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Consultation

Design

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Client



PARKES WAY WIDENING

TEMPORARY TRAFFIC MANAGEMENT

CONTROL MCE01

CH 374.0 TO CH 4.080

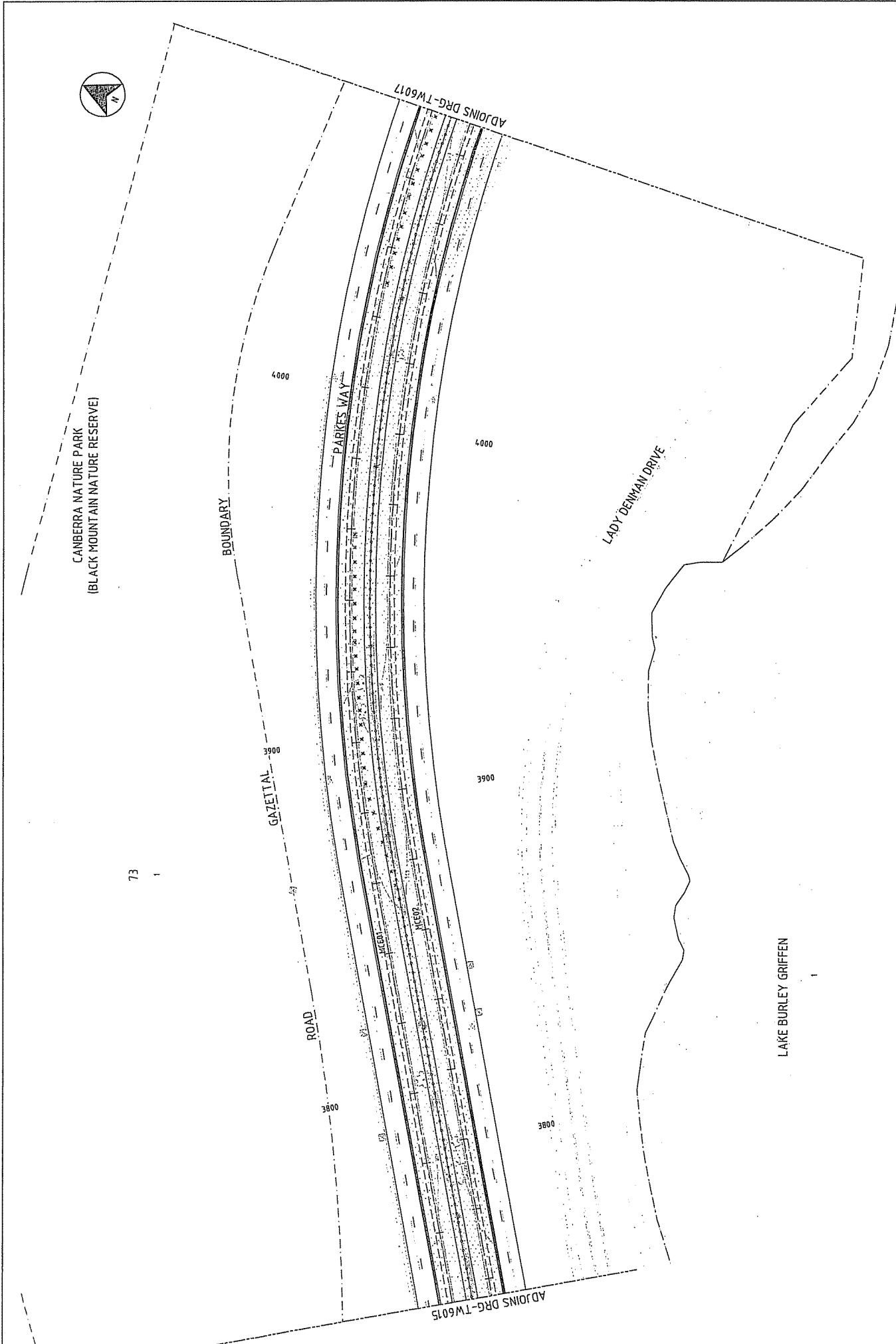
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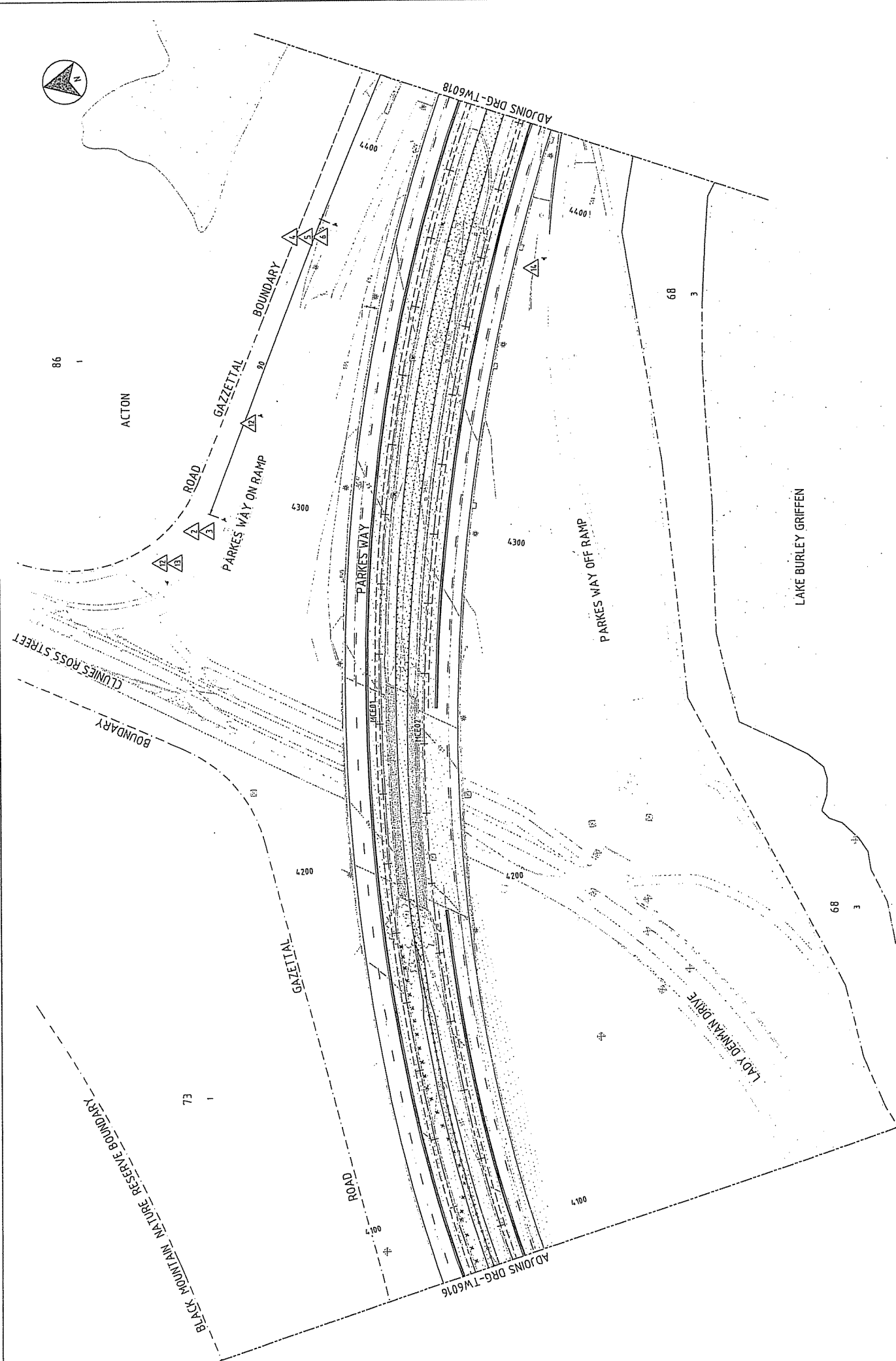
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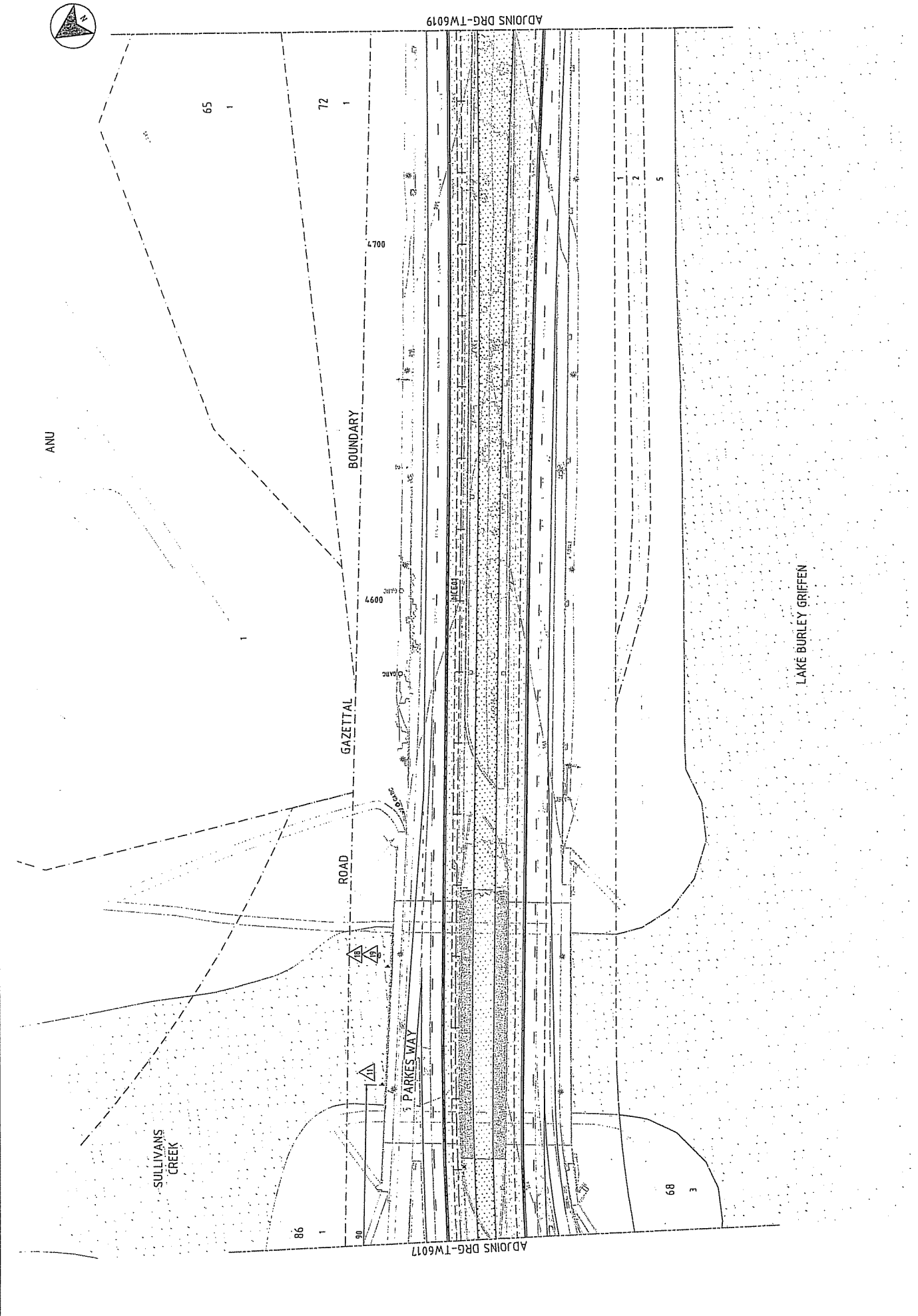
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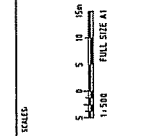
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T 03 9594 2000 F 03 9594 2001



