PROPOSED PORT BOTANY EXPANSION
LIGHTING ENVIRONMENTAL EFFECTS

For

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By

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1 INTRODUCTION

The purpose of this report is to examine the proposed Port Botany expansion in order to assess the impact of the new container terminal lighting on the airport and adjacent areas and to provide recommendations that address concerns raised during the investigation. The report will provide information on light spill including the extent and possible levels but does not consider what effect those changes will have on local ecology. The current operations at Brotherson Dock container terminals were used as a benchmark in assessing the likely impacts of the proposed facility.

Concerns identified and addressed in this report include effects of light spill on the airport, residents both adjacent to and around the Bay as well as Penrhyn Estuary.

The container terminals operate as follows:

- Upon arrival ships wait at the Pilot Boarding Ground outside Botany Bay to be brought in and berthed. No ships are anchored within Botany Bay.
- Ships are assisted by tug when arriving or departing Port Botany.
- Containers are loaded or unloaded by quay crane from ship and dock.
- Straddles or tractor/trailers and Rubber Tyred Gantries move containers from ship side to various storage areas around the terminal including loading onto road transport.
- Containers transported by rail are handled by rail mounted gantries or forklift trucks.
- Various vehicles move personnel around site.
- The terminals operate 24hrs per day.

2 METHODOLOGY

Many aspects of the proposed development will be similar to the existing terminals at Brotherson Dock (North and South), particularly Brotherson Dock North (Patrick Terminal). It is therefore appropriate to assess the various aspects of current operating terminals and consider the findings in assessing the effects of the proposed development.

Similarly an assessment was made of the existing Port Botany lighting and its impact at various locations around Botany Bay. This information was used to indicate the magnitude of any potential effects from the proposed development.

Issues raised and addressed during this process are summarised in the conclusion.

3 EXISTING CONTAINER TERMINALS LIGHTING

Both Brotherson Dock North (Patrick) and Brotherson Dock South (P&O Ports) have the general area lit by high pressure sodium lamps. This light source is a golden/yellow colour in comparison to whiter mercury vapour, metal halide or tungsten halogen lamps. High pressure sodium lamps are efficient, providing 120 lumens per watt (more or less depending on lamp wattage) and have relatively long lamp survival rates compared with most other light sources.

A list of lighting on existing container terminals is shown in Table 1 along with references to relevant Figures (photographs and diagrams).

TABLE 1 EXISTING CONTAINER TERMINAL (BROTHERSON DOCK NORTH) AND LIGHTING

Item	**Type of Lighting**	**Reference Figures**	**Comments**
High Mast (a), (b)	Floodlights horizontal front glass and or with shields.	1, 2, 10	
Buildings (c)	• External area flood lighting immediately adjacent. • Internal lighting.	1	
Quay cranes (d)	• Downlight – HID weatherproof high bays. Accessway fluorescent luminaires. • Rotating beacon lights when moving • Obstruction lights.	3, 4, 5, 8, 10	Difference between operating and parked
Straddles (e)	• Downlights – incandescent. • Headlights – usually tungsten halogen. • Rotating beacon lights.	6,7	
RMG's (f)	• Downlights • Rotating beacon lights		
Roads (g)	• Road lighting luminaires.		
Vehicles (h)	• Headlights - usually tungsten halogen although some vehicles now using miniature HID. • Rotating beacon lights.		Employees cars coming to and from. Trucks collecting and delivering cargo. Vehicles moving staff around site.
Ships (i)	• Floodlights from bridge and forward end. Lighting along handrails.	9,10	
Trains (j)	• Headlights.		Along route of rail line when moving
Navigation Lighting (k)	• Navigation front and rear lead.	11,12, 14, 17	

(a) **Brotherson Dock North (Patrick)** use flood lights with asymmetric distributions such that the front glass of the floodlight is 3 to 7 degrees above horizontal. Where the floodlights are at 7 degrees, a front shield is fitted to ensure strict compliance with the primary areas requirement of Civil Aviation Regulation (CAR) 1998 and its predecessor.

(b) **Brotherson Dock South (P&O Ports)** use floodlights that are not as asymmetric in distribution, the front glasses of floodlights are not horizontal and therefore appear brighter. Also, the terminal being completed at a later date, there was an increase in requirements for lighting level minimum standards.

(c) **Building mounted lighting** of adjacent areas. This is an application that appears to have been added or changed at a later stage to meet developing needs. Floodlights seem to be aimed at much higher angles and are far more noticeable.

(d) **The Quay cranes** are a luffing type and park the booms vertical when the units are not in use. Quay cranes have three types of lighting considered for this report

(i) The main lighting for moving containers etc is a series of large HID (High Intensity Discharge - usually high pressure sodium) weatherproof downlights mounted beneath the boom and along the line of travel of containers etc.

(ii) Weatherproof fluorescent lighting of access stairs and gangways. This is required for general access and emergency egress when the lift is not working. These luminaires form patterns of light up and along Quay cranes. The luminaires in the existing arrangement would not comply with CAR 1988, primary area restrictions and particularly when the luminaire is installed at angles of 45 degrees. When booms are parked near vertical and that lighting circuit is not switched off they become a series of vertically mounted, unshielded fluorescent luminaires.

(iii) Red obstruction lights.

(e) **Straddles** take the containers from beneath the Quay cranes and place them throughout the container terminal. There are many straddle units and they move all over the terminal. Straddle units have downlights to illuminate the container beneath, headlights at low level for circulation and rotating beacon warning lights.

(f) **RMGS** – Rail Mounted Gantry (RMG)and rubber tyred gantries (RTGs) are similar to (d) and (e) above in that they have downlights for the main working light and warning beacons, however, movement is clearly defined.

(g) **Road Lighting** is generally minimal with no special characteristic such as cut off or back light shields.

(h) **Vehicles** – there are a variety of vehicles on site at any one time. Whilst moving, the vehicles will use headlights and some will have rotating beacon warning lights. Queues of trucks wait along Penrhyn Road parked on the north road verge with lights off. Employees vehicles come and go to the site.

(i) **Ships** – this lighting is dependant on the ship. Typically there are floodlights mounted on the bridge aimed down toward the deck and floodlights mounted on a foremast also aimed down towards the deck. This lighting is usually only for working on the deck whilst loading and unloading cargo. The floodlights are open faced type and aimed at angles around 70 degrees above the horizontal. These floodlights can be metal halide, mercury vapour or tungsten halogen.

(j) **Trains** – On the night that a train movement was observed, no headlights were used within Brotherson Dock North.

(k) **Navigation Lighting** – the main item is the lead channel marker lighting and the main entrance lead. At Brotherson Dock the current end lead channel markers between Brotherson Dock North and South use an indirect lighting system. It consists of angled reflectors, and vertically aimed narrow beam floodlights focussed on to the reflectors. A navigation sector light is located on a 15m pole on the western end of Brotherson Dock.

4 PROPOSED NEW CONTAINER TERMINAL AND ASSOCIATED AREAS LIGHTING

As the proposed development will be closer to the parallel runway than Brotherson Dock North, there are a number of implications possibly requiring change to the way some activities are conducted or lit.

The addition of more lighting in the area has the potential to affect the wildlife in Penrhyn Estuary. More lighting also has the potential to impact on existing residential areas unless restrictions are applied.

Floodlighting on board ships whilst berthed has the potential to be distracting and is less controllable than the general area container terminal lighting. This needs to be assessed with respect to the parallel runway, residents and motorists.

Table 2 shows a summary of the lighting expected to be associated with the proposed development.

TABLE 2 THE PROPOSED DEVELOPMENT AND LIGHTING

Item	Type of Lighting	Reference Figures	Comments
High Mast	• Floodlights horizontal front glass and or with shields.		
Quay cranes	• Downlight – HID weatherproof high bays. • Access way fluorescent luminaires. • Rotating beacon lights when moving obstruction lights.		Horizontal shuttle boom.
Straddles	• Downlights – incandescent. • Headlights – usually tungsten halogen. • Rotating beacon lights.	6, 7	
Vehicles	• Headlights - usually tungsten halogen although some vehicles now using miniature HID. • Rotating beacon lights.		Employees cars coming to and from. Trucks collecting and delivering cargo. Vehicles moving staff around site.
Trains	• Headlights.		
Ships	• Floodlights from bridge and forward end. Lighting along handrails.	9, 10	
Navigation Lighting	• Navigation front and rear lead.	11, 17	
Buildings	• External area flood lighting immediately adjacent. Internal lighting.	1	
Roads	• Road lighting luminaires.		

(a) Light Source

The light source used could be with a white light source such as metal halide or a continuation of the existing high pressure sodium lighting.

(i) Metal halide has the advantage of considerably superior colour rendition. The clarity of definition for container handling equipment operators is considerably enhanced compared to working with predominately orange containers under golden/yellow light. This is noticeable where ships use metal halide light sources to illuminate the deck in comparison to high pressure sodium. Use of metal halide may improve work safety.

(ii) High Pressure sodium has the advantages of higher luminous efficacy which means lower running cost for the same lighting design level and lamps will last longer so maintenance costs are reduced. High Pressure Sodium is less likely to attract insects.

Yellow light is used in outdoor applications to reduce the likelihood of insect attraction. White light sources such as metal halide appear to attract insects for example those above the Sydney Harbour Bridge and various up-lit multi-storey buildings in Sydney. Insects attract birds and birds can be a hazard to aviation.

(b) Area lighting for container storage and general movement.

