with shell and carbonaceous bands, much of which is likely to be below water table except near the North Portal and the NYMS and variously
    d) Weathered Older Volcanics near eastern end of the tunnel.

25. Near the Spotswood Golf Course and the Donald McLean Reserve, the geomorphology of the landscape suggests that the area is underlain at shallow depth by Newer Volcanics with some minor alluvium as described above near Stony Creek.

RISKS

26. The groundwater risk profiles for construction and operation in these areas are seen as including:
    a) Depressurization of sand lenses within the Coode Island Silt such as to exacerbate consolidation and surface settlement.
    b) Dewatering of Coode Island Silt (CIS) such as to give rise to acid generation within the formation and acidic drainage from excavations into or interconnected to the CIS,
    c) Mobilisation of contamination from adjacent landfills and from contaminated sites especially close to the Northern Portal and the Southern Portals.
    d) Impacts on groundwater dependant ecosystems in Stony Creek and in the associated Backwash Swamp
    e) Impacts on water flows and on the water table beneath public open space areas such as the Yarraville Reserve and those abutting Stony Creek.

RISK MITIGATION TECHNIQUES

27. A range of risk mitigation techniques are set out and these include:

28. Around The Northern Portal and North Yarra Main Sewer realignment works
    a) The construction of secant walls to depths sufficient to largely prevent groundwater inflows.
    b) Jet mix grouting of soft sediment to reduce permeability and to increase material resistance to groundwater up-flow across the base of excavations.
    c) The application of pipe jacking technologies in soft sediments as part of the NYMS realignment works to minimise inflow opportunity
    d) Pressure grouting of rock formations as necessary.
    e) The injection of water into any significant aquifers to offset water table depression and hence the development of hydraulic gradients which might cause significant contamination movement.

29. In the Road Tunnelling and in the Cross Tunnelling
    a) The use of Earth Pressure Balancing Tunnel Boring Machine (EPB TBM) technology .
    b) The use of pipe jacking and or micro-boring of pre-grouted material in cross tunnel construction.

c) The expeditious reinforced cement lining of the bored tunnel perimeter immediately behind the EPB TBM.
d) The expeditious grouting of any annular space between the bored tunnel profile and the circular lining segments.

RESIDUAL RISKS

30. The above techniques would likely be applied where possible as part of the Groundwater Management plan of the CEMP in advance of construction.

31. Around the Portal areas and the NYMS realignment implementation the efficacy of mitigation works will be able to tested before extensive construction works begins. In this respect the residual risk profiles around the portal areas are likely to be very much mitigated to levels which are acceptable within the EPR as dictated by the project and the regulatory regimes applying within the Cut Paw paw Groundwater Management Precinct. However, it is noted that near the Portal area leakage of groundwater from shallow aquifers into the NYMS as it exists at present has caused the water table to decline to depths below sea level (> -7mahd) along Whitehall Street (Figure17 P59 , Volume C) . When this sewer is abandoned and backfilled as the realigned sewer takes the load it is to be expected that water tables in this area will then normalise to some extent. As this occurs, it is possible that some acid waters generated by the water table decline held in inter granular porosity may be flushed towards the surface with adverse effects upon vegetation, especially trees in Hanmer Reserve.

32. It is also possible that some contaminated water from former landfills and gasworks close to Whitehall Street may also have been drawn towards the sewer by this long term leakage .

33. These risks needs to be recognised and investigated and if the risk is significant, some remediation work undertaken to eliminate the risk magnitude identified.

34. In respect to the major road tunnelling where a wide variety of geological material are to be traversed, determining the efficacy of the proposed mitigation works will not be able to be tested in advance. Rather their implementation may need to be reactive to the knowledge of the materials gathered and perhaps monitoring and model predictions coincidental with the tunnelling progress.

35. The risk mitigation in respect to the tunnelling is largely about the degree to which the TBM can be operated in open, semi closed or closed mode to counteract the hydrostatic pressure differential, which apply across the cutting face and the unsealed segment of the tunnel perimeter as it proceeds. This in turn is dependent upon the characteristics of the formations surrounding and in front of the cut face to allow the pressures involved in balancing the hydrostatic and other ground pressures to be maintained. Further, the grouting of the annular spaces around the tunnel and for cross tunnel material stabilization will require the application of pressures sufficient to achieve effective grout permeation. If these pressures cannot be applied for any reason then the grouting is likely to be less effective in adequately mitigating inflow or other issues relating to groundwater movements and impacts both during and post construction.