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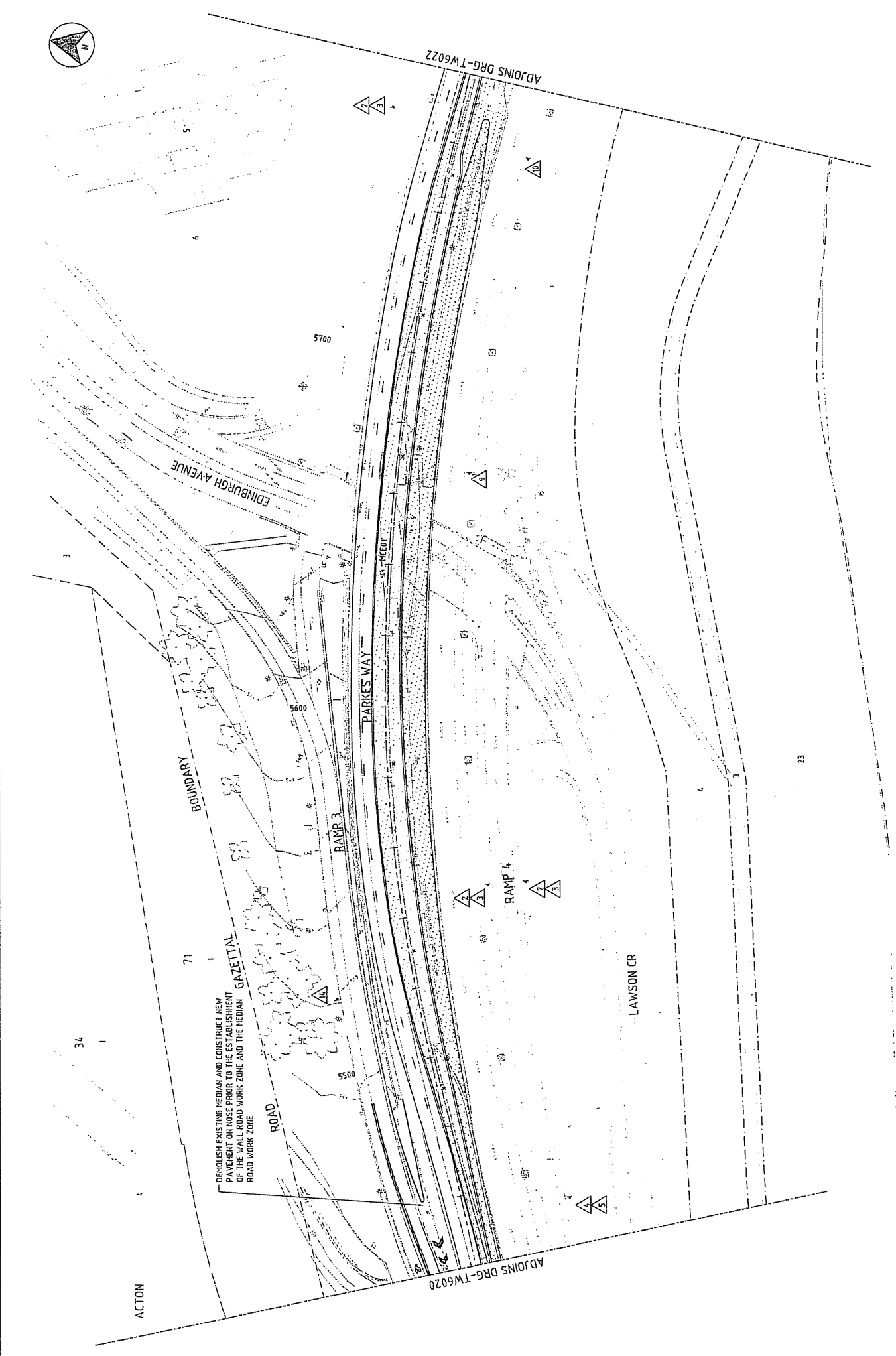


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CONTRACTOR

AZCOM

DESIGNER

AZCOM

CLIENT

LAKE RUDOLPH

PARKES WAY WIDENING

TEMPORARY TRAFFIC MANAGEMENT

CONTROL MCE01

CH 5440 TO CH 5780

STATUS

FSD

MANAGER

2010092722-NDG-20-TW6021

SHEET

12

REV

A

LAKE RUDOLPH

PARKES WAY WIDENING

TEMPORARY TRAFFIC MANAGEMENT

CONTROL MCE01

CH 5440 TO CH 5780

STATUS

FSD

MANAGER

2010092722-NDG-20-TW6021

SHEET

12

REV

A

4

ACTION

5800

5900

5954.909

ADJOINS DRG-TW6021

PARKES WAY

MAKE BUIRY GRIFFEN

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401

REGISTRATION

AECOM



PARKES WAY WIDENING

TEMPORARY TRAFFIC MA
CONTROL MCE01
CH 5780 TO CH 5954 909

050

Alus

60-20112

1987277-NRG-20-TW60272

22 V. A

LEGEND:

EXISTING

PROPOSED

--- FR --- FR ---

CONTINUOUS COIR FILTER ROLL

□

COIR FILTER ROLLS AT SUIPS

--- A --- A --- A --- A ---

TREE PROTECTION

X

REMOVE TREES/SHRUBS

▨

SITE COMPOUNDS

=====

CONCRETE BARRIER

--- X --- X ---

CHAIN MESH SITE FENCE

1:1 1:1

STORMWATER DIVERSION MOUND

STORMWATER OVERLAND FLOW PATH

REVISIONS		DATE		DESCRIPTION	
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PARKES WAY WIDENING
ENVIRONMENTAL MANAGEMENT PLAN
GENERAL NOTES AND LEGEND

STATUS: FSP
PROJECT NO: 60198222-DRG-20-EN7001
SHEET NO: A



CANBERRA NATURE PARK
(BLACK MOUNTAIN NATURE RESERVE)

BLACK MOUNTAIN
NATURE RESERVE
BOUNDARY

FROM GONGAHILLIN

GLENLOCH
INTERCHANGE

ROAD
GAZETTED
BOUNDARY

CITY OFF-RAMP

TO WEST BELCONNEN

TO TUGGERAH

PARKES WAY

LADY DENMAN DRIVE

ADJOINS DRG-EN7052

2700

2600

2536.660

1293CCD

1293CCD

1294CCD

1295CCD

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DESIGNER

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CONTROL MCE01
CH 2536.660 TO CH 2700

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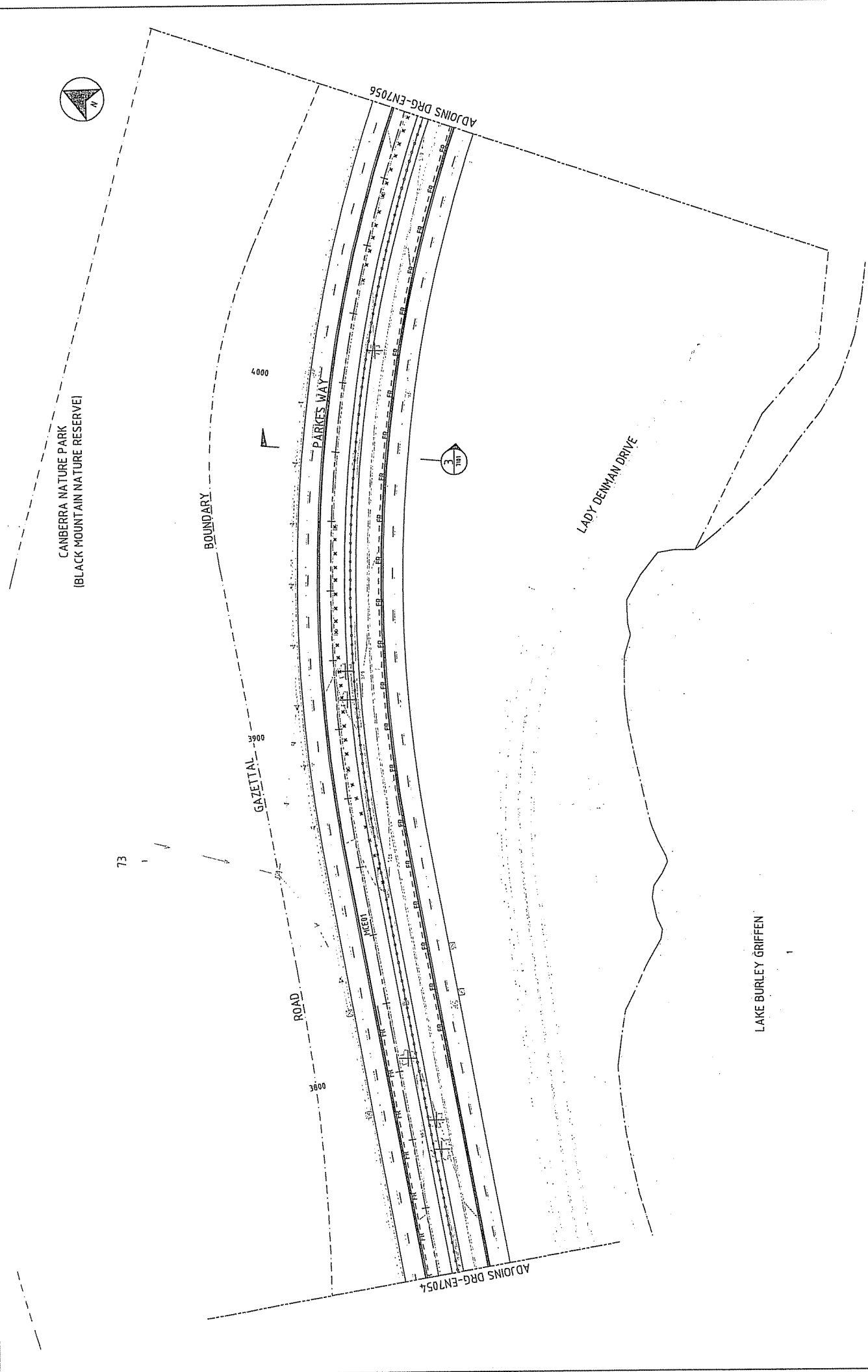
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60198222-DRG-20-EN7011