Design considerations include light penetration down between container stacks which increases the number of poles depending on the height of the stacks considered. The opposite consideration is the minimisation of obstructions such as lighting poles and the mass foundations associated with this type of application as well as the cost of each pole and associated structure. With 3-high container stacks, poles spaced 100 to 120 metres apart appear to be acceptable. 6-High container stacks will require poles at closer spacing to obtain the required light penetration down between stacks. If the number of poles increases this does not translate into a directly proportional increase in lighting as the average horizontal illuminance requirement will remain the same. In some locations the increase will be 10 to 15 percent and in other areas there will be no change. The current expectation for lighting is a maintained average horizontal illuminance at ground level of 50 lux in the main storage areas and 25 lux in the secondary areas.

(c) Sydney airport, its proximity and the implications.

The airport of Sydney operates a limited number of hours at night. Sydney Airport Corporation Limited determines whether or not a runway is operating and Airservices Australia provide the air space control to pilots directing them towards the appropriate runway. The decision to land or abort and re-try is made by the pilot. Control of air traffic on the ground and up to one minute after take off or before landing is directed from the control tower.

The Civil Aviation Safety Authority (CASA) is the overall regulatory authority and restricts any lighting in the vicinity of an airport that might prevent the easy identification of a runway, particularly for landing. The closest runway to the proposed development is the parallel runway R34/L16. CASA provide “Advice to Lighting Designers” for “Lighting in the vicinity of aerodromes” The advice provides restrictive zones within a general 6 kilometre radius of a runway and in particular four primary zones (A, B, C, D) concentric to the runway axis. This information is shown superimposed on drawing 5226-L01 (Appendix A).

An eighteen metre wide strip of the proposed container terminal dock lies within zone D. This means that the quay cranes and berthed ships are in Zone D. Lead in navigation lights would be in Zone C.

(i) **High Masts** – asymmetric distribution horizontal flat glass floodlights are required to optimally comply with CASA requirements and have maximum lighting efficiency directing all light down to the intended application area. Mast heights similar to those on Brotherson Dock North (40m) are within the height restrictions required.

(ii) **Quay cranes** – height restriction require the use of shuttle boom quay cranes (refer Figure 16).

- The main downlight type task lighting will meet all CAR 1988 restrictions.
- The access/egress stairs and gangways will not comply with requirements if the same weatherproof fluorescent arrangement is used as per the existing luff type quay cranes. Luminaires for this purpose can still be weatherproof fluorescent but must be mounted horizontal (no tilt) and have internal shielding of the lamps to ensure correct cut off. This design criteria is not expected to raise any operational concerns.

- Obstruction lights required.

(iii) **Straddles** – straddles will move mostly in the secondary zone but will pick up containers from beneath the quay cranes, thus entering Zone D for this period. The main task downlights will comply with CAR 1988 zones but the headlights and rotating beacon lights require consideration.

(iv) **RMGs** will only operate in the secondary zone lighting restriction. Their lighting is similar to straddles.

(v) **Buildings and associated areas** – external associated areas should be lit with floodlights that have a similar cut-off lighting performance to those mounted on the high mast.

Internal building lighting is unlikely to be any more distracting than that used at the airport terminal. Generally ceiling mounted lights with a downward throw are appropriate. Up-lights only to be used in areas where there is no direct views through windows.

(vi) **Roads** – cut off type road lighting luminaires to be used where-ever possible.

(vii) **Rail** – The head light on any train will be in the secondary airport restriction zone and is unlikely to be more or less distracting than currently on Brotherson Dock North. This is a transitory source.

Where the proposed line is parallel to Foreshore Road there is a potential for distraction to motorists although this is no different to any other situation where rail lines run parallel to roadways.

Light from any train movements will affect the vegetation area and wildlife either side of the track albeit a transitory source.

(viii) **Ships** – Once berthed the floodlights on ships are used to providing working light on deck. Ships on the north/south berths will be in zone D. The details of floodlights and their aiming will vary from ship to ship. The brightest light source is likely to be 1.5 to 2 kW metal halide in a symmetric distribution. There is potential to affect use of the airport, as well as motorists on Southern Cross Drive, motorists on Foreshore Road and residents in Botany.

As the lighting on board ships is not mounted on the highest point on a ship but usually somewhat lower as shown in figures 9 and 10, the anticipated mounting height relative to the dock for the larger ships will be approximately 20 to 25 metres. This is considerably lower than the highmast lighting at 40 metres and it is expected that the existing vegetation belt will form an effective screen for residents.

If the on board ship lighting is aimed like conventional floodlighting of a playing field where the peak intensity is 65 to 70 degrees up from the nadir, the lighting will be no more distracting to motorists along Foreshore Road than conventional playing field lighting anywhere else in the metropolitan area where it is set back 500 metres off the road. In addition there will be varying degrees of screening by vegetation and the road is straight and flat.

The situation is different for motorists travelling southward along Southern Cross Drive. Motorists travel up the fly-over over Botany Road, round a bend and over a rise. At this moment motorists would have a clear view of any northward aimed floodlights on board ships. The comments in the paragraph above are applicable, however, this time the distance to the light source is some 2.3km. In winter it will be night-time during peak traffic. In peak traffic vehicle flow has a tendency to back-up where the lanes merge resulting in a sudden deceleration for motorists entering the area. If a drivers' attention is distracted by the apparent sudden appearance of a bright light source(s) at the wrong moment there is the potential for an accident. There is an example of this a little further along on the new link to the M5. As a motorist leaves Southern Cross Drive going southwards and proceeds up the fly-over over Southern Cross Drive and round the bend, lighting of the St George Soccer Club playing fields is quite distracting. This lighting is less than 1km distant and there are many more floodlights than those mounted on the bridge of a ship, therefore the brightness impact is much greater. If the floodlighting on board ships is properly aimed a scenario similar to that of the St George Playing Fields is unlikely.

Unless floodlights on board ships are of the asymmetric type and the front glasses are no more than 3 degrees above the horizontal they will not comply with the requirements of CAR 1998 restrictions. The floodlights shown in Figures 9 and 10 do not comply and there currently is no control over lighting on board ships.

CASA rely on their own assessment of existing installations and complaints raised by any pilot as a practical determination of whether or not lighting in the vicinity of aerodromes is acceptable. Existence of a non-compliant lighting installation elsewhere is not deemed grounds for approval of another non-compliant installation.

It is not practical for the airport to divert traffic from the parallel runway between sunset and curfew because there would be loss of business. Likewise, it is not practical for the proposed container terminal to reduce activity rate on board ships between sunset and airport curfew because of loss of productivity. An assessment should be made from the air, of Brotherson Dock North with ships at berth. This is as close as possible to a full scale mock-up of the proposed development as the proposed highmast lighting will be very similar and a number of ships can be berthed at one time.

Some options include:

- Lighting on board ships whilst berthed to be provided mostly by the shuttle boom quay cranes with supplementary lighting on board only being provided where necessary.
- Ships berthed facing a specific direction, that is, north or south and using floodlights mounted on the bridge only. The fly-over mentioned above would provide valuable information on the appropriateness of this option.
- Provide restrictive temporary shielding to any permanent ship mounted floodlights if used whilst docked.

(ix) **Navigation** – channel alignment can be achieved by either front and back lead markers or by a single unit which is precisely optically controlled and also filtered internally to produce distinct bands of light (red, white and green). The markers can be mounted on a pole or on a building of an appropriate height for visibility from the bridge of ships.

Commercial products are available (such as Vega PEL sector lights – refer Fig 40) that will ensure nil light at 3 degrees above the horizontal whilst providing well defined bands of light in the horizontal. Only one PEL sector light is required. Different lamp wattages provide different intensities for operation depending if the light is meant to be seen by day or by night. Brighter intensities apply to day-time operation. (Refer also to residential (d)(ii)). This technology is already in use in the vicinity of both the north south runway and the parallel runway.

(x) **Associated Areas** – Areas such as tug berths and public boat ramps will be well lit whilst complying with light restriction above the horizontal with the appropriate selection of luminaries from the diversity available on the market.

(d) Effects on occupants and users of buildings in view of the proposed development.

It is assumed that industrial and commercial premises are unlikely to be affected in the same manner as residential and nursing care venues. The latter two being the critical considerations and subject as a minimum to the requirements of AS4282 – 1997 Control of the obtrusive effects of outdoor lighting.

There are two groups, namely those closest in suburb of Botany and the second being those some kilometres distant around the shores of Botany Bay.

(i) **Botany Residents** – There are two potential sources of unwanted light. One is light falling on adjacent properties. Direct light can be calculated with computer software and measured on-site with an illuminance meter.

Calculations (Appendix B) show that there will be strict compliance with AS4282 – 1997. There will be no measurable direct light spill in the vicinity of residences in Botany using horizontal front glass asymmetric floodlights.

The second consideration is a view of the lit luminaire. With high mast lights at 40 metres there will be situations where some residences would be able to view light sources. Figure 29 shows four areas likely to be affected and lists the types of residential housing. Fig 20 shows a general daytime view from midway along Brotherson Dock North and taken at a height of approximately 28 metres. The proposed light masts for the new container terminal have floodlights at heights of 40 m and closer in proximity, therefore slightly more housing will be exposed than shown in the photographs. Figures 20 to 22 inclusive provide enlarged images of parts of Fig 19.

Whilst AS4282 – 1997 places limits on the luminance of floodlights after curfew, it will be more appropriate to eliminate this potential obtrusive effect all together. The visibility of the lit floodlights can be eliminated by a shield of 5 degrees fitted to each floodlight (refer Figure 39).

Similar consideration should be given to quay crane lighting due to the mounting height of luminaries relative to residences and screening.