36. It is recognised that large tunnel boring machines have been in use for several decades elsewhere in the world and that the technologies have been progressively improving. However, these technologies have not been applied in Victoria before and hence their ability to proceed effectively un-delayed by the variety of conditions likely to be encountered in the WTP is not confirmed by experience.

37. It is noted from the hydrological testing undertaken along the tunnel route that the hydraulic conductivities determined for the volcanic sequences to be encountered vary though up to 5 orders of magnitude which suggests, on the face of the data in the documentation seen, that the conditions are quite widely variable from the mean and that the TBM will have to be able to mitigate the potential inflow regimes that each of these values represent if the risk profile is to be met.

38. Experience of the various formations that will be encountered by the TBM have included:

a) at the Sayers Road Shaft site very significant inflows from a single small lava tube in the Tvn1.
b) At the Brooklyn Pumping Station - a fracturing of 10m thick section of the Tmn consequent on unrelieved uplift pressure from presumably the Tew accompanied by a large groundwater inflow across the unsealed base of the shaft.
c) Air pressure blowouts at the surface whilst excavating the South East Trunk sewer.

39. The documentation provides no indication of the ability to manage such issues were they to occur during tunnelling.

40. It is noted that the EPB TBM can be operated in open , semi open or closed modes but no indication is given of the time involved in changing from one mode to the other or of what conditions might trigger such changes in mode. These are important issues as the occurrence of significant inflows carries with it the potential to mobilise any contaminated groundwater which may exist close to the tunnel alignment and give rise to contaminated water for management and contaminated spoil.

41. Similarly, the documentation indicates that 3m diameter cross tunnels between the two tunnel alignments will be constructed at about 120m intervals along the tunnel alignments between the North Portals and the eastbound South Portal near to Williamstown Road. Whilst these are short tunnels and not large in the context of the road tunnels, they will involve penetrating the grouted annular periphery of the tunnels and will involve variously jet or pressure grouting both of which can involve significant applied pressure if grout permeation is to be successful.

42. The application of significant pressures in Cross Tunnel construction where the cover depth above the tunnel obvert is low, such as near Williamstown road or Stony Creek, could give rise to grout excursions to the surface and poor grout permeation of the desired target zone. Similarly, if the materials being penetrated are weak and overlie higher unrelieved pressures then structural failures can occur.

43. The above issues are not addressed as risks in the documentation to date , but need to be considered by the CEMP as they have implications for the GMP especially in relation to contamination mobilisation issues both during construction and longer term should these issues give rise to enhanced or focussed flow paths for contaminant flows. These issues need to be recognised in the CEMP and in the Groundwater Management Plan, especially in those tunnel segments where the application of significant pressures in grouting or in penetration need to be employed within zones of weak formations.

44. Apart from the above risks relating to pressures applied during boring and grouting, other risks associated with contaminated groundwater inflows, the initiation of acid groundwater generation by dewatering, excessive groundwater extraction and groundwater beneficial use degradation are agreed as being low to non-existent. This is because the speed of tunnel penetration and tunnel line sealing as presented, when taken with ground pressure balancing, should render inflows small and locally short lived especially if the formations are of the limited hydraulic conductivity indicated by the geometric mean statistics presented in Tables 10 and 11 (p56) of Technical report C.

45. The indicated hydrological conditions act to minimise groundwater movement and the implications of that movement. It follows however that any occurrence which delays the rate of tunnel progression does impact upon the magnitude of the risks which might arise. Such occurrences could include :
    a) The need to pull back the TBM cutter for repair, replacement or removal of undrillable material mixtures (eg unknown steel cased bores; hard, rounded boulders in a soft matrix)
    b) The need to clear bogging of the machine should ground failure or groundwater upwellings cause fluidised sediment inflows at the face or behind the machine before machine operational mode can be changed to offset such conditions.
    c) Failure of cross tunnelling operation giving rise to uncontrolled water and sediment inflows into the machine tail areas.

46. Not-with-standing that some unforeseen risks still exist, the writer is confident that these problems can be overcome during the construction phase of tunnelling and that the environmental risks as outlined by modelling in the tunnel documentation for groundwater will be more or less accurate.

47. In respect to groundwater beneficial use degradation risks these are correctly assessed as being minor. To start with the beneficial uses of the natural groundwater are limited by the salinity naturally being in the Category C -D Range (Total Dissolved Solids 3,000 - 14,000mg/L) and by the only significant use being as a support to groundwater dependant ecosystems which are acclimated to these brackish to saline waters.

48. Some occurrence of low salinity groundwaters are recorded beneath public open space where garden watering has probably been practiced but no evidence of any use of groundwater extraction bores exist within or close to the project area albeit that many investigation and contamination monitoring bores may exist, all of which may not be accurately plotted as to location within the various government groundwater data bases.