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13.05.2011

DESIGN

AECOM

ARCHITECTURAL, CIVIL, ELECTRICAL, MECHANICAL AND STRUCTURAL ENGINEERING

CLIENT


GOVERNMENT OF WESTERN AUSTRALIA

PROJECT

PARKES WAY WIDENING
ENVIRONMENTAL MANAGEMENT PLAN
CONTROL MCE01
CH 374.0 TO CH 4.080

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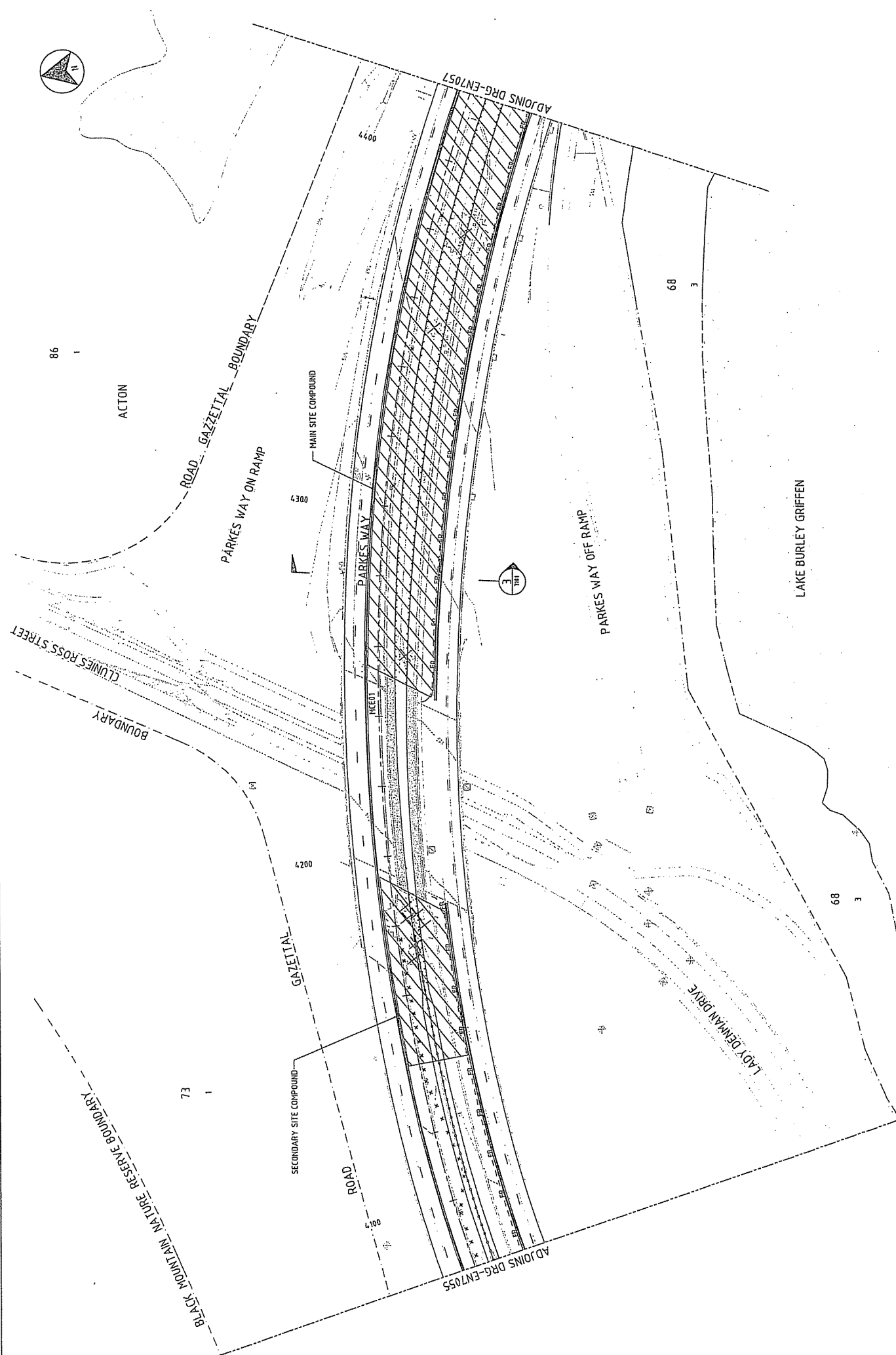
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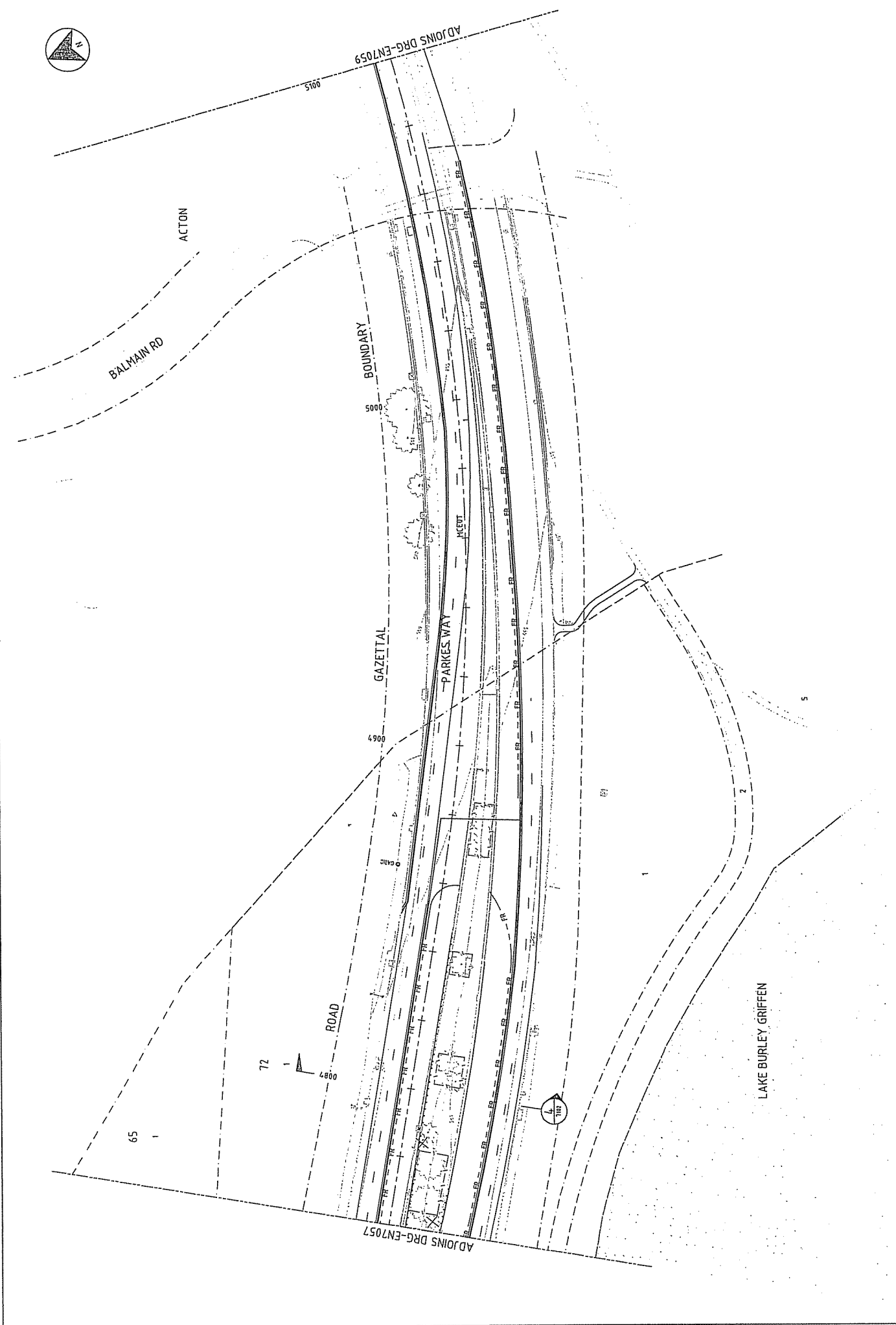
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ENVIRONMENTAL MANAGEMENT PLAN