(ii) **Botany Bay Foreshore Residents.** Due to the distances involved only luminance of light sources are a potential issue. A number of observation were made around Botany Bay as shown on drawing 5226-L01 (Appendix A). Illuminance measurements include all lighting in the field of view, that is, both docks, the liquid storage areas, ship lighting, street lighting and building lighting. With the total Ev values shown the contribution of just Brotherson Dock North would be insignificant.

Photographs show from some observation points the different perspectives. Depending on whether an observer considers distant lighting to add to the sparkle of the city or detract from the visual amenity at that point the development would be acceptable or non-acceptable. This is a personal choice. Luminance measurements were made with a 1/3rd degree luminance metre and the results are shown on drawings 5226-L01. There is a clear difference in luminance between the high mast lights on Brotherson Dock North and Brotherson Dock South.

The proposed development will add to the number of lights visible and the addition will be similar in brightness to Brotherson Dock North. The brightest light sources will be the floodlights on ships (as seen in Figures 26 and 28).

Navigation lighting has the potential to affect a narrow sector of Botany Bay. If a PEL sector light is used and is focused such that it is visible from Kurnell, a day-time PEL sector light with apparent flashing will be distracting to residents at night at that distance due to the intensity of the light source (even with a night-time neutral density filter attachment). The solutions include use of a night-time only PEL sector light which has a considerably lower intensity and or a combination of one day-time unit and one night-time unit operated accordingly. Depending on the mounting height of the unit, appropriate aiming will eliminate un-wanted views of this light source as the optical control is very precise restricting views to the target directions.

(e) Effects On Penrhyn Estuary and Foreshore Beach.

The Penrhyn Estuary and Foreshore Beach areas currently experience light from Port Botany and the existing Brotherson Dock North operation. The light is primarily due to reflection from the atmosphere, however, at closer observation points there is reflection from the water surface when there is little or no wind (refer Figures 30 to 38). An overcast night with very little wind similar to that of 21st October when observations and measurements were made on Foreshore Beach and the Penrhyn Estuary, the indirect light reflected from the clouds overhead registered 0.45 lux as noted Fig 30. This reflected component is from all the light sources in the vicinity of Port Botany and surrounding areas. Luminaires providing direct light into the atmosphere contribute the largest amount to indirect atmospheric effects (eg Caltex). Figure 30 indicates that the indirect reflected component from all lighting in Port Botany is of the order of 0.5 lux on the horizontal with a variation of 0.1 lux closer to Brotherson Dock North. At observation point 9 the difference between the total vertical illuminance from Botany Bay and that from Port Botany is 0.22 lux.

Adding the proposed development has the potential to increase light spill onto Foreshore Beach with a lesser impact on Penrhyn Estuary. Figure 40 shows the anticipated direct vertical light spill into this area. If an indirect reflected atmospheric component is added to the direct component anticipated along Foreshore Beach (0.1 plus 0.6) that will provide values of the order of 0.7 lux in the vertical for areas closest to the proposed container terminal. For people walking their dogs along the beach this may add to the sense of security whereas those wishing to enjoy a dark environment on the beach this will not be so advantageous.

It is important to avoid the use of high mast lighting immediately adjacent as it will be virtually impossible to shield light from such installations.

The road based activities shown in the proposal can help provide a buffer zone to the high mast lighting. Lower poles with cut-off type road lighting luminaires and back-light spill shields are required, Low mounting heights only require low wattage light sources, however, the number required is increased. The effect will be to provide greater control over light spill.

Headlights from turning vehicles can be screened from shining across Penrhyn Estuary by a suitable height physical barrier and that barrier obscured with vegetation as it grows.

5 CONCLUSIONS

Lighting of the proposed development and lighting associated with operating a container terminal have the potential to be obtrusive to the environment and adjacent commercial, social and residential activities.

That potential can be eliminated in some instances and substantially reduced in other aspects by adopting the following:

1. Use high pressure sodium as the light source.
2. General area and container storage area lighting to be provided by asymmetric floodlights installed with front glasses horizontal. Front glasses to have nil degrees tilt.
3. Any floodlighting or other lighting from buildings or other structures to also be of asymmetric distribution and installed with the front glasses horizontal.
4. High mast lighting and weatherproof HID downlights mounted on shuttle boom quay side cranes to have shields to eliminate any views of the lit luminaires by residents.

5. The lighting of shuttle boom quay side crane access and egress steps and walkways to be with luminaires to be mounted and shielded to prevent any light above the horizontal.
6. Any road lighting to be provided by luminaires mounted at low height and of the aero screened type with front glass installed horizontal. Light spill into Penrhyn Estuary and onto Foreshore Beach is to be avoided by the combination of positioning as well as using a luminaire which has no backward light spill if positioned along the eastern or northern boundaries.
7. Physical barriers to be installed along the perimeter facing Foreshore Beach and Penrhyn Estuary to eliminate the intrusion of the light from headlights of turning vehicles.
8. Navigation lighting for channel lead to be provided by a luminaire or luminaires that have very precise optical control such as the Vega PEL sector light system. Night time intensity to be of the order of 1% of daytime intensity and the luminaire is to be aimed to have no visibility to aircraft or to residents on the other side of Botany Bay.
9. Only ships working cargo to use deck floodlighting which is to be aimed down onto deck areas. Whilst docked the combination of shuttle boom quay crane lighting and appropriate supplementary lighting to be developed according to section 4(c)(viii).

REFERENCES

1. Aviation Legislation, Rules and Practices for Aerodromes, Chapter 12, Section 1: Appendix I Lighting in the vicinity of aerodromes – Advice to lighting designers. August 1999

2. Australian Standard AS 4282-1997 Control of the obtrusive effects of outdoor lighting.

APPENDIX A – IMAGES AND DIAGRAMS

OBSERVATION POINTS

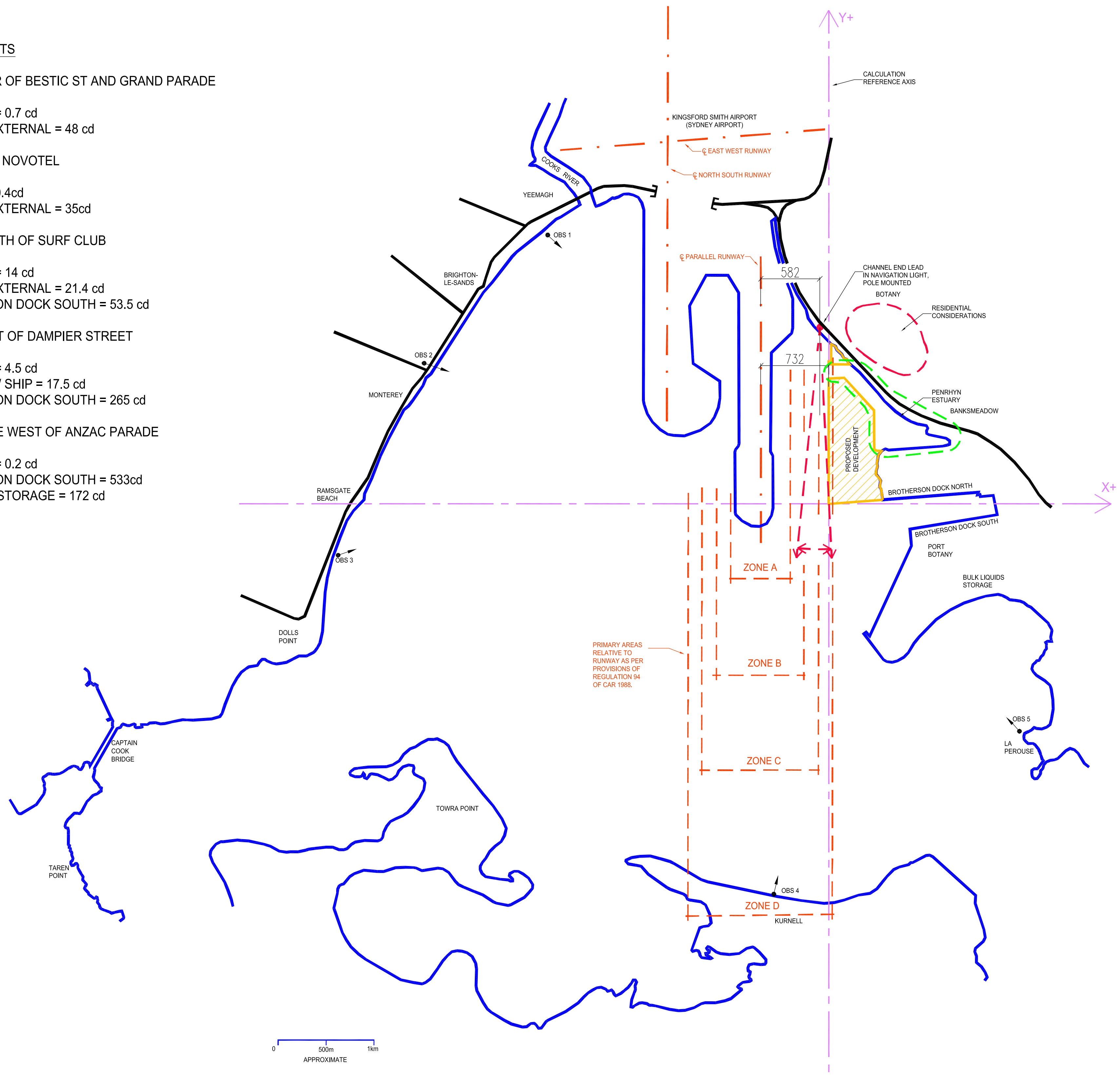
OBS1 BEACH, CNR OF BESTIC ST AND GRAND PARADE
Ev = 0.22 lux
HIGHMAST = 0.7 cd
BUILDING EXTERNAL = 48 cd

OBS2 12th FLOOR, NOVOTEL
Ev = 0.39 lux
HIGHMAST 0.4cd
BUILDING EXTERNAL = 35cd

OBS3 BEACH SOUTH OF SURF CLUB
Ev = 0.05 lux
HIGHMAST = 14 cd
BUILDING EXTERNAL = 21.4 cd
BROTHERSON DOCK SOUTH = 53.5 cd

OBS4 BEACH EAST OF DAMPIER STREET
Ev = 0.13 lux
HIGHMAST = 4.5 cd
PORTAINER/ SHIP = 17.5 cd
BROTHERSON DOCK SOUTH = 265 cd

OBS5 FORESHORE WEST OF ANZAC PARADE
Ev = 0.30 lux
HIGHMAST = 0.2 cd
BROTHERSON DOCK SOUTH = 533cd
BULK FUEL STORAGE = 172 cd



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Project

PORT BOTANY
EXPANSION PROPOSAL
THIRD CONTAINER TERMINAL

Drawing Title

LIGHTING SERVICES
EIS REPORT -
LIGHTING

Scale @ A3	APPROX 1:50,000	Checked
Date	OCT '02	Approved
Drawn	DJM	Verified

Drawing No.

