Memorandum

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From	s 9(2)(a) [redacted]
Office	Wellington
Date	22 May 2024
File/Ref	5-C4800.00 SH1 Wellington Upgrades
Subject	Long Tunnel - Preliminary Design Outputs V2

The purpose of this memo is to provide a work in progress summary of the design for cost estimating and specialist review. The material provided is still under development and requires review and verification. This interim deliverable is being developed in response to the agile project approach. A more developed design report will be available later in the process.

Attached are the following:

- Section 1. Scheme Overview. A high-level summary of the scheme.
- Section 2. Design Description and Construction Approach (incomplete). Further details on construction for the tunnel.
- Section 3. Limitations/Disclaimer
- Work in progress model outputs of the proposed alignment and interchange form, as well as additional supporting documentation.
    - Appendix A – Northern Approach (Terrace Tunnel)
    - Appendix B – Terrace Tunnel Duplication
    - Appendix C – Long Tunnel, Northern Connection (Terrace)
    - Appendix D – Long Tunnel Alignment and Long Section
    - Appendix E – Adelaide Road Ramp
    - Appendix F – Long Tunnel, Southern Connection (Kilbirnie)
    - Appendix G – Tunnel Design Memo
    - Appendix H – Structures, Staging Figures and Risks/Opportunities
    - Appendix I – Treatment Summary

Regards

Gareth

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1 SCHEME OVERVIEW

1.1 INTRODUCTION

The purpose of this document is to summarise investigations into the Long Tunnel solution. The Long Tunnel is broadly described as a grade separated connection between the Terrace Tunnel and Kilbirnie. A range of options to achieve this transport outcome and the scope has been defined as described in Section 1.2.

This approach has been undertaken over a period of six weeks and has been based on existing information and has been required to make assumptions to progress in the timeframes required.

Assumptions are recorded within this document. The timeframe has not permitted a complete review of alternatives or any optimisation of the design.

1.2 OPTION SCOPE

The feasibility assessment has been based on a previously developed option as shown in Figure 1.1, each of the components shown has been considered in more detail and are described in the following pages.

Figure 1.1. Option Scope and components

1.3 NORTHERN APPROACH (TERRACE TUNNEL)

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1.4 TERRACE TUNNEL DUPLICATION

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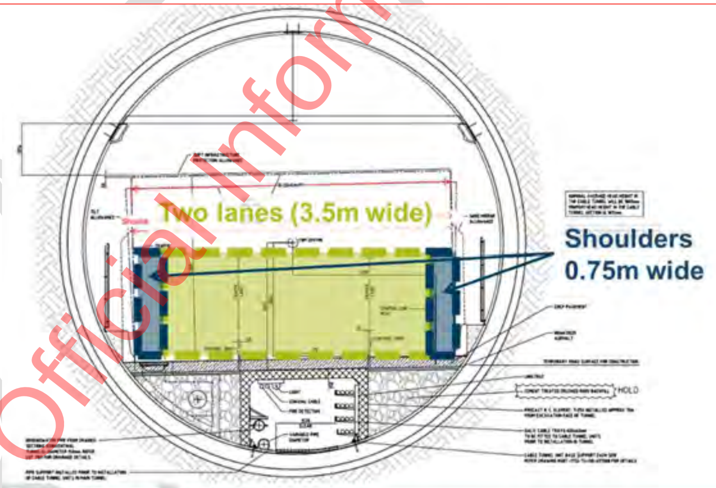
1.6 LONG TUNNEL

The Long Tunnel will provide two two-lane tunnels running from Willis Street to Wellington Road in Kilbirnie. Table 1.2 describes the features of the Long Tunnel.

Table 1.2 Features of the Long Tunnel

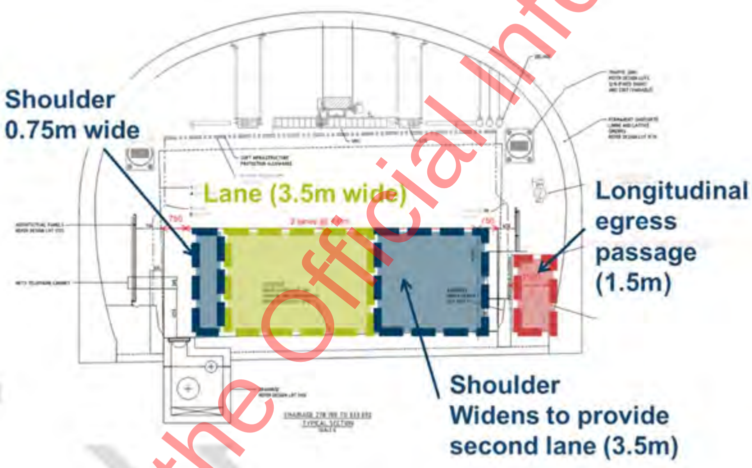
FEATURES	LONG TUNNEL
Length	~ 2870m
Gradient	max 5%, crossfall min 2%
Cross-section	TBM section, 12.5m OD (outer diameter)
No. of lanes	2 lanes unidirectional (3.5m wide, 0.75m shoulders) *Cross section source: North-South Bypass Tunnel (Brisbane)* 
Speed limit	Design speed 70km/hr Posted speed 60 km/hr
Ventilation	Ventilation buildings (exhaust stations) at each end with an exhaust stack for vehicle emissions with an allowance to emit air from vehicle emissions at the exit portal of each tunnel. A smoke duct has been allowed for in the cross section but there is opportunity to remove this requirement and manage the FLS risk via traffic control. This will be investigated in the next phase of design.
Fire and Life Safety Solution	Hazardous goods vehicles will be prohibited in the road tunnels. Cross passages approximately every 150m to provide egress to the non-event tunnel. Fixed fire-fighting systems in each tunnel.

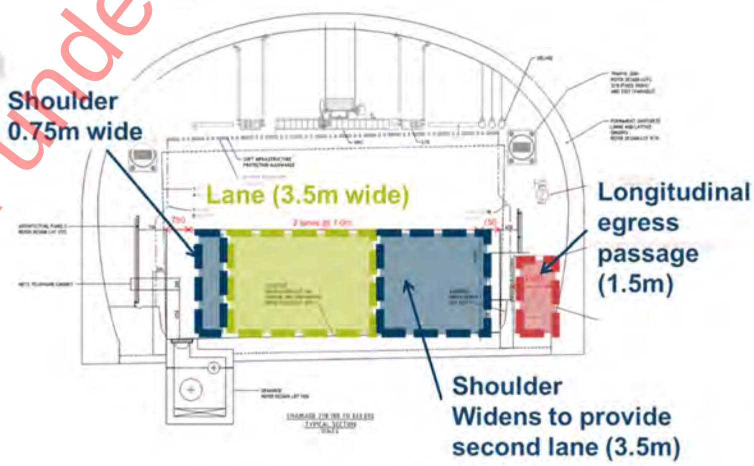
1.7 ADELAIDE ROAD RAMP

The inclusion of a ramp to Adelaide Road (southbound off-ramp) is still to be confirmed. Table 1.3 describes the features of the Adelaide Road Ramp.

Table 1.3 Features of the Adelaide Road Ramp

<table>
<tr><th>FEATURES</th><th>Adelaide Road</th></tr>
<tr><td>Length</td><td>~260m (tbc)</td></tr>
<tr><td>Gradient</td><td>max 6%, crossfall min 2%</td></tr>
<tr><td>Cross-section</td><td>Horse-shoe</td></tr>
<tr><td>No. of lanes</td><td>One lane (3.5m wide) initially. Transitions to 2 lanes (3.5m wide)
750mm minimum shoulder.



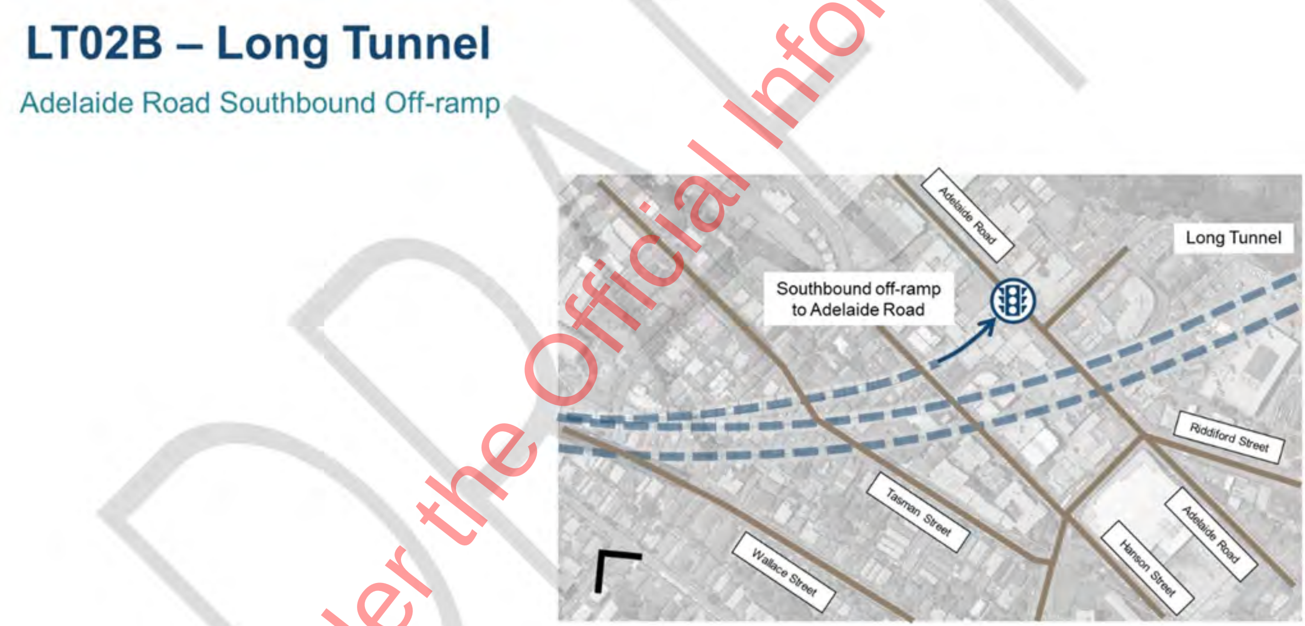


Cross section source: North-South Bypass Tunnel (Brisbane)</td></tr>
</table>

Speed limit	Design speed 70km/hr, Posted speed 60 km/hr
Ventilation	Assumption that a portal exhaust system is not required given the offramps size and distance from the portals. Design basis of portal emissions being acceptable or control portal emissions can be controlled by using jet fans in the ramp to push air against traffic back into the mainline tunnel.
Fire and Life Safety Solution	Longitudinal egress passage to be provided.

The Adelaide Road Ramp will have a portal on the east side of Hanson Street and come out to an intersection with Adelaide Road as shown in Figure 1.4.

Figure 1.4. Overview of Adelaide Road Ramp



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1.10 LONG TUNNEL ASSOCIATED TREATMENTS

There are several design treatment assumptions associated with the current design understanding. These are summarised for cost estimating purposes in Appendix I.

2 DESIGN DESCRIPTION AND CONSTRUCTION APPROACH

2.1 OUTLINE APPROACH

The overarching approach to the identification of the structures/walls requirements has been based on geometric alignments that meet the project objectives. No optimisation has been undertaken. Given the time available for the sprint, geotechnical interpretation for calculations is not available, but high level

A key risk to be considered in future stages is whether the new draft TS-1170.5 (which outlines potential increases in seismicity for Wellington) will be used. No projects have yet been delivered of this scale in Wellington but an increase of 25-50% depending on structural period is anticipated. Therefore, use of previous projects as examples could result in under-pricing of the solution.

The key approach has been to find a way to logically move live traffic around to move between current operations and future. More detailed work will be required at each transition point to the current network, alongside a more accurate survey and other design input information (e.g. comprehensive utilities searches, geotechnical information).

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2.3 TERRACE TUNNEL DUPLICATION

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2.5 LONG TUNNEL

The long tunnel construction will utilise a Tunnel Boring Machine (TBM). The current assumption is to use two TBMs with associated programme and cost implications.

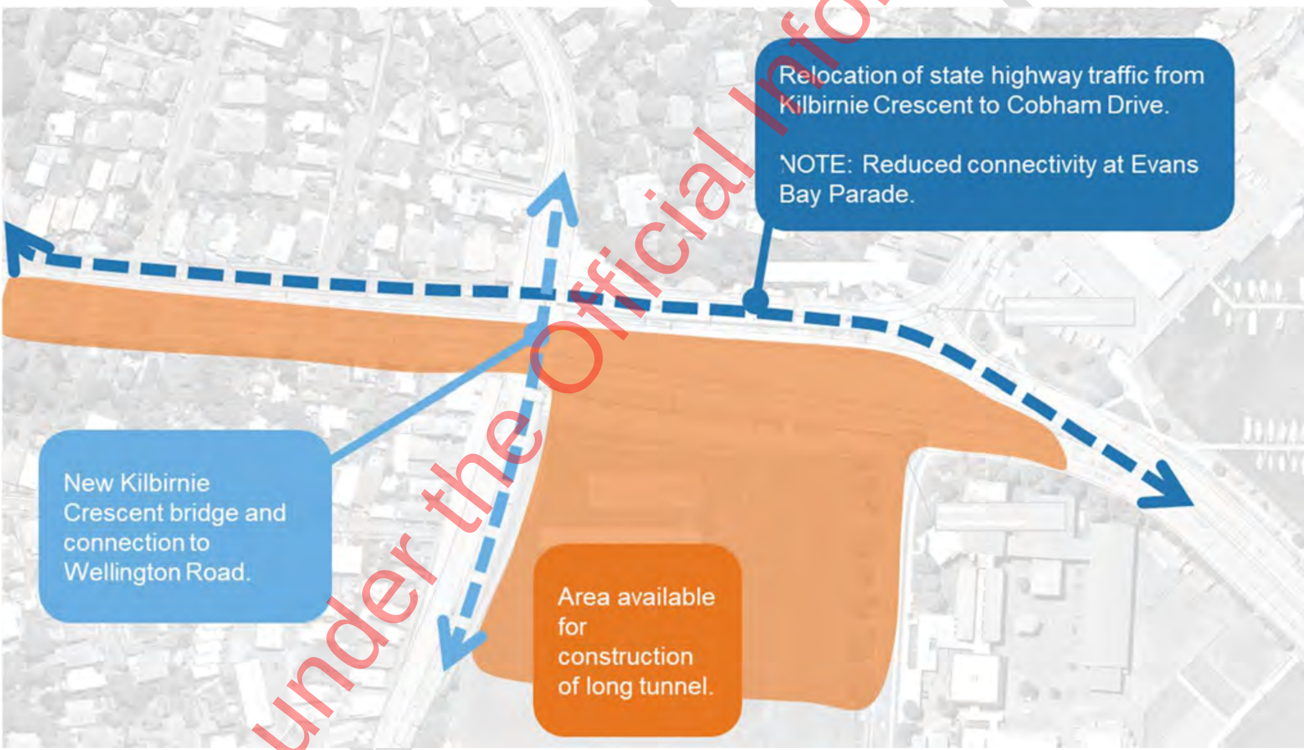
There will be two mined sections where a TBM will not be used as follows:

- Adelaide Road ramp –including widened (merge) section of southbound tunnel. See Section 2.5.
- Aotea Fault – Section of mined tunnel to assist in resilience.

An indicative TBM support site and launch and operations area has been identified in Kilbirnie and is shown in Figure 2.5.

Precast segments for tunnel construction will be transported from this site. Excavated spoil will be conveyed through the tunnel to this construction area in Kilbirnie prior to disposal.

Figure 2.5. Long Tunnel Primary Construction Area



2.5.1 AOTEA FAULT

In the vicinity of Adelaide Road, the long tunnel is expected to encounter the Aotea Fault. Very limited information exists on this fault and further investigations are required. In the absence of more information it is assumed that some localised work will be undertaken to improve the resilience of the tunnel at this location. At this time it is proposed that a specific design solution will be employed similar to that used for the Los Angeles Pink Line that crosses the Hollywood Fault. This includes excavating an oversized cavern across the fault. This would help the tunnel accommodate potential movement and also improve the ability to repair the tunnel after an event.

This will require construction of a temporary shaft over the tunnel alignment and mining of this area prior to receiving the TBM at this location.

2.5.2 OPERATIONS STRUCTURES

At each portal for the long tunnel it will be necessary to provide a portal exhaust system (elevated outlet approximately 20m in height) and a control building (approximately 80m x 30m footprint). Examples of these structures from other projects are shown in Figure 2.6.

Figure 2.6. Examples of tunnel operations structures from other projects.

Portal Exhaust Structure, Waterview Auckland

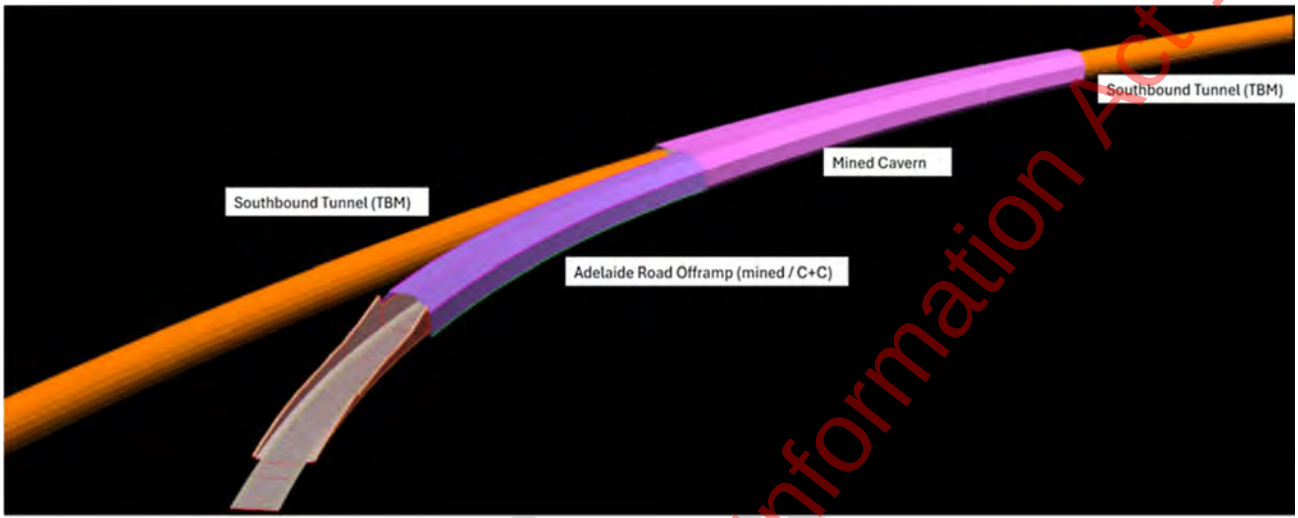
Southern Tunnel Portal and Control Building with portal exhaust structure, Waterview Auckland

These structures will not be required for the Adelaide Road Ramp. The pollution generated in this short length of single lane off ramp will be low and external air quality requirements are likely to be met when emitting the vitiated tunnel air from the portal. If external air quality criteria is not met, then the ventilation system can be used to push air in from the portal and down the off ramp into the mainline tunnel.

2.6 ADELAIDE ROAD RAMP

The Adelaide Road Ramp will include an offramp and mined cavern as shown in Figure 2.7.

Figure 2.7. Adelaide Road Ramp mined sections (in purple and pink)



The mined cavern is expected to be around 20 m wide at the widest section and can be constructed using sequential excavation method. It would be mined with a combination road-headers and excavators as required based on the materials encountered. The excavation will be temporarily supported by shotcrete lining and a range of support types including canopy tubes, spiles, and rock bolts. Permanent lining will be constructed upon completion of excavation and waterproofing.

This mined section will need to be completed before the TBM reaches this location.

A construction area will be required at Adelaide Road and is currently estimated to cover the extents shown in Figure 2.8.

Figure 2.8 Adelaide Road Ramp Construction Area

Further details on this design approach are included in Appendix G.

2.7 LONG TUNNEL SOUTHERN CONNECTION (KILBIRNIE)

The Southern Connection design is illustrated in Figure 2.9, a description of new retaining and civil structures is shown in Table 2.5..

Figure 2.9. Southern Connection - Structures

The structures shown have a non-sequential numbering as some have been removed due to optimisation in alignment.

Table 2.5 Southern Connection – Retaining and Civil Structures

ID	BRIEF DESCRIPTION	FORM	NOTES
SI-RW-01	South Portal Wall	3100 Soil nail/rock anchor wall west from this point 23m deep 1:2 slope	Given Mount Victoria slope to west - is there an opportunity to reduce overburden and thus height of walls at portal i.e. move portal east
SI-RW-02	Northbound Wall 1	3200-3300 Soil nailed wall assume 1:2 for spaceproofing (and allows temporary slope for TBM).	Opportunity to optimise western end to soil nails partial with a propped secant wall below 13m temporary height vs. 8.5m at west end (note)
SI-RW-03	Northbound Wall 2	3320-3340 MSE - build from bottom up	Not built till after TBM complete

ID	BRIEF DESCRIPTION	FORM	NOTES
SI-RW-05	Kilbirnie Wall 1	South of Bridge, approx 120m long. MSE Wall	Potentially temporary – needs to be built without permanent ramps to enable construction access
SI-RW-06	Kilbirnie Wall 2	Permanent MSE wall required east to the park	
SI-RW-07	Kilbirnie Cres Offramp Wall 1	3370-3480 MSE wall	Not built till after TBM complete
SI-RW-08	Kilbirnie Cres Offramp Wall 2	3370-3460 MSE wall	Not built till after TBM complete Potential to tie to RW-07 for efficiency
SI-RW-09	Southbound Wall 1	3370-3520 MSE wall	Only built to approx 3460 for temporary phase during TBM construction.
SI-RW-12	Hamilton Wall 1	40m cut wall adjacent to 115 Hamilton Road. Rock bolt/trimming to existing	Existing rock cut in this location. Assume that driveway can be retained and additional rock bolting /trimming required
SI-RW-13	Hamilton Wall 2	(by northwestern corner of Hamilton-Wellington road intersection) Currently a slope	May require MSE and to push slightly west to minimise work to slope/wall RW-12
SI-RW-14	Southbound Wall 2	3200-3370 MSE to support bridge abutment, built during phase 1	MSE should fit based on staging. Allow risk more expensive wall is required
SI-ST-01	Mainline Propped Trench	3100-3200 Secant piled walls outside and down the median with props above TBM level for temporary (approx 10.5m). May need additional bracing and or anchors in the temporary case at the western end. Approx 21-22m temp depth west, to 16m permanent. Approx 14-15m temporary depth, 10m permanent at east.	To confirm numbers for whether second stage of props required for the permanent solution South Wall needs to be extended in height to provide a prop at this point Baseslab installed after – assume ground water control required
SI-ST-02	Kilbirnie Cres Bridge	3350-3370 Two span –900 hollowcore + surfacing, 1000 total. Approx length 35-40m Abutment MSE	Temporary case requires overdig to enable TBM equipment to pass underneath Also appropriate to allow potential for longer span to fit TBM trains through MSE at south can be built fully from ground up

3 LIMITATIONS

This report ('Report') has been prepared by WSP New Zealand Limited ('WSP') exclusively for NZTA ('Client') in accordance with the Short Form Agreement 10331 SH1 Wellington Corridor Upgrades – Traffic Engineering, Design, Geotechnical and tunnel Services ('Agreement').

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APPENDIX A

NORTH APPROACH (TERRACE TUNNEL) WORKING DRAWINGS

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APPENDIX B

TERRACE TUNNEL DUPLICATION WORKING DRAWINGS

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APPENDIX C

LONG TUNNEL, NORTHERN CONNECTION (TERRACE) WORKING DRAWINGS

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APPENDIX D

LONG TUNNEL WORKING DRAWINGS

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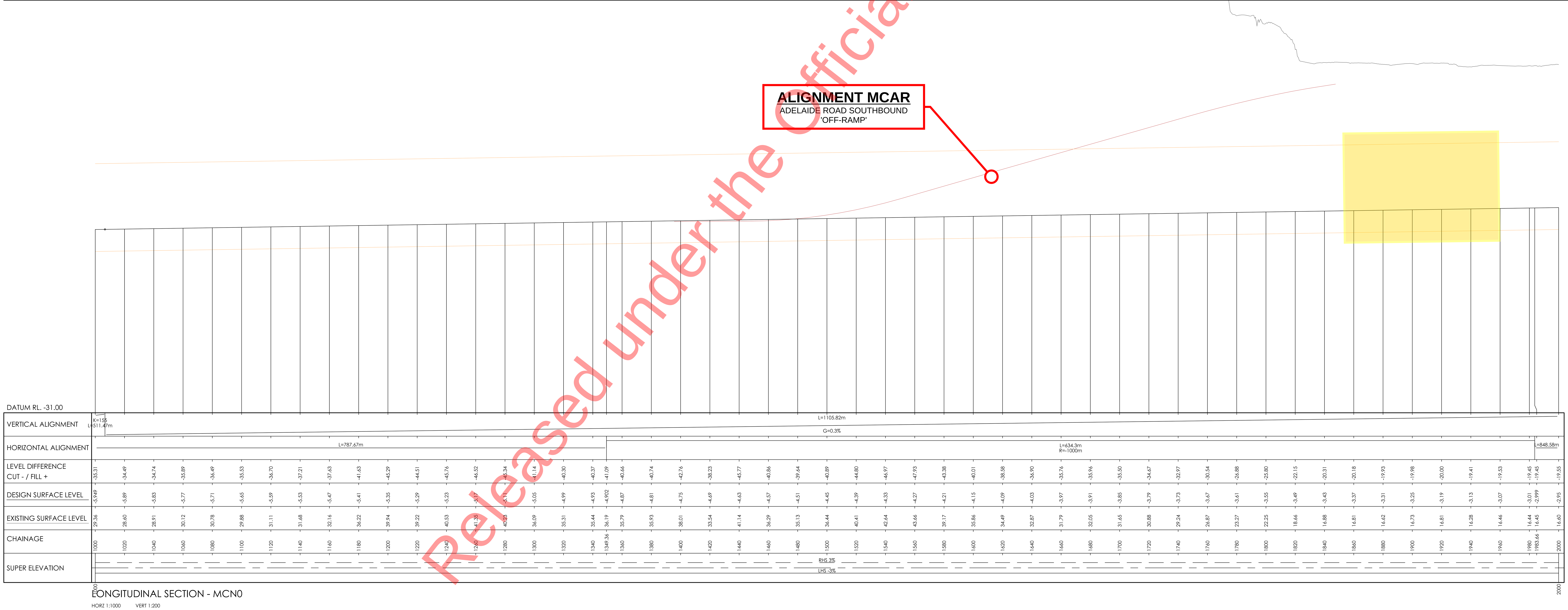

LONGITUDINAL SECTION
TUNNEL ALIGNMENT MCN0 (NORTH-BOUND LANES)

CONFIDENTIAL
WORK IN PROGRESS

Long Tunnel - Alignment
Fig D.22

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Vertical Scale 1:200
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LONGITUDINAL SECTION - MCN0

HORZ 1:1000 VERT 1:200

LONGITUDINAL SECTION
TUNNEL ALIGNMENT MCN0 (NORTH-BOUND LANES)

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WORK IN PROGRESS

Long Tunnel - Alignment
Fig D.23

5-C4800-00-DES-GEM-FIG-D023
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APPENDIX E

ADELAIDE ROAD RAMP WORKING DRAWINGS

LONGITUDINAL SECTION - MCS0

HORZ 1:500 VERT 1:100

LONGITUDINAL SECTION
TUNNEL ALIGNMENT MCS0 (STH-BND EXIT - ADELAIDE RD)