CONTROL MCE01

CH 4.760 TO CH 5.100

STATUS

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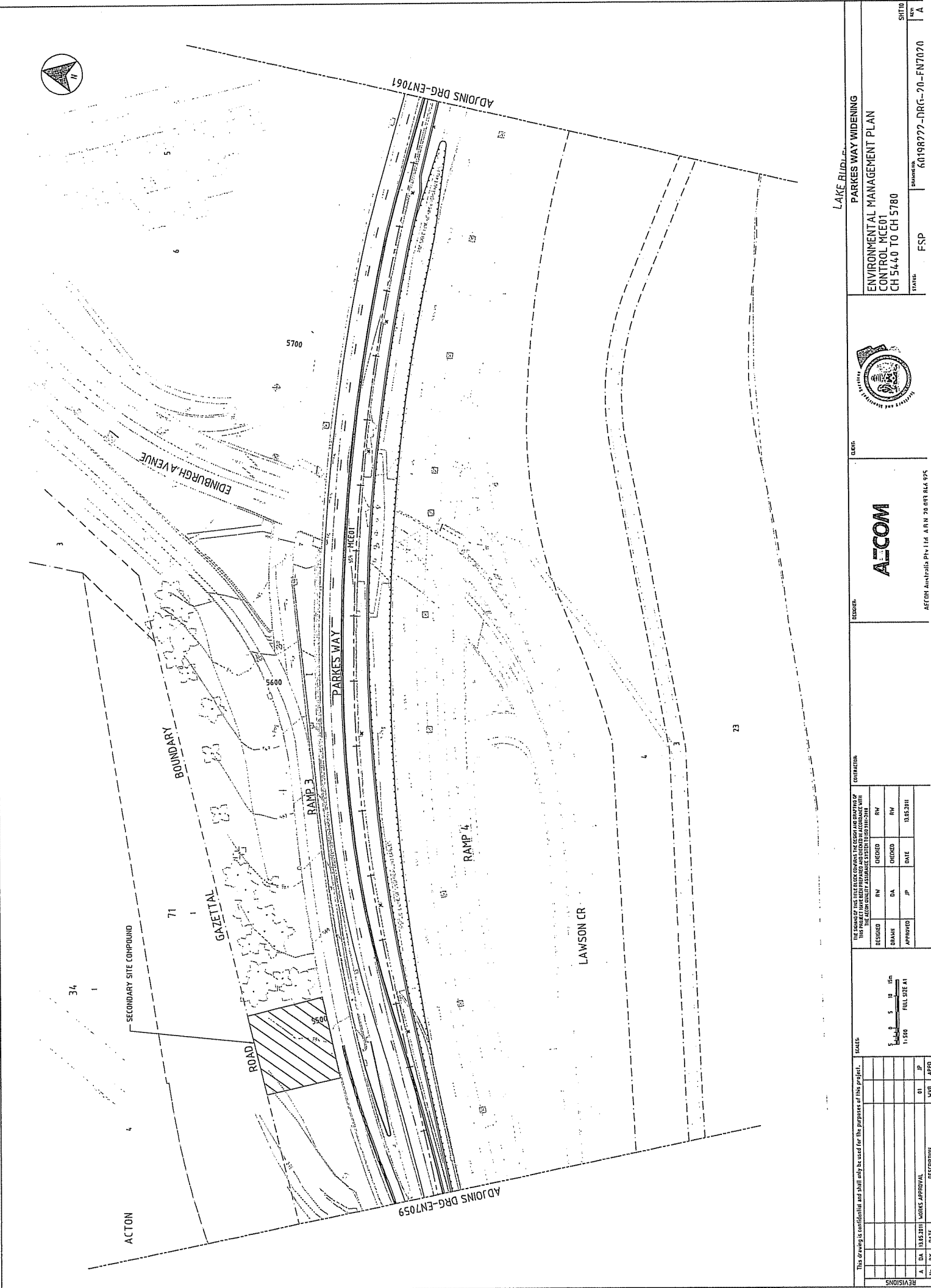
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60198777-DRG-20-FN7020

ENVIRONMENTAL MANAGEMENT PLAN

CONTROL MCE01

CH 54.40 TO CH 5780

LAKE BUDLE

PARKWAY WAY WIDENING

1000

54

ACTION

5954.909

5900

5800

ADJOINS DRG-EN7060

PARKES, WAY

SECONDARY SITE COMPOUND -

WAKE BURLLEY GRIFFEN

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ENVIRONMENTAL MANAGEMENT PLAN

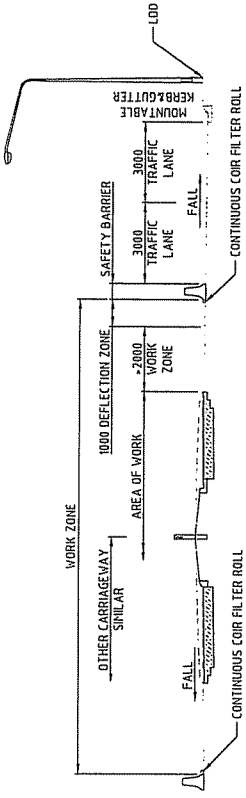
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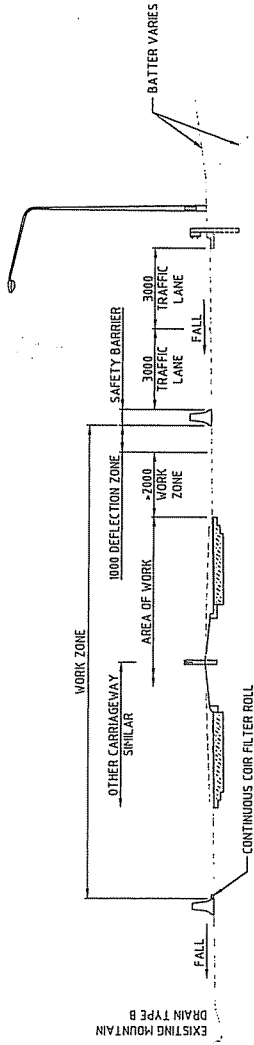
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BLACK MOUNTAIN ESCARPMENT



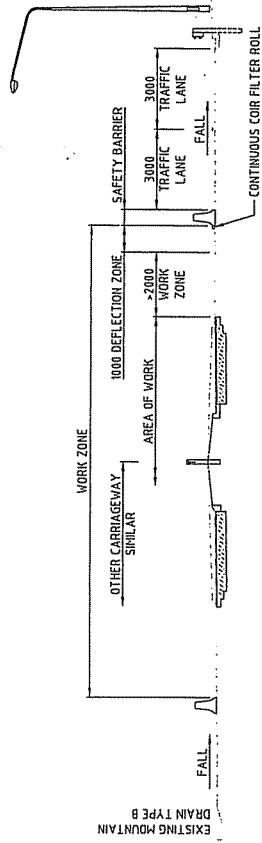
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BLACK MOUNTAIN ESCARPMENT



CONDITION 2
SCALE: 1:100

BLACK MOUNTAIN ESCARPMENT



CONDITION 3
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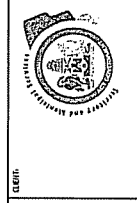
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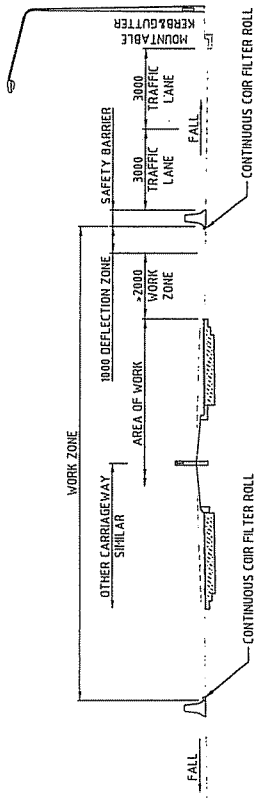
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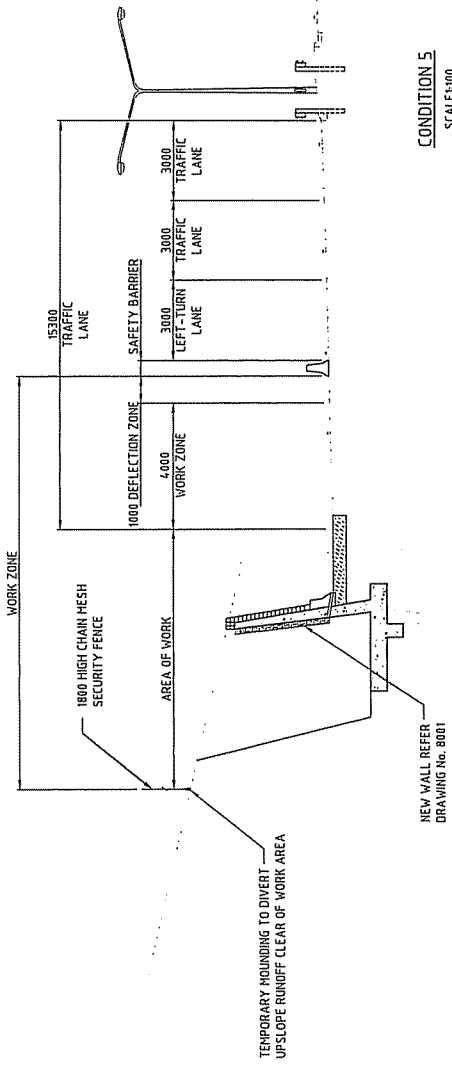
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PARKES WAY WIDENING	
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CONDITION 4
SCALE 1:100



CONDITION 5
SCALE 1:100

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PARKES WAY WIDENING
ENVIRONMENTAL MANAGEMENT
TYPICAL CROSS SECTIONS
CONDITIONS 4 AND 5

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PARKES WAY WIDENING

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TOE OF WALL AT PAVEMENT
PLAN AND ELEVATION