49. Anthropogenic use of any of the naturally occurring groundwater within the shallower sequences which extend down to the surface of the Maribyrnong River palaeo-valley base are also limited by the threat and reality of extensive groundwater contamination and by the declared Groundwater Quality Restricted Use Zones as are shown on figures 20 and 21 (p66 and 79 of Technical report Volume C).

50. Groundwater has been and may still used by industry and at some public recreation sites from the Werribee Fm. (Tew) . This deep sand aquifer which underlies Tmn and Tov. and is recognised within the Cut Paw Paw Groundwater Management Area as the only aquifer with significant extraction potential as it is largely hydraulically isolated from the shallower more contaminant prone aquifers. It is the aquifer for which an aquifer volumetric limit (a CAP) has been set for extractions. Since no water is expected to be extracted from this aquifer it seems most unlikely that the WTP could be at risk of breaching the extraction CAP unless uncontrolled up flows of groundwater were to be initiated by failures of overlying strata as occurred at the Brooklyn Pump Station to the west of the areas where significant excavations are proposed.

Ground movement

51. Ground movement consequential on major engineering and excavation works such as those associated with the WTP derive simplistically from the stresses created by
    a) surface loadings on pre-existing sediments , including fill - compression
    b) The removal of water from hydrated minerals or from intergranular spaces (porosity) in which location they provided buoyancy or a largely incompressible support for sedimentary structures. - consolidation
    c) Plastic creep of strata horizontally and vertically towards excavated void spaces in the ground , until gravitational and hydrostatic balance is re-established - void closure
    d) Mobilisation of pre-existing failure plains such as faults or planes of instability in steep slopes - slope instability.

52. In each case the impact is mostly settlement of surface levels to greater or lesser extent which is dependent upon proximity to the area of applied geotechnical stress, the geotechnical intensity and area over which the stresses are applied and the geotechnical parameters of the underlying materials and strata. In some cases loadings on weak compressible material can result in perimeter surface uplift due to volume displacement.

53. The WTP is being constructed over a wide variety of geological strata which are well known within the context of civil engineering works around Melbourne (Peck et al 1992,Engineering Geology of Melbourne, Balkema, Rotterdam). In addition, past land uses have created anthropogenic features

such as quarries, pits and embankments which have been variously filled as landfills compacted only to the extent of self weight consolidation or to the engineering standards demanded by proposed future use as industrial land or public open space (Figures 9-11 ,P39-41, Technical Report D-E)

54. The risks involved in the construction and operation of the engineering features of the WTP then relate to the geotechnical properties of the natural formations which will be subjected to stresses relating to road, bridge, tunnel and embankment construction, as well as the degree to which these stresses also translate or directly impact upon anthropogenic structures and buildings (domestic, public and heritage) and infrastructure (drains, sewers, pipelines, power conduits) built on and or within them.

55. All the above aspects are addressed comprehensively in the EES documentation albeit that it does not address every single building within the project precinct. What it does do is to identify the risks and where and how risks can be addressed and mitigated by engineering and management procedures. Also, while the documentation does not present all the data that has been obtained, Table 1 in Appendix B sets out Preliminary engineering parameters (Table 1, Appendix B, Volume D-E) and notably comparing the statistical averages generated with the data value ranges show reasonable consistency (> 1 order of magnitude) in all cases) Thus, it is clear that the very thorough and targeted testing programme undertaken provides confidence to the conclusions drawn in Section 11 (p99-101 0f Technical ReportD-E).

Risk Profiles and Risk Mitigation

56. Risk profiles in the EES documention are presented in relation to three segments of the project namely:
    a) Port, Citylink and City Connections- Section 8
    b) Tunnels - Section 7
    c) Westgate Freeway - Section 6

57. Each of these segments was assessed in relation to the potential for ground movement consequential on the necessary engineering and earth moving requirements of the WTP. The risks were determined rigorously by analyses based upon geotechnical evaluations undertaken on a large number of investigation boreholes, laboratory evaluations and testing of the geological materials found and on the occurrence of existing structures (landfills, filled ground, sewers, pipe and other subsurface infrastructure) beneath or adjacent to the project areas which might give rise subsidence of geotechnical issues in the engineering.