5226-L01

PRELIMINARY

Revision **01**

CAD File V:\5226\5226-L01

Fig 1. Typical container storage lighting
Brotherson Dock North (Patricks)
Compliant with CASA requirements
And external building lighting using
open face floodlights.

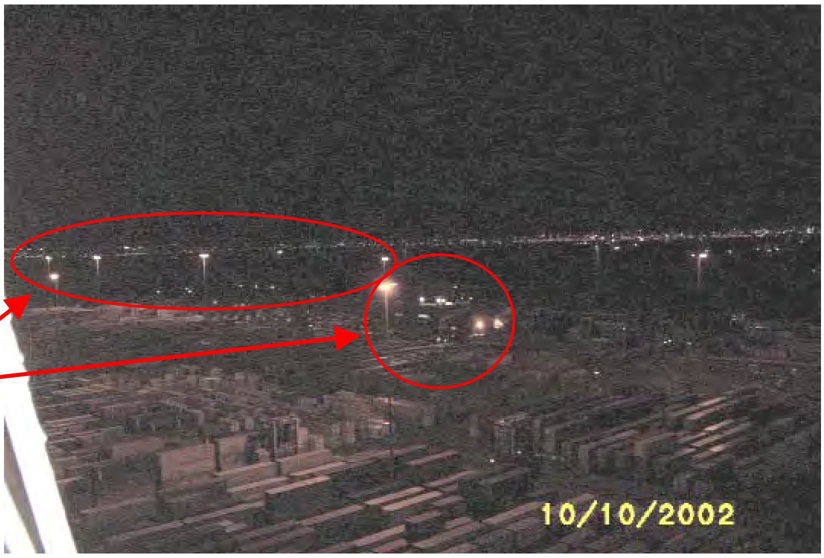


Fig 2. Brotherson Dock South (P&O)
Open face floodlights

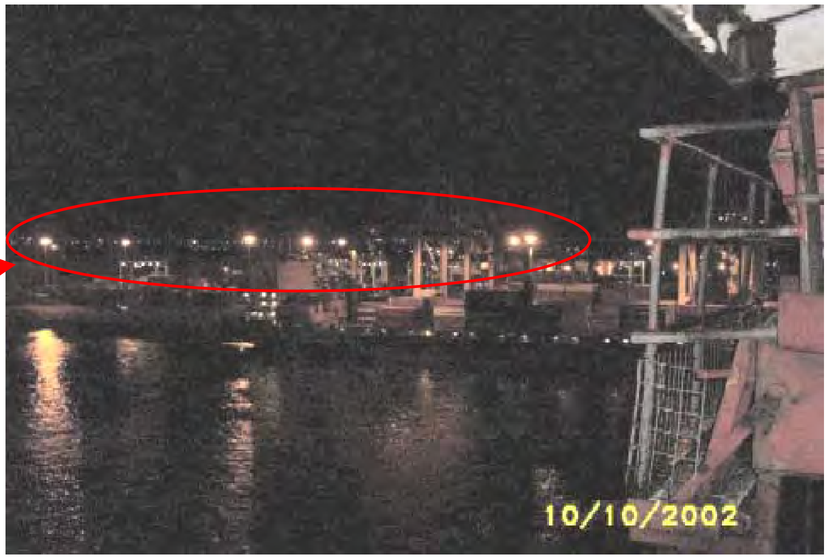


Fig 3. Typical downlights beneath
quay crane and fluorescent lights
on access stairs.

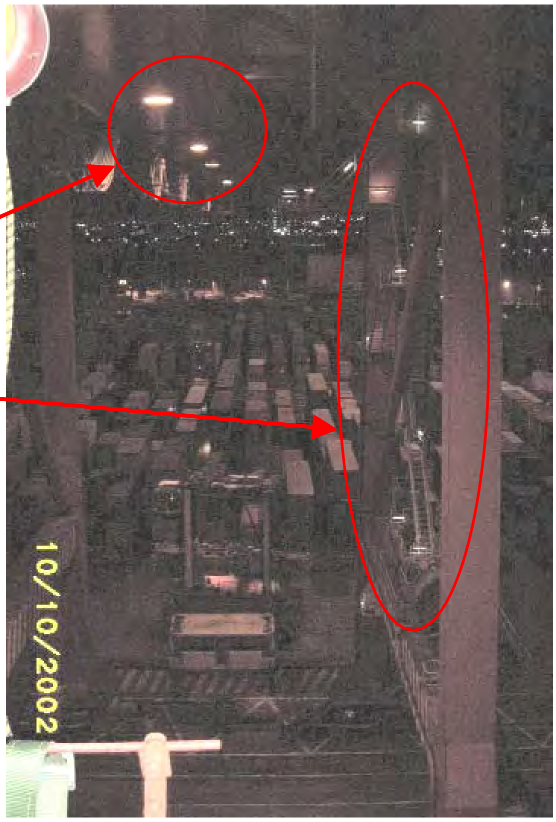


Fig 4. Typical weather proof quay crane walkway boom lighting.

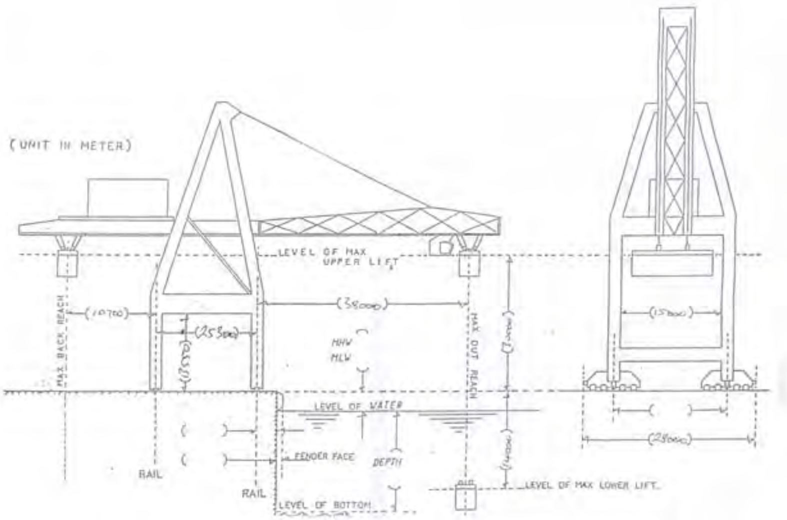


Fig 5. Typical quay crane showing normal operating position and parked position.

Fig 6. Typical ‘straddle’ downlights

Fig 7. Headlights on front of ‘straddle’. Lack of shadows between containers beneath light pole and longer shadows between containers further away.

Fig 8. Typical ship quay crane scenario.

Fig 9. Typical ship bridge lighting – open face floodlights.

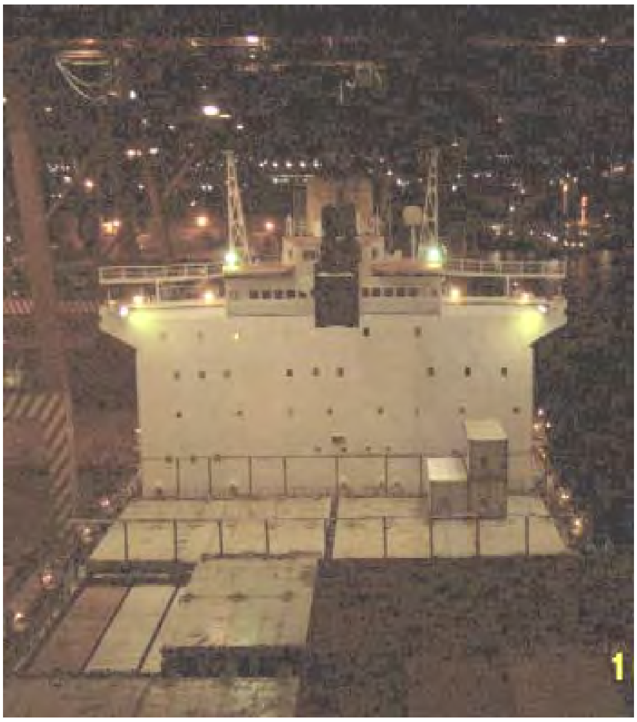


Fig 10. Typical open face floodlights at the forward end of ship. Also in distance quay crane access way lighting as well as general container storage lighting.