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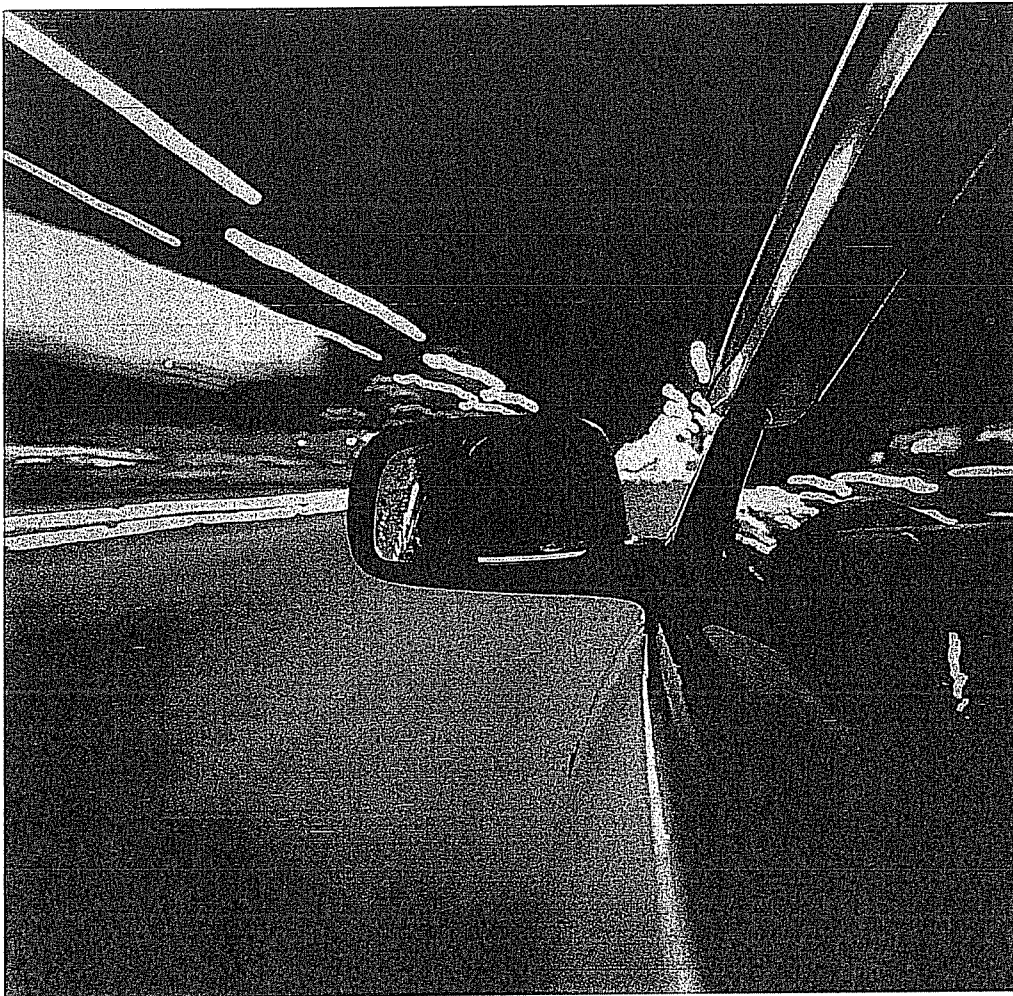
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Acton Tunnel Lighting Upgrade
TAMS
11 June 2010
Document No. 60154465_ELE_RP_001

Preliminary Sketch Plan Report



Preliminary Sketch Plan Report

Project No: 12541

Prepared for
TAMS

Prepared by
AECOM Australia Pty Ltd
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11 June 2010

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11 June 2010

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Ref 60154466
Date 11 June 2010
Prepared by Anthony Linard
Reviewed by Andrew Todd

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			Name/Position	Signature
A	23-May-2010	Draft	Mark Stefanac Group Leader - Buildings	
B	11-Jun-2010	Final	James Henriques Group Leader - Buildings	

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Executive Summary

Preliminary investigations and design has been carried out for a lighting upgrade to Acton Tunnel. An investigation into the possible reuse of the existing lighting suggests that this is not a feasible option. A range of new lighting options have been investigated, and a preferred solution in terms of luminaire types and placement has been developed. A major factor in the upgrade that has become apparent is the surface cladding of the tunnel walls. The existing cladding has poor reflectance properties and works against an optimal design. A re-cladding of the tunnel walls with a higher-reflectivity aluminium panel is recommended. Approximate costing of the wall cladding is included.

Two design options have been developed for two solutions, one with the existing walls remaining, and one with the new higher-quality wall claddings. A second version of the latter option is also presented, with approximately half of the wall clad with aluminium and the remainder painted. For both options, estimates of costs and energy usage have been provided.

The recommended upgrade option includes the re-cladding of the tunnel walls with the higher reflectivity aluminium panels, as this gives the highest quality and lowest energy lighting installation. Estimates suggest that the extra cost would be offset completely by lower energy consumption costs over a 20 year design life.

It is recommended that a bulk re-lamping frequency of four years be implemented for the tunnel, as well as a regular cleaning regime for the walls and luminaires.

1.0 Introduction and background

1.1 Project background

The Department of Territory and Municipal Services (TAMS) has an ongoing program to progressively upgrade street lighting in the ACT, and as a part of this has begun the process of investigating the upgrade of lighting in the Acton Tunnel. Acton Tunnel is Canberra's longest tunnel, at approximately 190 metres long. The Tunnel is on the major arterial road Parkes Way, and caters for large volumes of traffic on a daily basis.

The majority of the tunnel's existing lighting infrastructure is original equipment from the building of the tunnel approximately 30 years ago. The tunnel has separate carriageways for East- and Westbound traffic, each with three lanes and a bicycle/emergency-stopping lane. The tunnel floor is concrete, and the walls clad in a type of particle board which ranges from light to dark grey. The extent of other services in the tunnel appears to be limited to fire sprinklers, with no apparent ventilation systems.

The speed limit through the tunnel is 90 km/h, and the surrounding parts of Parkes Way are illuminated to Category V3, with metal halide light sources on the Eastern side and high pressure sodium to the West.

AECOM have been commissioned to investigate an upgrade to the tunnel's lighting. This will include an investigation into the possible upgrade or reuse of the existing luminaires as well as the design of a new lighting system that is independent of the existing arrangement.

2.0 Design methodology

2.1 Preliminary calculations

2.1.1 Assessment of tunnel against AS/NZS 1158.5

The tunnel lighting design process began with an analysis of the tunnel in accordance with the procedures outlined in AS/NZS 1158.5:2009. This determined the required light technical parameters to be met by the lighting design.

2.1.2 Computer modelling of tunnel

The next stage of the process was the creation of a three-dimensional model of the tunnel in the lighting calculation program AGI32. The model was based on the physical dimensions of Acton Tunnel and included surface reflectance properties selected based on those observed on site. Calculation points were included on road surfaces and walls as dictated by the Standard. The bicycle/emergency stopping lane has been included as part of the carriageway as per the requirements of the Standard.

2.1.3 Preliminary calculations

A number of preliminary calculations were run to determine the optimum layout and type of luminaires needed to meet the specified light technical parameters. In terms of luminaire placement, several options were trialled, including a single central row of luminaires, two side rows of luminaires (similar to the existing installation) and three rows of luminaires. Luminaires with various light output distributions were trialled, including symmetrical distribution, angled symmetrical and wall-washing to determine the best-performing arrangement to suit the tunnel's geometry. Other options were trialled as appropriate, such as tilting of luminaires to improve light distribution.

2.1.4 Development of design options

As the preliminary designs were refined, two rough design options were developed. These were based on two scenarios: the first that no internal surface treatments were to be changed in the tunnel, primarily meaning that the existing wall surfaces remain, and the second assuming that new higher reflectivity wall treatments will be added to the tunnel walls. Each scenario was developed to approximately 80% completion to prove the concept and await confirmation of design parameters for final design. TAMS will be required to choose which design option is to be taken to 100% design.

2.1.5 Development of budget estimates

For each of the two proposed design options, budget estimates have been developed to predict the upfront installation costs of each scheme as well as projected long-term running costs. These are presented in terms of monetary cost, energy usage and carbon dioxide emissions. Similar estimates are made for the existing scheme to allow a point of comparison. It should be noted that the existing scheme would not necessarily be usable for the time period of the calculations due to physical deterioration and difficulties sourcing lamps, however the comparison should be able to be used for comparison purposes.

2.2 Detailed design

Once the design parameters have been approved by TAMS, detailed design will commence for the new lighting scheme. The design will be developed to comply with the requirements of the Standard, and further details such as daytime switching levels, lighting controls, circuiting etc will be developed, and the design progressed to Tender stage.

Acton Tunnel Lighting Upgrade
Preliminary Sketch Plan Report

AECOM

3.0 Review of existing tunnel lighting infrastructure

3.1 General Overview

The existing tunnel lighting infrastructure is approximately 30 years old. It appears that in that time the electrical infrastructure and controls equipment have been maintained and upgraded and that the luminaires have degraded significantly. It is unknown to what Standard the tunnel lighting design was designed to, however given that Standards Australia did not have a tunnel lighting standard until 2009, it is unlikely that the design would comply even if all components were in good working order.

3.2 Existing luminaires

3.2.1 Condition and maintainability

The luminaires in the tunnel are approximately 30 years old. The luminaires are a combination of low pressure sodium (SOX) lamps and linear fluorescent. The condition of the luminaires is poor, with a general accumulation of dirt and apparent damage to some diffusers. Given the age of the installation, this poor condition is to be expected, as this is well past the expected lifetime of any luminaire constantly exposed to the elements and constantly in use. Given also that the lamp types in use (SOX) are not readily available, there is a strong case for refurbishment or replacement.

We understand that the luminaires in use were manufactured by a company named GEC. This company is no longer trading under that name, and we understand that it was taken over by Rexel in 1998. The luminaires in use are no longer produced, and photometric information is not available. Given this, refurbishment of the existing luminaires is not feasible, as calculations are not able to be performed to assess the photometric performance of the luminaires.

Given the above, to achieve an as-new, Standards compliant tunnel lighting design for Acton Tunnel, the only available option is to install new luminaires. To achieve a best-practice low energy installation, the use of new luminaires with high quality optics and best available lamp technology is required.

3.2.2 Recycling potential of existing luminaires

It was observed during a site inspection of the switch room, where spare luminaires are stored, that the existing luminaires appear to be constructed of very solid gauge of aluminium. Considering the large number of luminaires installed, and that they have reached the end of their useful life, there is potential to recover some costs by recycling the luminaire bodies.

3.3 Existing control equipment

The tunnel lighting is currently controlled by a programmable logic controller (PLC) which appears to have been installed or serviced in 1997. This equipment appears to be in good working order, however an apparent lack of documentation may cause difficulties for upgrade or maintenance. The detailed design phase of this project will look into the feasibility of keeping this equipment or replacing it with new.

3.4 Electrical infrastructure

The existing electrical infrastructure appears to be of good quality and in good condition. A previous electrical condition report (S.Sih, Oct 2008) recommended a number of rectification measures be undertaken on the equipment, but found the infrastructure to generally be in good condition. It was also noted that there appears to

be a general lack of documentation on changes that have been made to the infrastructure, including issues such as missing distribution board schedules.