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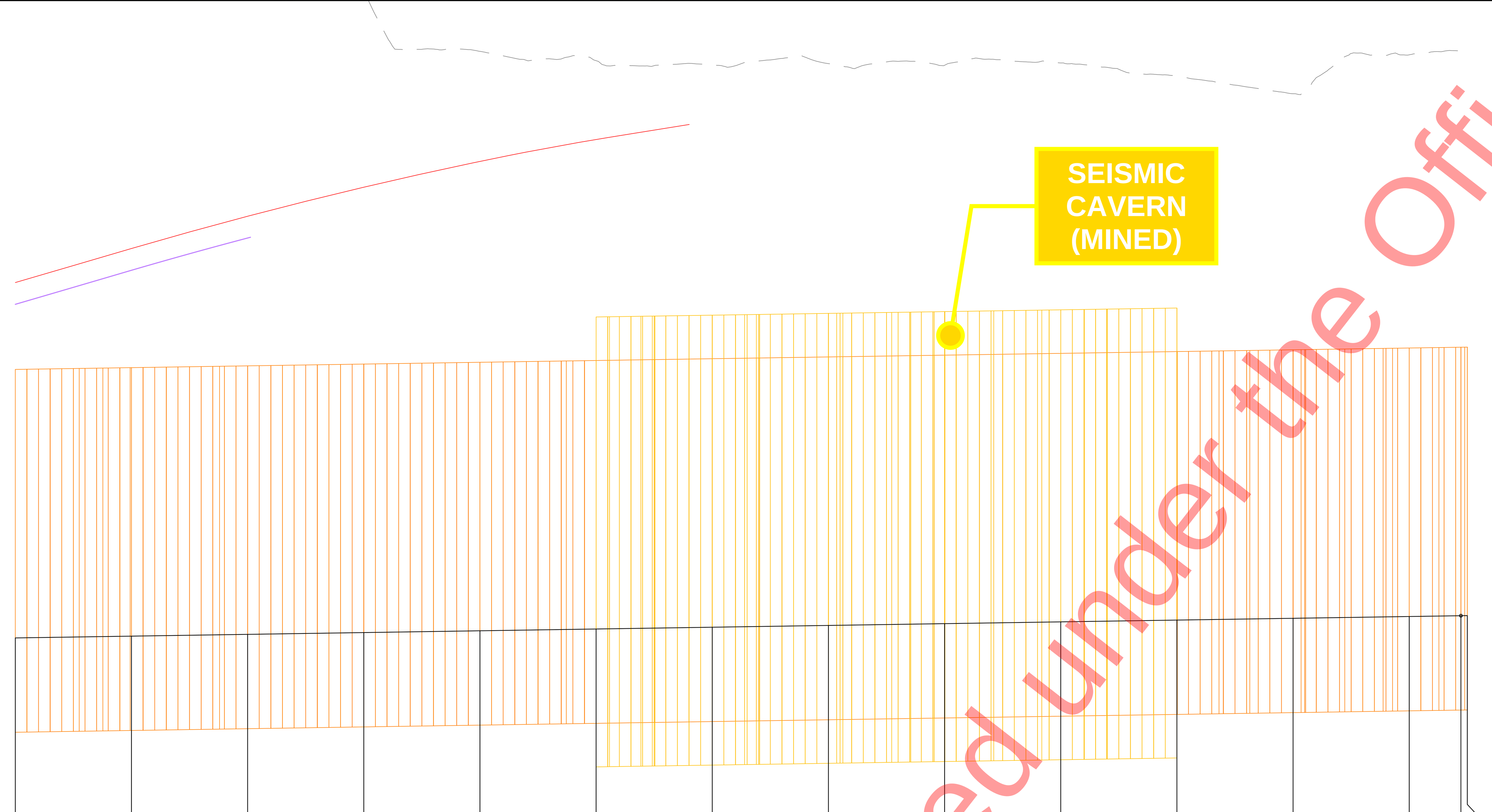
Adelaide Road Ramp
Fig E.21



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HORIZONTAL ALIGNMENT							L=619.08m R=-976m							L=853.63m	
LEVEL DIFFERENCE CUT - / FILL +	-32.98	-28.20	-26.12	-22.06	-19.96	-19.58	-19.37	-19.35	-19.24	-19.25	-18.74	-18.07	-19.35	-19.45	-19.43
DESIGN SURFACE LEVEL	-3.764	-3.703	-3.641	-3.58	-3.518	-3.457	-3.395	-3.334	-3.272	-3.211	-3.149	-3.088	-3.026	-2.999	-2.996
EXISTING SURFACE LEVEL	29.21	24.50	22.48	18.48	16.44	16.12	15.97	16.02	15.96	16.04	15.59	14.98	16.32	16.45	16.43
CHAINAGE	1700	1720	1740	1760	1780	1800	1820	1840	1860	1880	1900	1920	1940	1948.9	1950
SUPER ELEVATION							RHS 3% LHS -3%								

1700 1950

LONGITUDINAL SECTION - MCS0

HORZ 1:500 VERT 1:100

LONGITUDINAL SECTION
TUNNEL ALIGNMENT MCS0 (STH-BND EXIT - ADELAIDE RD)

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Adelaide Road Ramp
Fig E.22

5-C4800-00-DES-GEM-FIG-E022
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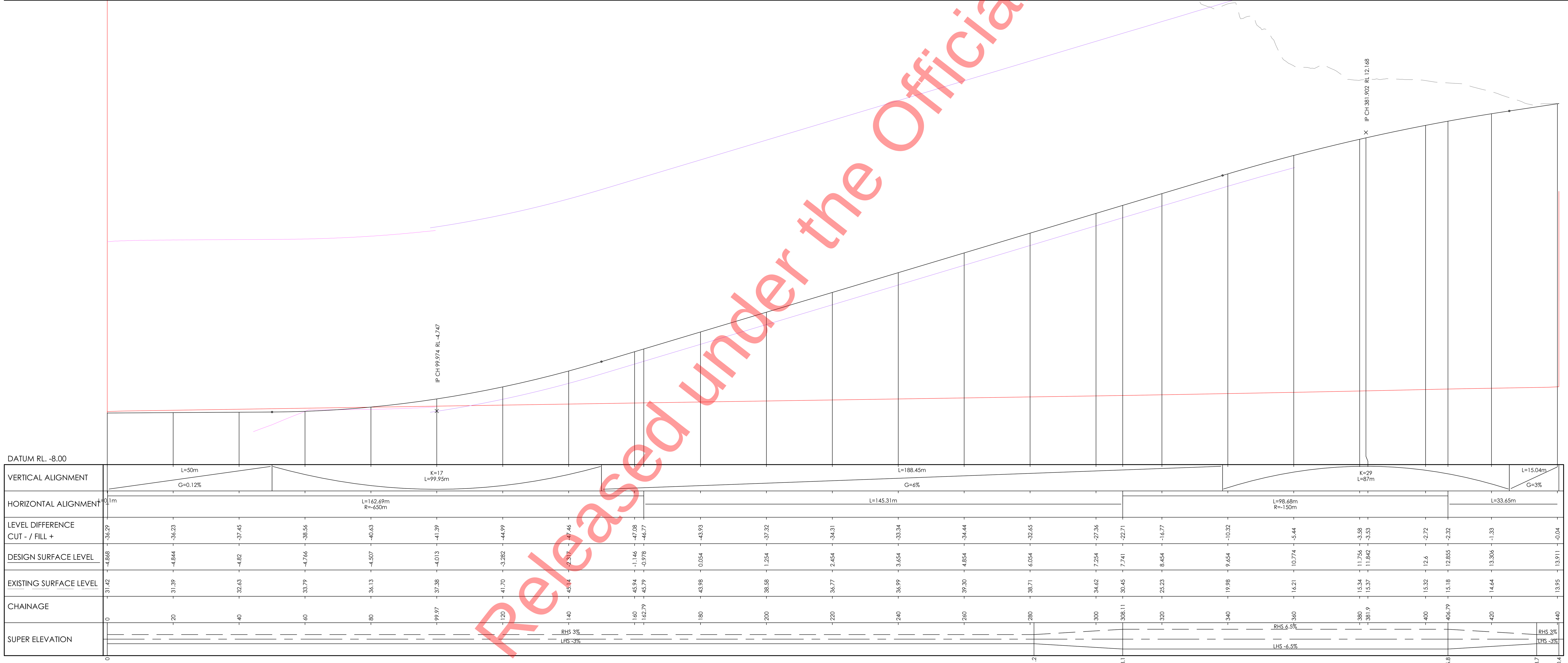

LONGITUDINAL SECTION - MCAR

HORZ 1:500 VERT 1:100

LONGITUDINAL SECTION
TUNNEL ALIGNMENT MCAR (STH-BND EXIT - ADELAIDE RD)

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Adelaide Road Ramp
Fig E.23

5-C4800-00-DES-GEM-FIG-E023
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Vertical Scale 1:100
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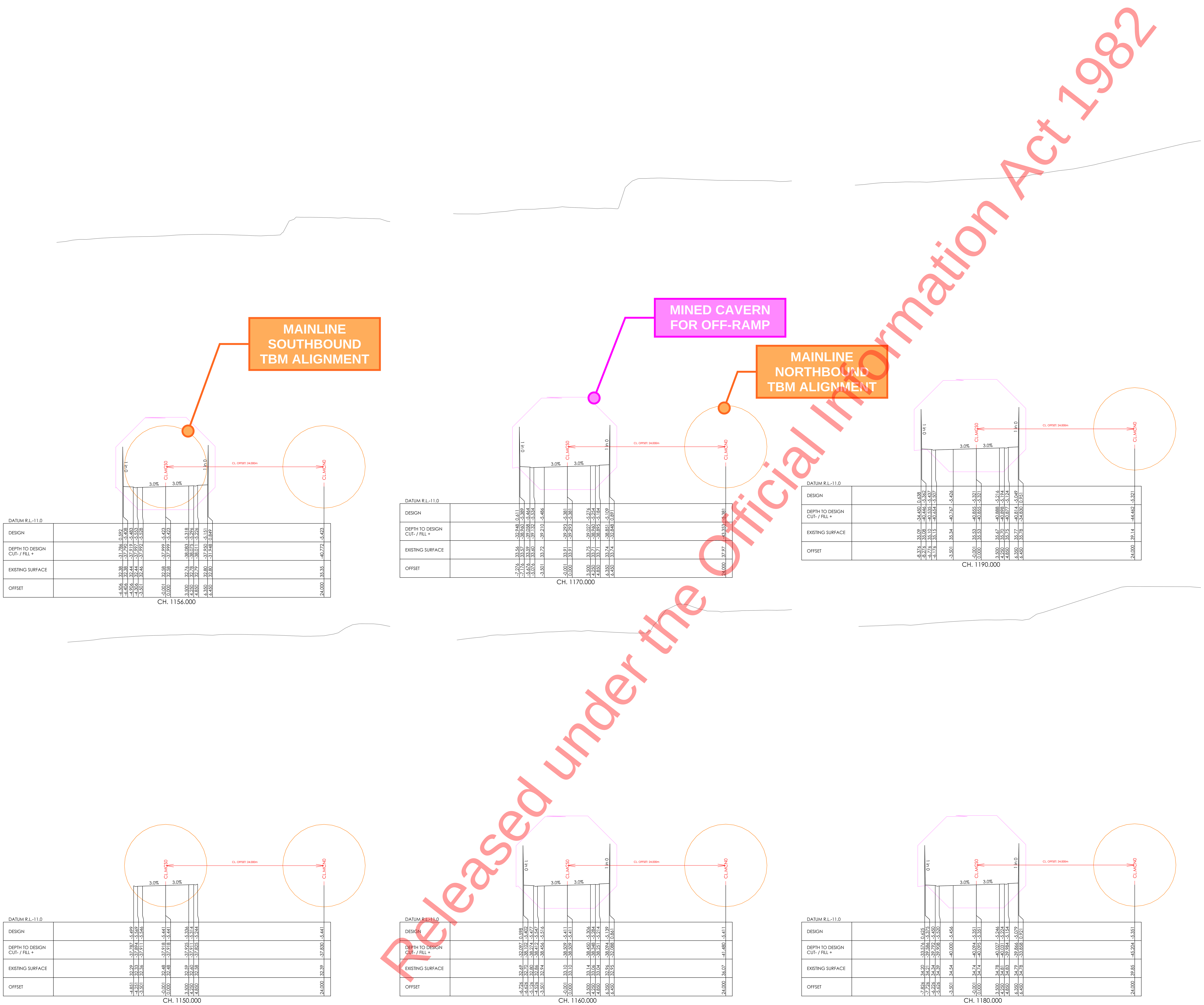

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

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Adelaide Road Ramp
Fig E.31

5-C4800-00-DES-GEM-FIG-E031
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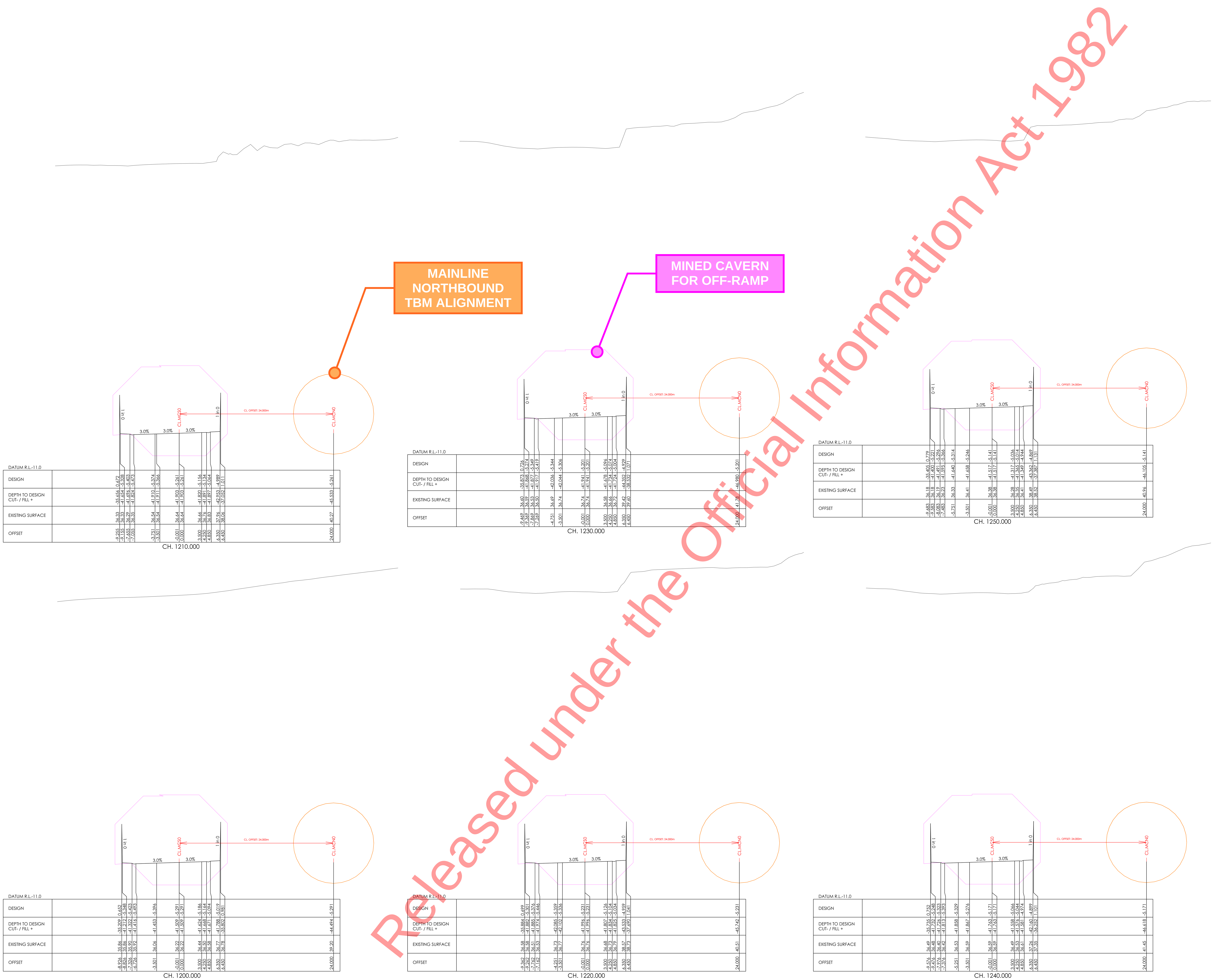

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

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WORK IN PROGRESS

Adelaide Road Ramp
Fig E.32

5-C4800-00-DES-GEM-FIG-E032
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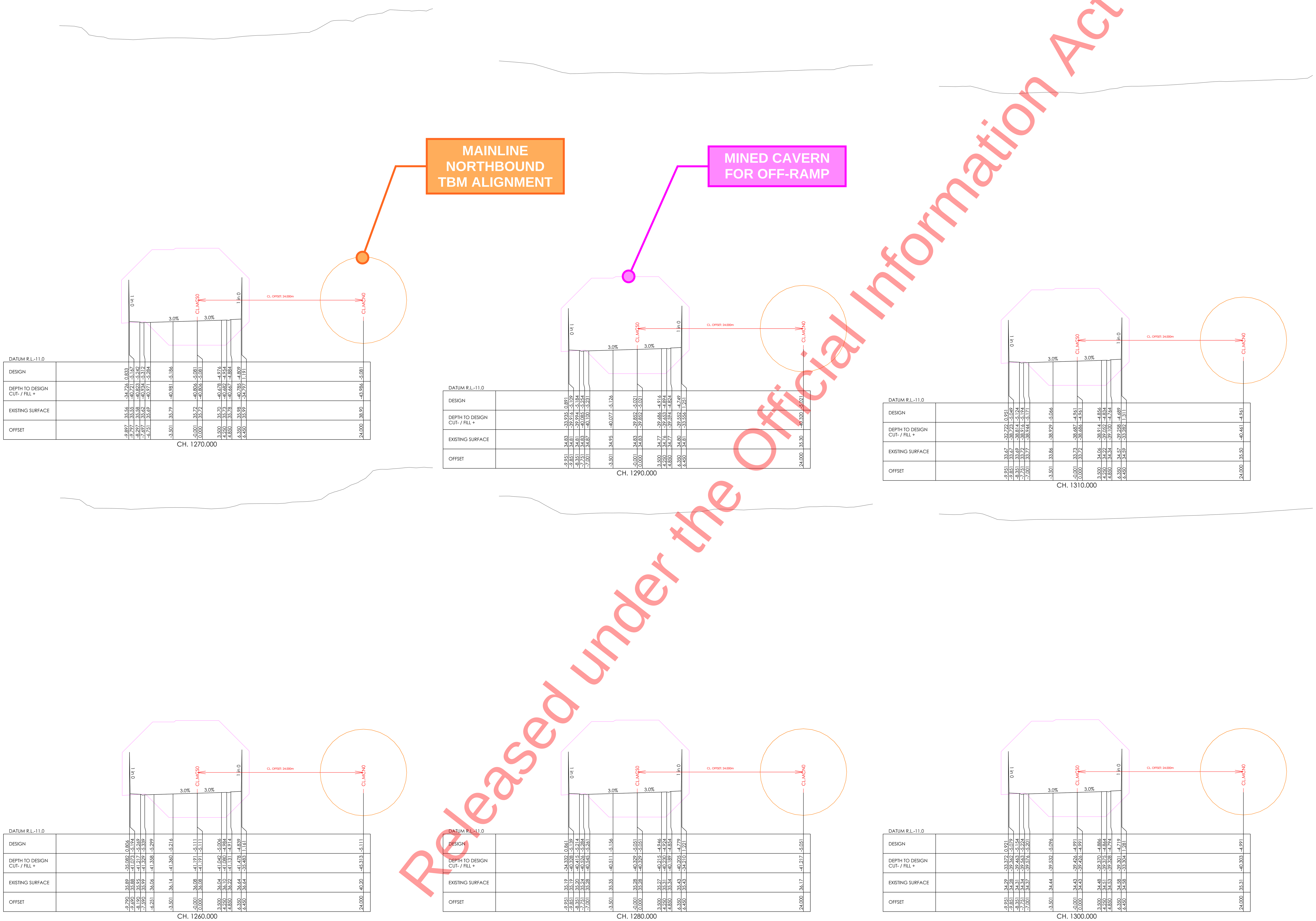

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

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WORK IN PROGRESS

Adelaide Road Ramp
Fig E.33

5-C4800-00-DES-GEM-FIG-E033
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Vertical Scale 1:200
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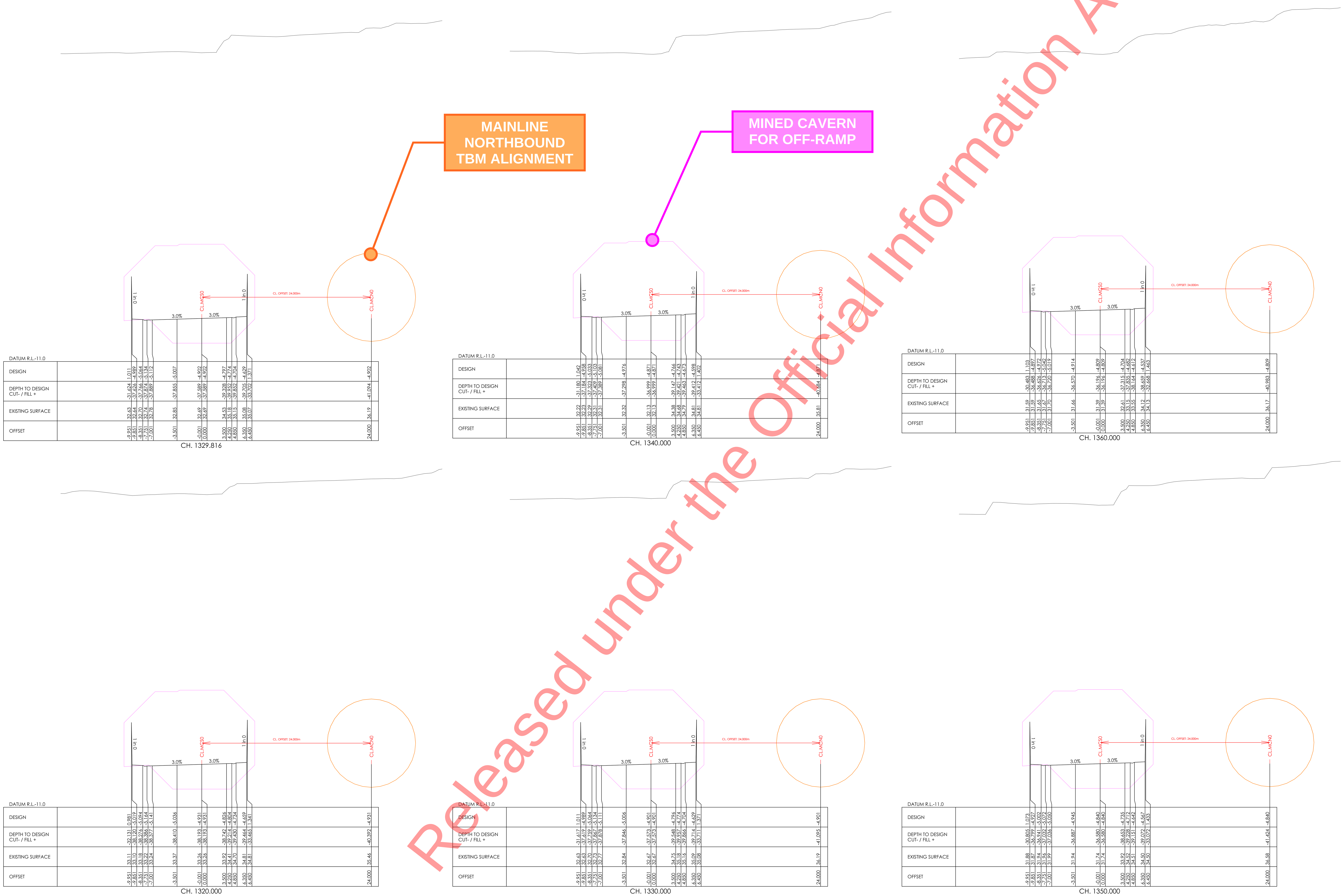

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

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WORK IN PROGRESS

Adelaide Road Ramp
Fig E.34

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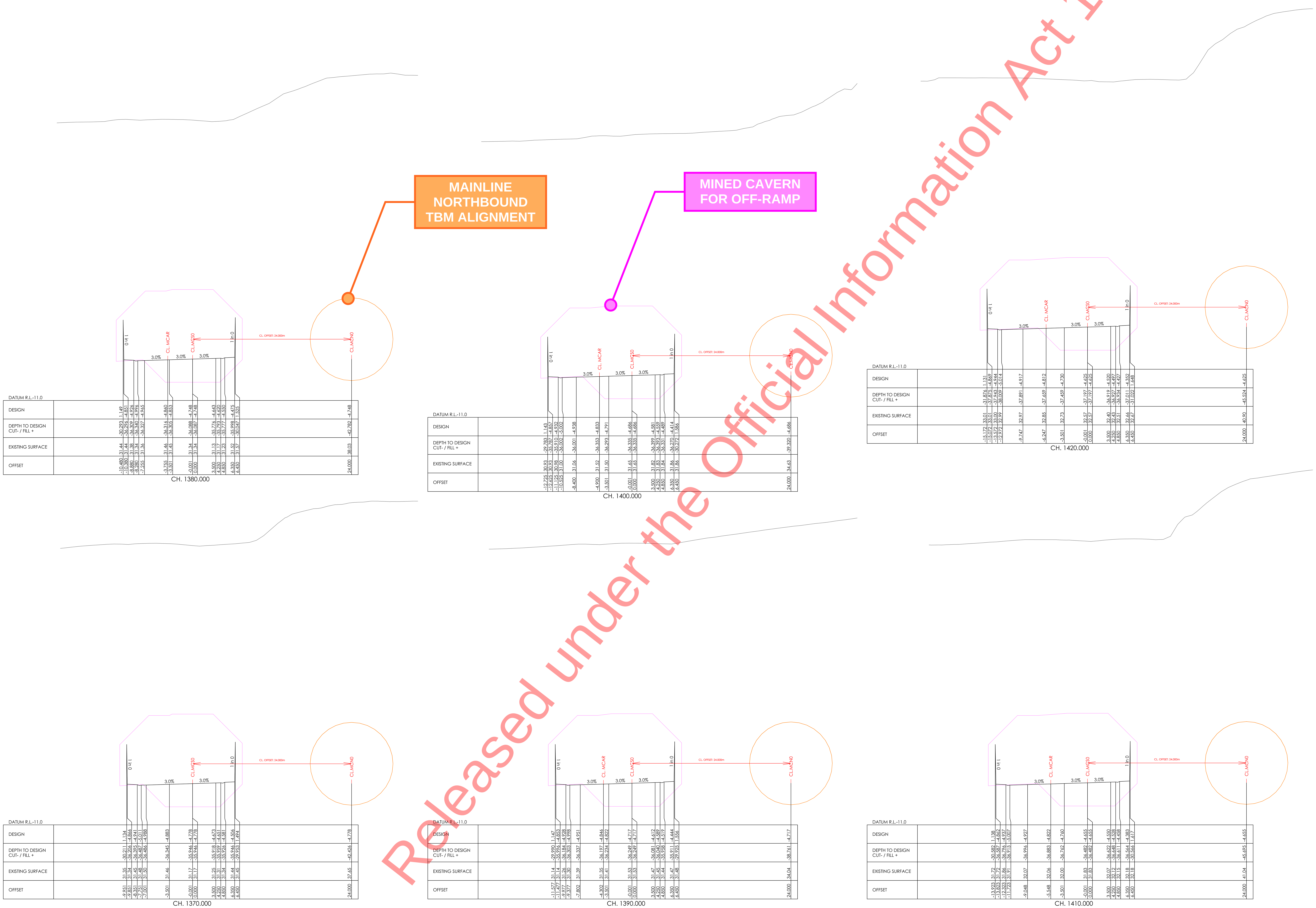