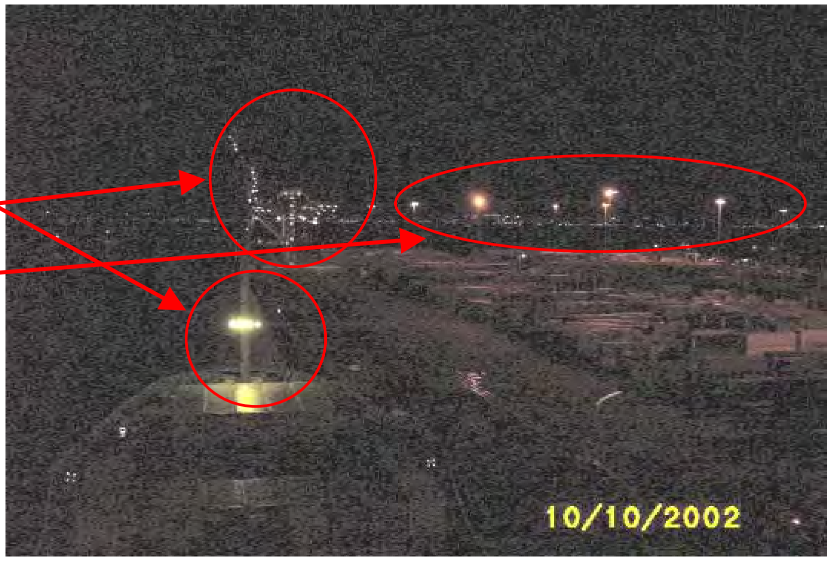


Fig 11. Navigation beacon west end Brotherson Dock North.

Fig 12. Navigation lead tower lighting between Brotherson Dock North and Brotherson Dock South.

Fig 13. Typical view of Port Botany from the Grande Parade – Brighton-Le-Sands, Monterey, Ramsgate, Sans Souci.

Fig 14. Existing channel end lead in light(s) Brotherson Dock (Refer Fig 13.)

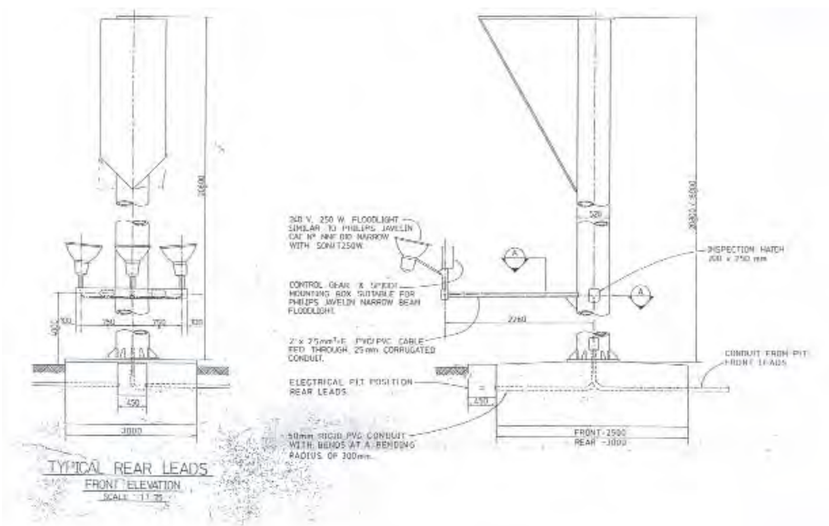


Fig 15. Typical open face floodlights mounted on ship bridge.

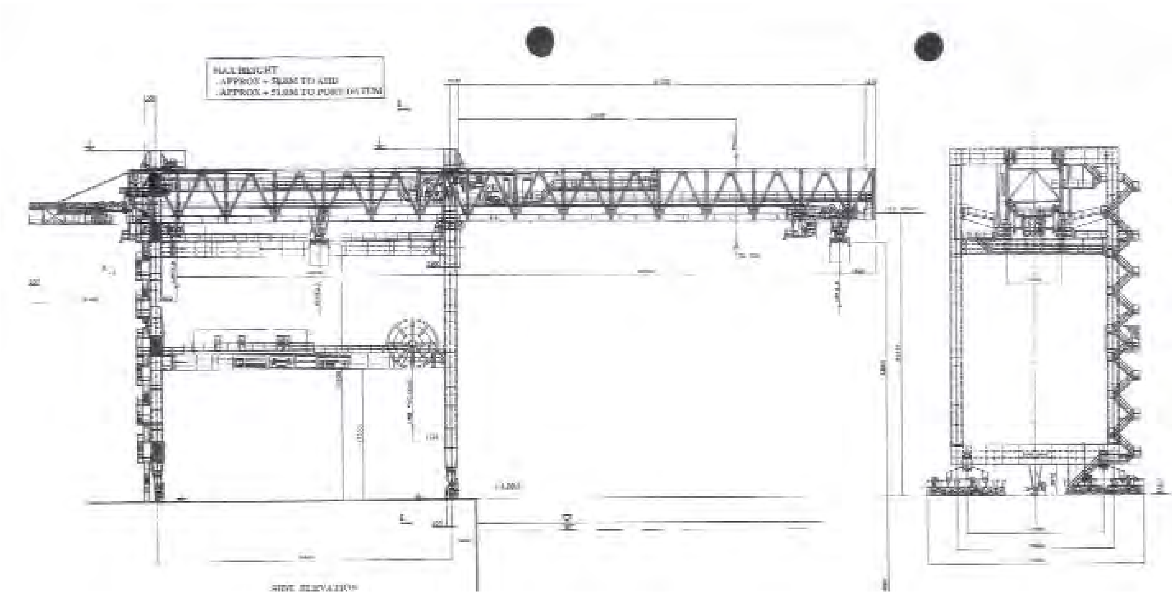


Fig 16. Proposed shuttle boom quay crane

Fig 17. Navigation light on West End of Brotherson Dock North.

Fig 18. Navigation light, pole mounted, to be relocated.

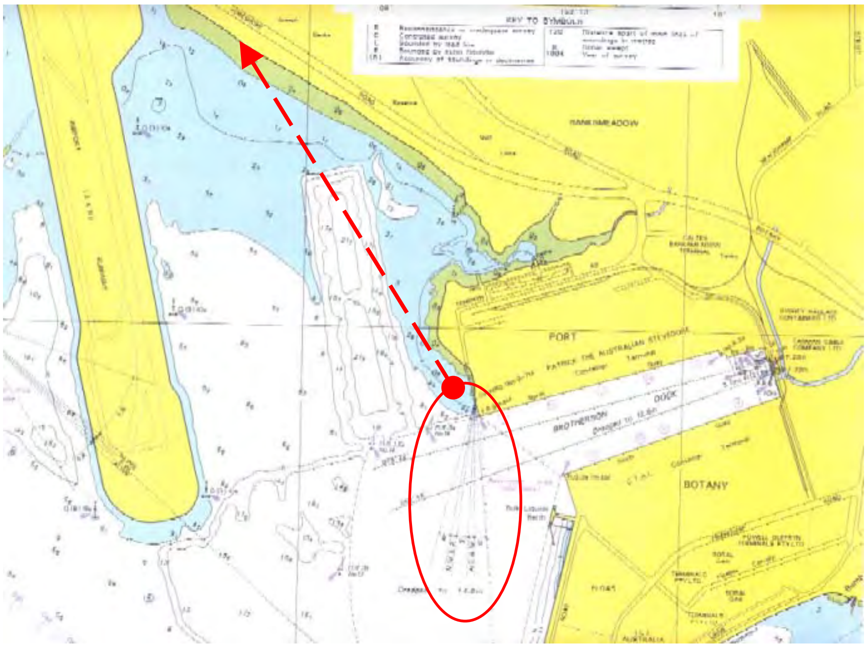


Fig 19. View of Botany from approx 27m height and middle of Brotherson Dock North

Fig 20. Residential accommodation that will be exposed to light from high masts if not screened

Fig 21. Residential accommodation that will be exposed to light from high masts if not screened.

Fig 22. Residential accommodation that will be exposed to light from high masts if not screened.

Truck on Foreshore Road.

Fig 23. View from OBS .1.

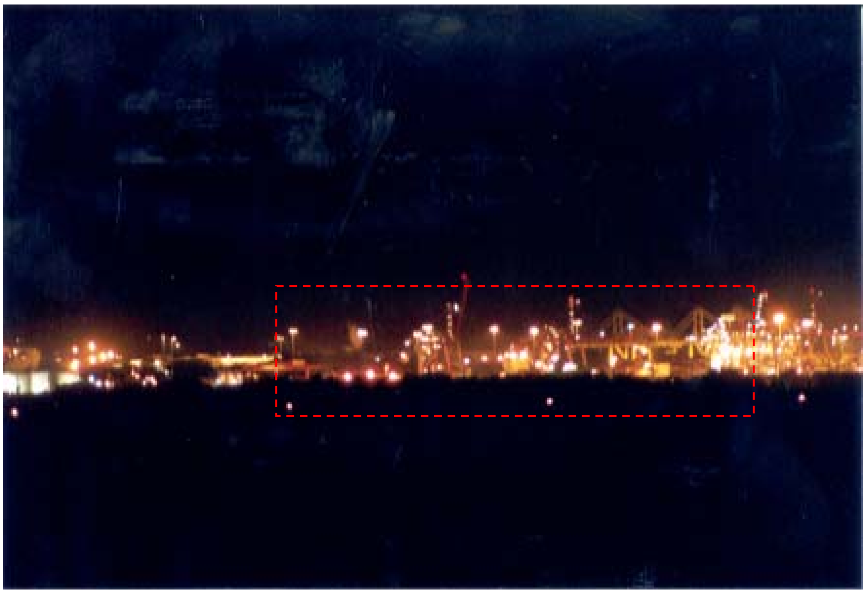


Fig 24. 500mm telephoto lens view from OBS 1.