In general, it appears that the electrical infrastructure is able to be retained and reused with the tunnel lighting upgrade. When the upgrade is undertaken, it will provide the opportunity to correctly balance loads across the distribution boards and accurately document sub circuit layouts.

3.5 Tunnel wall surface cladding

The internal wall surfaces of the tunnel are clad in a material that appears to be a type of particle board. The panels are screwed onto the surface. The majority of the panels appear to be an off-white colour, although a number of panels throughout both sides of the tunnel appear to be a dark grey colour. All panels are dirty and have poor reflective properties. Given that compliance with the Standard required achieving certain levels of diffuse luminance (i.e. brightness) on walls, the reflectivity of the tunnel wall claddings will have a significant impact on the design of lighting in the tunnel. The wall cladding in the tunnel will be relevant for two reasons. The first reason concerns the reflectivity as mentioned, whereby the higher the reflectivity of the wall, the less illumination (and therefore less lighting energy) will be required to achieve the required levels of luminance. Secondly, the ability to resist grime and the ability to be cleaned will affect the room surface maintenance factor (RSMF) that is chosen during the design process. A surface that is more resistant to dirt build-up and is easier to clean will allow the use of a higher RSMF, thereby decreasing the amount of luminaires needed to achieve the required lighting parameters.

A similar but lower cost option for re-cladding the walls is to clad to a height of 2.4m (standard panel height) above the concrete crash barrier with the aluminium panelling, and paint the remaining upper portion of the wall with an appropriate high-reflectance, dirt-resistant paint. This will give much of the same benefits without such a high initial cost.

4.0 Acton Tunnel lighting classification – AS/NZS 1158.5

4.1 Introduction

The Australian Standard AS/NZS 1158.5:2009 Lighting for roads and public spaces Part 5: Tunnels and Underpasses (hereafter referred to as the Standard) specifies performance and design requirements for lighting schemes in tunnels and underpasses. The Standard begins with procedures for determining the applicable classification of a tunnel or underpass, based on the physical properties of the tunnel and the speed limit of the road. Subsequent calculations based on various roadway and tunnel characteristics give rise the required luminance at the entrance to the tunnel, and subsequent reductions in luminance along the length of the tunnel.

The procedures from the Standard have been followed for Acton Tunnel, and are summarised below.

4.2 Road element classification

Classification of the tunnel to determine its Lighting Subcategory is achieved by determining the Stopping Sight Distance (SSD), examining the tunnel from this distance to determine the extent of see-through, and applying the results to Figure 2.2 of the Standard.

4.2.1 Stopping sight distance

From Table 2.2 of the Standard, for a road with a speed limit of 90km/h and no corrections for grade, the Stopping Sight Distance is 140 metres.

4.2.2 Determination of see-through from SSD

A site investigation was undertaken, whereby photos were taken from the stopping sight distance at each approach to the tunnel. Figure 1 and Figure 2 show the approach view in the Eastbound and Westbound directions respectively. It can be seen that neither view has see-through.

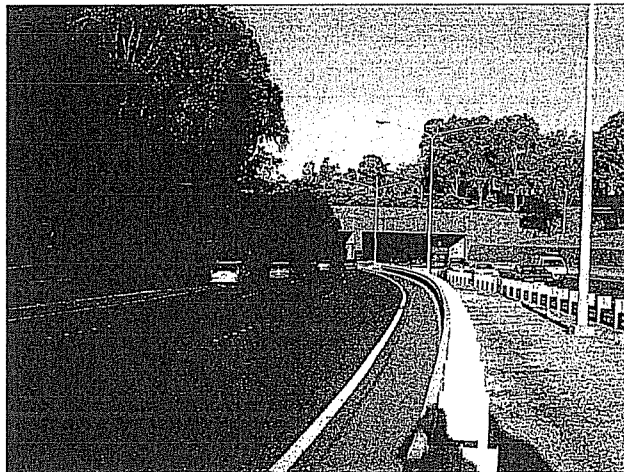


Figure 1: Eastbound view from SSD

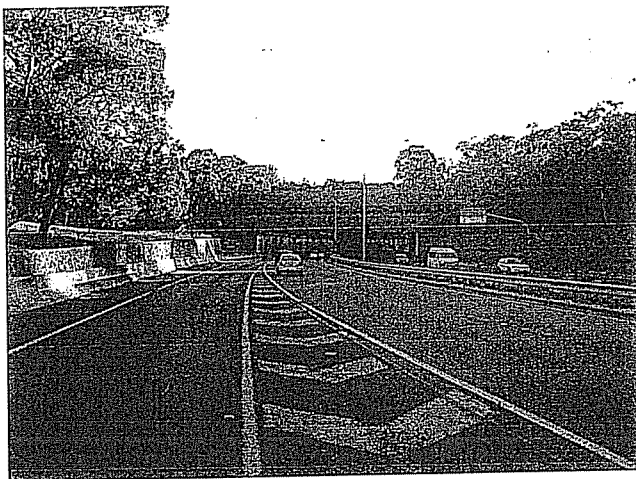


Figure 2: Westbound view from SSD

4.3 Determination of lighting subcategory

Applying Figure 2.2 of the Standard indicates that with no see-through the road element classifies as a 'Tunnel'. The tunnel length (approximately 190 metres) is less than the transition zone (transition zone equals 450m, from Figure 3.2 of the Standard), therefore the applicable lighting category for the tunnel is Category TU2.

The Standard describes TU2 as follows:

"Tunnel of shorter length which requires an abbreviated tunnel lighting treatment after the threshold zone. Part of urban, high traffic volume road network for motor vehicle traffic only." (From Table 2.1 of the Standard).

4.4 Determination of access zone luminance

The access zone luminance describes the brightness of a view of the tunnel entrance, and is estimated using the technique outlined in Appendix H of the Standard. This includes the estimation of the brightness of each element in a 20° field of view of the tunnel entrance as observed from the SSD. An image of the tunnel entrance is divided into discrete areas based on the objects in that view, and luminances are assigned to each element as per the recommendations in Tables H1 and H2 of the Standard.

The calculations used in determining the access zone luminances for each carriageway are summarised in Section 11.1.

Access zone luminances calculated in each direction of travel are as follows:

Direction of travel	Access zone luminance L_{20}
Eastbound	4852
Westbound	5115

4.5 Threshold zone luminance

The road surface luminance of the threshold zone is determined by multiplying the L_{20} values by a scaling factor k . The value of k is interpolated from Table 3.1 of the Standard for a SSD of 140m to be 0.08677; therefore the threshold zone luminances to be used in the tunnel lighting design are as follows:

Direction of travel	Threshold zone luminance L_{th}
Eastbound	420.64
Westbound	443.44

These are the values that will be used as the primary design criteria on which the tunnel lighting is based.

4.6 Luminance reduction in the threshold and transition zones

Figure 3.2 from the Standard outlines the decrease in luminance throughout the transition zone. The rate of decrease is dependent on the design speed of the road, which in this case is 90 km/hr. Luminance levels are stepped down in increments corresponding to 100%, 75%, 50%, 25% and 12.5%, with the length of these zones being 70m, 35m, 20m, 35m, and 45m respectively.

4.7 Interior zone

The average road surface luminance in this zone shall not be less than the value derived from Table 3.2 of the Standard. For a SSD of 140m, the interior zone luminance shall be above 9.2 cd/m^2 . Although the Acton Tunnel is not long enough to require interior zone lighting, this value is used to determine the night-time lighting level.

4.8 Exit zone

For a lighting scheme designed to Category TU2, where the exit is reached in the threshold or transition zone, exit zone lighting is not required.

4.9 Night-time lighting

The night-time lighting is required to be not less than 50% of the lighting applicable to the road and walls in the interior zone. In this case, with the interior zone luminance calculated to be 9.2 cd/m^2 , the night-time lighting level shall not be less than 4.6 cd/m^2 .

4.10 Mains failure lighting

The Standard includes the following requirements for a Subcategory TU2 lighting scheme:

"5.1.2 Subcategory TU2 - Short Tunnels

Duplicate main power supplies plus UPS"

4.10.1 Duplicate power supplies requirements

The Standard requires that the normal entrance and interior zone lighting be provided with duplicate power supplies. This may be achieved either by having two permanent supplies from alternative sources, each supplying part of the normal lighting, or by having normal lighting fed from one supply with an automatic and practically instantaneous changeover from one supply to the other upon failure of the first.

The existing supply arrangement includes duplicate feeds from two substations and an automatic transfer switch, so complies with this requirement.

4.10.2 Mains power failure lighting requirements

Lighting subcategories TU1, TU2 and TU3 require a mains failure lighting scheme to be installed. This shall form a part of the normal night-time lighting scheme throughout the length of the tunnel and shall consist of a number of evenly spaced luminaires energised from a UPS.

The average illuminance level from the mains failure lighting scheme shall be at least 10 lux horizontal average at the carriageway surface, with a minimum of 2 lux at any location within the tunnel. The lighting shall remain active for a minimum of 30 minutes under mains failure conditions

Exit signage should be installed to the requirements of AS/NZS 2293.

4.11 Light technical parameters

A summary of the light technical parameters and tunnel properties used in the calculations is as follows:

The design parameters shall be as follows:

• Road surface	CIE R1 (Concrete)
• Wall reflectance	0.25 (existing surface), 0.6 proposed new surface
• Concrete barrier reflectance	0.35
• Ceiling reflectance	0.2
• Maintenance factor (existing walls)	0.68
• Maintenance factor (new walls)	0.74
• Luminaire optical mounting height	5.35 metres
• Tunnel width:	14.8 metres
• Number of lanes:	3 lanes plus cycle/emergency stopping lane
• Design maximum speed:	90 km/h
• Stopping sight distance:	140 meters
• Traffic flow:	Single directional
• Zone lengths and luminance	as per AS1158.5 (2007)
• L20 value Southbound:	10000cd/m2
• Threshold zone luminance:	500 to 550 cd/msq
• L20 value Northbound:	10800 cd/msq
• Threshold value:	540 to 600 cd/msq
• Type of tunnel lighting installation	symmetrical

The tunnel lighting system switching sequence shall occur in accordance with the varying luminance levels detected in the access zone by the photometers at each tunnel portal.

5.0 Lighting technology study

5.1 Best available technology

Industry best practice and previous AECOM studies have established a current best practice combination of technologies for tunnel lighting. These include the use of high pressure sodium and fluorescent lamps. The benefits of each are outlined below.