58. Table 10 (p35, Technical Report D-E) presents summaries of the major geological units identified by the investigations and includes qualitative descriptions of their geotechnical character and these descriptions alone suggest that there are only a few areas where there is potential for ground movement likely to give rise to significant damage or degradation of buildings or infrastructure. Further, where potential for ground movement exists which might impact structures mitigation measures are set out as means of meeting the environmental performance requirements set out in each of the above project segments (port,Citylink and city connections - Table 14, Tunnels - p 95; West Gate Freeway - Table 13, p85 and Table 11,p45) These will be used by Project co to direct the use of mitigation measures such as those set out in Table 3 - Summary of ground movement engineering control measures with the design (p15)

59. Specific area models have been developed using the geotechnical parameters determined by the testing programs to conservatively evaluate the extent and magnitude of vertical displacement movements along the tunnel alignment. These evaluations take into account the variation in strata thicknesses and void loss ratios of 0.5 and 1% to determine initial indications of cumulative ground movement This work then extended to evaluate whether the movements represented the development of slopes or elastic strain sufficient to cause structural damage to overlying buildings or rigid pipelines (Appendix B of Technical Report D including sub Appendixes C-F).

PORT, CITYLINK AND CITY CONNECTION

60. This segment of the WTP extends from the Northern Portal area across the Maribyrnong River and across the Yarra delta area to the south west edge of Melbourne City. It is underlain by alluvial and estuarine sediments such as the compressible Coode Island Silt (Qhi) and the area has been subject to significant filling with a variety of materials including construction and industrial waste as well as dredge spoils. Water tables are mostly very shallow.

61. The weak and compressible materials are subject to ground movement under further loading and hence nearly all of the structures in this areas will be supported by bored piles sunk to depth. It is possible that some embankments will be required in places and here ground strengthening in advance or the use of light weight materials to lessen the applied loads may be applied at specific sites in accordance with the environmental performance requirements and the CEMP when finalised.

62. It is anticipated that further specific site evaluations may be undertaken in this area to define the optimum final design for the various structures across this segment and especially for the Maribyrnong River bridge and the ramps which will service McKenzie road and the port access and in relation to the new bridge proposed to cross Moonee Ponds Creek and the ramps associated with that structure.

63. The writer is conscious of the fact that extensive experience now exists in the construction of infrastructure across the Yarra delta area and that the issues have been addressed sufficiently to give confidence that with additional investigations specific to the critical above ground structures that the conclusions drawn in the EES documentation are supported.

64. The most sensitive area of construction will be around the North Portal where the construction of this facility plus the excavation works associated with the NYMS realignment, the initiation of tunneling and loadings which may arise through the logistics of waste rock and tunnel spoil and waste water management may create local loadings may interact. The latter does not seem to have been evaluated fully.

65. Most significantly, the complex interactions of the various engineering elements is recognised and it should be expected that as final designs are completed to meet the environmental performance criteria that using the variety of mitigation measures associated with ground stabilization and ground water inflow management the results will not create unacceptable impairment of structures and infrastructure within the project boundary.

TUNNELS AND PORTALS

66. The tunnels and the North Portal and South Portal areas have already benefitted from the data gathering and modelling pursued. The magnitude of the ground movements that eventuate will be an outcome of the extent to which the mitigation technologies outlined in the EES documentation are effectively and expeditiously deployed and the degree to which the use of the use of the EPB TBM is effective in minimising groundwater inflow and over excavation.

67. The writer has concerns about the possibility of delays due to issues of effective grouting at locations where the necessary applied pressures may be limited by tunnel head cover. The documentation does not give guidance as to the nature of the grouts which may be used or indeed of the constituents of the paste which may be used in closed or semi closed face operations of the TBM. Nor indeed does the documentation address the issue of issues which may give rise to delays entailing adverse inflow or other consequences. Rather, the documentation and the evidence of the various experts commenting upon the environmental issues associated with the tunnel construction and operations seem to presume that the operation of the TBM will minimise almost all of the issues which can afflict more conventional tunnelling approaches.

68. Given the extremely varied characteristics of the materials to be penetrated by the TBM face at times (mixed formations, boulders material, etc), not to mention the issues associated with achieving effective annular grouting and grouting of cross drives between the tunnels, plus issues associated with drill and blast driving of some cross cuts, it is likely that some delays at least will be incurred in tunnelling progress due to the need to rectify inadequacies in grouting or cross cut water inflows at least, if not in pressure blowouts where the tunnel obvert has limited cover such as in the approach sections towards the southern east bound portal where the tunnel passes below the Stony Creek valley (figure E4, Appendix E of Appendix A - Technical Report D)

69. In respect to the two southern portals, the issue of ground movements seem to be more serious in respect to impacts on the linear infrastructure of the West Gate Freeway fill, the fuel pipelines, HV Power lines and any impacts upon Williamstown Road and its associated drainage infrastructure and on the Freight Rail line than on any adjacent properties. This statement is in the writer's opinion quite reasonable as it is inherent in preliminary modelling that a conservative approach is taken and this appears to be the case with the model parameters applied.