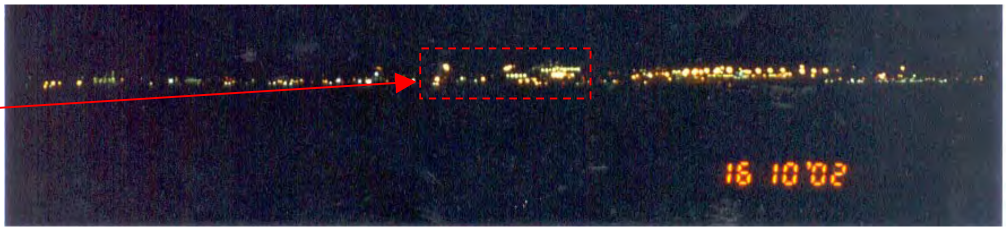


Fig 25. View from OBS 3.

Fig 26. 500mm telephoto lens view from OBS 3. Bright white lights from Caltex tank farm behind Brotherson Dock North

Fig 27. View from OBS 4.

Fig 28. 500mm telephoto lens view from OBS 4.

Fig 29 Closest housing likely to be affected by the proposed development.

1. Nursing home – single and double storey buildings
2. Home units – three storey
3. Mostly single storey and some two storey housing
4. Row of two storey housing

OBS Pt	Eh (lux)	Ev (lux)	COMMENTS
6	0.59	1.09	Ev towards Brotherson Dock
7	0.54	1.08	Ev towards Brotherson Dock
8	0.49	0.58	Ev towards Brotherson Dock
9	0.47	0.52	Ev towards Brotherson Dock
9		0.31	Ev towards end of runway
General sky	0.45		Shielded from Brotherson Dock

Fig 30 Penrhyn Estuary and Foreshore Road Beach (low tide) observation points (red) and photograph points (yellow).

Fig 31. View of Brotherson Dock North from OBS 7

Fig 32. Night view of Brotherson Dock North from OBS 7.

White Floodlights on Caltex Tank Farm

Fig 33. North Side of Penrhyn Estuary from OBS 7.

Fig 34. Bird life on peninsula off end of Brotherson Dock North.

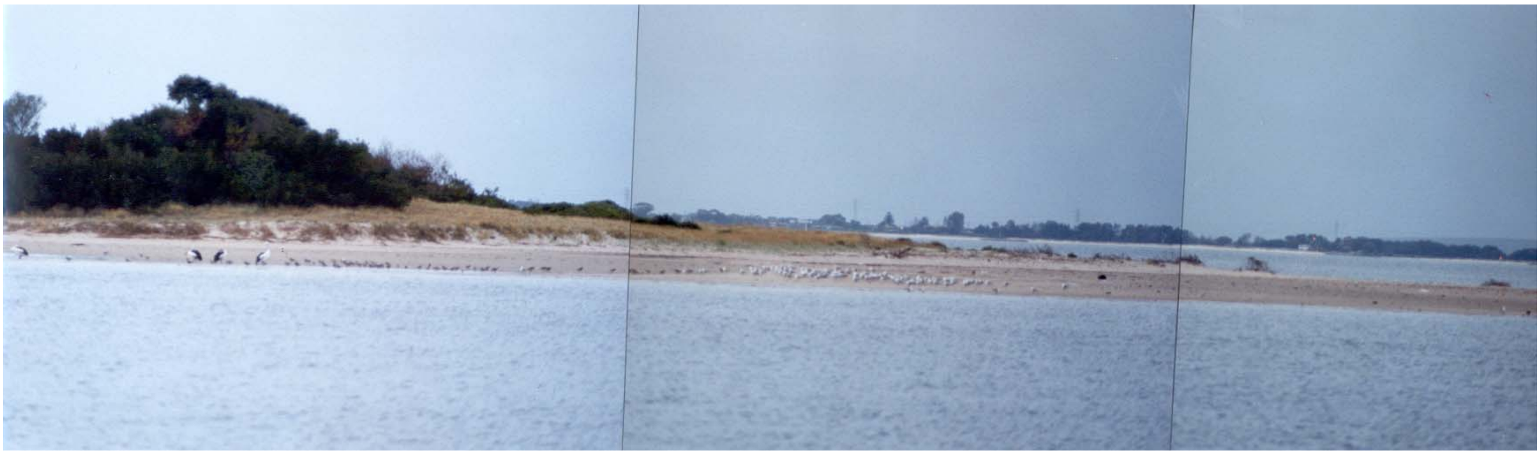


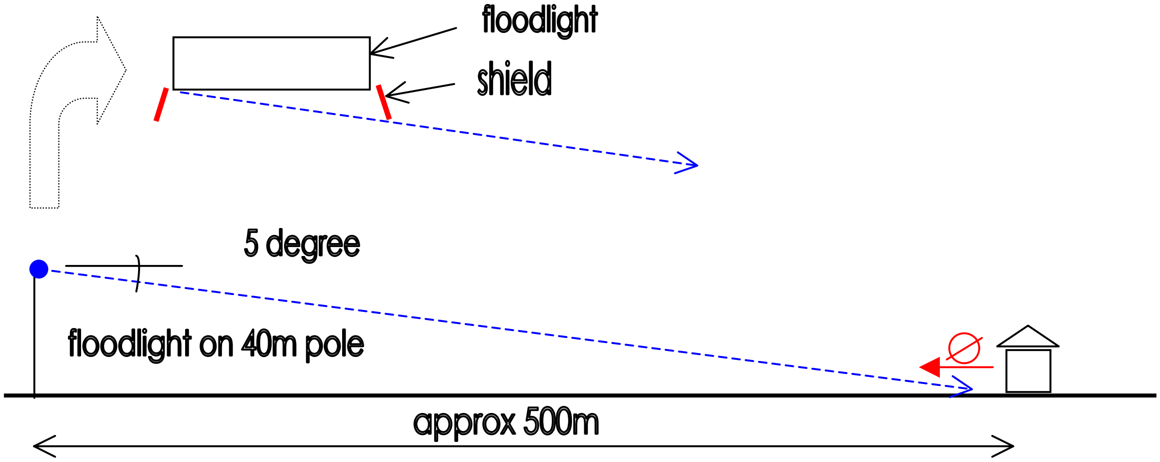
Fig 35. Brotherson Dock North from location on Foreshore Road Beach.

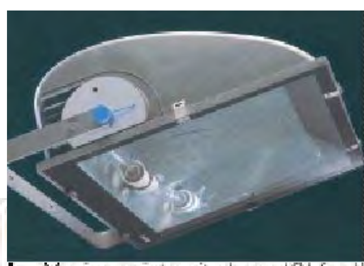
Fig 36. Foreshore Road Beach looking westward.

Fig 37. Penrhyn Estuary from point on Foreshore Road.

Fig 38. Drain into Penrhyn Estuary as seen from junction of Penrhyn and Foreshore Roads.

Fig 39. The type of highmast floodlight and photometric distribution required to provide downward only lighting for the proposed development. Also shielding necessary to screen views of floodlights from residential properties.





1 x SON-T 1000W

Maximum intensity Imax 1016 cd/1000 lm at B = 59.0 degr
Light output ratio 0.68
Measured according to CIE publication no. 43 (TC2.4)

Beamspread in degrees on the basis of	0.5 Imax	0.1 Imax
In main plane (Beta = 0 degr)	-10(K) 7(J)	-59(K) 12(J)
In B-plane through Imax	-38(L) 38(M)	-55(L) 55(M)