5.1.1 High pressure sodium

High pressure sodium lamps (HPS) are among the highest efficacy lamps in general use. The latest generation of HPS lamp (Osram's Vialox NAV-T Super 4Y and similar) combines very high efficacy with long lifespan and very good lumen maintenance. HPS lamps are stable at high temperature, which is important in tunnel lighting schemes. From a practical viewpoint, HPS lamps are available in a useful range of wattages, which make them well suited for tunnel lighting designs, where graduated lighting levels are required.

5.1.2 Fluorescent

Fluorescent luminaires are very well suited to tunnel lighting at lower luminance levels, therefore are the preferred choice for night-time tunnel lighting. The ease of switching and dimming of luminaires make them flexible to use. In addition they are well suited for use as emergency lighting, due to their instant starting ability and low input power requirements. Extremely long-life T8 lamps are available, such as the Aura Ultimate long-life lamp, which is rated to a service life of 48,000 hours life when operated with magnetic ballasts or 70,000 when operated with electronic ballasts.

5.2 Energy saving techniques

Energy saving techniques available for tunnel lighting can be summarised into three broad categories, as follows:

5.2.1 Best available lamp and luminaire technology

As described above, there is an established industry best practice regarding the type of light sources that are best used in tunnel lighting. These include the very high efficacy high pressure sodium lamp and the high efficacy fluorescent lamp. Luminaire technology contributes to overall efficiency through the selection of luminaires with high quality optics and high protection from dirt ingress.

5.2.2 Optimised design of tunnel interior surfaces and luminaire layout

The tunnel lighting Standard includes requirements for the brightness levels of walls. This means that lighting must be arranged such that light is directed on the tunnel walls, creating brightness to satisfy the required levels. In addition, reflection of light off the walls can contribute to increasing light levels on the tunnel floor. The implication of both of these items is that increasing the reflectivity of the tunnel walls can decrease the amount of lighting energy that is required to be installed. Given that the existing tunnel wall coatings are not very reflective and are not resistant to dirt build-up, there is an opportunity to reduce potential energy usage by re-cladding the tunnel walls with higher-reflectivity, dirt-resistant materials.

5.2.3 Switching of light levels in response to ambient light levels

The intent of the design is to employ a total of five daytime switching levels. Switch groups would be configured such that light levels can be varied in response to ambient light levels during the day. Lower luminance levels at the tunnel opening will allow for the tunnel transition lighting to be set to a lower level. Luminance meters at each tunnel entrance will constantly monitor ambient light levels, allowing the graduated switching to take place. Switching levels of 100%, 75%, 50%, 25% and 12.5% will be used. Two extra light levels will be included, for night-time usage and for emergency lighting.

5.3 Active reactor technology

TAMS has requested that 'Active Reactor' technology be considered for use in the tunnel lighting. Active Reactor is a proprietary technology which makes use of the fact that discharge lamps require lower power at the beginning of life than they do at the end of life, therefore allowing energy savings by tailoring the delivered power to the actual requirement of the lamp. The device consists of an iron core ballast to supply a constant base of approximately 70% power, and an electronic device to supply a variable amount of power depending on the age of the lamp. The electronic component of the device has an expected life in the order of seven years (manufacturer's claim), which is temperature dependent. Higher running temperatures will shorten the life of the electronic component. Since the device combines an iron core component and an electronic component, with the former having a much longer expected lifetime, the fallback position of the Active Reactor upon failure of the electronic component will be a maximum of 70% power.

From the research we have conducted, it appears that the Active Reactor technology is well suited to outdoor and road lighting, where ambient temperatures during operation are not expected to be high. This is similar to the recommended applications of electronic ballasts. The use of Active Reactor technology in a tunnel situation may be problematic due to the expected high temperatures that may be experienced, primarily in the higher wattage luminaires (up to 400W) which will operate during the daytime. Luminaire manufacturer Schröder has indicated that they could incorporate the technology in their luminaires, but expressed reservations about using them in a tunnel situation due to temperature effects, particularly for higher wattage luminaires.

It may be possible to use the Active Reactor technology in housings separate from the luminaire to remove them from the source of heat of the lamps. In this case, the Active Reactor and ballast would be in a separate, IP-rated housing mounted next to the luminaire. This method will be explored for the detailed design.

Although electronic ballast technology is becoming more widely used in external lighting, tunnel lighting generally uses magnetic ballasts as standard due to their longevity and resistance to high temperatures. In this instance we would recommend against the use of Active Reactor in the tunnel.

6.0 Related issues

6.1 Maintenance

The planned cleaning and maintenance regime of the tunnel will have an impact on the design of the tunnel lighting. The lighting design process takes into account maintenance and cleaning through the use of Maintenance Factors, which are used to predict the light output depreciation of the tunnel lighting system in the worst case (i.e. at the point where maintenance is undertaken). The overall maintenance factor is a combination of several factors, as described below:

6.1.1 Lamp maintenance factor

This value is taken from manufacturer's data, and predicts the drop in lumen output of the lamp after a certain time period (the re-lamping period). A re-lamping period of four years has been assumed in preliminary calculations.

6.1.2 Luminaire maintenance factor

This value predicts the amount of dirt build-up on the luminaire, and is taken from tables in AS/NZS 1158.1 Appendix E. This value is dependent on the cleanliness of the environment and the frequency of cleaning. A cleaning frequency of four years has been assumed in preliminary calculations.

6.1.3 Room Surface Maintenance factor

This value predicts the amount of dirt build-up on reflective room surfaces, and is dependent on the cleanliness of the environment and the ability of the surface to resist dirt build-up. This value is estimated from tables in the Australian Lighting Standards, and has been estimated to be worse for the existing walls than it would be for new wall claddings, as new wall cladding would be smooth, therefore resistant to dirt build-up and easy to clean. The existing wall surfaces are slightly textured, therefore would be less resistant to dirt build-up and harder to clean.

6.2 Survey of tunnel

Considering that there appears to be little documentation existing on the tunnel, it may be appropriate for TAMS to commission a detailed survey of the tunnel to allow production of detailed drawings, elevations and sections of the tunnel. This could include ceiling plans and surveys of existing services such as fire sprinklers. This would also allow detailed design and as-built drawings to be produced of the lighting upgrade.

6.3 Interior wall surface finishes

As discussed in several places in this report (refer to sections 3.5, 4.11 and 5.2.2), to achieve the best possible lighting design for the tunnel in terms of Standards compliance, energy use minimisation, long-term maintenance and driver seeing conditions, it is advised that the existing wall cladding be replaced with new cladding which will give higher reflectivity and greater resistance to dirt build-up. An example of an appropriate cladding material is Alpolic aluminium panels. Details of this product are included as an attachment to this report.

6.4 Building impacts of lighting works

The removal of the existing lighting will create a continuous gap the length of each tunnel on each side of the ceiling. This gap presumably opens into the ceiling void. It is beyond the scope of this investigation to propose remedial work to these ceilings, however it may be desirable to investigate the filling of these gaps as part of the upgrade works.

7.0 Design options

7.1 Description

As discussed previously, two general lighting options have been explored to date. The two situations investigated are where the existing tunnel wall cladding is retained, and where the wall cladding is replaced with a new higher reflectivity surface. For each option, lighting designs have been refined to a level of completeness where comparisons in terms of installation and running costs and energy use can be made. Both lighting schemes have been designed using similar luminaires and lamp types.

We request that TAMS reviews the budget and energy calculations for each scheme and chose which option is preferred for use in the detailed design phase.

7.2 Design option 1: utilising existing wall cladding

This option involves changes to the lighting in the tunnel only. The existing wall cladding is retained. The reflectivity of the wall surfaces in these calculations is relatively low, and the room surface maintenance factor is lower due to the surface's texture. These factors will result in the requirement of higher light levels to achieve compliance with the Standard. This option uses approximately 1308 luminaires.

Design option 1 is shown on sketch drawing SKE01.

7.3 Design option 2: utilising new wall cladding

This option involves re-cladding the tunnel walls with new higher reflectivity materials (for example aluminium wall cladding). This will significantly increase the reflectivity of the walls, and will allow the use of a higher wall surface maintenance factor due to the improved ease of cleaning. The higher reflectivity will allow for the use of fewer luminaires, however there will be the extra cost of the installation of the new wall cladding. This option uses approximately 1033 luminaires.

Design option 2 is shown on sketch drawing SKE02.

8.0 Estimated Energy usage

8.1 Introduction and assumptions

Assumptions used in comparisons are listed in section 11.2. These estimates do not take into account energy reductions achievable through switching in response to daytime light levels, and as such are intended for use for comparison purposes.

The energy usage of the existing system is based on the documented number and wattage of luminaires listed in a previous electrical report, and assumes that lighting runs at 100% during daytime and fluorescent luminaires only at night time. This may not be representative of how the tunnel currently functions, but is intended to be used for comparison purposes.

Note that the projected design life has been chosen as 20 years for comparison purposes.

8.2 Energy usage projections

The projected energy usages of the existing scheme and two design options are presented in the table below. Estimates are presented in terms of total installed energy, and also in terms of annual and lifetime use in terms of energy, cost and carbon emissions.

	Total Installed Energy (kW)	Annual Energy Use			Design Life Energy Consumption		
		kWh	\$	kgCO2	kWh	\$	tCO2
Existing System	735	3,220,132	\$ 579,624	3,026,924	64,402,644	\$ 25,100,424	60,538
Option 1 with Existing Walls	355	1,556,455	\$ 280,162	1,463,068	31,129,098	\$ 12,132,321	29,261
Option 2 with New Walls	308	1,350,466	\$ 243,084	1,269,438	27,009,323	\$ 10,526,671	25,389

Table 1: Energy comparisons

A comparison of each of the two new design options with the existing system is given below.

Energy Consumption Comparison with Existing Installation	
Option 1: Existing Walls	48.34%
Option 2: New Walls	41.94%

Table 2: Projected savings over existing system

9.0 Budget estimates

9.1 Introduction and assumptions

Assumptions used in comparisons are listed in section 11.2. The budget estimates for the new lighting schemes allow for full construction, including luminaires, new wall claddings, labour and materials.