70. It is noted that all the Portals are large structures and that they will be open to potential inflows of groundwater for up to a year before being entirely sealed. Mitigation measures such as grouting should minimise the inflow but at the southern eastbound Portal it is possible that even small groundwater inflow from sand bands in the Coode Island Silts (Qhp) could give rise to wider are consolidation of the formation due to pressure declines which could destabilise and contribute to the fill base of the Westgate Freeway which is immediately adjacent to the site . This is an aspect which does not seem to have been considered in modelling or planning albeit it was recognised as a potential issue in the documentation. The writer believes such an issue, should it become apparent in the site monitoring, could be easily off set by locally recharging the sand beds to offset ant drainage depressurization.

71. The writer is of the opinion that all of these above have been prudently addressed and will be subject to close monitoring and to updated and verified model predictions as the excavations proceed and incorporate such mitigation measures (Bracing struts, grouted ground anchors, rock bolting, Gunnite cement coatings , etc) as may be necessary to offset any unacceptable ground movement potential.

72. The writer is satisfied that the approach outlined in the EES documents and in the evidence is sound at this location and also notes that the evidence presented by the Golder expert notes in response to Submission 255 and referring to the Newer Volcanics upper sequence (Tvn1) that " the rock mass is likely to be stiffer than the model assumes"

WESTGATE FREEWAY

73. There are few issues associated with the Westgate Freeway, as most of the length to approximately Chainage 52000 (Figure B1 in Appendix A of Appendix A -Technical Report D) is underlain by the Newer Volcanics upper sequence(Tvn1) which is a strong formation or by fill compacted to engineering standards. Beyond 52000m, the western freeway is bordered initially on both sides by alluvium which is a lateral equivalent of the Coode Island Silt (Qhp) or by the the Coode Island Silt to the north and east along the north side of the Freeway through the Donald McLean Reserve on the southside and the Spotswood Golf Course and the Hyde Street Reserve on the northside.

74. This area is where the Hyde Street off and on ramps will be constructed parallel to the Freeway. The final design of these ramps is yet to be determined but it seems likely that they will involve some above ground embankment development and a considerable amount of piled foundations.

75. The presence of reactive soils subject to severe expansion and contraction consequent upon wet and dry periods will however remain an issue in the public mind. Some of the submissions received already reflect concerns that the WTP elements will impact upon water table levels and this in turn upon soil moisture variations and or changes in soil water demand by deeper rooted vegetation. These will be real concerns in some locations, dependant upon the depths to water table and the nature of local vegetation in residential areas and adjacent public open spaces.

76. It would seem advisable that, not only should dilapidation surveys be conducted on properties close to the project boundaries, but also in areas further removed where the above interaction of could give rise to losses in soil moisture and soil cracking accompanied by property damage as a consequence of the WTP. In addition, soil moisture monitoring in these perimeter areas once defined could be a prudent exercise in data gathering both a basis for initiating mitigating actions and as a defence against claims both during construction and in the future.

77. Neither of these constructions is likely to be a source of ground movement as it is expected that the designs will reflect the high standard of construction integrity as is assured by adherence to the environmental performance requirements and the close oversight of the construction environmental management plan by the regulatory authorities and by the Independant Review and Environmental Auditor.

Residual Risks

78. The only risks which do not appear to have been adequately considered in relation to ground movement issues are as follow:
    a) Any inadequacy of the EPB TBM not to perform in preventing groundwater inflows and over excavation.
    b) Any issues related to ground movement which may arise due to the progress of tunnelling and tunnel sealing being delayed or impeded.
    c) Issues relating to the effectiveness of grouting where the applicable grout pressure regime is constrained by surrounding formation weakness and the possibility of pressure or grout break out or excursions at the surface.
    d) Issues relating to depletion of soil moisture content as a consequence of water table declining below the short turn reach of deep rooted vegetation.
    e) Depressurization issue in sands within the Coode Island Silt impacting upon the Westgate Free way sub grade fill

79. If any of the above issues arise during construction then the writer has no doubt that they can be resolved by the implementation of mitigating engineering solutions retroactively. However, such approaches are frequently time consuming, expensive and less effective than avoiding the issues or being prepared in advance so as to ensure that, if they do occur, their impact is minimal and able to be expeditiously addressed.

80. The above issues should all be further considered as the CEMP and as final designs and work plans are developed and submitted for approval within the project management framework.