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

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WORK IN PROGRESS

Adelaide Road Ramp
Fig E.35

5-C4800-00-DES-GEM-FIG-E035
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Vertical Scale 1:200
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CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

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WORK IN PROGRESS

Adelaide Road Ramp
Fig E.36

S-C4800-00-DES-GEM-FIG-E036
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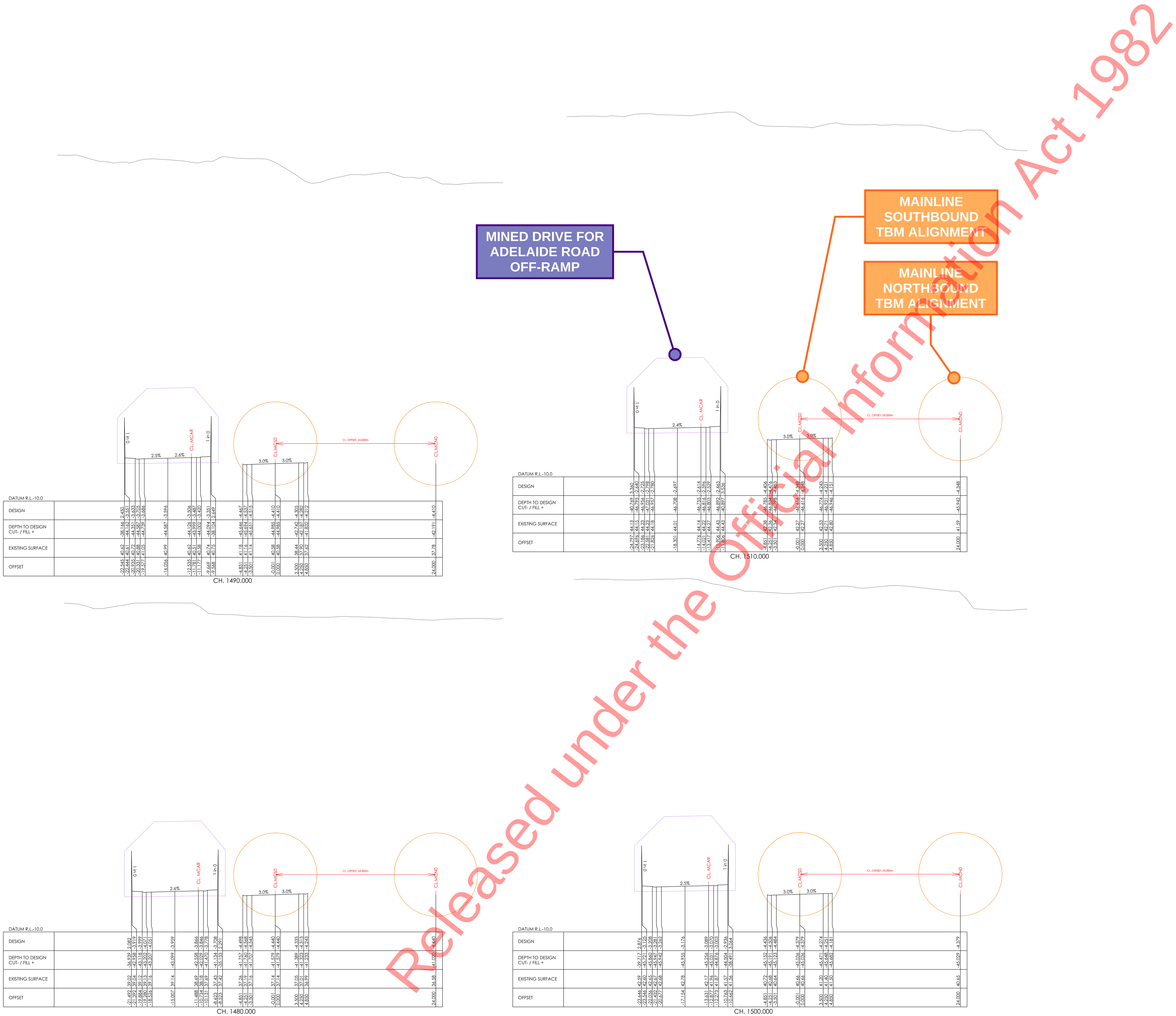

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.37

5-C4800-00-DES-GEM-FIG-E037
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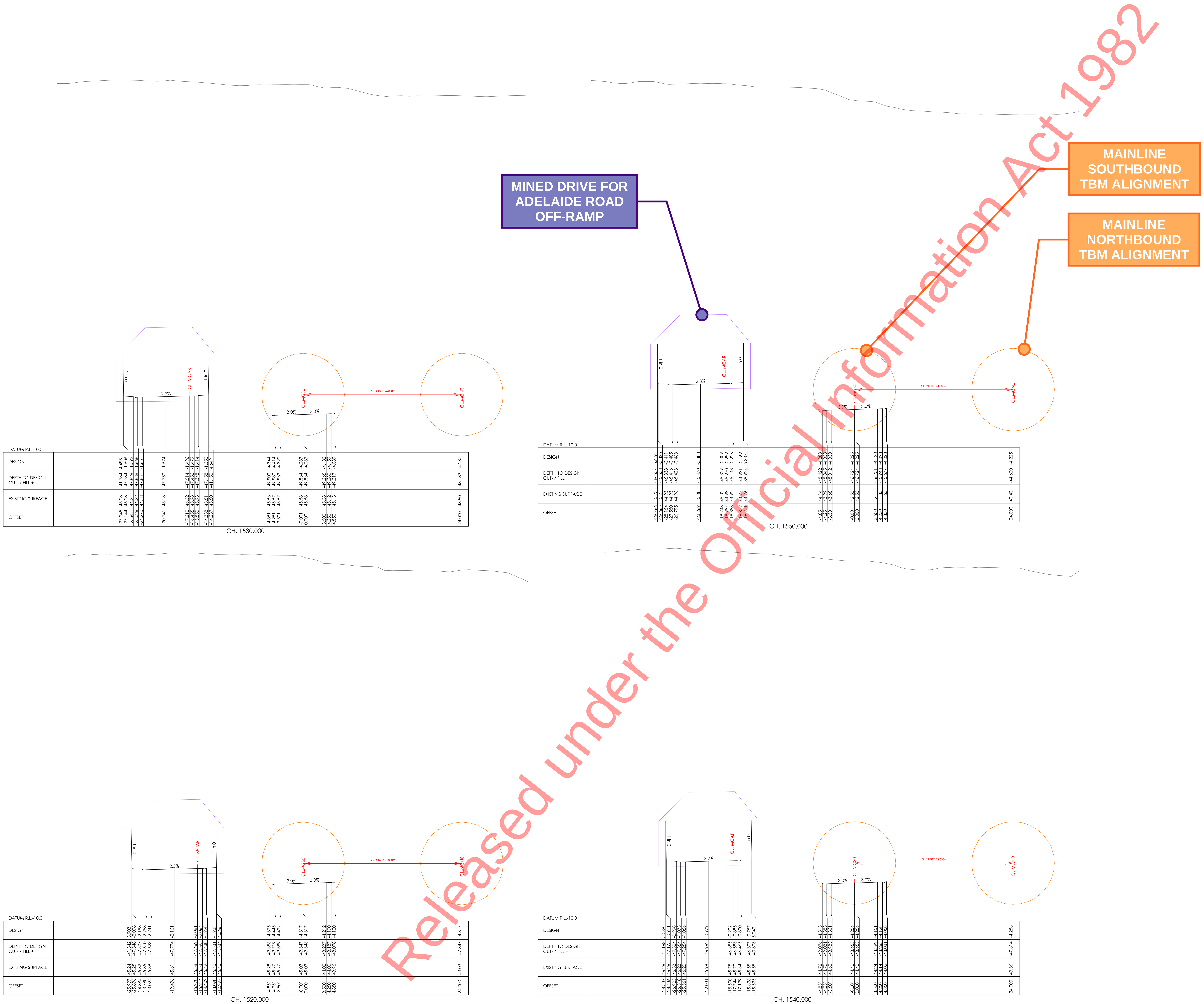

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.38

5-C4800-00-DES-GEM-FIG-E038
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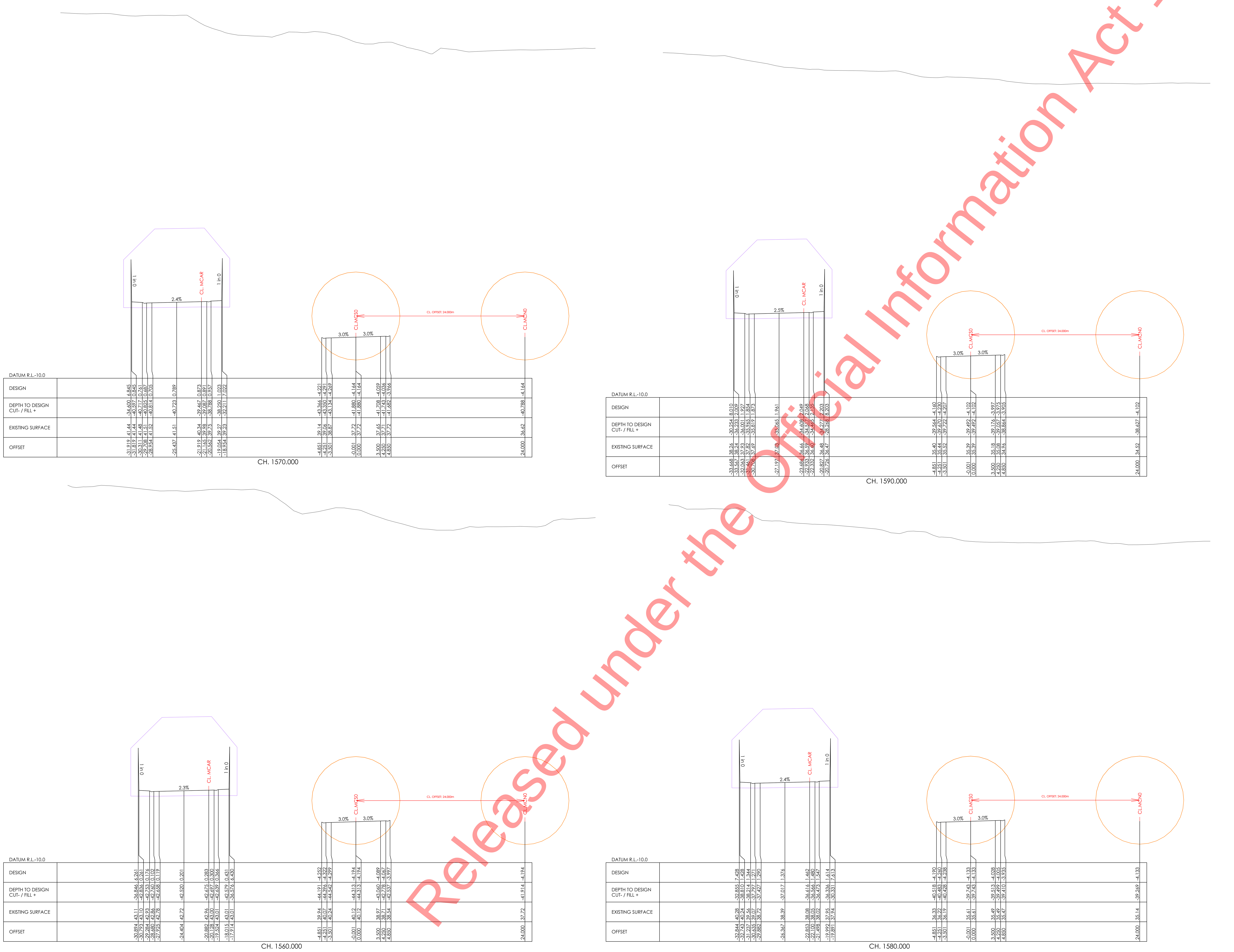

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.39

5-C4800-00-DES-GEM-FIG-E039
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Vertical Scale 1:200
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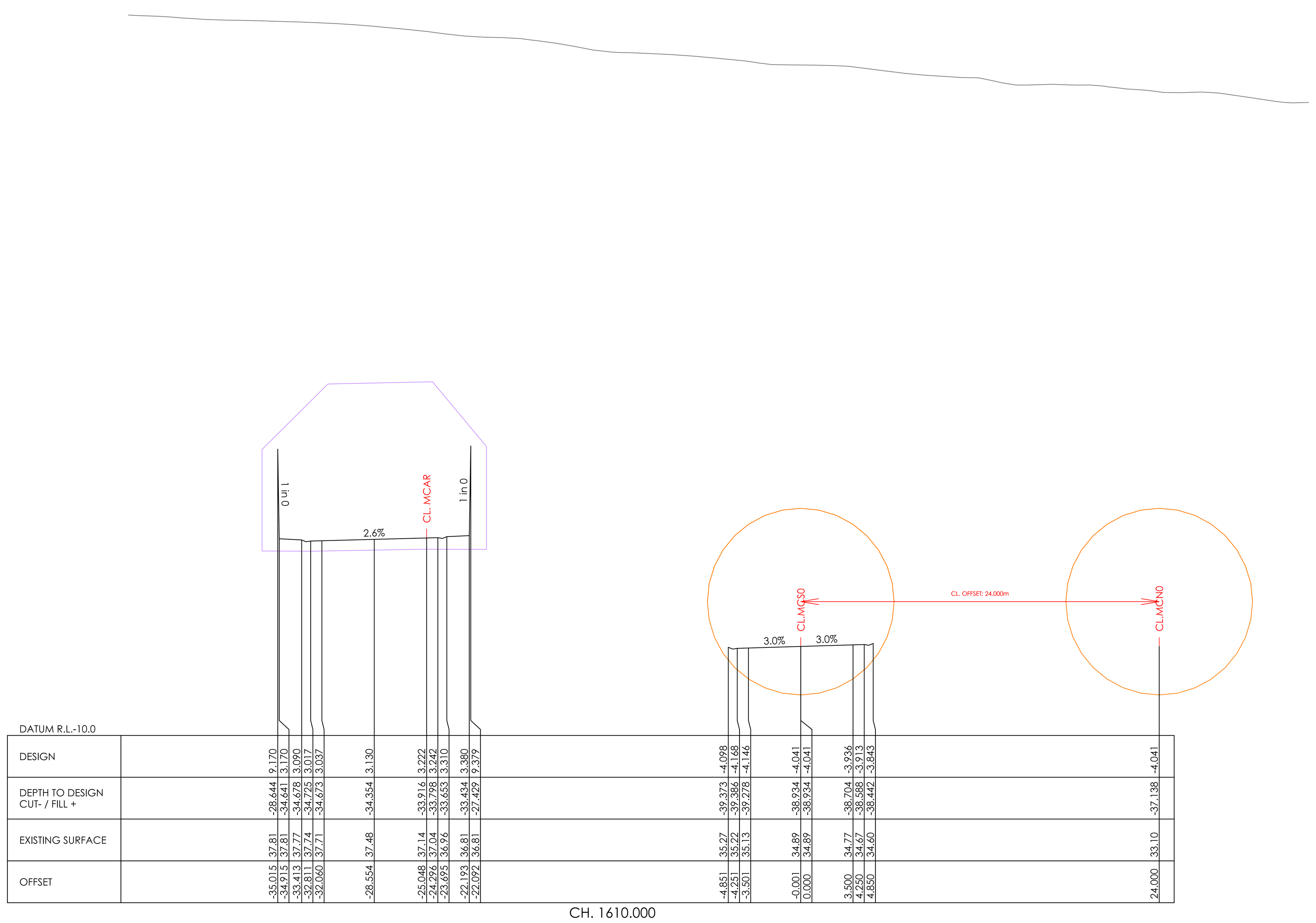