Measuring code: LVW10332

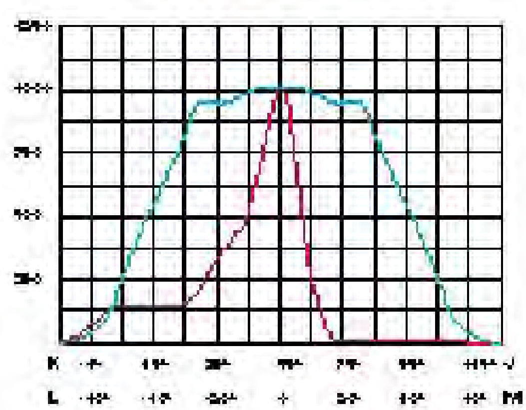
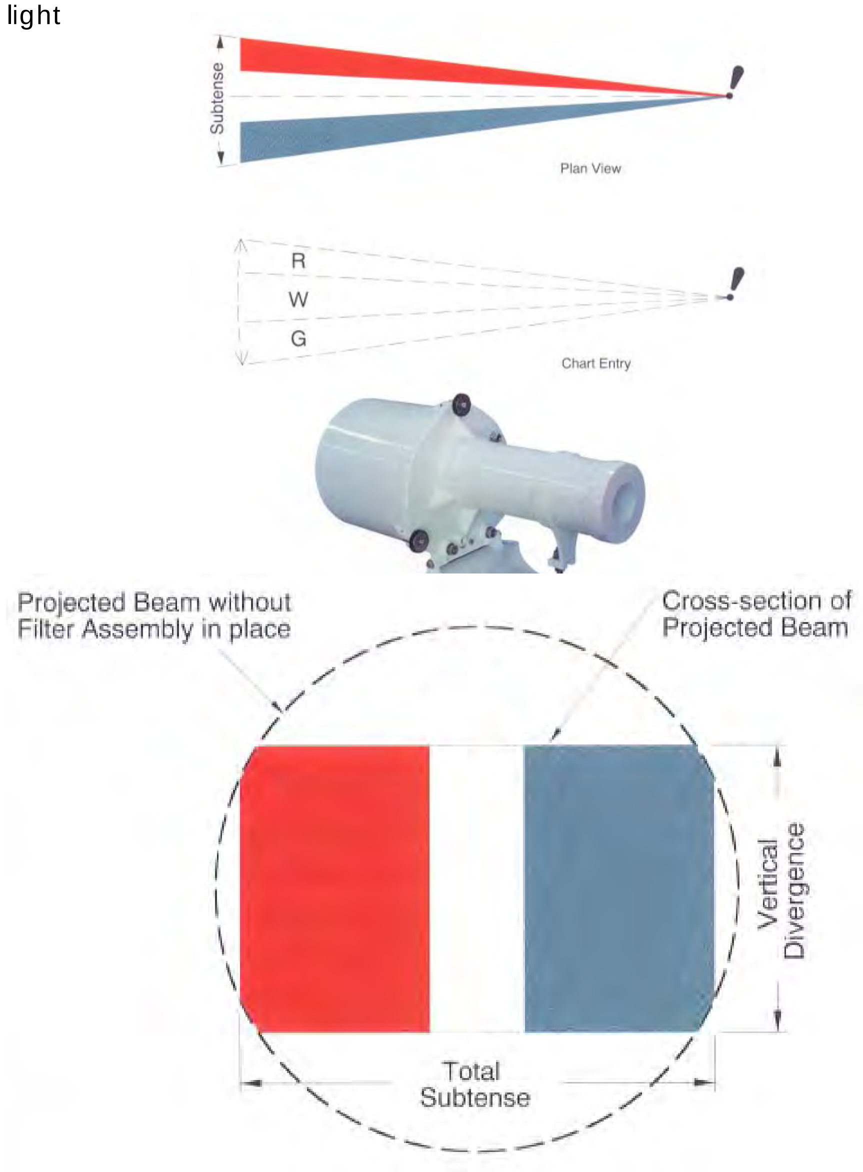
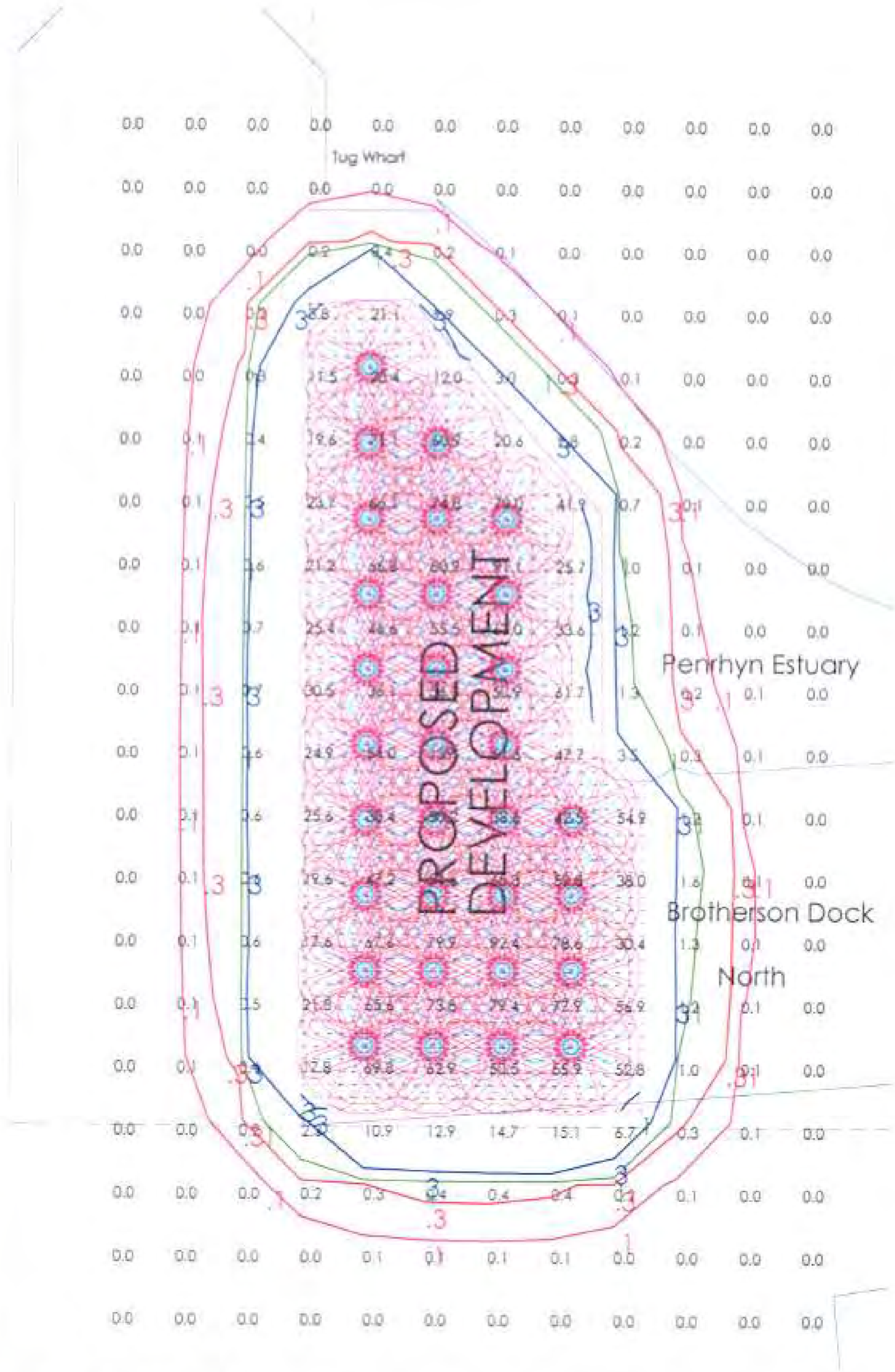


Fig 40. Navigation – Vega PEL sector light



APPENDIX B – CALCULATIONS OF ANTICIPATED DIRECT LIGHT SPILL

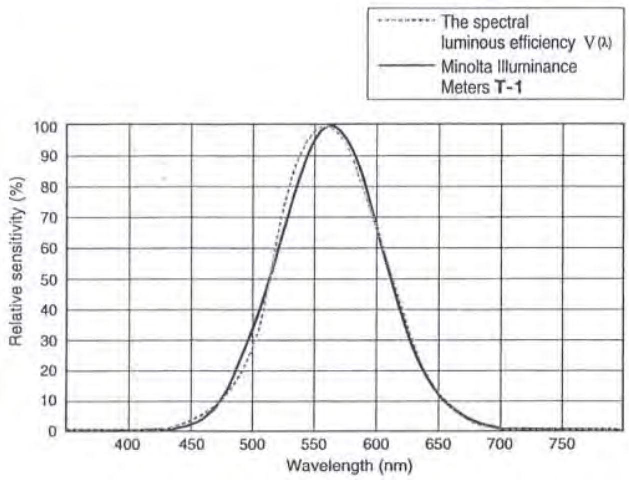


Vertical Light Spill
Scale= 1: 10000

APPENDIX C – MEASURING INSTRUMENT DETAILS

1. Luminance meter
2. Illuminance meter

Relative Spectral Response

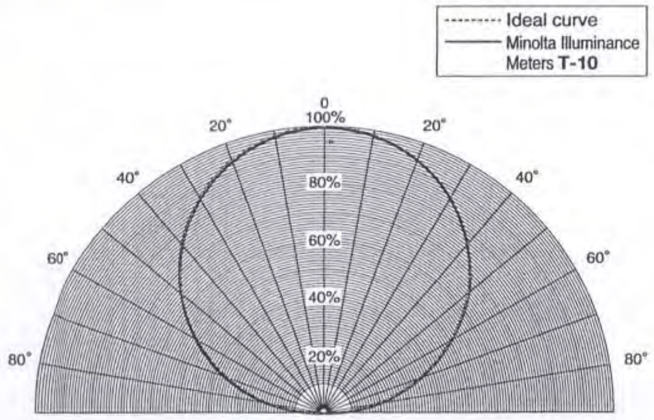


Ideally, the relative spectral responsivity of the illuminance meter should match V (λ) of the human eye for photopic vision.
As shown in the graph at left, the relative spectral responsivity of Minolta Illuminance Meters **T-1** is within 8% (f1') of the CIE spectral luminous efficiency V (λ).

CIE ; Commission Internationale de l'Eclairage

f1'(CIE's symbol) ; The degree to which the relative spectral responsivity matches V (λ) is characterized by means of the error f1'.

Cosine Correction Characteristics

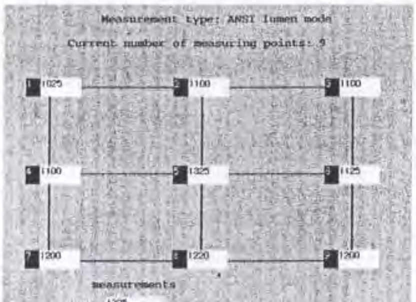


Since the brightness at the measurement plane is proportional to the cosine of the angle at which the light is incident, the response of the receptor must also be proportional to the cosine of the incidence angle.
The graph at left shows the cosine correction characteristics of Minolta Illuminance Meters **T-1**
The cosine error of **T-1** are shown in the table right.