Waste and Spoil Management

81. Protection of the environment in relation to waste and spoil management subdivide into several issues which are inter-related. These are:
    a) Solid wastes
    b) Liquid wastes and for each of these
    c) Logistics and
    d) Management options

82. Solid wastes include all those material excavated from the four dive and portal constructions; from the drilling of piled foundations; and generated by the TBM as it progressively creates the two major tunnels. In total the solid waste is stated to be about 2.11Mcum in situ. Included in this volume is 85Kcum of possibly acid sulphate soils (PASS), 3Kcum of Class A Prescribed Industrial waste

(PIW), 14Kcum Class B PIW and 156Kcum Class C PIW (Table 4, Sect. 6.0 of Appendix D in Technical Report B Part 2)

83. Liquid waste includes all the water drained from those excavations extending below water table and or draining from the solid industrial waste, some of which will be variously brackish groundwaters or groundwaters that are contaminated from industrial activities within the area or by contact with contaminated materials. In addition there will be some water which enters the waste accumulation areas from local runoff or incident rainfall which may become contaminated by contact with the solid waste.

84. The logistics involved in handling all the waste will be complex but is common to both solid and liquid wastes. There is the need to provide adequate accumulation areas for the the various solid waste types with drainage and drainage storage facilities provided to prevent off site excursions. The accumulation facilities also need to be large enough to provide for waste holding until such time as the wastes can be classified as to their necessary handling which, in some cases (Category A Industrial Waste and Actual Acid Sulphate Soils) may include treatment before being removed for disposal or reuse as may be determined.

85. The logistics of waste handling will arise at the northern portal area as this is where all the tunnelling spoil will report and also where major excavations will take place associated initially with the realignment of the NYMS and subsequently the construction of the Dive and Portal elements of the two road tunnels.

86. Similar logistical requirements will arise at the southern portal sites and at the various works management areas associated with the widening of the Westgate Freeway from the souther portal sites out to the M80 interchange and on to Kororoit Creek Road; in the areas where the Hyde Street ramps are to be constructed and between the northern portals, the port, City Link and the city connections. These will however be much less complex logistics than those adjacent to the Northern Portal area because the volumes of solid waste reporting to these areas are so much less as is set out below:
    a) Westgate Freeway - 469 Kcum
    b) Tunnels and Portals - 1,504 Kcum
    c) Port, Citylink and City Connections. - 137 Kcum

87. The above volumes are all described as “bank” volumes which means they are volumes in place , not volumes when disaggregated by excavation. A “swell” factor of at least 30% needs to be added to evaluate trucking logistics. An average density for weight evaluations in truck loads would then be about 1.7 t/cum loose.

88. Apart from the volumetric logistics, a number of other issues arise at the accumulation areas. These relate to characterising the wastes for disposal and reuse purposes. These will need to be defined within the Construction Environmental Management Plan and into the final designs as they are prepared. They will also need to meet the requirements of EPA and of the Independent Reviewer and Environmental Auditor as well as fit within the Environmental Management Framework and the Environmental Performance Requirements. Some reuse options may also require specific Works Approval and EPA licensing.

89. Within the EES documentation it is clear that a considerable amount of investigation and contamination evaluation work has been done to identify the areas and types of issues likely to be involved in characterising the waste and spoil. This work all goes towards determining the risks present both from contamination and aesthetic impacts in respect to any health risks they represent to the construction workers, the community, the natural ecosystems and to the project materials themselves in so far as reuse or disposal options are concerned.

Contamination Evaluations - Soil and Spoil

90. Evaluations of the presence and types of soil and spoil contamination that the WTP would confront in construction and in which environment it would have to operate has been intensively evaluated by a rigorous investigation program involving the following elements :
    a) Establishing existing conditions deriving from the past known and suspected uses of the land within the project boundary and proximal to it from existing public records.
    b) Evaluating the stratigraphic units subject to disturbance or excavation for their geochemical characteristics and or potential to give rise to contamination or corrosive attack on the materials that might be used in construction .
    c) Sampling the materials present in the project area for the presence, forms and concentrations of contaminants or contaminant generation potential.
    d) Focussing sampling and contamination on areas of known or likely contamination deriving from past land uses both within the project boundaries and proximal to it especially in areas where significant sensitivity exists for the project as a consequence of the magnitude of the in - ground engineering works to be developed (eg Portal and tunnel areas).
    e) Relating the contamination characteristics where possible to those stratigraphic units subject to disturbance.
    f) Defining the presence or otherwise of contamination into those categories whereby the options for disposal in environmentally acceptable ways can be determined in accordance with applicable regulation and policies.
    g) Estimating conservatively the volumes of all categories of waste that will need to be managed as the WTP progresses

91. All of the above is presented in Appendixes B-E within the Technical Report B Part 2 . It is seen as a very comprehensive evaluation. This work should be a guide for further evaluations to be undertaken within the CEMP to more specifically pre-plan in so far as is practicable the arrival of contaminated soil and spoil at the accumulation areas and the necessary management of those materials.