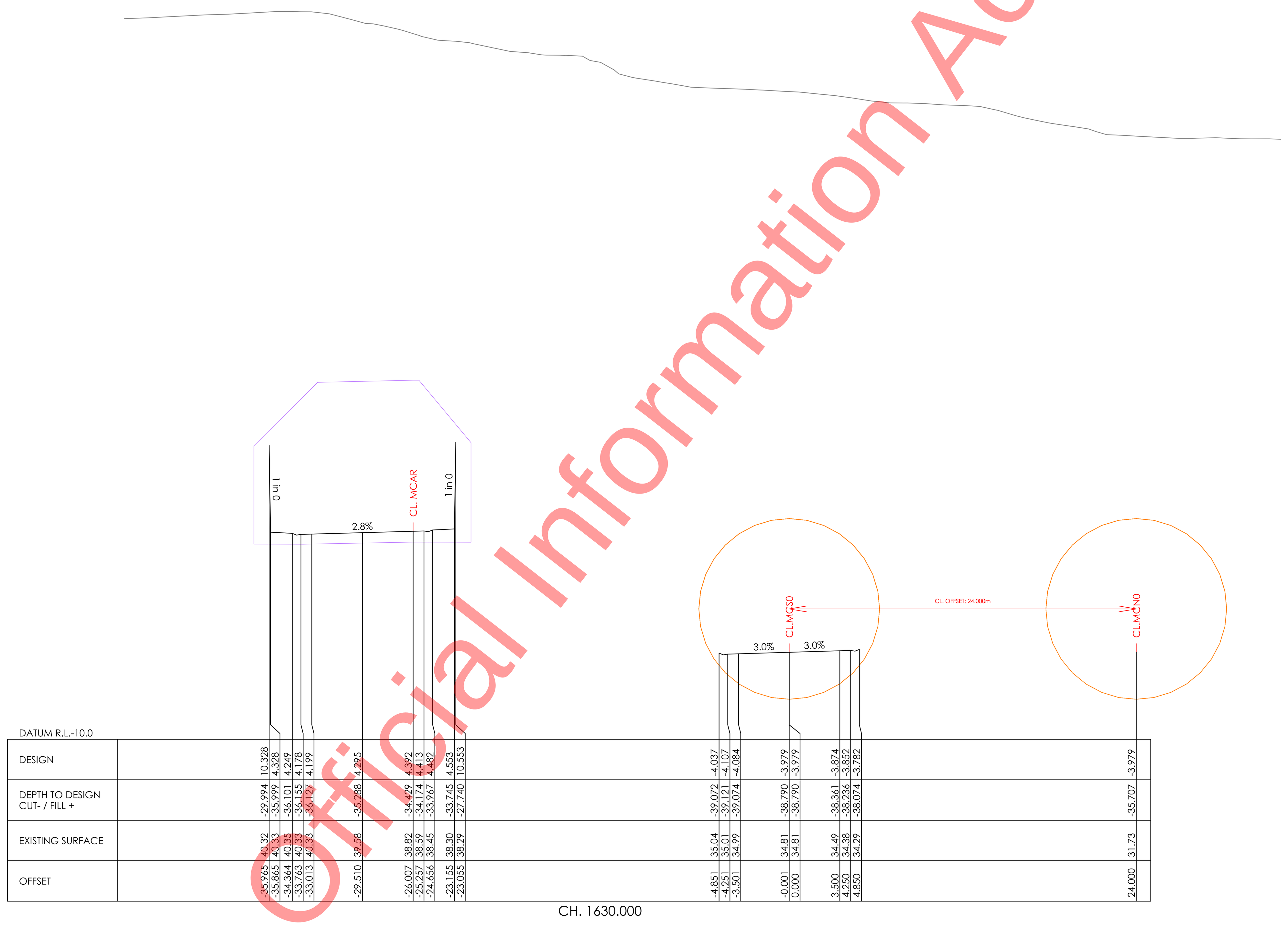

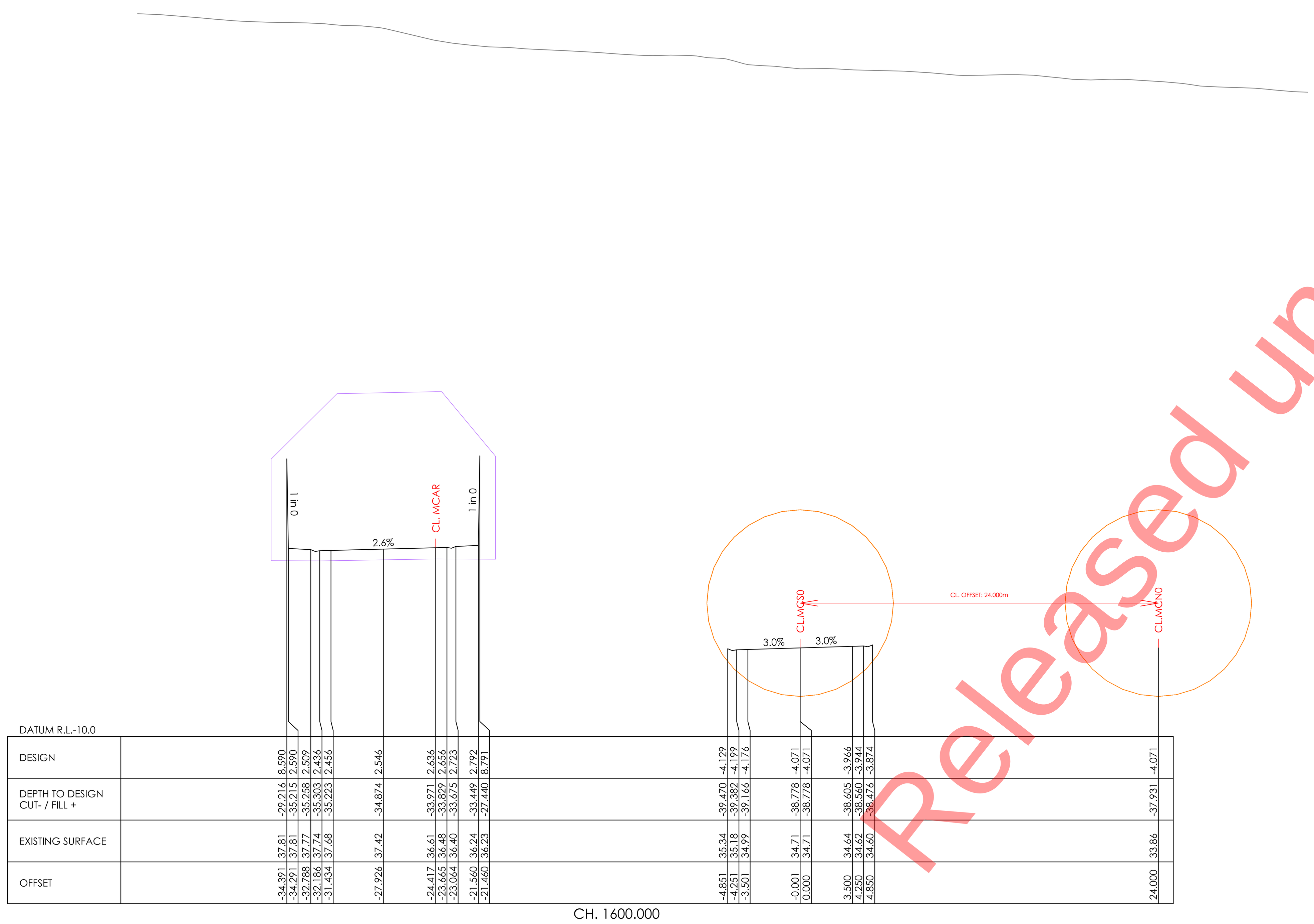

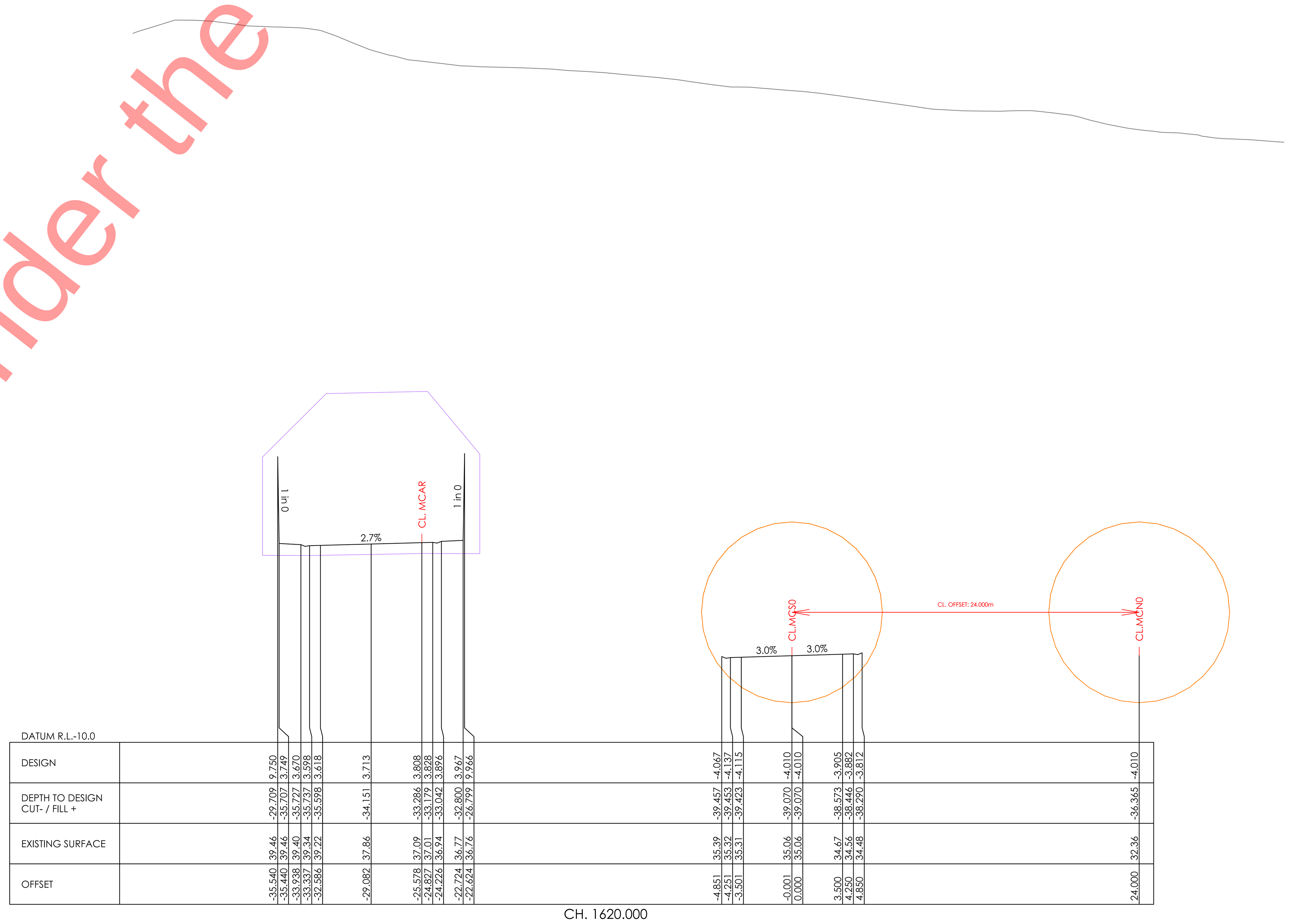

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.40

5-C4800-00-DES-GEM-FIG-E040
Horizontal Scale 1:200
Vertical Scale 1:200
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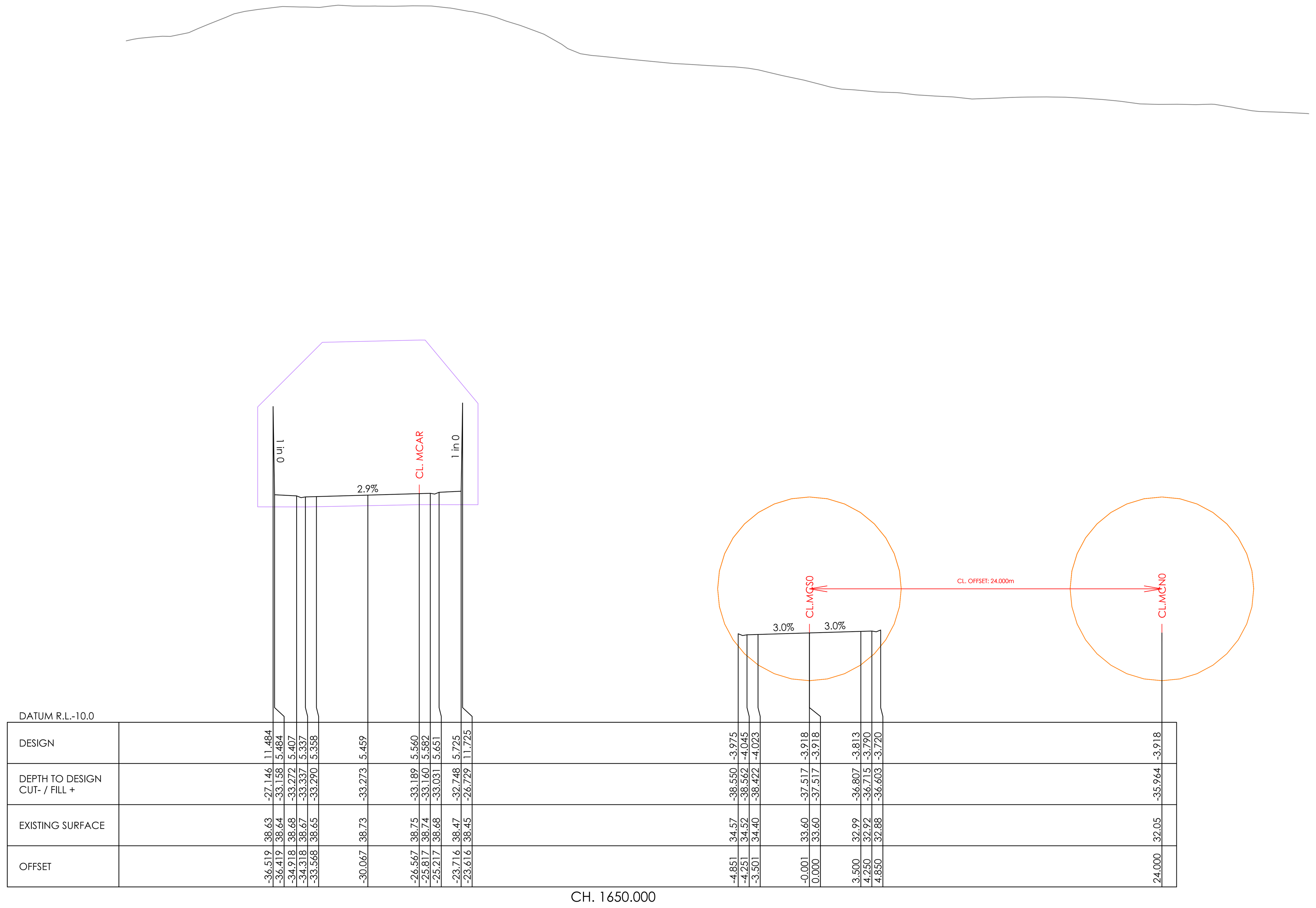
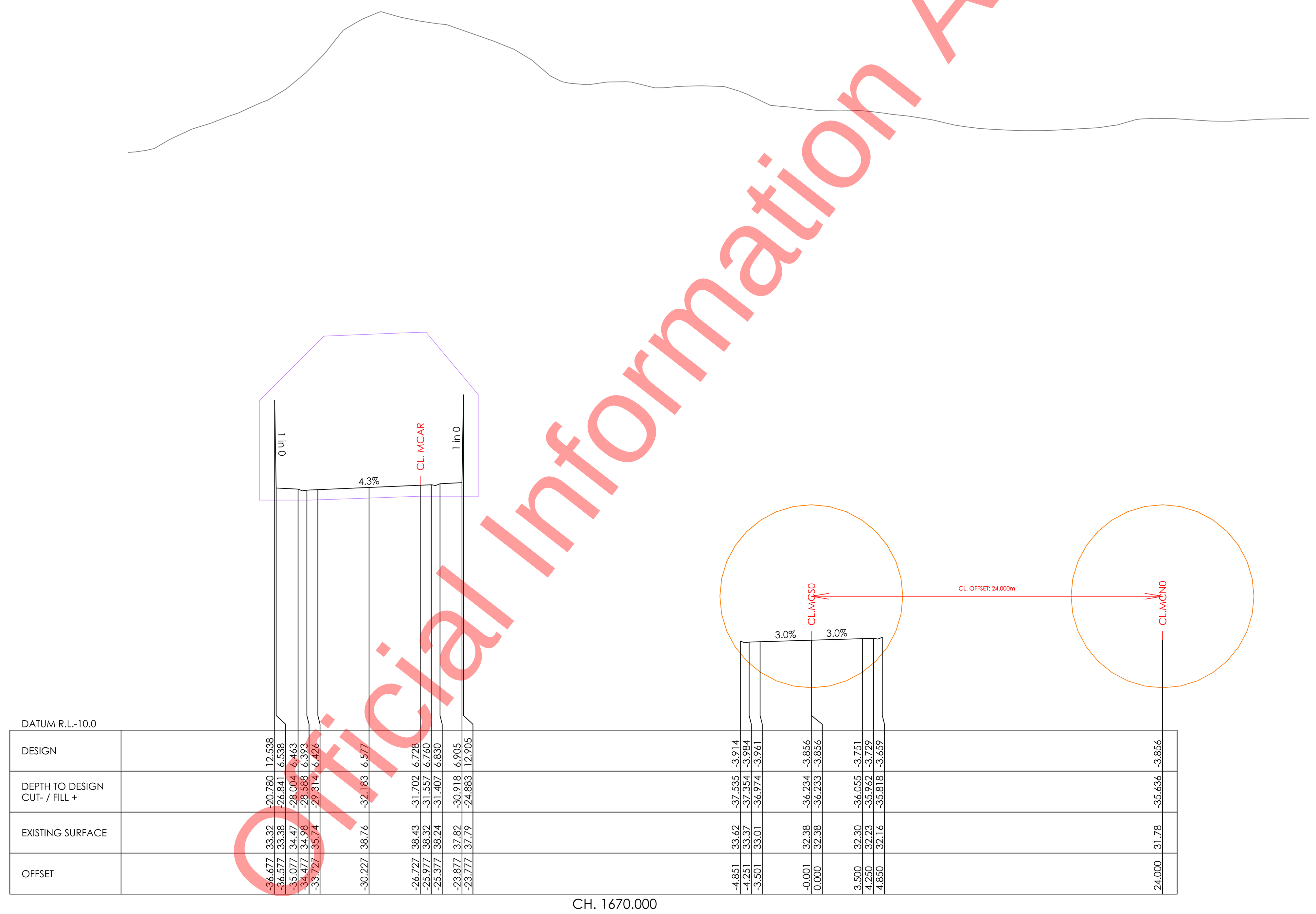


CH. 1650.000



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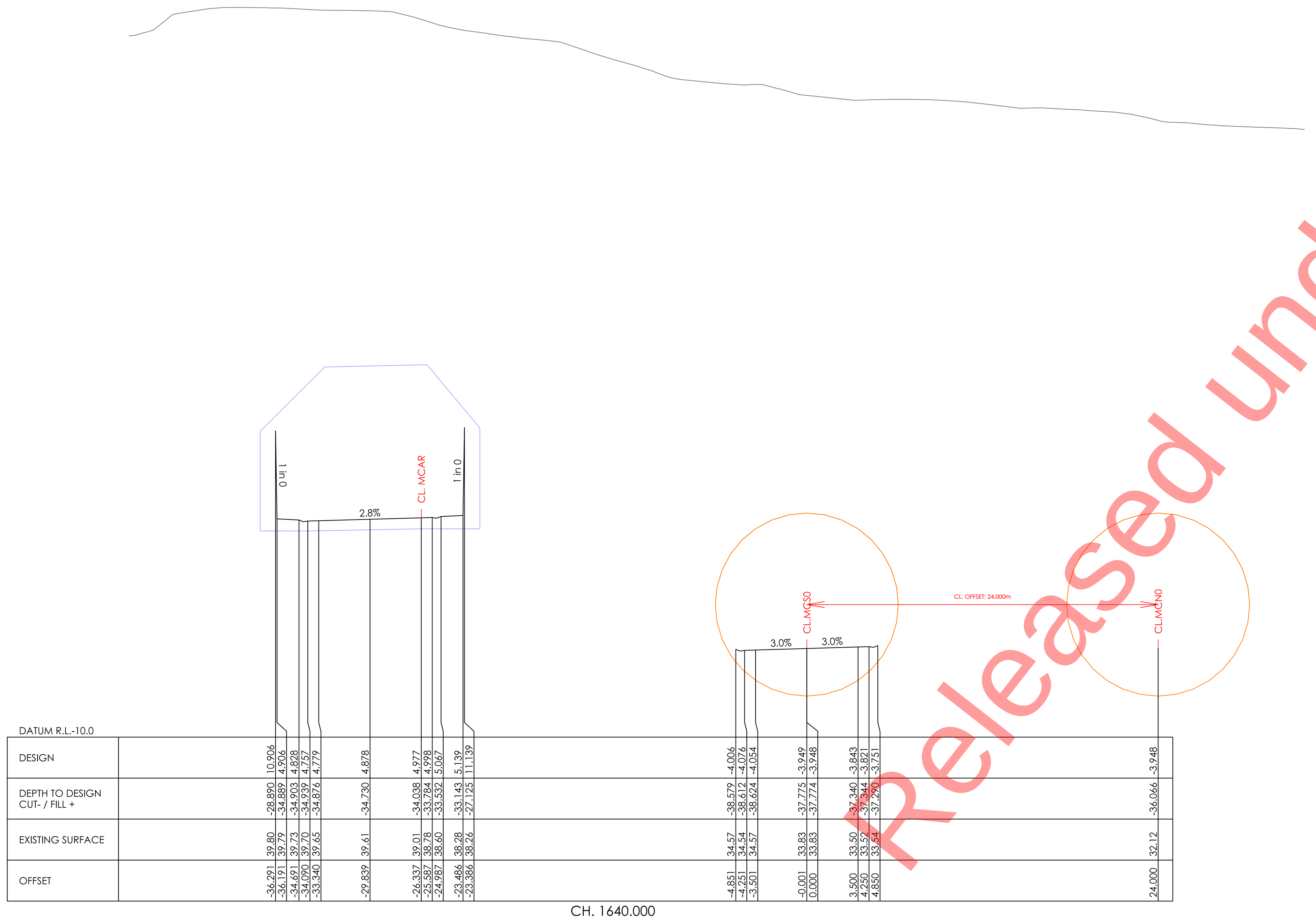

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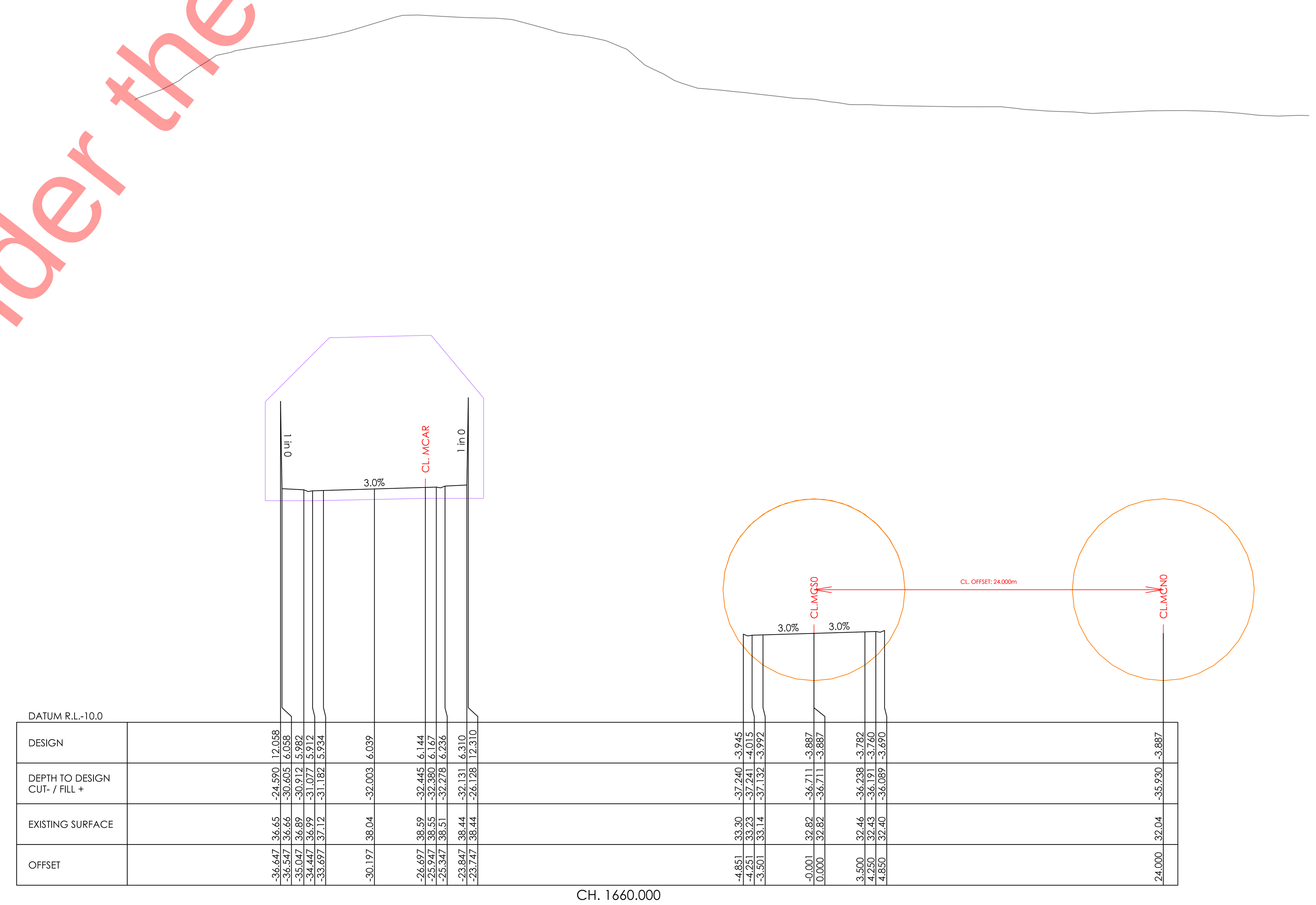

CH. 1660.000

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.41

5-C4800-00-DES-GEM-FIG-E041
Horizontal Scale 1:200
Vertical Scale 1:200
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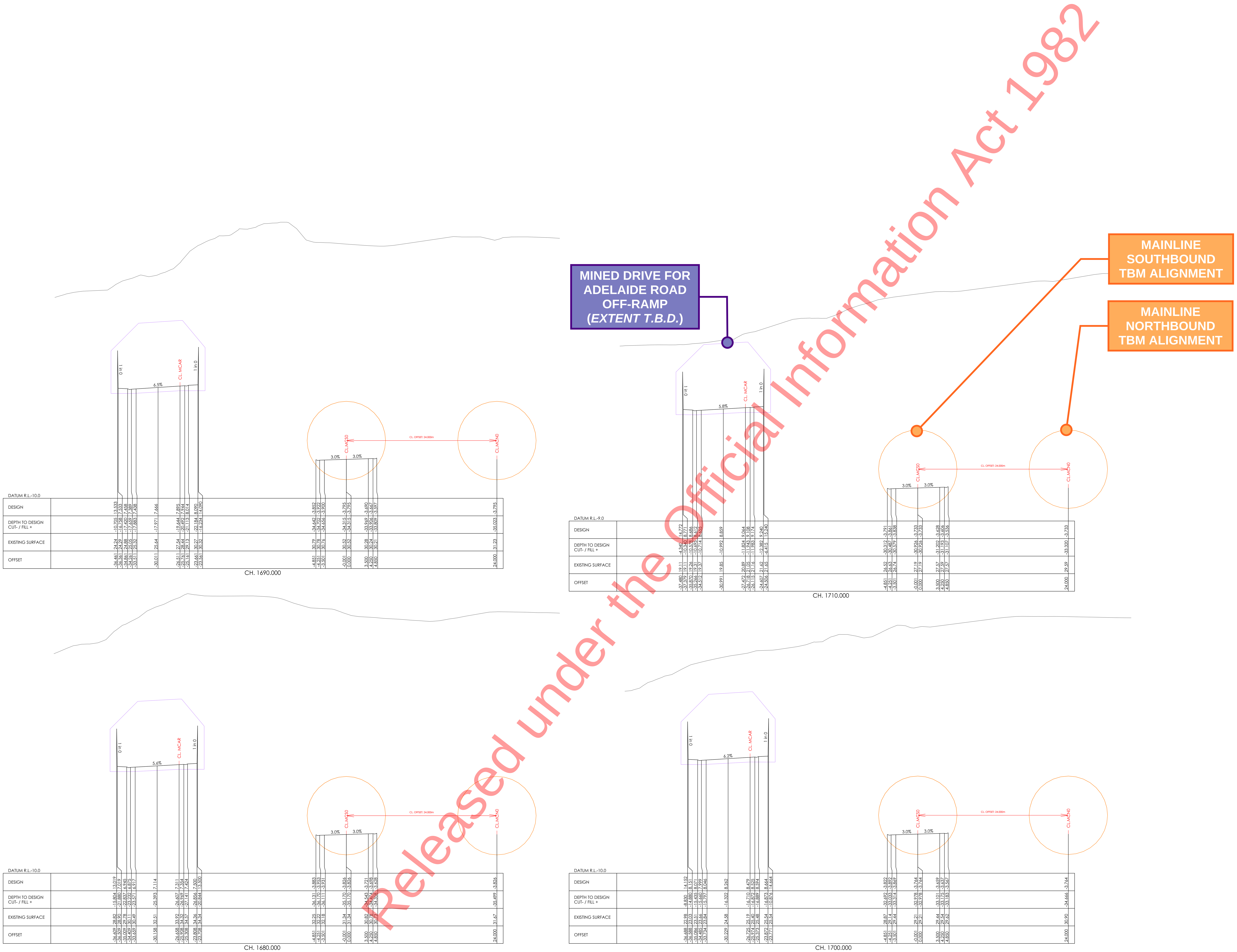

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.42

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.43

5-C4800-00-DES-GEM-FIG-E043
Horizontal Scale 1:200
Vertical Scale 1:200
PLOTTED: 14-May-2024 18:25:29

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.44

5-C4800-00-DES-GEM-FIG-E044
Horizontal Scale 1:200
Vertical Scale 1:200
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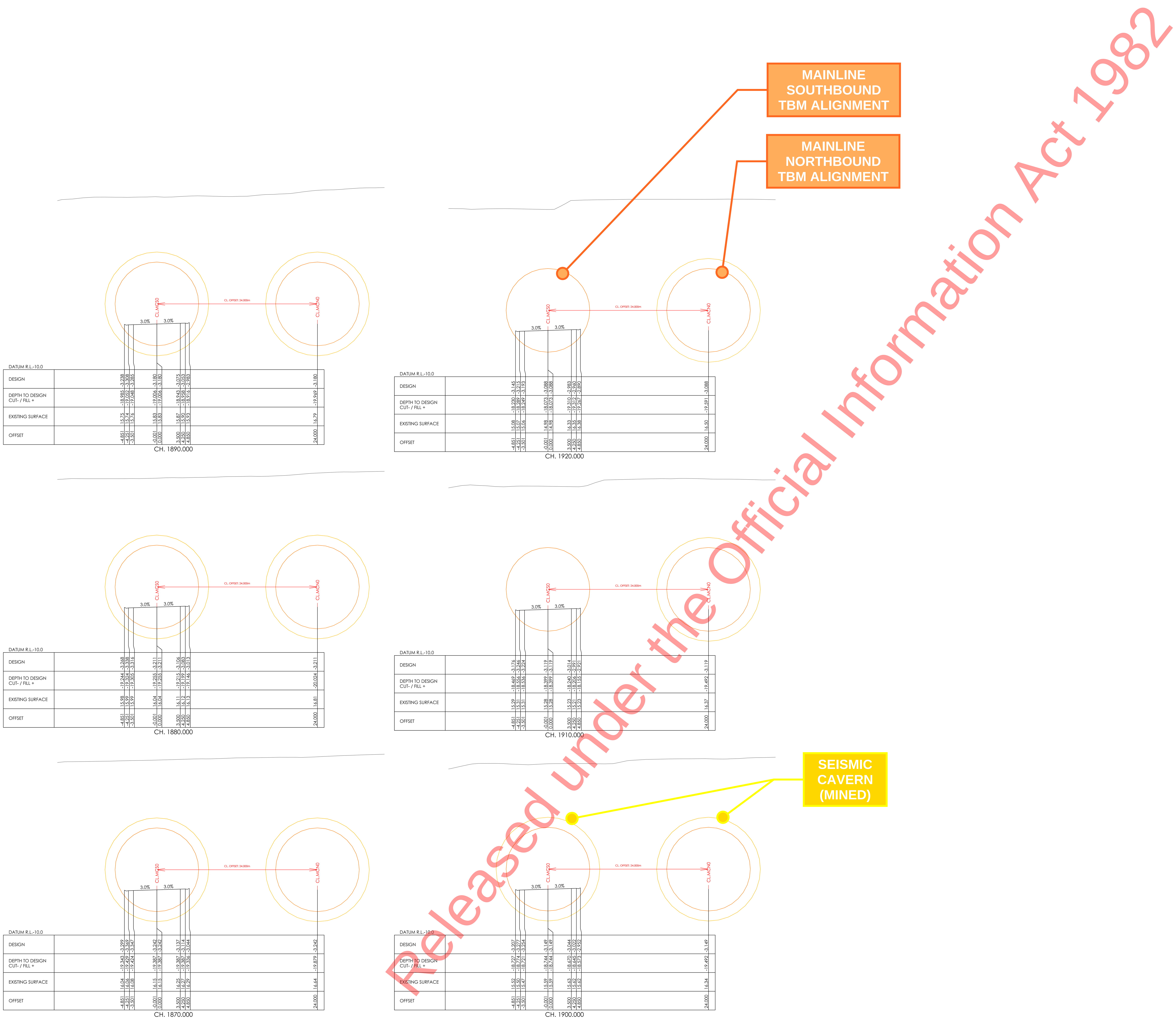

CROSS SECTIONS
ADELAIDE RD EXIT - ALIGNMENT MCS0

CONFIDENTIAL
WORK IN PROGRESS

Adelaide Road Ramp
Fig E.45

APPENDIX F

LONG TUNNEL, SOUTHERN CONNECTION (KILBIRNIE) WORKING DRAWINGS

PLAN - KILB_GS
RAW OUTPUT

CONFIDENTIAL - WORK IN PROGRESS

Long Tunnel - Southern Connection
Fig F.11

5-C4800-00-DES-GEM-FIG-F011
Horizontal Scale 1:500
Vertical Scale 1:500
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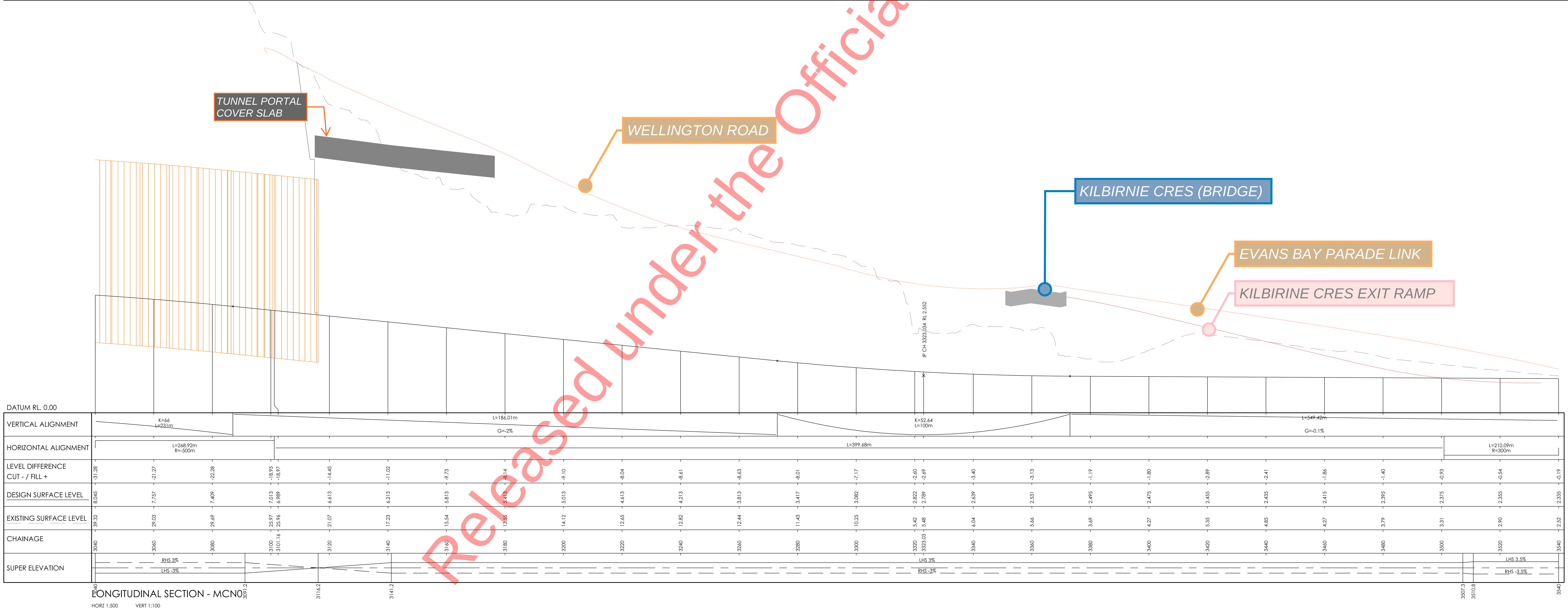
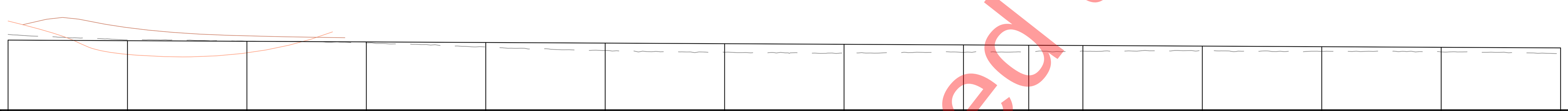
WELLINGTON ROAD
EVANS BAY PARADE LINK
TBM PORTAL
APPROX. LOCATION
ALIGNMENT MCN0
NORTHBOUND USED FOR
CROSS SECTION REFERENCE
KILBIRINE CRES EXIT RAMP


TUNNEL PORTAL
COVER SLAB
WELLINGTON ROAD
KILBIRNIE CRES (BRIDGE)
EVANS BAY PARADE LINK
KILBIRINE CRES EXIT RAMP
DATUM RL. 0.00
VERTICAL ALIGNMENT
HORIZONTAL ALIGNMENT
LEVEL DIFFERENCE
CUT - / FILL +
DESIGN SURFACE LEVEL
EXISTING SURFACE LEVEL
CHAINAGE
SUPER ELEVATION
LONGITUDINAL SECTION - MCN0
HORZ 1:500 VERT 1:100