9.2 Initial and design life cost projections

The table below provides estimates on the estimated installation cost, single bulk lamp replacement and 20-year design life costs of each scenario including the existing situation. The projected costs of the existing installation are for comparison purposes and do not allow for the likely scenario of replacement lamps not being available.

	Initial Cost	Single Relamp Cost	Design Life Total Cost
Existing	\$ -	\$ 121,414	\$ 18,254,995
Option 1: Existing Walls	\$ 2,762,637	\$ 84,629	\$ 10,806,923
Option 2: New Walls	\$ 3,920,613	\$ 67,416	\$ 10,686,537

Table 3: Budget comparisons

A Net Present Value calculation has been prepared using the Roads ACT method, and this is shown below. The calculation shows an extra option of cladding half of the walls with aluminium panelling and painting the upper portion with reflective paint.

Option 1 Original walls		2010	2011	2012	2013	2014	2015	2016	2017	2018
NPV		\$2,889,965	\$127,328	\$127,328	\$211,957	\$127,328	\$127,328	\$127,328	\$211,957	\$127,328
		\$4,163,500.47								
Option 2 New walls		2010	2011	2012	2013	2014	2015	2016	2017	2018
NPV		\$4,028,290	\$107,677	\$107,677	\$175,093	\$107,677	\$107,677	\$107,677	\$175,093	\$107,677
		\$4,687,897.20								
Option 3 New walls half painted		2010	2011	2012	2013	2014	2015	2016	2017	2018
NPV		\$3,428,290	\$107,677	\$107,677	\$175,093	\$107,677	\$107,677	\$107,677	\$175,093	\$107,677
		\$4,127,149.54								

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
\$127,328	\$127,328	\$211,957	\$127,328	\$127,328	\$127,328	\$211,957	\$127,328	\$127,328	\$127,328	\$211,957	\$127,328
2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
\$107,677	\$107,677	\$175,093	\$107,677	\$107,677	\$107,677	\$175,093	\$107,677	\$107,677	\$107,677	\$175,093	-\$1,150,323
2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
\$107,677	\$107,677	\$175,093	\$107,677	\$107,677	\$107,677	\$175,093	\$107,677	\$107,677	\$107,677	\$175,093	-\$1,150,323

Table 4: NPV calculation

10.0 Recommendations

10.1 Recommended design option

A number of items are recommended, as follows:

10.1.1 Upgrade of wall cladding material

The existing wall cladding has poor reflectance properties, which will be a liability in terms of the new lighting designs. It will be possible to provide a solution with lower energy consumption and higher visual quality if the tunnel walls are re-clad with a higher-performing material. This solution will give an overall upgrade that is closer to 'as new' than would the alternative of upgrading lighting only and retaining the existing walls.

The option of cladding half the wall (to a standard panel height of 2.4m) and painting the remaining upper portion is considered as a good, lower cost alternative to cladding the entire wall.

10.1.2 Implementation of bulk lamp-changing regime

It is recommended that a bulk lamp-changing regime on a four-yearly basis is introduced. This would match the expected lifetime of the high pressure sodium lamps in use, and ensure a high standard of upkeep for the tunnel lighting.

10.1.3 Implementation of a regular cleaning cycle for walls and luminaires

A regular cleaning cycle for walls and luminaires is important to maintain light levels within design tolerances. Currently the design allows for four-yearly cleaning, however if a more regular cycle was chosen and implemented (for example annual or bi-annual), higher values of maintenance factors could be used, which would reduce the number of luminaires required and thereby reduce energy usage. It is recommended that a realistic and achievable maintenance regime be chosen based on TAMS experience and best practice.

11.0 Appendices

11.1 Access zone luminance calculations

The calculations to determine the access zone luminance as per Appendix H of the Standard are summarised below.

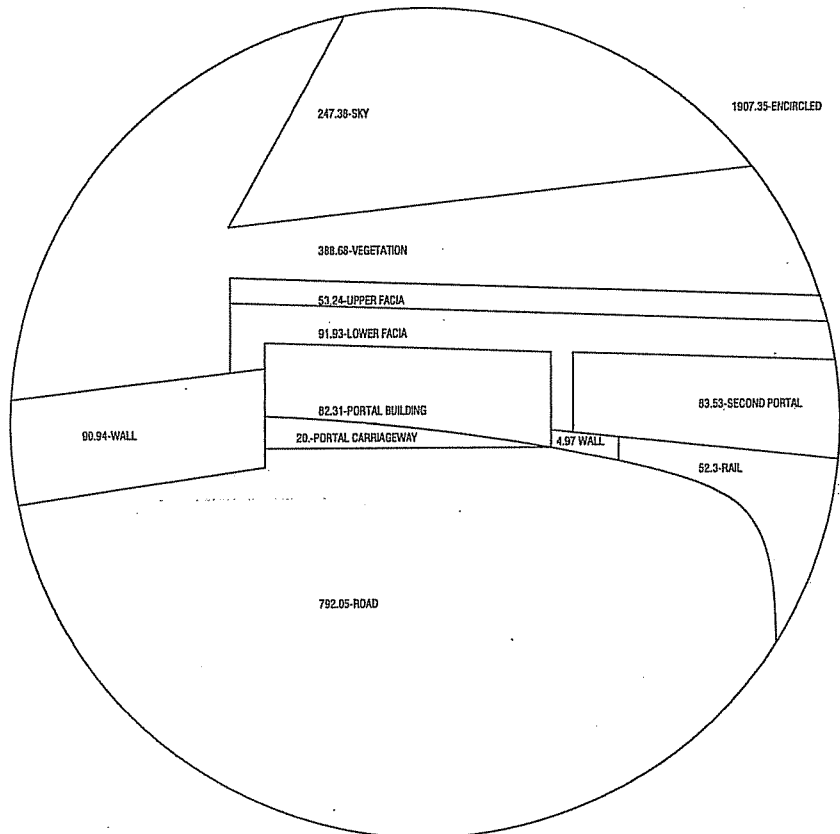


Figure 3: Eastbound 20° view divided into luminance elements (areas shown in m²)

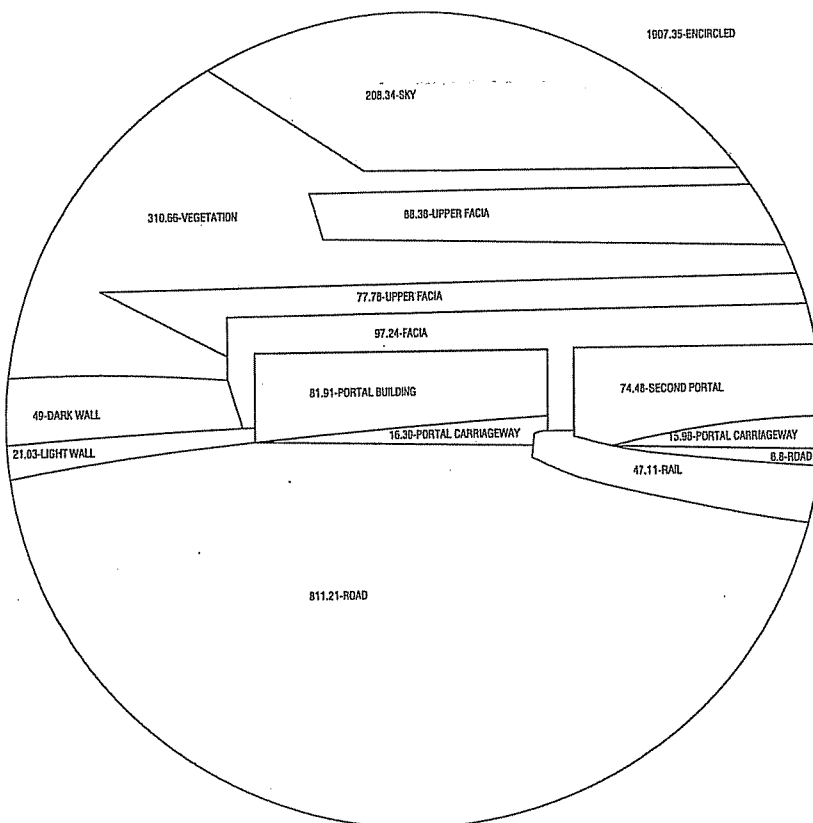


Figure 4: Westbound 20° view divided into luminance elements (areas shown in m²)

East-bound portal

Object	Area	Luminance	A x L
Sky	247.38	12000	2,968,560
Veg	388.68	2000	777,360
Upper Facia	53.24	6000	319,440
Lower Facia	91.93	9000	827,370
Wall	90.94	6000	545,640
Portal building	82.31	1500	123,465
Portal road	20	2000	40,000
Second portal	83.53	1500	125,295
Wall	4.97	9000	44,730
Rail	52.3	6000	313,800
Road	792.05	4000	3,168,200
Sum:	1907.35		9,253,860
		L20:	4852
		k	0.0867
		Lth	420.64

West-bound portal

Object	Area	Luminance	A x L
Sky	208.34	14000	2,916,760
Veg	310.66	2000	621,320
Upper Facia	88.38	6000	530,280
Upper Facia 2	77.78	6000	466,680
Lower Facia	97.24	9000	875,160
Wall upper	49	6000	294,000
Wall lower	21.03	9000	189,270
Portal building	81.91	1500	122,865
Portal road	16.3	2000	32,600
Second portal	74.48	1500	111,720
2nd portal rd	15.98	2000	31,960
Rail	47.11	6000	282,660
Road	8.8	4000	35,200
Road	811.21	4000	3,244,840
Sum:	1907.35		9,755,315
		L20:	5115
		k	0.0867
		Lth	443.44

Figure 5: Access zone luminance calculations

11.2 Assumptions used for calculations

Item	Assumed value
Night Time Mode running hours	12 Hours
Day Time Mode running hours	12 Hours
Days in a Year	365
Design in Life	20
Electrical Costs per Kilowatt Hour	\$0.12
Annual Electrical cost Increase Factor	7.00%
Maintenance Person cost Per Hour (after-hours)	\$180.00
Time to Relamp Per Fitting	30 Minutes
Equipment Cost (Flat Rate)	5000
Cost to Install Per Fitting	150
Time between bulk re-lamping	4 years
Cost per Metre of new wall cladding	\$793.60
Cost per Metre of existing wall removal	\$20.00
Metres of Tunnel Wall	800
kgCO2/kWhr	0.94