Contaminated Soil and Spoil Management Options

92. It is notable that the only waste and disposal concept presented for the solid waste and spoil is to landfill be it for wastes classified directly or after treatment as Fill, Category B or C Industrial Wastes or as Potential or Actual Acid Sulphate soils. Further, whilst the need to be compliant with the EPA waste hierarchy (Section 5.10 P 5-46 , Main Report Volume 1) is recognised, this is only interpreted as being met because landfills have a need for clean fill and that this is the highest and best use envisaged. Finally, no landfill is specifically identified as the location for disposal (except in so far as Category B Industrial waste is concerned, where only one landfill (Lyndhurst) is licensed to accept this waste. This largely precludes consideration of any routes by which waste and spoil would be transported from the sites of initial accumulation.

93. It would seem to the writer that there are significant opportunities for reuse of at least some of the spoils by the project itself. These could include :
    a) as fill for the road sub grade where the Westgate Freeway is subject to widening and in the embankments associated with the Hyde Street ramps and/ or where levees are required to provide flood protection around the North and the east bound Southern portal.
    b) within cement in piles and in the beam structures and platforms required for the various bridges across the Maribyrnong River, Moonee Ponds and Kororoit Creeks and in the overhead structures associated with the project.
    c) perhaps also in some of the grout mixtures such as those involved in the annular grouting around the tunnel linings.
    d) Notably some contaminated soils (Category A wastes and some Potential Acid Sulphate Soils) will need to be treated on site before disposal and could be better beneficially treated and immobilised by use in cement and grout mixes provided EPA Works Approval and license conditions can be rationally agreed.

94. It is recognised that such uses will be dependent upon the engineering characteristics of the waste rock and other spoil materials and perhaps also on their contamination status, but uses of spoil within the project could contribute significantly to reducing the traffic issues arising from offsite transportation.

95. Further, since it is recognised in the EES documentation that the Metro Rail project will be proceeding in parallel with the WTP (Section 5,10.2 p 5-48 , Main Report Volume1 and Section 9.0,p109, Technical Report B)and it too has a waste and spoil disposal issue to resolve, that the demand by landfills for suitable cover material will not be great if indeed any shortage exists now. Certainly the EES documentation does not seem to have presented any evaluation of the magnitude of need for landfill cover demand being a driving reuse justification.

96. These options need more consideration as they impact on the logistical practicalities involved in waste and spoil management

Waste Management Accumulation and Disposal Logistics

97. The presence of contaminated fill and natural strata within and adjacent to the project area makes it essential that all waste soils and spoil reporting to the accumulation area will need to be at least classified as to its category before it can be removed from the site. Specifically the categorisation will involve at least evaluations of the following:
    a) Acid Sulphate Soil status - this may be avoided for some tunnel spoil where the material comes from a strata and / or depth which have been agreed in advance to not have potential for acid generation potential (eg Tvn 1 and 2, Tovi and 2; Tpb,)
    b) Industrial Waste Classification or Fill designation - will need to be tested except where the spoil derives from a depth well below and away from any sources of industrial contamination or former landfill

98. These classifications will need to involve a rigorous sampling regime to be implemented along with a rapid turn around analytical service. It should be possible in the CEMP development to agree a minimum lot size for bulk sampling and a statistical protocol to fairly represent the material as waste for disposal.

99. The definition of any bulk sample size must however take into account the need to ensure that spoil drainage and drying do not create contamination issues in their own right such as oxidation of Potential Acid Sulphate Soils as well as the potential for dust and odour generation at the sites of initial accumulation.

100. Further, if on site reuse of certain categories of spoil or contaminated soil is to be an option, then it will be necessary to check the engineering application suitability characteristics at the sites of accumulation. Environmentally stable stock piles for reusable materials, complete with appropriate drainage and provisions to minimise any degradation, will be necessary and for some materials a time schedule for reuse or off-site disposal determined in advance.

101. None of these aspect are evaluated in the present EES documentation and yet they have the capacity to mitigate some of the off-site traffic issues as well as better engage with the EPA Waste Hierarchy at the same time as better using and minimising the magnitude of the waste volumes which are inherent in the development and operation of the WTP.