DATUM RL. 0.00

VERTICAL ALIGNMENT: L=549.42m, G=-0.1%

HORIZONTAL ALIGNMENT: L=210.09m R=300m; L=211.52m

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
3540	-0.19	2.335	2.52
3560	-0.03	2.315	2.34
3580	-0.00	2.295	2.30
3600	0.03	2.275	2.24
3620	0.15	2.255	2.11
3640	0.25	2.235	1.99
3660	0.28	2.214	1.93
3680	0.29	2.194	1.90
3700	0.25	2.174	1.93
3710.93	0.23	2.163	1.94
3720	0.19	2.154	1.97
3740	0.15	2.134	1.98
3760	0.16	2.114	1.96
3780	0.15	2.094	1.94
3800	0.19	2.074	1.88

SUPER ELEVATION: LHS 3.5%, RHS -3.5% (3540 – 3700.9); LHS 3%, RHS -3% (3704.5 – 3800)

3540 3700.9 3704.5 3800

LONGITUDINAL SECTION - MCN0

HORZ 1:500 VERT 1:100

LONGITUDINAL SECTION
ALIGNMENT MCN0 (KILBIRNIE SECTION)

Long Tunnel - Southern Connection
Fig F.22

5-C4800-00-DES-GEM-FIG-F022
Horizontal Scale 1:500
Vertical Scale 1:100
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CROSS SECTIONS
KILBIRNIE - ALIGNMENT MCN0

CONFIDENTIAL WORK IN PROGRESS

Long Tunnel - Southern Connection

Fig F.31

5-C4800-00-DES-GEM-FIG-F031
Horizontal Scale 1:200
Vertical Scale 1:200
PLOTTED: 21-May-2024 13:54:45

CROSS SECTIONS
KILBIRNIE - ALIGNMENT MCN0

CONFIDENTIAL
WORK IN PROGRESS

Long Tunnel - Southern Connection
Fig F.32

5-C4800-00-DES-GEM-FIG-F032
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Vertical Scale 1:200
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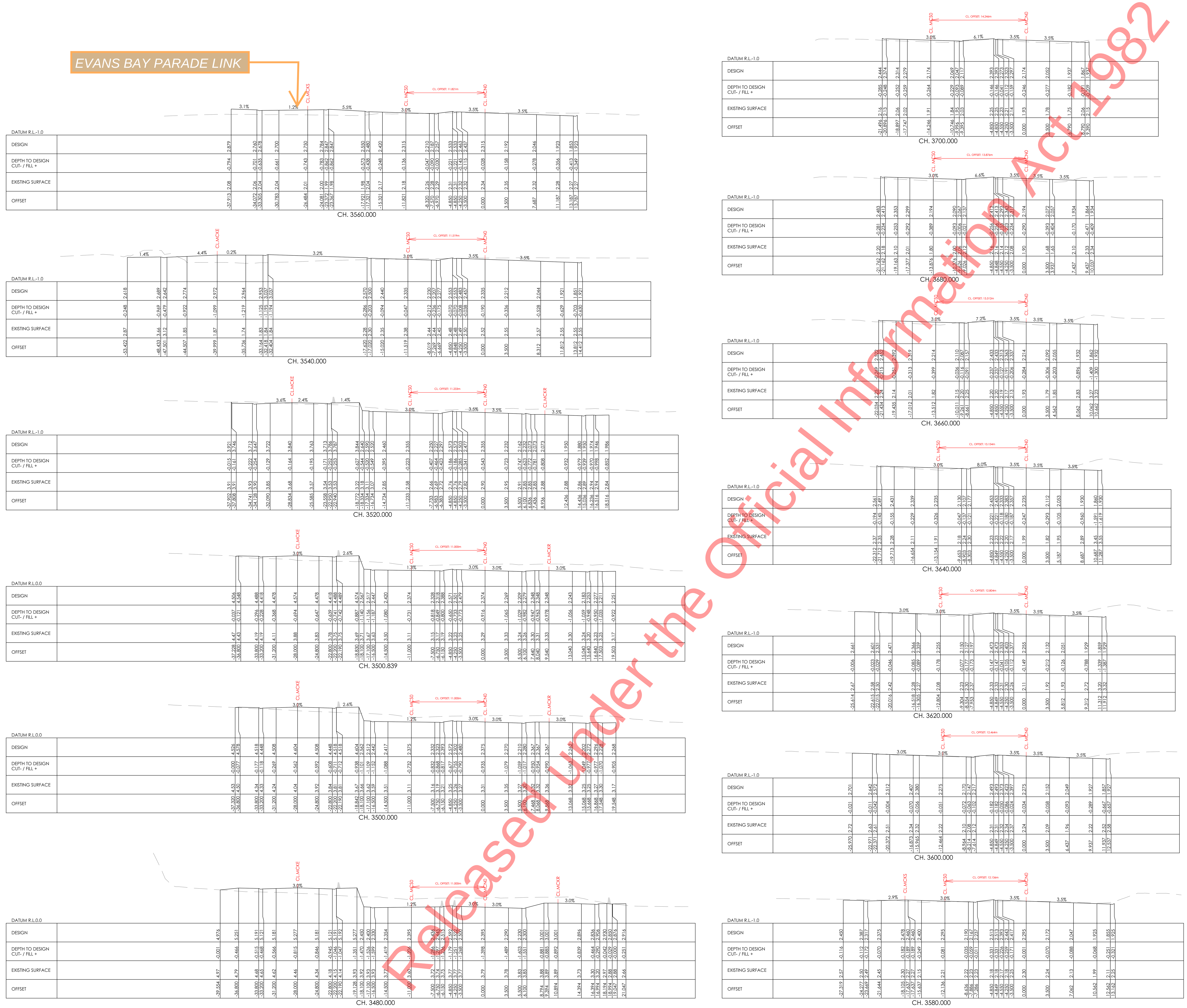

CROSS SECTIONS
KILBIRNIE - ALIGNMENT MCN0

CONFIDENTIAL
WORK IN PROGRESS

Long Tunnel - Southern Connection
Fig F.33

5-C4800-00-DES-GEM-FIG-F033
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Vertical Scale 1:200
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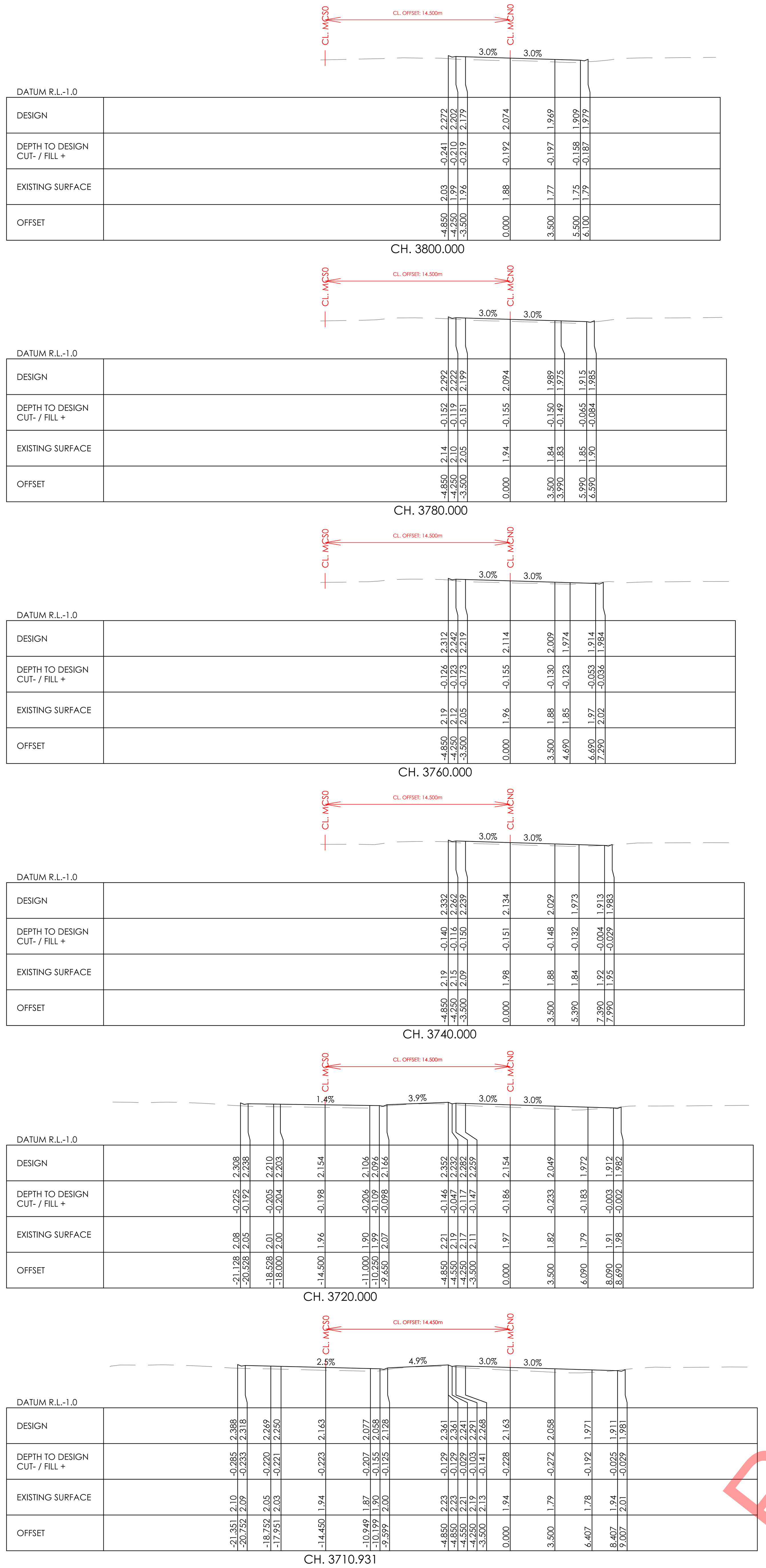

CROSS SECTIONS
KILBIRNIE - ALIGNMENT MCN0

CONFIDENTIAL
WORK IN PROGRESS

Long Tunnel - Southern Connection
Fig F.34

5-C4800-00-DES-GEM-FIG-F034
Horizontal Scale 1:200
Vertical Scale 1:200
PLOTTED: 21-May-2024 13:55:00

APPENDIX G

TUNNEL DESIGN MEMO

Memorandum

To	s 9(2)(a) [redacted]
Copy	
From	s 9(2)(a) [redacted]
Office	Wellington
Date	22 May 2024
File/Ref	5-C4800-00-DES-TUN-MEM-0001 Rev B
Subject	Long Tunnel design memo – Tunnels

Introduction

The long tunnel design memo has been revised from the original memo (dated 13 May 2024) to include the following design basis:

1. Two tunnel boring machine (TBM) methodology.
2. The removal of the Kilbirnie Crescent on-ramp at northbound tunnel at Kilbirnie for the Long Tunnel option.

1 Scope of Design

As part of the SH1 Improvements Scoping this memo presents feasible options for fire life safety, ventilation and construction methodologies reviewed for the tunnels considered as part of the Long Tunnel option.

Design information and construction approaches have been used from other projects in both New Zealand and Australia to develop the concept design. No specific design analysis has been undertaken due to the limited time available.

2 Tunnel Scope

The Long Tunnel consists of two tunnels and an off-ramp:

1. Terrace Tunnel duplication - the new Terrace Tunnel, a 3 lane southbound tunnel running parallel with the existing Terrace Tunnel serving as a dedicated southbound tunnel.
2. The Long Tunnel (2 tunnels with 2 lanes of traffic in each direction).
3. The Adelaide Road off-ramp extends from the southbound Long Tunnel and is treated as a separate element due it's construction methodology and it potentially being an option addition to the Long Tunnel.

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Figure 1 shows an overview of the Long Tunnel and Terrace Tunnel duplication.

Figure 1. Tunnel Overview

2.1 Tunnel Design Parameters

The design parameters assumed for the investigation are shown in the Table below.

Tunnel	Design Parameter	Design Requirement	Cross-Section (Appendix B)
[redacted] s 9(2)(ba)(ii)			
Long Tunnel	Tunnel diameters Tunnel separation and cover - Horizontal separation - Minimum cover (alignment)	12m OD Min. one tunnel diameter except for the norther portal area Min. 8m	B.3
Long Tunnel Portals	Bored tunnel separation and cover - Horizontal separation - Minimum cover portal (northern interchange)	 Min. 8m 6m at CH 260m (heavily reinforced tunnel lining segments to be used until	

	- Minimum cover portal (southern interchange)	minimum 8m cover can be achieved – approx. CH 280m) 8m at CH 3120	
	-		
Long Tunnel Mined Aotea Fault Zone	Widened area of long tunnel cross the fault zone. Design solution to be confirmed in future stages based on ground investigations.	Schematic included in Section 6.4.1 as a possible solution due to limited information on the fault.	
Adelaide Road Off-ramp and Long Tunnel Mined Cavern	Mined cavern for off-ramp: - Length - Min width - Max width Off-ramp: - Length - Min width:	 330m 12m 20m 260m 10m	B.4, B.5 and B.6

3 Ground Conditions

The project site primarily comprises the Rakaia terrane greywacke with a series of undifferentiated alluvial deposits occurring in paleo-valleys intersecting the alignment. A preliminary geological long section is shown in *Figure 2*

Long Tunnel Section

s 9(2)(ba)(ii)

[redacted]

The tunnel section will mostly be constructed in the greywacke of various degrees of weathering which comprises moderately strong to very weak rock and residual soil.

Geotechnical and hydrogeological conditions are discussed in a separate geotechnical desktop study memo.

4 Fire Life Safety (FLS) and Ventilation Design

Work to date has focused on utilising tunnel configurations from other recent tunnel projects in New Zealand and Australia and also reviewing the as-builts of the Terrace Tunnel along with the Asset Owners Manual following the upgrades in 2012.

The Terrace tunnel is 460 m long with bidirectional traffic. It opened in 1978 and reflects fire safety standards at the time. A fire safety upgrade was completed in 2012 with the work included ventilation and fire fighting systems. The design of these upgrades have not been reviewed as part of this stage.

The North South Bypass Tunnel (Brisbane) cross sections for the main tunnels, cross passages, mined cavern in the main tunnel and Adelaide Road off-ramp have been used for the Long Tunnels. It is considered a reasonable basis as the cross sections allow for the one or two traffic lanes with shoulders.

The Waterview tunnel cross passages have been used for the Long Tunnel and the Terrace duplication as well, being representative of Fire and Emergency New Zealand (FENZ) emergency and access requirements.

The Long Tunnel option assumed will accommodate the design traffic envelope, provisions for signage, ventilation, communication equipment, drainage, and other mechanical and electrical fillings.

Refinement of the cross sections have not been completed and will be needed in a future design stage to allow for the specific requirements of the Long Tunnel option including:

- Road traffic envelope (horizontal and vertical requirements) and shoulder widths
- Fire and life safety systems
- Fire and Emergency New Zealand – emergency and access requirements
- Ventilation requirements
- Utilities requirements
- Traffic control systems (e.g. comms, security).

The extent of bored tunnels, mined tunnels and open trenches will need to be reviewed once more information is known, specifically geotechnical conditions and topographical surveys.

4.1 Tunnel Ventilation

4.1.1 Terrace Tunnel Duplication

4.1.1.1 Tunnel Ventilation Concept

s 9(2)(ba)(ii)

[redacted]

s 9(2)(ba)(ii)

[redacted]

4.1.1.2 Tunnel Controls

The tunnel control system will need to incorporate the ventilation system of the new tunnel and the existing tunnel that is likely to require upgrading, expanding or replacing:

The functionality of the control of the existing tunnel ventilation system will need to change due to the switch from bidirectional to unidirectional.

The ventilation system in the existing tunnel and new tunnel will need to operate as a single system for an emergency scenario. The incident tunnel fans will operate to control smoke and the exact fans operated may depend on the fire location. The non-incident tunnel fans will operate to pressurise the non-incident tunnel and may also depend on fire location.

The new tunnel control building that will house the controls and plant for operating both tunnels can be located either on the open cut section above the southern portal or next to the decommissioned controls building on MacDonald's Crescent.

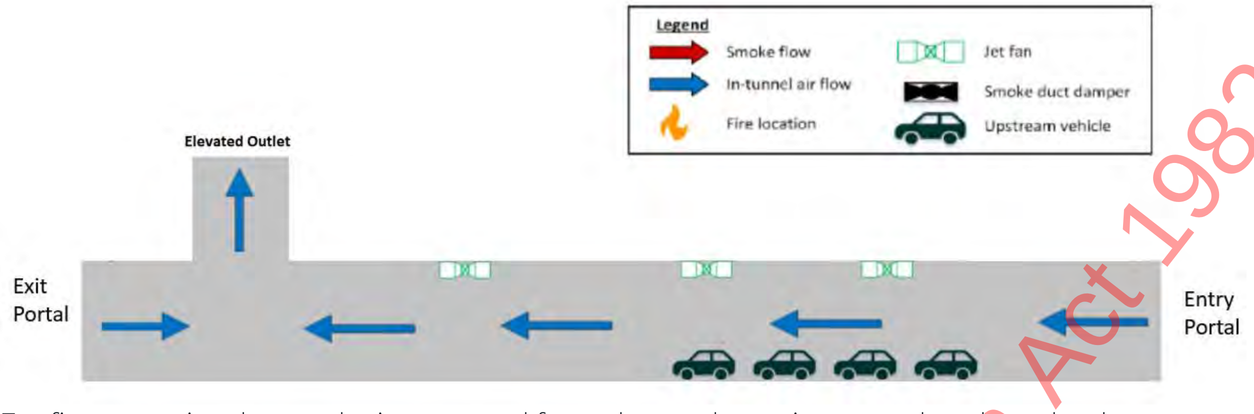
4.1.2 Long Tunnel

4.1.2.1 Tunnel Ventilation Concept

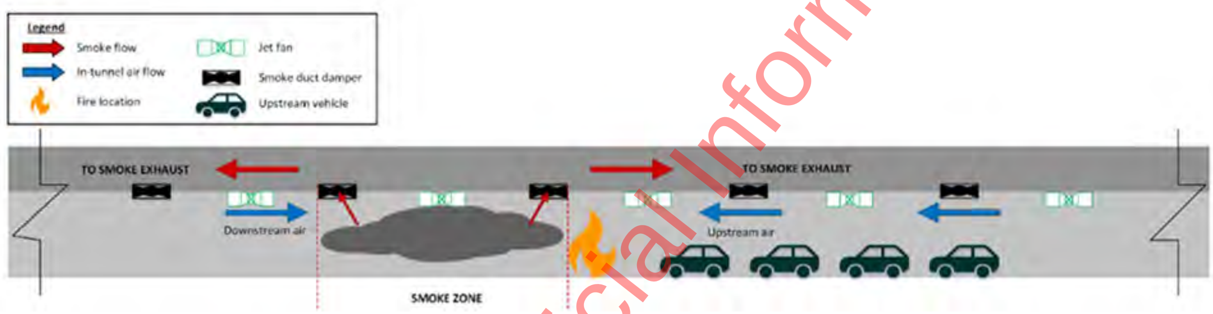
A longitudinal ventilation system combined with an overhead smoke exhaust system is an appropriate and typical system for unidirectional tunnels of this length.

For normal and heavy traffic conditions the longitudinal ventilation system will control in-tunnel air quality by drawing in fresh air from the entry portals of the tunnel. The vehicle movement in the tunnel will generally generate an airflow itself that will be sufficient to control in-tunnel air quality for most normal traffic conditions. In abnormal and congested traffic conditions, the tunnel airflow will need to be supplemented by the ventilation system.

At the tunnel exit portals an exhaust system will capture the tunnel air before it can be emitted through the exit portal. The portal exhaust system will emit the tunnel air to the atmosphere through an elevated outlet. The outlet emits the tunnel air at an increased velocity compared to emitting out of the portal. The elevation and velocity of the outlet helps to disperse the vitiated tunnel air to achieve external air quality requirements.



For fire scenarios the smoke is extracted from the roadway via an overhead smoke duct running the length of the tunnel. The smoke is drawn along the smoke duct by smoke exhaust fans at the portals. The smoke is then emitted to atmosphere using the elevated outlets. The longitudinal ventilation system is used in conjunction with the smoke exhaust system to ensure that smoke is contained with the fire smoke zone.



4.1.2.2 Tunnel Ventilation Equipment

The longitudinal ventilation system comprises of the following equipment:

- Jet Fans
    - Jet fans are suspended above the roadway.
    - Jet fans will typically be grouped into banks of two or three fans.
    - Each bank of jet fans will be separated typically by 100m.
    - The number and size of jet fans required will depend on numerous factors including traffic conditions, fire criteria and atmospheric conditions.
    - The jet fans will generally be located as close as possible to the electrical substations to minimise cable lengths.
- Portal Exhaust System
    - Exhaust fans located in plant rooms at each mainline tunnel exit portal.
    - Connections between the inlet side of the exhaust fans and the mainline tunnel prior to the exit portal, including dampers.
    - An elevated outlet at each exit portal, approximately 20m in height that is connected to the discharge side of the exhaust fans.
- Smoke Exhaust System
    - An overhead smoke duct running the full length of each mainline tunnel.
    - Smoke dampers mounted in the smoke duct to extract air from the tunnel into the duct. Smoke dampers will be space approximately every 60m.
    - Smoke exhaust fans located in a plantroom at each portal.
    - Connections between the inlet side of the smoke exhaust fans and the smoke duct

- Connection between the discharge side of smoke exhaust fans and the elevated outlet.

4.1.2.3 Tunnel Control Buildings

The southern portal buildings from Waterview Tunnel have been used as reference which includes the ventilation outlet and the substation – approximately 80m long and 30m wide. It is assumed for the Long Tunnel that both portals would have the control buildings and portal exhaust system built on top of it.

These assumptions will be further investigated/validated in the next stage of design development.

4.1.2.4 Future Opportunities

Elimination of the portal exhaust system. As vehicle fleets become cleaner and the proportion of electric vehicles increases, the pollution concentration of the vitiated tunnel air improves. External air quality requirements may be met even when emitting the tunnel air out of the exit portal. This would be subject to detailed modelling of the in-tunnel air quality and its dispersion to atmosphere at the portal. The probability of this opportunity is likely to increase into the future as the vehicle fleet changes.

Combining the portal exhaust fans and smoke exhaust fans. The operating duty of the two fan types is likely to be very different and has driven having separate systems. However, there may be an opportunity to have a single set of fans to serve both systems which would reduce plant room space requirements. This would require detailed design calculation of the two systems and engagement of industry fan suppliers.

Elimination of the smoke exhaust system. Subject to the Fire and Life Safety assessment, it may be possible to remove the smoke exhaust system. In this case the longitudinal ventilation system would push the smoke down the tunnel towards a portal. The smoke would then be either pushed out of the portal or extracted by the portal exhaust system.

4.1.3 Adelaide Road Off-ramp

A portal exhaust system is not proposed for the Adelaide Road off ramp. The pollution generated in this short length of single lane off ramp will be low and external air quality requirements may be met when emitting the vitiated tunnel air from the portal. If external air quality criteria is not met, then the ventilation system can be used to push air in from the portal and down the off ramp into the mainline tunnel.

4.2 Evacuation Passages

4.2.1 Terrace Tunnel Duplication

s 9(2)(ba)(ii)

s 9(2)(ba)(ii)

4.2.2 Long Tunnel

The adopted spacing for egress via cross passages is at 150 m centres, the same as the Waterview Tunnel. The internal width for egress should be minimum 1.5 m and 2.1 m height, with refuges for wheelchair users if stairs are needed in any cross passages.

4.2.2.1 Adelaide Street Off-ramp

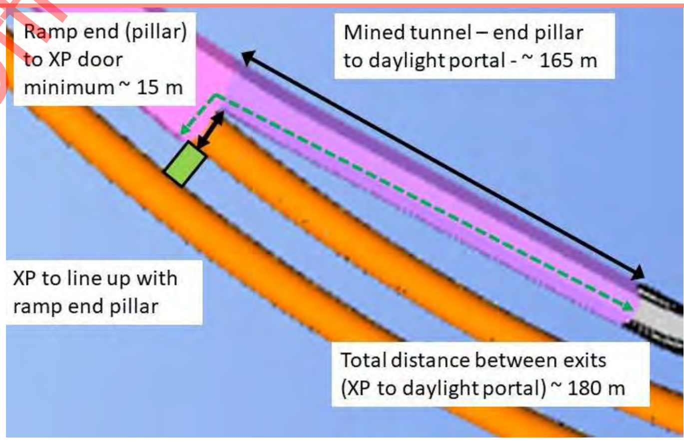
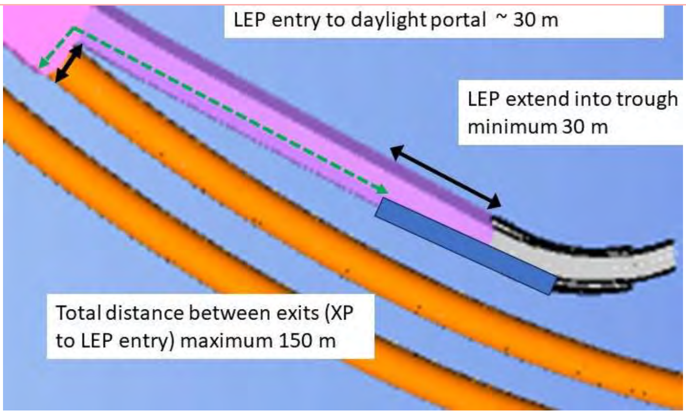
The ramp is approximately 180 m long from the end of the rock pillar at the diverge cavern, to the daylight portal.

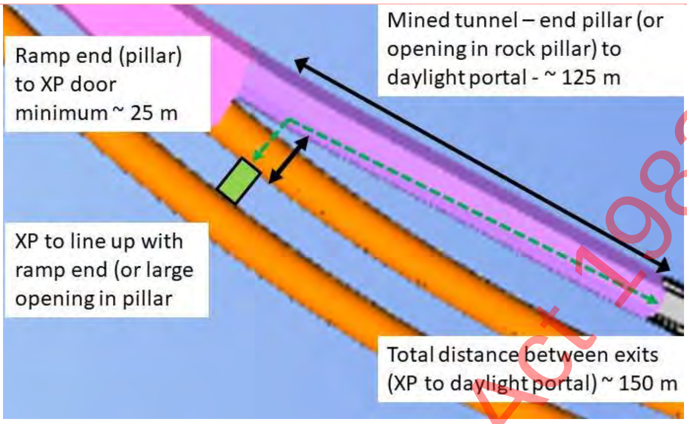
The trench/trough beyond the daylight portal is 70 m long, rising from a depth of approximately 10 m to grade.

It is approximately 15 m from the corner of the ramp rock pillar to the nearest possible cross passage (XP) door location (XP door to adjacent mainline tunnel).

The total distance between the daylight portal (exit) and nearest possible XP door location is approximately 180 m which is over 150 m limit between XPs. This distance could be exceeded, subject to analysis and approval by stakeholders; however, feasible options to keep to a 150 m limit, and issues around exceeding 150 m are presented in Table 1 below. Included in Appendix C is the full list of options considered.

Table 1 – Emergency Egress Options for Adelaide Off-ramp

Option	Description	Arrangement
1	No additional measures Distance between exits 180 m	
2	Longitudinal Egress Passage (LEP) LEP would require an internal clear width of 1.5 m Distance between exits 150 m (reflected in Appendix B.6 cross section)	

5	Keep face of rock pillar at current location (100 m chainage) and have large opening in pillar approximately 3 m wide, and 2.4 m high. Distance between exits 150 m	

Option 2 is recommended to continue in the next stage of design development and a cross section including the LEP provided in Appendix B.6.

4.3 Fire Services

4.3.1 Terrace Tunnel Duplication

s 9(2)(ba)(ii)

[redacted]

4.3.2 Long Tunnel

4.3.2.1 Deluge and Hydrant

The deluge and hydrant systems have a large spatial requirement, for water storage, pump rooms and boosters for fire service use, at the surface; and valve sets below ground.

At the surface, water storage in the order of 2,000,000 L is required (deluge and hydrant). This could be located below surface, although construction and maintenance costs increase significantly.

The cross passages can accommodate the deluge and hydrant valves. Similar arrangements to Waterview can be adopted. The internal width should be approximately 4 to 5 m minimum, with an internal wall length of at least 6 m to accommodate the deluge valve set arraignments.

The cross passage opposite the ramp end rock pillar will need to accommodate the ramp services equipment and valve sets, and may need to need to be wider, by approximately 4 m. This additional width could be reduced, if a plantroom is provided close to the tunnel portal to serve the whole ramp, or part of the ramp.

4.3.2.2 Electrical Services

It is likely that a substation for power intake and distribution will be required for the Long Tunnel.

The distribution substation and switch room location arrangements will depend on equipment locations and distribution voltage strategy.

Currently it is assumed to be part of the portal buildings however is dependent on the power supplier's recommendations to supply the total power requirements.

5 Tunnelling Techniques

Tunnelling techniques, which are anticipated for the Long Tunnel Option, are discussed below:

A Tunnel Boring Machine (TBM) is anticipated to be feasible for the expected site ground conditions. There are several recent tunnelling projects where a TBM was used in similar materials, most notably the Waterview Tunnel, Auckland (Figure 3). The TBM is expected to provide a better tunnelling productivity than mined tunnelling methods and therefore offers a lower programme risk. A shielded TBM will help manage geotechnical and hydrogeological risks better and be less susceptible to variations in ground conditions and groundwater than an open mined tunnel operation would be.

An Earth Pressure Balance (EPB) TBM is expected to be feasible for this project, based on a preliminary review of the ground conditions, material characteristics and hydrogeology. A double shield TBM is probably also suitable, which would give increased tunnelling rates compared to a single shield EPB TBM, although at the expense of its ability to balance ground and groundwater pressures. This option is therefore subject to confirmation through further detailed investigation and geotechnical and hydrogeological assessment, whereby geotechnical risks may outweigh production rate advantages. At this stage an EPB machine should be assumed.

It is considered economically viable to purchase TBMs and associated infrastructure for the proposed 2.4 km twin Long Tunnels, even with sections of mined tunnels along the length. TBMs require a large construction space for assembly and operation logistics. This dictates methodology and is further discussed in the following sections.

Figure 3 EPB TBM used for the Waterview Tunnel, Auckland

5.1 Mined Tunnel

Mined tunnelling is also technically feasible based on the expected ground conditions, but less preferred for the Long Tunnel because of a lower productivity and increased geotechnical and groundwater risk that may arise if adverse conditions were encountered. s 9(2)(ba)(ii) [redacted]

Details are discussed in subsequent sections.

Figure 4 Mined Tunnel Construction, using a roadheader

5.2 Cut and Cover Tunnel

Cut and cover tunnels are required where ground conditions and over-tunnel cover make TBM and mined tunnelling methods unfeasible and where the excavated ground needs to be restored to its original level. Cut and cover tunnels are suitable when the excavation depth is not excessive due to the volume of material that needs to be excavated to construct the tunnel, this depth is typically up to 30m. Cut and cover tunnel structures are required for the northern and southern portal ventilation structures and likely the shallower part of the Adelaide Road off-ramp.

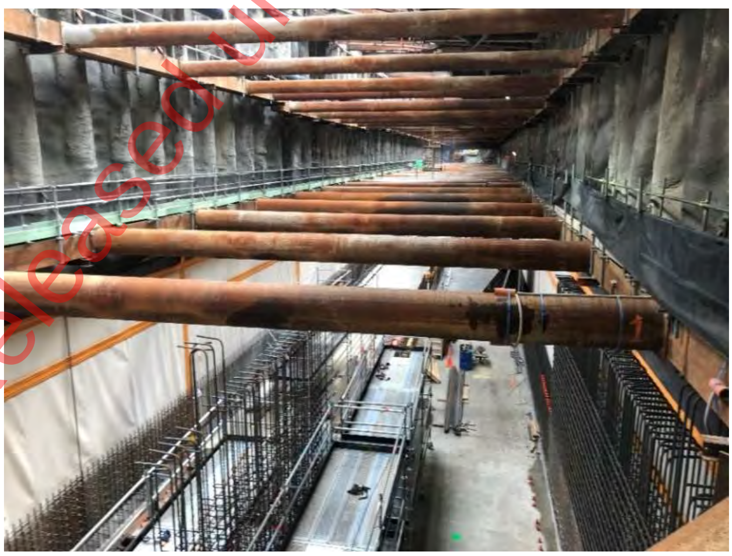


Figure 5. Cut and Cover Tunnel Construction

6 Construction Methodology

6.1 Terrace Tunnel Southbound

s 9(2)(ba)(ii)

s 9(2)(ba)(ii)

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6.2 Long Tunnel

6.2.1 Construction Sequence

The proposed tunnel alignment is located almost entirely in built up residential and commercial areas of Wellington. The construction methodology and sequence therefore needs to be developed to maximise the available space for work sites and minimise the construction footprint.

It is considered desirable to utilise two TBMs to construct the twin tunnels, from an overall project construction program perspective, although it should be noted that a single TBM could be used to construct both northbound and southbound tunnels, with a turnaround shaft at one end, akin to the method adopted for the Waterview Tunnel in Auckland a few years previously.

Given the site constraints at and access routes into the northern portal area, in the vicinity of the Northern Interchange, the two TBMs would more realistically be launched and driven in a northerly direction from Kilbirnie to a reception shaft at the northern portal. The Kilbirnie area offers far greater space to assemble and operate two TBMs from and also to supply the segmental lining in and handle spoil out than the northern interchange area.

Figure 8. Dual TBM assembly and launch from Legacy Way, Brisbane (left) and Westgate, Melbourne (right)

When driving two TBMs in a parallel formation, such as this, is it sensible to allow a stagger between the two machines. This is in part due to the possibility of the first TBM encountering adverse ground conditions that would give the second (trailing) TBM time to prepare for. Staggered TBM drives help mitigate ground surface settlement risk. But there are also practical and logistical reasons for a stagger between TBMs. Machines of this size (nominal 12,5m cut diameter) require specialist labour and plant / support equipment to assemble, such as cranes and transport vehicles, plus a significant amount of space to lay out the machine component pieces and unpack a large number of shipping containers containing necessary components. Therefore, the established approach of assembling one TBM and launching it before doing the same for the other TBM(s) places less demand on the specialist labour, support plant and space required.

The TBM manufacturer ultimately selected for the project will deploy a team of experienced mechanics, technicians and electricians along with the delivery of the TBMs to help the contractor correctly assemble and commission their machines. Staggering the assembly and launch of two TBMs allows the manufacturer's specialists to concentrate on one machine at a time to ensure it is in complete running order, before commencing on the second machine build and launch. Contractual commissioning milestones are also generally attached to a TBM supply contract that require the sign-off and acceptance by the contractor (sometimes also the end client), thus a high order of quality assurance is expected in the build, launch and commissioning of such complex, high-value TBMs.

It is anticipated that the northbound tunnel will be launched first from the Kilbirnie end of the alignment. This will give additional time for the Adelaide Off Ramp cavern to be constructed before it needs to receive the southbound tunnel TBM. The recommended construction sequence for receiving the two TBMs at the northern end of the alignment is shown in Figure 9.

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Tunnel work site and access road concepts are discussed in the following sections.

6.2.2 Tunnel Work Site

Due to operational logistics of both plant, spoil removal and segment supply, it is assumed that the TBMs will be driven from the south end of the alignment, as this end has far better access for plant, materials and spoil removal, as well as potentially available open space for the work site. Kilbirnie Park and the zone adjacent to SH1 has been identified as a possible TBM tunnelling site, it is close to the alignment and of a decent size (approx. 36,000m^2). In addition, the close proximity to the waterfront of Evans Bay may be beneficial for delivery of heavy over-dimension TBM components and tunnelling equipment via barge. By comparison, the Waterview TBM operation site in Auckland was around 30,000m^2. The TBM work site concept at the Kilbirnie end of the alignment is shown in Figure 10.

Figure 10. TBM work area (South end at Kilbirnie)

In this concept, the TBM work site comprises two main areas, TBM launch and operation site area adjacent to SH1, which will be required to assemble and launch the TBMs, and the TBM support site area within Kilbirnie Park, where support plant and equipment will be based. Details of the TBM work area and site access are provided in Appendix A.

At the Northern Interchange end of the Long Tunnel alignment, the TBMs will be received and demobilised from the tunnels. A TBM reception box shaft concept at the north end is shown in Figure 11. The TBM reception shaft used for the 14 m outside diameter (OD) Waterview Tunnel TBM was approximately 40 m by 40 m. For the slightly smaller Long Tunnel machine (circa 12.5m OD), the required dimensions of the shaft would be in the order of 35 to 40m by 35 to 40m.

Figure 11. TBM reception box shaft at the north end of the alignment

6.2.3 Construction Methodology

The southern portal decline trench can be constructed using retaining structures such as secant piles or diaphragm walls. Part of the southern portal is anticipated to be a cut and cover structure to accommodate a ventilation building.

Precast segments to be placed by the TBMs during tunnel excavation will be transported from the southern end into the tunnels using specialist high-capacity transport vehicles. There will need to be a sufficiently sized precast segment storage area in close proximity to the southern tunnel portal, as well as appropriate craneage such as a gantry crane, to feed the TBMs as they advances. Additional segmental lining elements would be held offsite, likely at the casting yard, and delivered regularly to the Kilbirnie tunnelling in line with the production rate. With two TBMs excavating in parallel over the planned tunnel length, the number of segments elements required will be significant (potentially in excess of 25,000 units), and thus a manufacturing and logistics operation in its own right.

Spoil would be conveyed to a spoil handling building (shed) at the tunnelling operations site in Kilbirnie to then be disposed of or reused if suitable. Each tunnel would require a tunnel conveyor to support its TBM but both can be routed to a combined spoil handling building. The spoil shed will need to have sufficient capacity to manage the anticipated peak production of two TBMs, which although operating in a staggered arrangement will be excavating simultaneously. The spoil shed should also have sufficient buffer capacity to store several days' worth of spoil in the event of delay in spoil removal such as inclement weather or transport issues.

A cut and cover structure and a ventilation building are anticipated be constructed in the northern TBM reception shaft after the completion of tunnelling works, as was the case with the Waterview tunnel and various other reginal tunnelling projects.

There is an option to provide an off-ramp in the southbound tunnel connecting to Adelaide Road. At this location, an enlarged mined cavern is constructed to provide a bifurcation. This is further discussed in Section 6.3.

6.3 Adelaide Road Off-ramp

6.3.1 Overview

An off-ramp is proposed to branch out from the southbound tunnel under Mount Cook. The off-ramp starts as a single lane with a shoulder and becomes a two-lane off-ramp outside the cavern. The 3D model showing the off-ramp and bifurcation mined cavern is shown in Figure 1212.

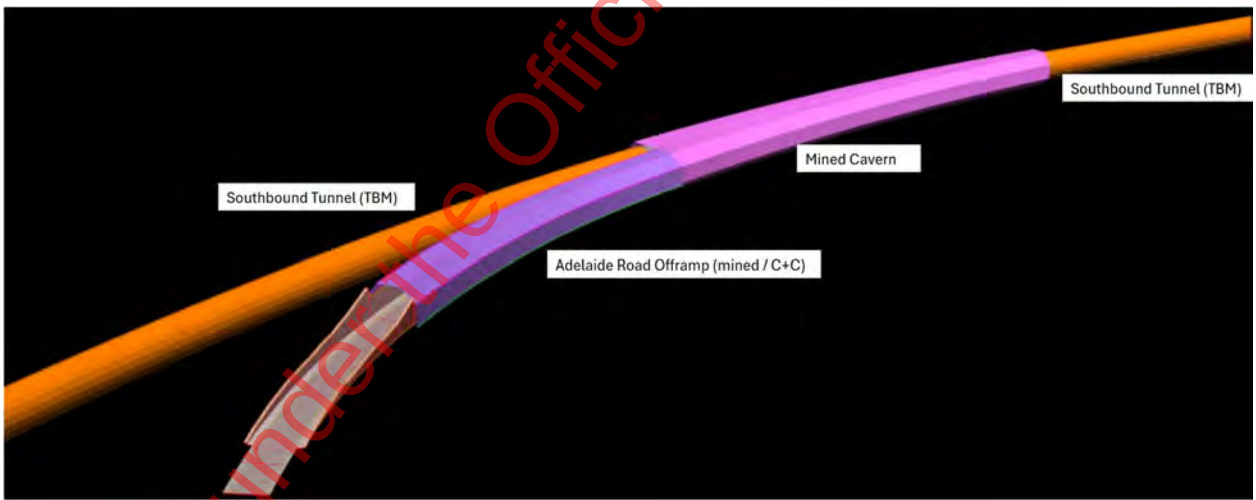

Figure 12. Adelaide Road Off-ramp and Mined Cavern, plus Southbound Tunnel

6.3.2 Tunnel Work Area

The construction area required for the Mined Cavern and Adelaide Road Off-Ramp tunnel has been estimated and developed from a similar recent tunnel project (Airport Link, Brisbane) and is assumed to be approximately 6,400m^2. This is shown in Figure 13.

Access to the mined cavern would be via the off- ramp tunnel which would be constructed first from the work site on Adelaide Road. the worksite is assumed to be located within current light industrial zoning, whereby a number of buildings will need to be removed to allow the formation of the site. This is necessary to minimise disruption to roads and local residents.

Figure 13. Tunnel Work Area for Adelaide Road Off-ramp and Mined Cavern, Southbound Tunnel

6.3.3 Construction Methodology

The bifurcation cavern could be constructed using the sequential excavation method (SEM) subject to confirmation of ground conditions and hydrogeological assessment so as to reduce the construction risk. This cavern is expected to be around 20 m wide at the widest section where three lanes (two road lanes plus off-ramp) and shoulder effectively exist. The construction of such a wide span cavern would likely involve subdividing the tunnel profile and excavating in multiple headings and benches to minimise ground movement. This is a well proven methodology for excavating large diameter tunnel / cavern spans in weathered rock conditions.

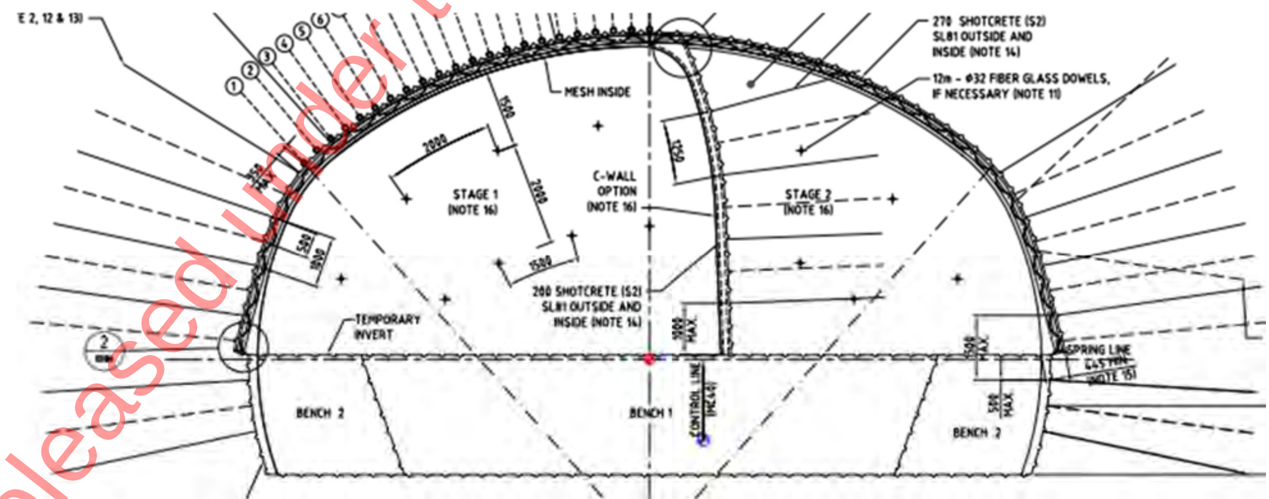

Figure 14. Split Heading and Bench Excavation of a Mined Tunnel (Airport Link, Brisbane example)

Figure 15. Examples of SEM excavation

Expected ground conditions are variably weathered greywacke. A combination of roadheaders and excavators will be suitable to excavate various materials. The excavation will be temporarily supported by shotcrete lining and a range of support types including canopy tubes, spiles and rock bolts. Permanent lining will be constructed insitu upon completion of excavation and waterproofing to form an undrained (tanked) lining.

The southbound TBM breaks in from the southern headwall of the cavern and then 'walks' through to the northern headwall to be relaunched using a combination of hydraulic jacks and skid cradles. This is a well proven approach to move a TBM through a cavern or mined tunnel. TBM transfer such as this was recently carried out in a mined tunnel on City Rail Link Project, Auckland

Figure 16. TBM transfer through a mined cavern, City Rail Link, Auckland

The off-ramp tunnel is envisaged to be constructed using either a mined tunnelling or cut and cover / trench approach. The extent of mined tunnel and cut and cover / trench is subject to confirmation of ground conditions, groundwater conditions and alignment, as well as the location of any overlying sensitive services and utilities.

6.4 Aotea Fault Crossing

6.4.1 Aotea Fault Section Cavern

The proposed Long Tunnel crosses the Aotea Fault which is an active fault inferred to run along Adelaide Road as shown in Figure 17.

Figure 17. Long Tunnel Aotea Fault Crossing

There is currently limited information on the recurrence period, the magnitude and orientation of the fault rupture. The consequence of a fault rupture is significant and warrants a provision for fault displacement. WSP has experience in the design of tunnels crossing faults for international projects including the Eurasia Tunnel, Turkey and LA Metro Red Line, USA. With little information available an assumption has been made that a specific engineering solution will be required. At this stage of the project, it has been assumed that oversized caverns will be constructed in advance of the TBM tunnels to accommodate some potential movement and also potentially enable repair of the tunnel from within the structure following an event. The fault zone cavern adopted for LA Metro is shown in Figure 16. The figure only shows a concept. The required dimensions of the Aotea Fault crossing section depend on the anticipated fault movement and orientation which need to be determined in further stages. Granular aggregates could be used as tunnel invert backfill so that pavement could be reinstated speedily following a fault rupture event. The TBM tunnel alignment either side of the mined caverns may need to diverge slightly to provide sufficient pillar width between each cavern, whereby the cavern size will be dependent upon the expected magnitude of fault movement.

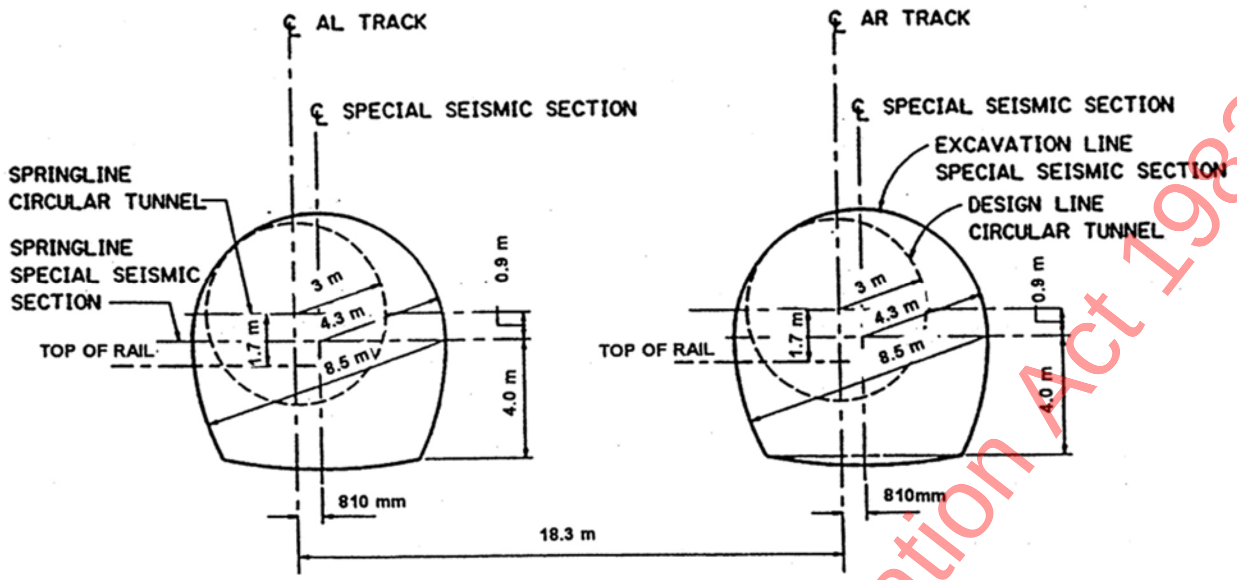

Figure 18. LA Metro Red Line – Seismic Zone Fault Crossing Caverns (Smirnoff et al, 1995)[1]

6.4.2 Tunnel Work Area

The same work area would be used for the Adelaide Road Off-ramp and the Aotea Fault Section Caverns (refer section 7.3.2). If the off- ramp tunnel and bifurcation cavern and fault caverns are constructed simultaneously (likely required), a larger work area is expected to be required due to the additional area taken up by the fault caverns and the additional plant and equipment plus workforce needed to undertake the work.

6.4.3 Construction Methodology

Access would be via a temporary shaft which may span across both caverns as shown in Figure 19. The shaft would likely need to be D-walled or secant piled with internal strutting due to ground loads in the alluvial soils expected here.

Figure 19. Access Shaft for Aotea Fault Section Caverns

[1] Smirnoff, T.P., Elioff, M.A., Monsees, J.E. (1995) *Tunneling through the Hollywood Fault Zone for the Los Angeles Metro*, Mechanics of Jointed and Faulted Rock, 913-919.

The caverns should be excavated and supported sequentially to minimise ground movement. Top heading (nominally 6 m high) would be excavated and supported by pre-support methods, likely using canopy tubes and fibre reinforced shotcrete, potentially with steel sets as well if indicated through design modelling. This heading would be followed by bench and tunnel invert excavation. Following the completion of excavation and primary support installation, the TBMs will break in at the southern end and 'walk through' the excavated cavern. The TBMs will then be relaunched at the northern end of the cavern. The mined caverns would then be lined insitu and waterproofed to prevent long-term groundwater drawdown and consolidation of alluvial sediments here. Permanent lining of the caverns could be constructed before or after TBM walk through, depending on program constraints and other critical path activities. Details of the recommended construction sequence are included in Appendix A.

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6.6.1 [redacted] s 9(2)(ba)(ii)

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6.6.2 TBM Tunnels

The TBM Tunnels to be driven from the Kilbirnie site will require substantial support logistics to ensure that the machines can be operated at full capacity. Volumes of excavated material and the rate of excavation over the total length will likely require the establishment of an in-tunnel conveyor belt system in each tunnel, rather than deploy a large number of tunnel trucks, which as the distance increases will be more prone to delay. The tunnel conveyor would run out to the surface support site adjacent to SH1 / Kilbirnie Park where a covered spoil enclosure ('shed' is the common term) would be established. The 'shed' ought to have sufficient capacity to store several days' worth of excavated material in case of onward movement delays due to say weather to traffic issues. The volume needed would be determined by the expected tunnelling program for two machines.

Where the TBM excavated spoil is ultimately taken will need to be determined, as the total volume will be significant, so landfill disposal is one option but a demanding one. Ideally the TBM excavated spoil could be reused for filling or reclamation if there is a need at the time, to save setting up a temporary spoil storage location off-site. For the twin TBM tunnels proposed for the Long Tunnel option the total bulk spoil volume will be in the order of 400,000m^3 per tunnel, so 800,000m^3 for the pair, hence logistics handling and end use management of this volume will be a critical consideration.

The TBM tunnels to be excavated by EPB machine will likely not have to deal with notable groundwater inflows due to the pressurised nature of the machine, which will act to restrain the ground and groundwater inflows, as well as the pre-cast lining placed immediately behind the shield. This assumption is subject to appropriate machine specification, crew skill and ongoing presentative maintenance to ensure that the machines can operate as required. However, some groundwater will still enter the tunnel at the TBM tunnel cutterhead, as well as there being construction water pumped in to the machine for cooling, spoil conditioning and dust suppression. The groundwater and construction water will be collected (together) and pumped out to surface it will be treated prior to disposal.

Materials to be taken into the TBM tunnels will primarily be the precast segmental lining elements installed behind the shield. The precast segmental lining would be manufactured offsite and transported to the TBM operations site. Sufficient segments must be available on site to keep up with the rate of tunnelling of both TBMs and to act as a buffer in case of delays in delivery from the offsite manufacturing yard. The site set up employed on the Waterview Tunnel in Auckland offers a good parallel to the needs the Long Tunnel will face in terms of segmental lining logistics and onsite storage for a linear construction site, noting though that this was for a single TBM (used twice). Segments would be delivered to the TBM through the tunnel using purpose-built carriers which can operate on the curved invert of the ongoing tunnel and surface access roads. They are specialist pieces of equipment that are fundamental to the safe and effective construction of TBM tunnels.