Contaminated Water Disposal

102. It is notable in the Contaminated Soil and Spoil Volume B Part 1 and 23 that no mention is raised of the issue of contaminated water management or of the potential of contaminated water entry into excavations to render the spoil contaminated.

103. The documentation recognises that contaminated waters do exist within the project area boundaries (Section 6.2, p41 and 7.2.6, p65 - 74 , Technical Report C) and that groundwater will flow into the excavations (Section 7.1, p49 , Technical Report C) to the extent that engineering of the site or the

balance pressures exerted by the TBM cannot preclude such inflows. There is certainly potential for this water to contaminate otherwise uncontaminated spoil if the contamination concentrations are sufficient and if the inflows are significant or prolonged. Under any circumstances, the contaminated water will report at the Spoil and soil accumulation areas where it will become part of the over all water drainage requiring disposal.

104. Section 2.5 of Technical Report C - Groundwater at page 19 notes that disposal and beneficial use options need to be detailed within the Groundwater Management Plan with the options being determined by discussions with the EPA and Melbourne Water. Disposal options are further considered at Section 6.4.3, p 44 and at Section 7.6.5 at p119 and 120 but no firm suggestions are made as to how disposal will be achieved other than it is to be decided based on water quality monitoring and should be addressed in the CEMP and in the Operational Environmental Management Plan (OEMP).

105. This is not an adequate response in an EES especially where reference is made to significant groundwater contamination. It would seem that some attention needs to be addressed and commitments given that the excess water reporting to the waste accumulation areas can be either reused in injection , treated or discharged to sewer. At present, the only comments are in relation to sewer disposal that the estimated salinity load based on the estimated inflows to the tunnels after their being sealed would be acceptable on a daily basis. Other options are speculated upon but are seen to be severely limited. No estimates are presented of the water volumes which could be used in formulating cement or grout mixes, nor is there any consideration of the extent to which contamination may represent a constraint in such uses.

106. These issues need to be addressed in the CEMP and OEMP and options and triggers for those options defined and included into the logistical management requirements which apply at the sites at which wastes from construction and from the project long term accumulate.

Vibrational Consolidation Issues

107. In Technical report I which addresses Vibration and Regenerated Noise (Tunnel) in Section 3.4 Impact assessment at subsection 3.4.2.3 (p25 of 260) it is stated that"*an understanding of the local geology is required to assess* local *impacts. Seismic conditions of the existing rock mass and soil profile together with type of construction equipment will define the level of vibration and regenerated noise."*

108. In section 3.4.2.5 - Summary of vibration (p 26 of 260) comment that the "*cutting performance of the TBM determines the level of induced ground vibration. Machine variables which affect this include torque, speed and thrust as well as physical characteristics of the machine including type and number of cutters*" The vibration intensities are then shown for a number of projects on Figure 7 (p 26 of 260) from which it is clear that significant vibration intensities can arise within at least 25m distance from the operational cutters.

109. It may follow from the above that, when the EPB TBM tunnelling is progressing through the relatively hard Newer Volcanics (Tvo1) below water table, significant vibration will be transmitted into the surrounding material. This rock, where it is relatively fresh will require substantial applied energy for penetration and if the TBM is operating in open mode it seems likely that considerable levels of low frequency vibrations will be generated. To the degree that these vibrations transmit in a vertical plane they could impact upon compressible sediments especially where they are saturated.

110. The Stony Creek valley is likely to include compressible Coode Island Silt (Qhi) deposits which could suffer exacerbated consolidation should ground vibrations deriving from the TBM transmit into these or similar materials .

111. This is not an area of expertise of the writer, but experience of the transmission characteristics of seismic wave vibrations during seismic surveys suggest that sedimentary consolidation due to TBM generated applied energy should be considered as a concern to be addressed especially as the most sensitive area involves potentially compressible sediment near to and beneath the fill underlying the Westgate freeway embankments.

112. It is noted that in the evidence submitted by the Noise and Vibration expert at p 8 of 14 he states " *It is known that vibrations can affect soils, although densification depends on the soil type and the level of the vibration. Only certain ground conditions are however susceptible to vibratory densification and the vibrations have to be high. The British Standard 7385-2 reports on laboratory tests that identified soils that would be far more susceptible to impact from vibration than those of the West Gate Tunnel Project……the EPRs for the West Gate Tunnel Project restrict continuous vibration levels to less than 20% of the BS 7385 reported minimum vibration level*s"

113. The writer has seen no testing results of soils that relates to this issue . Advice is required from vibration experts and from experts in TBM tunnelling as to what further testing should be included to guide the CEMP so as to ensure that transmission of vibrations to vulnerable sediments and infrastructure is mitigated to acceptable levels.