Appendix A – Tunnel Work Areas

A.1: Terrace Tunnel duplication

A.2: Long Tunnel

A.3: Adelaide Road off-ramp

A.4: Adelaide Road (Aotea fault)

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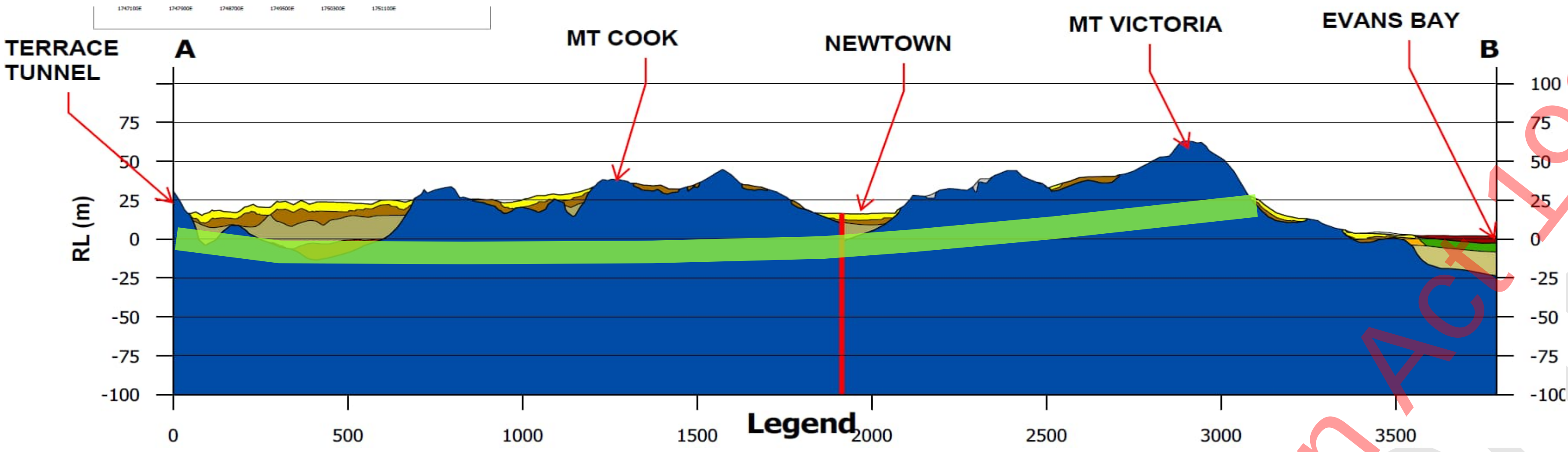
LONG TUNNEL - TBM BORED TUNNEL METHOD FROM SOUTH END

Long tunnel assumed to run from Wellington Road to just south of the Terrace Tunnel
Assumes driving from the southern end where space can be provided as well as spoil removal, potentially by sea
Assumption that TBM will excavate through the Greywacke rock forming the high ground, as well as alluvial sediments infilling the low areas between
TBM to be received at a reception / turn around site in the vicinity of Buller St / Oak Park Ave to then be relaunched south back to Kilbrinie Park (similar approach to Waterview in Auckland)
TBM reception / turn around site needs to be a box shaft nominally 40m by 40m in plan with capacity for heavy craneage adjacent to box for TBM reception works



TBM OPERATIONS AND SUPPORT SITE - SOUTH END AT KILBRINIE PARK AND SURROUNDS

Major site set up consisting of TBM launch and operations site plus support site
Nominal site areas aim to keep SH1 open, as well as Kilbrinie Crescent and Evans Bay Parade
TBM assumed to launch into hillside west of Wellington Road where topography climbs steeply

TBM Launch and Operation Site (yellow polygon) - area approx. 16,000m2
Established south of SH1 along tunnel alignment
Takes over several properties to south of SH1
Provides the following support to TBM operation;
- > TBM delivery and assembly area
- > Heavy crane platform for assembly
- > TBM launch structure and portal
- > Segmental lining storage and handling facilities (gantry crane)
- > Plant and equipment laydown (storage)

TBM Support Site (light blue polygon)
Takes a portion of Kilbrinie Park (approx. half) - to be reinstated following completion of works - area approx. 20,000m2
Provides the following support to TBM operation;
- > Project office
- > Workforce welfare facilities and first aid
- > Segmental lining storage area
- > Spoil handling facility - shed and conveyor
- > TBM cooling plant
- > Workshop and warehouse
- > Water Treatment Plant
- > Electrical substation for TBM power
- > Office / workforce parking
- > Opportunity exists to run an elevated conveyor belt from site to sore for spoil removal by barge

NOTIONAL TBM RECEPTION / TURN AROUND BOX SHAFT AT NORTH END OF ALIGNMENT

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WORK IN PROGRESS
A.2 Main Alignment

TBM TUNNELLING SEQUENCE

OPTION A - SINGLE TBM DRIVEN TWICE WITH TURN AROUND SHAFT

Open cut formed for road alignment, propped where vertical height dictates
Kilbirnie Crescent kept operational through a bridge constructed over the open cut portion of the alignment
TBM assembled in Kilbirnie Park area at southern end of alignment - past open cut props
TBM walked forward to launch point below open cut props to launch face
Reception / turnaround shaft constructed at the northern interchange area
Northbound tunnel excavated first through to reception / turn around shaft
TBM shield turned through 180 degrees to launch position for the southbound tunnel
TBM relaunched and operated via umbilical lines until sufficient distance in to accommodate backup gantries
Backup gantries then turned through 180 degrees and connected to the TBM shield
TBM continues to excavate south, passing through the Adelaide Road off ramp cavern formed in advance
TBM continues to excavate south to Kilbirnie Park where it breaks through and is dismantled there

OPTION B - TWO TBMs DRIVEN ONCE EACH

Open cut formed for road alignment, propped where vertical height dictates
Kilbirnie Crescent kept operational through a bridge constructed over the open cut portion of the alignment
TBM1 assembled in Kilbirnie Park area at southern end of alignment - past open cut props
TBM 1 walked forward to launch point below open cut props to launch face
TBM Reception shaft constructed at the northern interchange area
Northbound tunnel launched first and driven through to reception shaft
Southbound tunnel launched second and driven through to reception shaft (staggered by several months)
Northbound TBM received into the reception shaft, either slid sideways to southbound tunnel and removed or removed vertically above breakthrough point
 - depending on gantry crane set up
Southbound TBM received into reception shaft and removed vertically above breakthrough point

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ADELAIDE ROAD FAULT ZONE - CAVERN METHOD

Due to the expected presence of the Aotea fault running along Adelaide Road, it has been suggested that tunnel caverns be constructed to address movement.
TBM tunnel itself would be more susceptible to fault movement, so a mined tunnel with movement allowance would be constructed in this location.
One cavern per tunnel is proposed rather than a single large cavern of at least 38 metres width to cover both TBM tunnels.
TBM tunnel alignment either side of the mined caverns may need to diverge slightly to provide sufficient pillar width between each cavern.
Cross passages either side of the cavern (fault) zone may need to be slightly longer to cater for increased tunnel separation.
TBM would then be pulled through the mined cavern and relaunched to complete the northbound and southbound drives.
The mined caverns would be lined insitu and waterproofed to prevent long-term groundwater drawdown and consolidation of alluvial sediments here.

SUGGESTED METHOD AND HIGH-LEVEL SEQUENCE

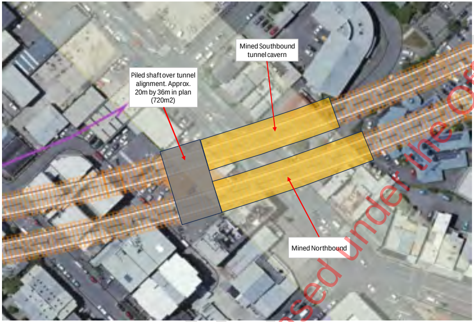
Mined cavern worksite

Construct access shaft / box over the tunnel alignment, encompassing both tunnels

- Shaft size approx. 36m wide (over both tunnels) by 20m long - area approx. 720m2
- Shaft would likely need to be D-wall or secant pile with internal strutting due to ground loads in alluvial soils
- Risk of groundwater ingress into shaft between piles / panels, so grouting would be recommended to seal
- Shaft ultimately excavated full depth to TBM tunnel invert level to allow translation of TBM later
- Likely that a larger site footprint would be required here if fault zone access shaft is constructed in addition to the Off Ramp (approx. 8,500m2)

Mined cavern tunnels excavated as heading and bench, potentially split headings to reduce ground movement above

- Excavate access shaft to a temporary invert level to allow mined tunnel heading to be excavated, nominally 6m high heading
- Excavate tunnel heading of both southbound and northbound tunnels and install primary (temporary) crown ground support
- Excavate access shaft to bench level to allow mined tunnel bench to be excavated, nominal 4m high bench
- Excavate tunnel bench of both southbound and northbound tunnels and install primary (temporary) wall ground support
- Excavate access shaft to final invert level to allow mined tunnel invert to be excavated, nominal 2m high invert
- Excavate tunnel invert of both southbound and northbound tunnels and install primary (temporary) invert ground support



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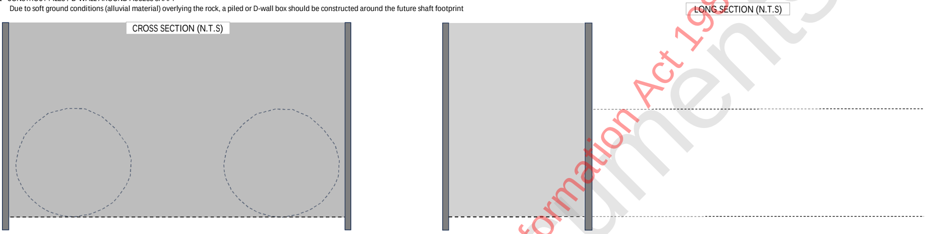
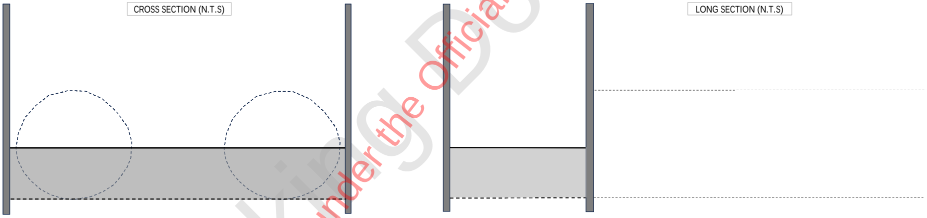
A.3 Adelaide Rd (fault zone)

STAGE 1 - CONSTRUCT PILES / D-WALL AROUND ACCESS SHAFT
Due to soft ground conditions (alluvial material) overlying the rock, a piled or D-wall box should be constructed around the future shaft footprint



STAGE 2 - EXCAVATE SHAFT TO TEMPORARY BASE LEVEL EQUAL TO BOTTOM OF TUNNEL HEADING LEVEL
Excavate shaft down to mined cavern tunnel heading bottom level
Install shaft propping across opening to resist ground loads at appropriate vertical spacing



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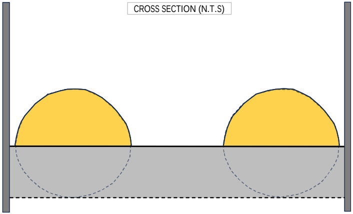
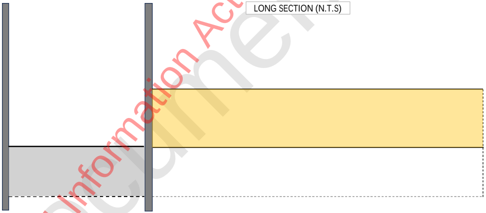
A.3 Adelaide Rd (fault zone)

STAGE 3 - EXCAVATE BOTH MINED TUNNEL CAVERNS FOR FULL LENGTH OF HEADING

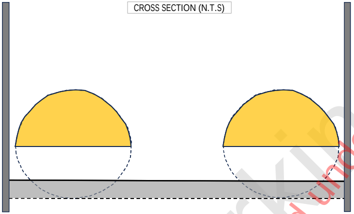
- Excavate top headings of both tunnel using rock or soft ground mining methods as required
  - Equipment would include, tunnel excavator, roadheader, rock bolting rig, shotcrete rig, other support equipment
- Install necessary ground support based on encountered conditions (for rock, soft ground or mixed)
  - Rockbolts, face presupport, split heading, steel sets / lattice girders and fibre reinforced shotcrete
- Undertake appropriate ground and building movement monitoring

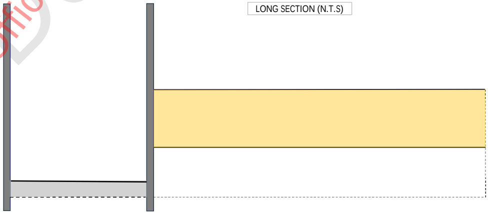




STAGE 4 - EXCAVATE SHAFT TO TEMPORARY BASE LEVEL EQUAL TO BOTTOM OF TUNNEL BENCH LEVEL

- Continue to excavate shaft down to mined cavern tunnel bench bottom level





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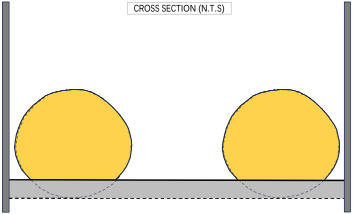
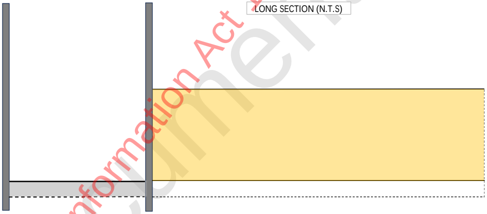
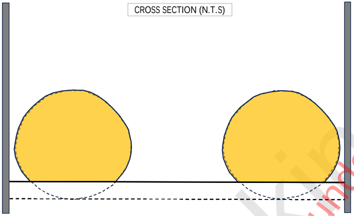
A.3 Adelaide Rd (fault zone)

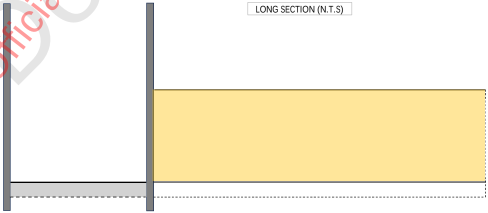
STAGE 5 - EXCAVATE BOTH MINED TUNNEL CAVERNS FOR FULL LENGTH OF BENCH
Excavate bench of both tunnels using rock or soft ground mining methods as required - as noted in Stage 3
Install necessary ground support based on encountered conditions (for rock, soft ground or mixed) - as noted in Stage 3
Undertake appropriate ground and building movement monitoring





STAGE 6 - EXCAVATE SHAFT TO FINAL FORMATION LEVEL EQUAL TO MINED AND TBM TUNNEL INVERT LEVEL
Continue to excavate shaft down to mined cavern tunnel invert level





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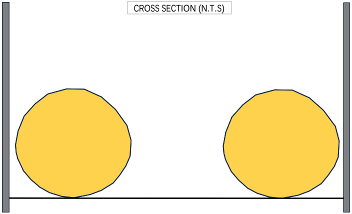
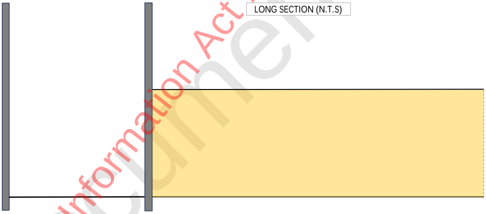
WORK IN PROGRESS
A.3 Adelaide Rd (fault zone)

STAGE 7 - EXCAVATE BOTH MINED TUNNEL CAVERNS FOR FULL LENGTH OF INVERT

Excavate invert of both tunnels using rock or soft ground mining methods as required - as noted in Stage 3
Install necessary ground support based on encountered conditions (for rock, soft ground or mixed) - as noted in Stage 3
Undertake appropriate ground and building movement monitoring





STAGE 8 - POST MINED CAVERN EXCAVATION

Once excavation and primary support is complete the caverns would be prepared for TBM transfer (walking through)
Temporary works such as cradle and push rings and rail installed to allow TBM to move through excavated cavern
TBM would be relaunched at the end of the cavern tunnel once the fault treatment zone
Permanent lining of cavern tunnel could be installed before or after TBM walk through, depending on program constraints

CONFIDENTIAL
WORK IN PROGRESS
A.3 Adelaide Rd (fault zone)

CONFIDENTIAL
WORK IN PROGRESS
A.4 Adelaide Rd Ramp

ADELAIDE ROAD OFF-RAMP MINED TUNNEL SITE
Total available land area approx. 6,400m2
Site facilities areas based on AirportLink, Brisbane project - Kedron Cavern access ramp site

Coppard, Glenn 4:46 PM
IMPORTANT!
Evening NZ Project - Wellington Highway Improvements Scoping (5-C4800.00) team,

Updated PDF on the Notes Tab above.
Ramp realigned to intersect opposite Hospital Rd.
Ramp Length increased to allow for 250m Dual Lane Stacking
100m of Parallel Lane Length within the main cavern (ie. 3 lanes wide)
plus the numerous lane & shoulder tapers that will need to be further 'smoothed' in due course

3D Model Viewer in the PDF has a few Cross Sections Views saved for you navigating pleasure
Look for these on the 'Views' drop-down as shown below.

KEDRON MINED TUNNEL / CAVERN WORK SITE

Offices / crew facilities	1,000 m2	(assume double stack)
Workshop	400 m2	
Support equipment area	1,000 m2	
Workshop	900 m2	
Laydown	2,000 m2	
Spoil/opps noise shed	1,500 m2	

Appendix B – Proposed Cross Sections

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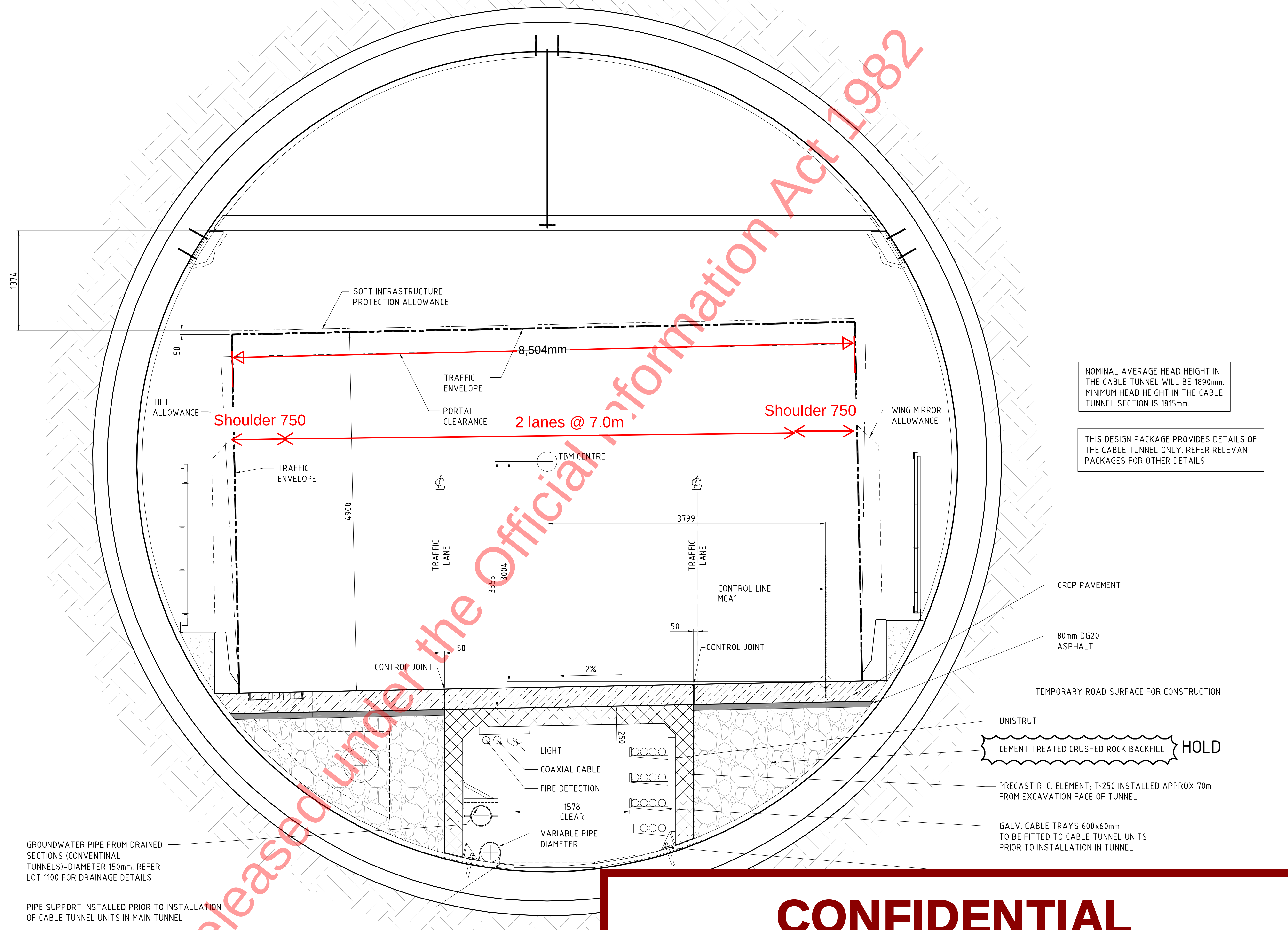


NOMINAL AVERAGE HEAD HEIGHT IN THE CABLE TUNNEL WILL BE 1890mm. MINIMUM HEAD HEIGHT IN THE CABLE TUNNEL SECTION IS 1815mm.

THIS DESIGN PACKAGE PROVIDES DETAILS OF THE CABLE TUNNEL ONLY. REFER RELEVANT PACKAGES FOR OTHER DETAILS.

REVISIONS

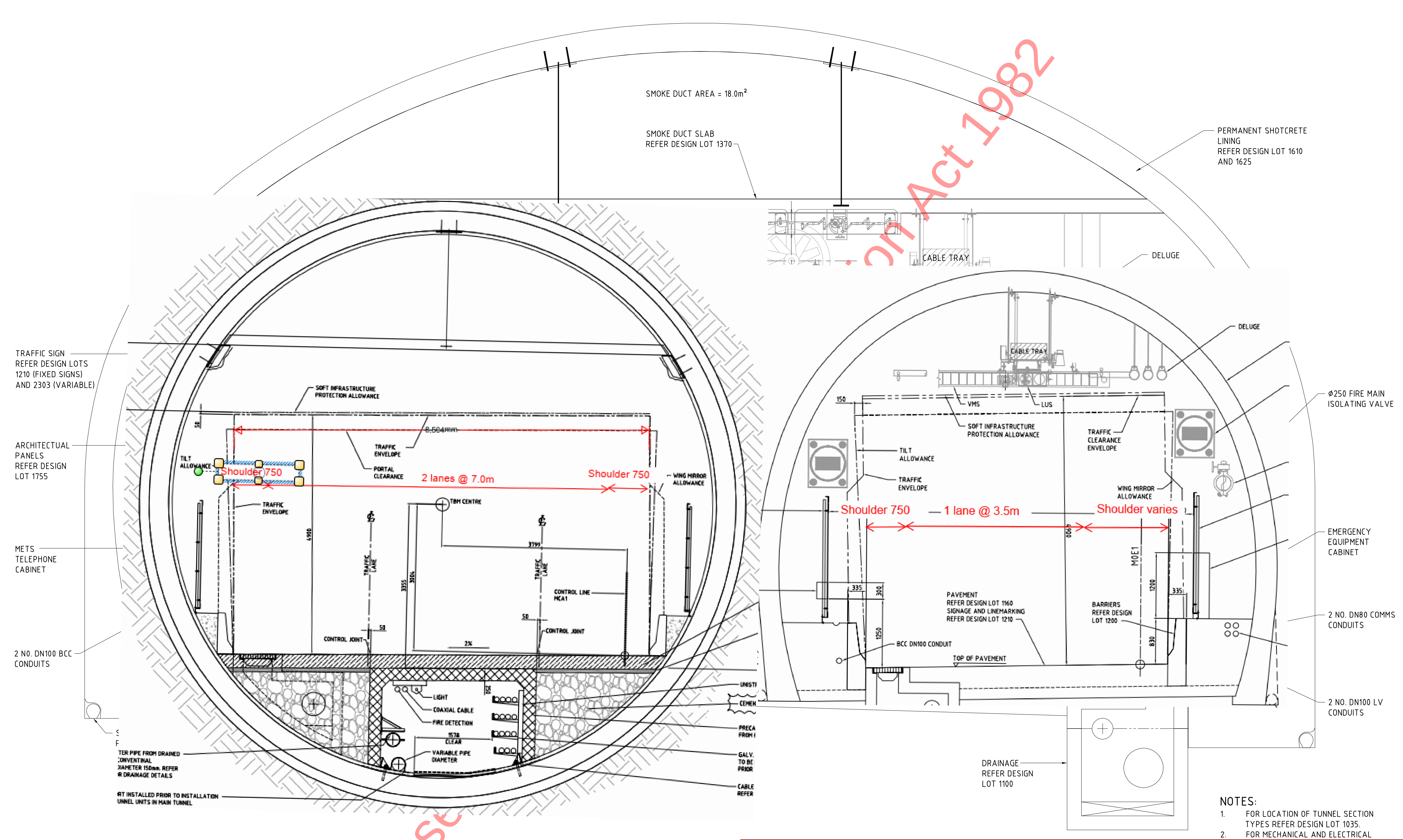
REV	DATE	DESCRIPTION	APPD
03	25.01.07	ISSUED TO INDEPENDENT VERIFIER FOR DESIGN VERIFICATION	
02	22.12.06	ISSUED TO LBBJV FOR REVIEW & MPB FOR INTERNAL VERIFICATION	
01	12.12.06	ISSUED TO LBBJV FOR REVIEW - BACKFILL REVISED, HEAD HEIGHTS ADDED	
00	29.11.06	ISSUED TO LBBJV FOR REVIEW	

SCALE BARS
SCALE G 0 500 1000 1250mm
1 : 50 (A3) 1 : 25 (A1)

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE MPB DJV DESIGN VERIFICATION PLAN

DESIGNED	DTT	CHECKED	JJA
DRAWN	JLP	CHECKED	APW
APPROVED		DATE	

CONFIDENTIAL
WORK IN PROGRESS
B.3 Main Alignment Cross Section



NOTES:

1. FOR LOCATION OF TUNNEL SECTION TYPES REFER DESIGN LOT 1035.
2. FOR MECHANICAL AND ELECTRICAL

CHAINAGE 1413.0

TYPICAL SECT

This drawing is confidential and shall only be used for the purposes of this project.

REV	DATE	DESCRIPTION	APPD
00	12.03.07	ISSUED TO LBBJV FOR REVIEW	

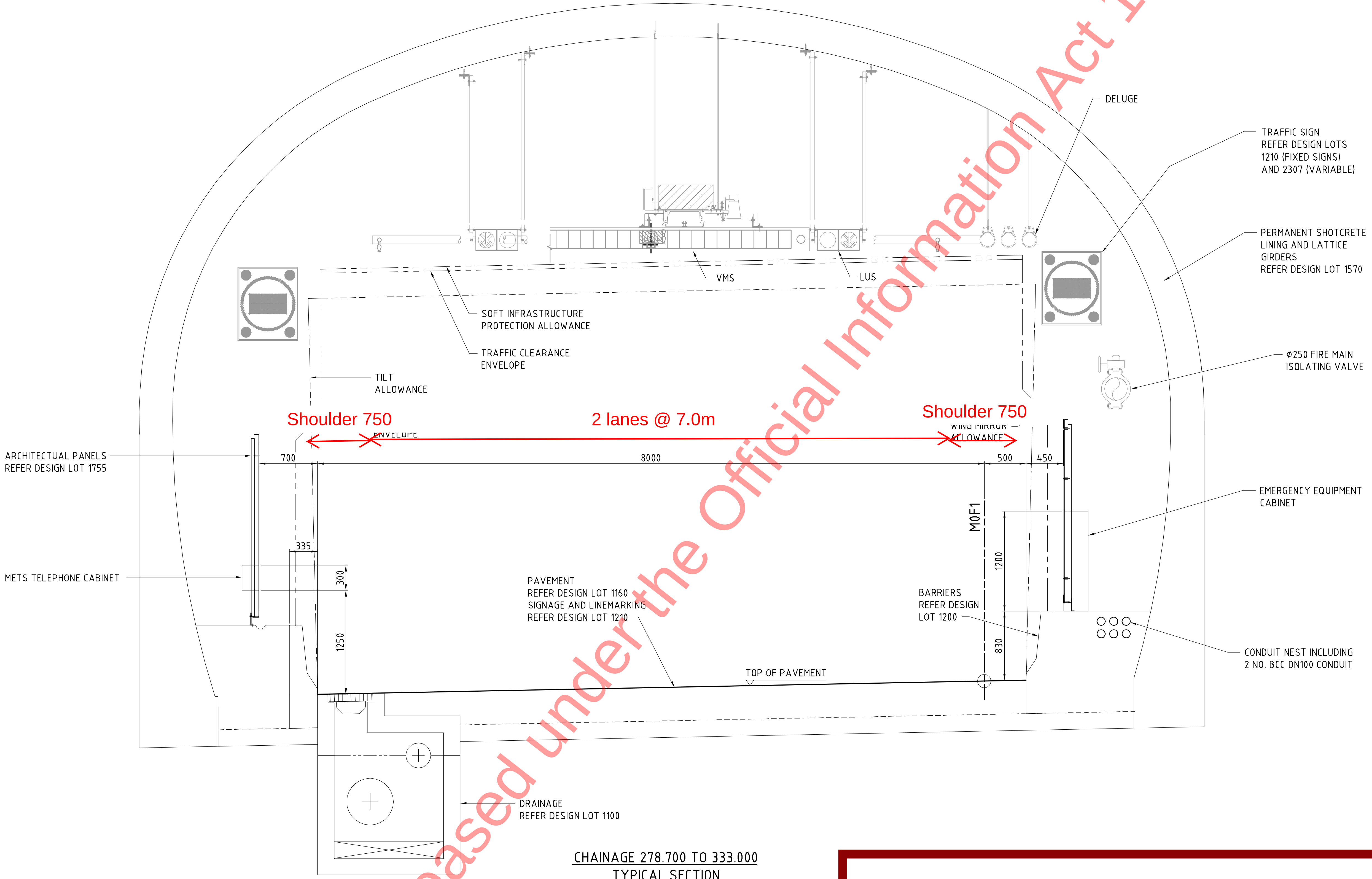
SCALE BARS

SCALE F 0 1000 2000 2500mm 1 : 100 (A3) 1 : 50 (A1)

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE MPB DJV DESIGN VERIFICATION PLAN

DESIGNED	RJJ	CHECKED	
DRAWN	JLP	CHECKED	
APPROVED		DATE	

CONFIDENTIAL
WORK IN PROGRESS
B.4 Main Alignment Adelaide Road Cavern



CHAINAGE 278.700 TO 333.000
TYPICAL SECTION
SCALE G

NOTES:
1. FOR LOCATION OF TUNNEL SECTION TYPES REFER DESIGN LOT 1035.
2. FOR MECHANICAL AND ELECTRICAL DETAILS REFER DESIGN LOT 2305

REVISIONS

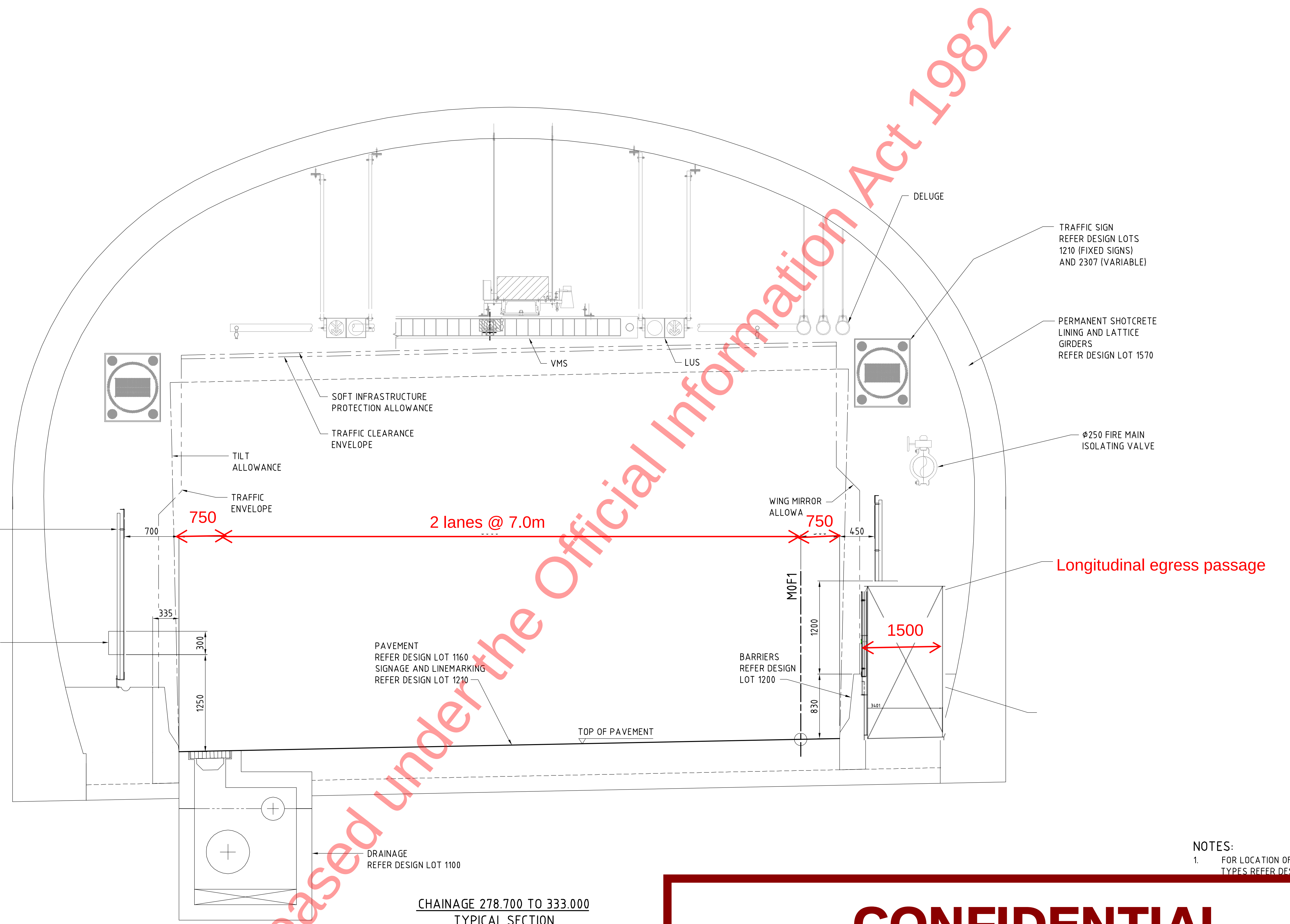
REV	DATE	DESCRIPTION	APPD
00	23.02.07	ISSUED TO LBBJV FOR REVIEW	

SCALE BARS
SCALE G 0 500 1000 1250mm
1 : 50 (A3) 1 : 25 (A1)

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE MPB DJV DESIGN VERIFICATION PLAN

DESIGNED		CHECKED	
DRAWN		CHECKED	
APPROVED		DATE	

CONFIDENTIAL
WORK IN PROGRESS
B.5 Main Alignment Adelaide Road Cavern



CHAINAGE 278.700 TO 333.000
TYPICAL SECTION
SCALE G

NOTES:
1. FOR LOCATION OF TUNNEL SECTION TYPES REFER DESIGN LOT 1035.

REV	DATE	DESCRIPTION	APPD
00	23.02.07	ISSUED TO LBBJV FOR REVIEW	

REVISIONS

SCALE BARS
SCALE G 0 500 1000 1250mm 1 : 50 (A3) 1 : 25 (A1)

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE MPB DJV DESIGN VERIFICATION PLAN

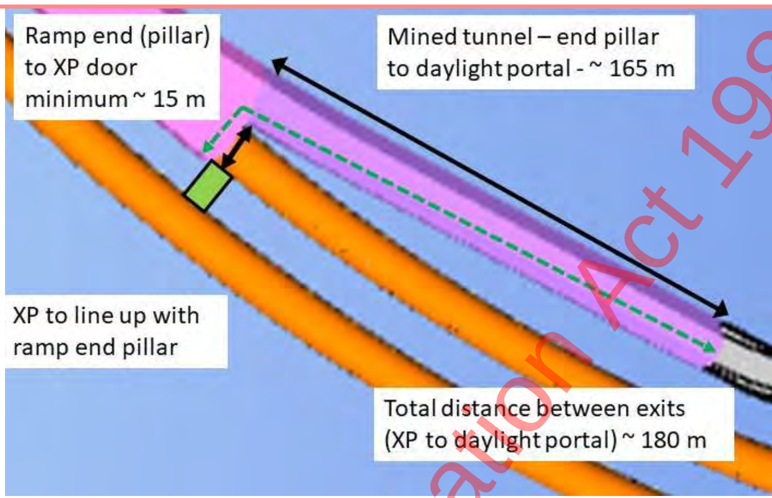
DESIGNED		CHECKED	
DRAWN		CHECKED	
APPROVED		DATE	

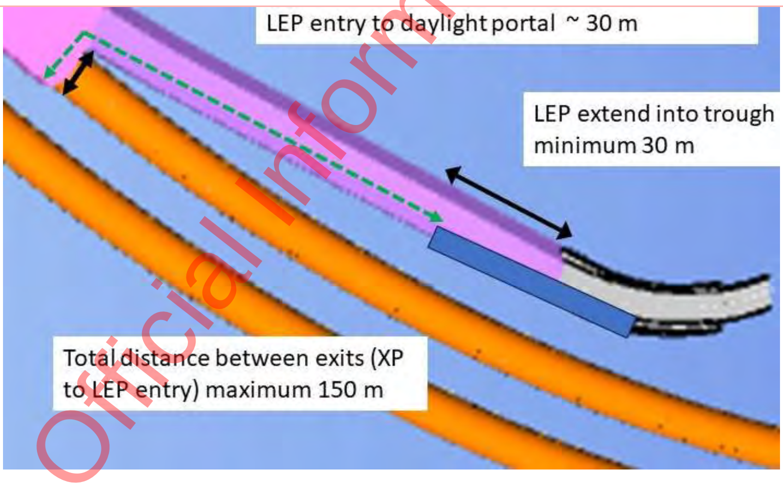
CONFIDENTIAL
WORK IN PROGRESS
B.6 Adelaide Road Ramp

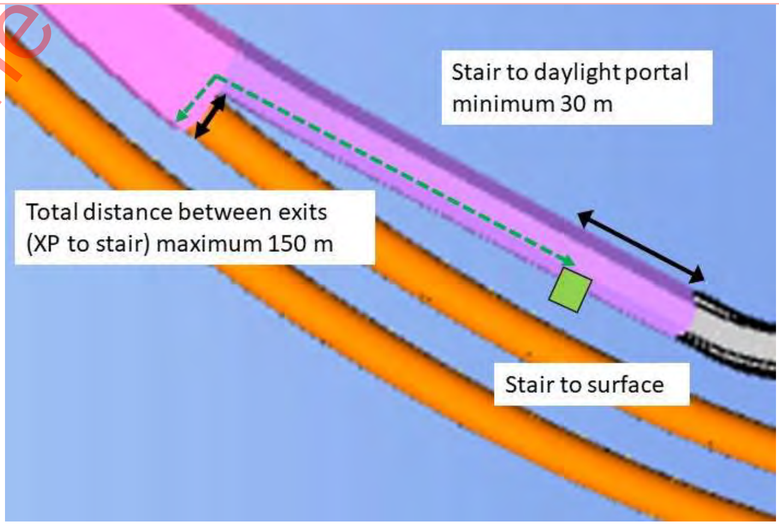
Appendix C – Egress options Adelaide Road off-ramp

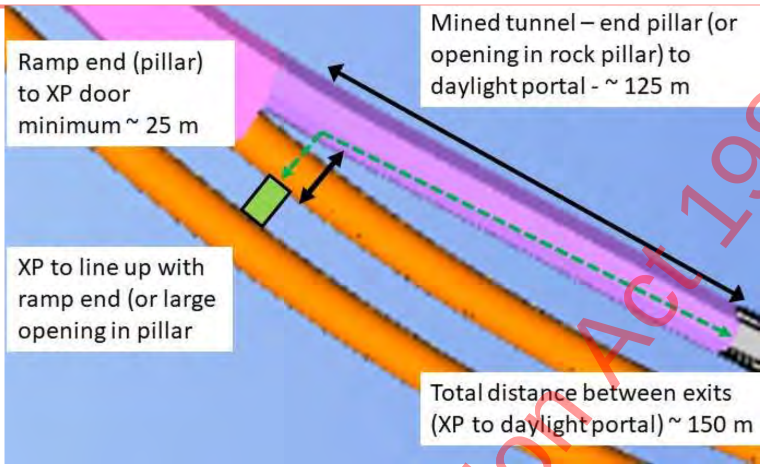
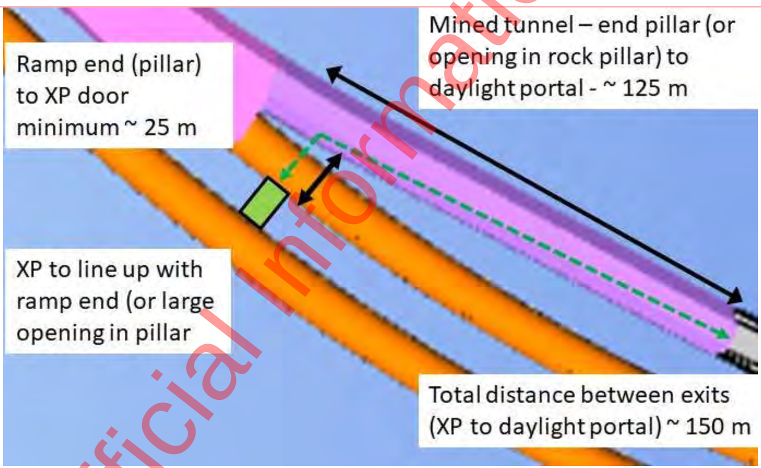
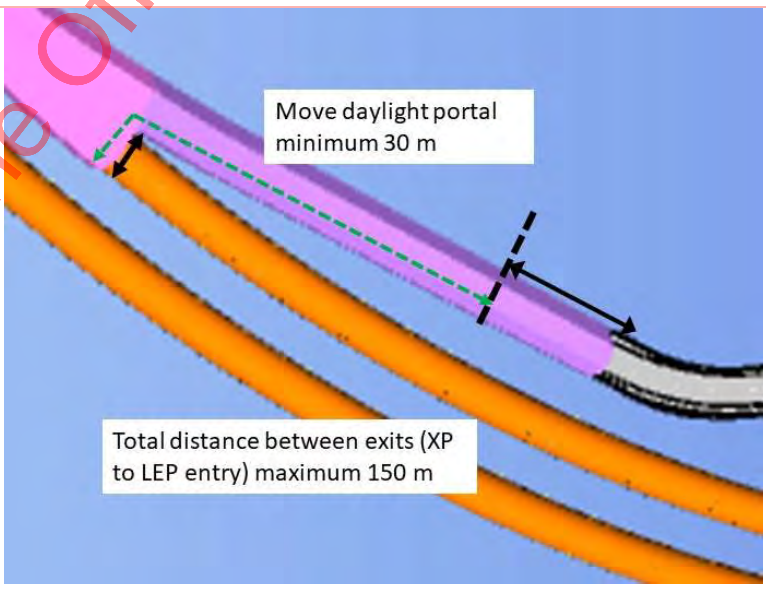
Table C.1: Adelaide Road Ramp Egress Options

<table>
<tr><th>Option</th><th>Description</th><th>Arrangement</th></tr>
<tr><td>1</td><td>No additional measures
Distance between exits 180 m

Risk that FENZ will not accept 180m between cross passages.</td><td>
</td></tr>
<tr><td>2</td><td>Longitudinal Egress Passage (LEP)
LEP would require an internal clear width of 1.5 m
Distance between exits 150 m

Recommended solution</td><td>
</td></tr>
<tr><td>3</td><td>Fire stair
Distance between exits 150 m

Large structure would be required and additional property take.</td><td>
</td></tr>
</table>

Option	Description	Arrangement
4	Move rock pillar back 30 m Distance between exits 150 m	
5	Keep face of rock pillar at current location (100m chainage) and have large opening in pillar approximately 3m wide, and 2.4m high. Distance between exits 150 m Complex with vertical alignment of off-ramp and main tunnel	
6	Move daylight portal 30 m Portal would be in the road, not favourable.	
7	Combination of options For example: adjusting rock pillar face, and daylight portal, and justifying 165 m between exits	

APPENDIX H

STRUCTURES STAGING FIGURES AND RISKS/OPPORTUNITIES

4 NORTHERN APPROACH

4.1 CONSTRUCTION PHASES

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[redacted]

5 LONG TUNNEL, NORTHERN CONNECTION (TERRACE)

5.1 CONSTRUCTION PHASING

Abbreviations: ICB=Inner City Bypass Trench/Walls, SB = Southbound, NB = Northbound, 1L/2L = One/two lanes

[redacted] s 9(2)(ba)(ii)

PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES

[redacted] s 9(2)(ba)(ii)

[redacted] s 9(2)(ba)(ii)

PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES
[redacted] s 9(2)(ba)(ii)				

[redacted] s 9(2)(ba)(ii)

PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES
3. Main Tunnel Portal Build	SB 2L new terrace tunnel, Vivian NB 2L Karo, old terrace tunnel	Potential one lane restrictions on Vivian to build RW-04 One lane restrictions on Karo due to build up of adjacent walls Closures of Karo to install permanent props	NI-RW-03 NI-RW-04 Receive TBM/turnaround NI-ST-02 (finish) NI-ST-03 (finish)	Removal of ICB required Temporary works for receiving TBM Construction staging split into 3A (receive TBM) and 3B (build back to final levels)

Construction in phase 3 will need to go through multiple stages of temporary and permanent construction. Figure H.1 illustrates potential cross sections near the tunnel portal.

Figure H.1 – Example of staging process to construct Long Tunnel northern portal area.

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6 NORTHERN AREA RISKS AND OPPORTUNITIES

s 9(2)(ba)(ii) [redacted]

ID	RISK OR OPPORTUNITY?	DESCRIPTION	OUTCOME/MITIGATION

s 9(2)(ba)(ii) [redacted]

ID	RISK OR OPPORTUNITY?	DESCRIPTION	OUTCOME/MITIGATION
[redacted]			

s 9(2)(ba)(ii)

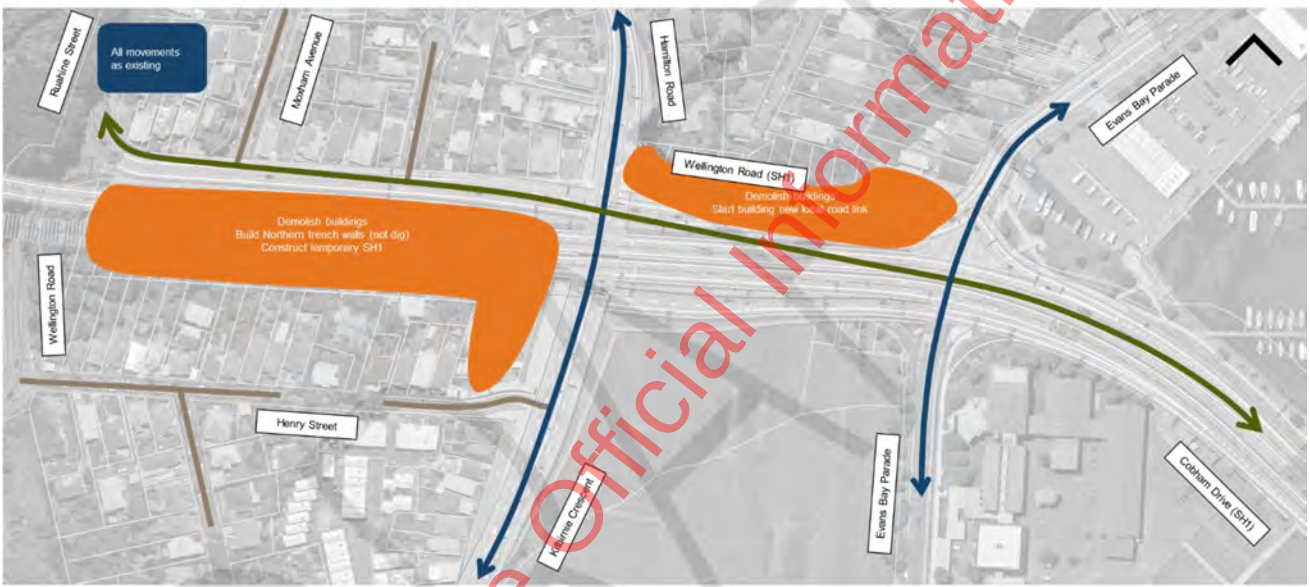
7 LONG TUNNEL, SOUTHERN CONNECTION (KILBIRNIE)

7.1 CONSTRUCTION PHASING

Abbreviations: SB = Southbound, NB = Northbound, 1L/2L = One/two lanes etc, EVP = Evans Bay Parade, TBM = Tunnel Boring Machine

LT01 – Long Tunnel. Construction Phases

Kilbirnie Interchange – Phase 0 Existing Demolition



PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES
0	Existing Operations	Existing	Demolish all buildings/property Temporary alignment south future trench SI-RW-01 SI-ST-01 (no dig)	Relocate substations (potential pre-work) May need to fill to locate temporary alignment Locate alignment as far south as possible to minimise temporary works Opportunity to build partial EVP link early

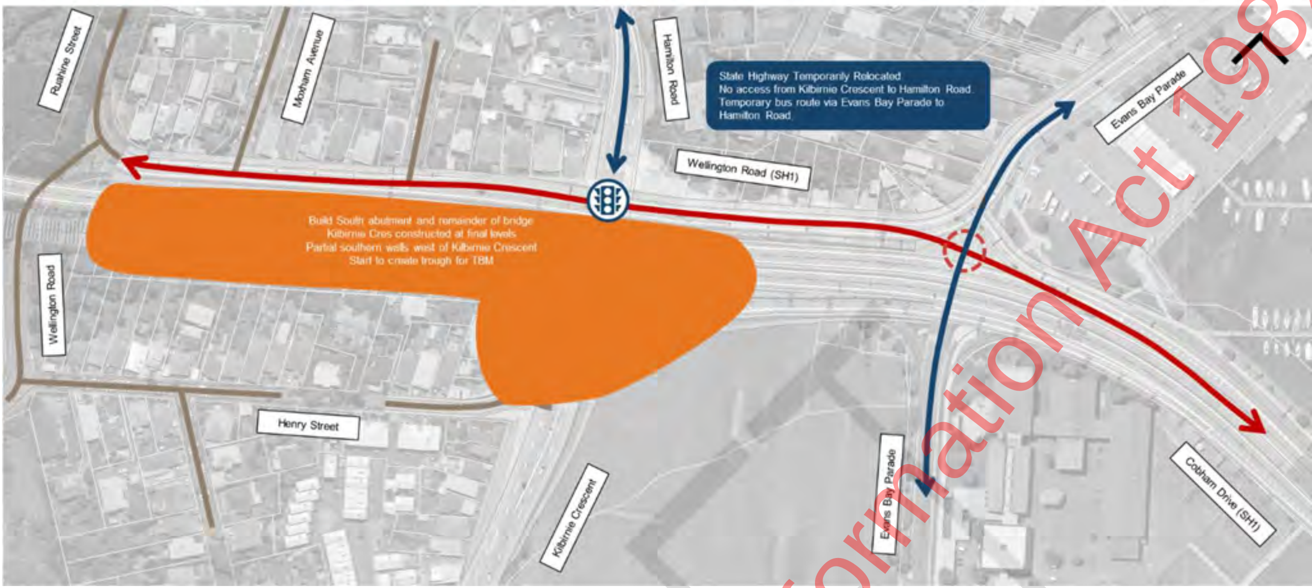
LT01 – Long Tunnel. Construction Phases

Kilbirnie Interchange – Phase 1 Construct North Facing T

PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES
1	Build North facing T	Hamilton closed north EVP closed north Bus as existing	SI-RW-10 to 13 North Abutment SI-ST-02 SI-RW-09 (partial to enable temporary tie in of Wellington Rd to Cobham Drive)	The eastern end of SI-RW-14 might need a higher up wall from 3320 to support level change to new Hamilton Rd Levels all still within a few metres of existing level to retain temporary Wellington Rd – could partial lower

LT01 – Long Tunnel. Construction Phases

Kilbirnie Interchange – Phase 2 Construct South Facing T



PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES
2	Build South facing T	Hamilton road open Kilbirnie Cres closed EVP fully open Bus route EVP to Hamilton Wellington Rd Temporary alignment (restricted compared with current 3L total)	Rest of SI-ST-02 SI-RW-02, 04, 05,06 (some partial)	Levels all still within a few metres of existing level Can start to drop levels to suit staging NOT SI-RW-07, 08 or 03 as restricts space for TBM

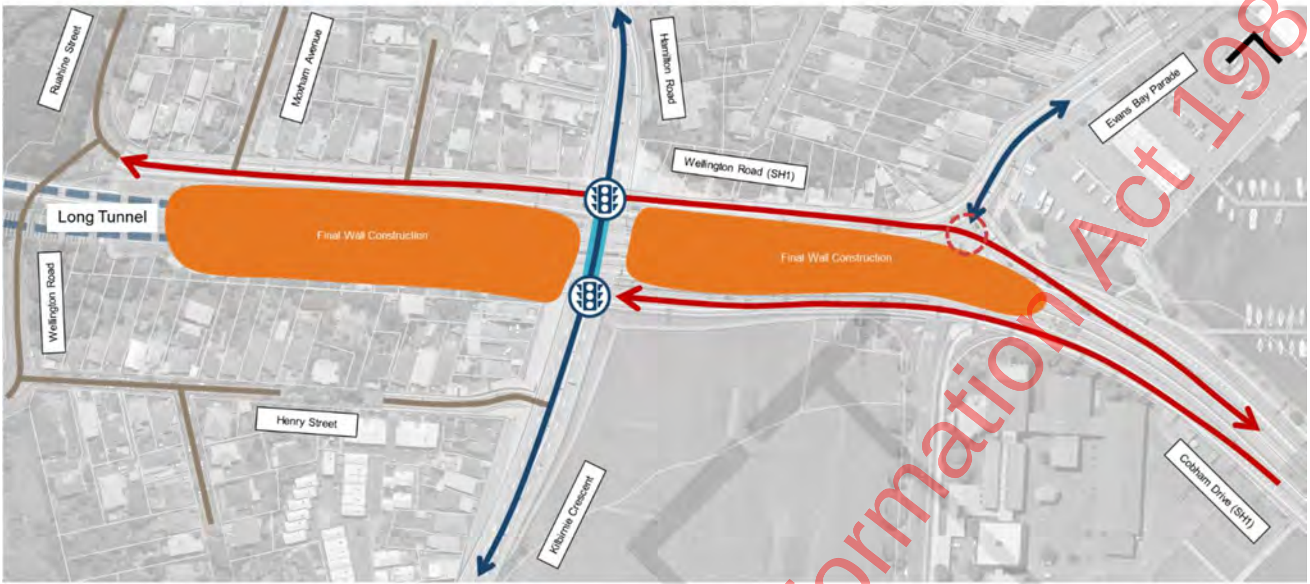
LT01 – Long Tunnel. Construction Phases

Kilbirnie Interchange – Phase 3 Tunnel Construction

PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES
3	Temporary permanent TBM ops	Wellington Rd mostly final alignment (restricted compared with current 3L total) Hamilton/Kilbirnie at new levels Option to retain EVP at ground level	Dig Trench to temporary levels for TBM, complete all partially built walls and structures apart from SI-RW-09 (still partial to enable alignment)	Stays this way for a long time whilst TBM is building

LT01 – Long Tunnel. Construction Phases

Kilbirnie Interchange – Phase 4 Complete Tie Ins



PHASE	ACTIVE TRAFFIC	TRAFFIC RESTRICTIONS	BUILD	NOTES
4	Tie ins once tunnel done	Close EVP cross access if not already done Movements for local roads change to permanent	Everything that is left SI-RW-03, 07 and 08, permanent - 09	Once TBM demobilises

8 SOUTHERN AREA RISKS AND OPPORTUNITIES

ID	RISK OR OPPORTUNITY?	DESCRIPTION	OUTCOME/MITIGATION
SI-01	Risk	No geotechnical interpretation for design calculation available for at time of writing	Structures based on combined experience of team, but need to be verified by concept design utilising calculations
SI-02	Risk	Construction lay down/access has been considered for structures, but not in detail	Additional walls/temporary works and property to be confirmed
SI-03	Risk	LIDAR has been used. In many cases there is vegetation so walls may be in different locations.	Topo survey of the area
SI-04	Risk	Utilities searches/clashes have not been undertaken yet	Additional work to identify any major clashes which result in changes in scope or methodology
SI-05	Opportunity	More stages to leave Kilbirnie Crescent open for longer	Future team to look a sequence in more detail to see if offline temporary alignment could use offramp/onramp alignment to Kilbirnie crescent
SI-06	Opportunity	Take out slip lane, move portal east, move tunnel south overall	If three align could reduce or even eliminate portion of propped wall as there may be enough space to construct a cheaper wall solution
SI-07	Opportunity	Look in more detail at temporary alignment during Phase 1	Potential to move to cheaper wall solutions – opportunity for future designers

APPENDIX I

TREATMENT SUMMARY

The following pages identify expected treatments to be applied to the design.

Long Tunnel

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