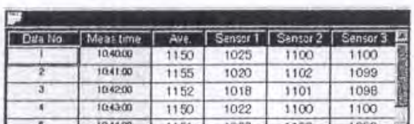
Incidence angle (deg.)	Cosine error (within)
10°	± 1%
30°	± 2%
50°	± 6%
60°	± 7%
80°	± 25%

Illuminance measurement

Example of multi-point illuminance measurement
(9 points)



**sensor position



Data No	Meas time	Ave.	Sensor 1	Sensor 2	Sensor 3
1	10:40:00	1150	1025	1100	1100
2	10:41:00	1155	1020	1102	1099
3	10:42:00	1152	1018	1101	1098
4	10:43:00	1150	1022	1100	1100
5	10:44:00	1151	1023	1102	1099

*grid

This optional PC software offers several desirable features (e.g. easy operation, visual data display, and flexible data processing).
This software provides multi-point graphical data.
Examples shown: grid*, trend graph, and sensor position.**

- Single-point measurement and Multi-point measurement (2 to 30 points) are available.
- Automatic measurement at user-selected intervals.
- Tolerance setting.
- Capability of file save, print-out and data-transfer to excel sheet.

OS	Windows®95/98/NT (ver4)
CPU	Pentium 166 MHz or higher
Memory	32MB or more
Hard disk	20MB or more free space
Display resolution	800 x 600 or higher

"Windows®"and"Excel®" are a trademark of Microsoft Corporation in the USA and other countries.

Specifications are subject to change without notice.

LUMINANCE METERS LS-100/LS-110

Compact, lightweight, easy-to-use SLR luminance meters with a wide measuring range

Luminance Meter LS-100

1°acceptance angle,
Measuring range: 0.001 to 299,900cd/m^2
(0.001 to 87,530fL)

Luminance Meter LS-110

1/3°acceptance angle,
Measuring range: 0.01 to 999,900cd/m^2
(0.01 to 291,800fL)

LS-100

MAIN FEATURES

Flareless SLR optical system for accurate measurements

The SLR (single-lens-reflex) optical system allows precise aiming and ensures that the viewfinder shows the exact area to be measured. The optical system is also virtually flareless, eliminating the influence of light from outside the measurement area.

Narrow acceptance angle for measurements of small specimens

Acceptance angles of only 1° for **LS-100** and 1/3° for **LS-110** allow accurate measurements of small specimen areas.
In addition, optional close-up lenses can be used to measure areas as small as ø1.3mm when using **LS-100** and ø0.4mm when using **LS-110**.

User calibration and color-correction functions

To increase the versatility of the **LS-100** and **LS-110**, both models are equipped with user calibration and color correction functions. The user calibration function allows the meter to be calibrated to a user-selected standard instead of the preset Minolta standard; this function can also be used to standardize the response of several meters. The color correction function allows the response of the meter to be adjusted when measuring colored specimens.

Luminance ratio and peak luminance measurements

In addition to measurements of the present luminance, the **LS-100** and **LS-110** can also determine the percent ratio of the measured luminance to a luminance value stored in memory as well as the peak luminance or luminance ratio measured.

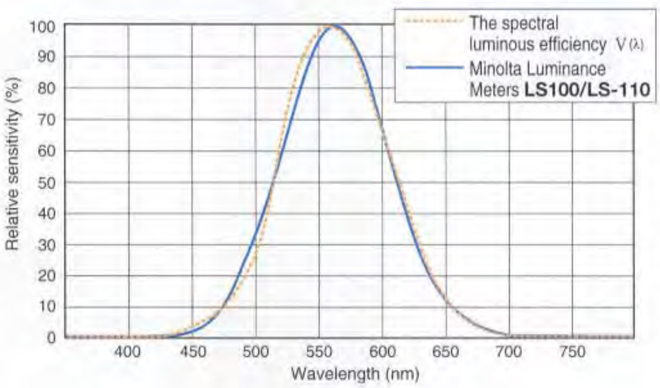
RS-232C data communication

Use of the built-in RS-232C interface allows the meter to be connected to a personal computer.

Lightweight, compact design powered by a single 9V battery for portability

(Power can also be supplied by optional Data Printer **DP-10**.)

RELATIVE SPECTRAL RESPONSE

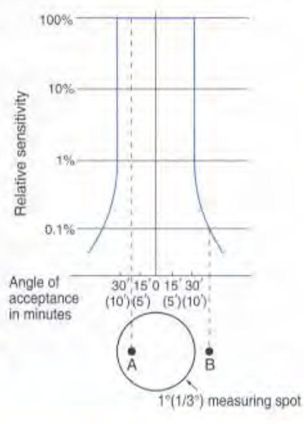


Ideally, the relative spectral responsivity of the luminance meter should match V (λ) of the human eye for photopic vision.
As shown in the graph above, the relative spectral responsivity of Minolta Luminance Meters **LS-100/LS-110** is within 8% (f1') of the CIE spectral luminous efficiency V (λ).

CIE ; Commission Internationale de l«Eclairage
f1'(CIE«s symbol) ; The degree to which the relative spectral responsivity matches V (λ) is characterized by means of the error f1'.

REDUCTION OF FLARE

The degree to which the influence of light from outside the defined measuring area is eliminated is an important factor in the performance of luminance meters. In Minolta Luminance Meters, the flare factor is kept to below 1.5%, even if an object with extremely high luminance is just outside the meter's measuring area.
The graph at right shows the effect when a bright point is moved from A inside the measuring area to B just outside the measuring area.
If the measured value at A is defined at 100%, the measured value at B would be less than 0.1%.



SPECIFICATIONS

Model	Luminance Meter **LS-100**	Luminance Meter **LS-110**
Type	SLR spot luminance meter for measuring light-source and surface brightness	
Acceptance angle	1°	1/3°
Optical system	85mm f/2.8 lens; SLR viewing system; flare factor less than 1.5%	
Angle of view	9°	
Focusing distance	1014mm (40 in.) to infinity	
Minimum measuring area	ø14.4mm	ø4.8mm
Receptor	Silicon photocell	
Relative Spectral Response*	Within 8% (f1') of the CIE spectral luminous efficiency V (λ)	
Response time	FAST: Sampling time: 0.1s, time to display: 0.8 to 1.0s; SLOW: Sampling time: 0.4s, time to display: 1.4 to 1.6s	
Luminance units	cd/m^2 or fL (switchable)	
Measuring range	FAST: 0.001 to 299,900cd/m^2 (0.001 to 87,530fL) SLOW: 0.001 to 49,990cd/m^2 (0.001 to 14,590fL)	FAST: 0.01 to 999,900cd/m^2 (0.01 to 291,800fL) SLOW: 0.01 to 499,900cd/m^2 (0.01 to 145,900fL)
Accuracy	0.001 to 0.999cd/m^2 (or fL): ±2% ±2 digits of displayed value 1.000cd/m^2 (or fL) or greater: ±2% ±1 digit of displayed value	0.01 to 9.99cd/m^2 (or fL): ±2% ±2 digits of displayed value 10.00cd/m^2 (or fL) or greater: ±2% ±1 digit of displayed value
	(Illuminant A measured at ambient temperature of 20 to 30°C/68 to 86°F)	
Repeatability	0.001 to 0.999cd/m^2 (or fL): ±0.2% ±2 digits of displayed value 1.000cd/m^2 (or fL) or greater: ±0.2% ±1 digit of displayed value	0.01 to 9.99cd/m^2 (or fL): ±0.2% ±2 digits of displayed value 10.00cd/m^2 (or fL) or greater: ±0.2% ±1 digit of displayed value
	(Measurement subject: Illuminant A)	
Temperature/humidity drift	Within ±3% ±1 digit (of value displayed at 20°C/68°F) within operating temperature/humidity range	
Calibration mode	Minolta standard/user-selected standard (switchable)	
Color correction factor	Set by numerical input; range: 0.001 to 9.999	
Reference luminance	1; set by measurement or numerical input	
Measurement modes	Luminance; luminance ratio; peak luminance or luminance ratio	
Display	External: 4-digit LCD with additional indications	
	Viewfinder: 4-digit LCD with LED backlight	
Data communication	RS-232C; baud rate: 4800bps	
External control	Measurement process can be started by external device connected to data output terminal	
Power source	One 9V battery; power can also be supplied by optional Data Printer DP-10	
Power consumption	While measuring button is pressed and viewfinder display is lit: 16mA average While power is on and viewfinder display is not lit: 6mA average	
Operating environment conditions	Temperature: 0 to 40°C (32 to 104°F); relative humidity 85% or less (at 35°C/95°F) with no condensation, Maximum altitude: 2000m, Installation category: II, Pollution degree: 2	
Storage temperature range	-20 to 55°C (-4 to 131°F); relative humidity 85% or less (at 35°C/95°F) with no condensation	
Dimensions	79x208x150mm (3-1/8x8-3/16x5-7/8 in.)	
Weight	850g (30 oz.) without battery	
Standard accessories	Lens cap; Eyepiece cap; ND eyepiece filter; 9V battery; Case	

* Equivalant to 2% specified for **T-1** series.
8% CIE(f1'),new JIS(1993)
2% old JIS

Specifications are subject to change without notice.

OPTIONAL ACCESSORIES

Data Printer DP-10

A compact, lightweight data printer with built-in D/A converter

Compact, lightweight, and battery-powered for complete portability

Timer-controlled measurements

Measurements can be taken automatically at intervals of 10s, 30s, 2m, or 10m.

Optional AC Adapter can be used.Power can also be supplied to the Luminance Meter from the DP-10.

Built-in D/A converter

Analog output is provided for connection to an analog recorder or similar device when taking continuous measurements.
Six analog output ranges: 10, 10^2, 10^3, 10^4, 10^5, or 10^6 (cd/m^2 or fL)

SPECIFICATIONS (DP-10)

Type		24-character thermal-dot (7x5 dot matrix)
Printing speed		0.8s/line (1.2s/line including return to start of next line)
Printed data		Measurement number: 1 to 9,999 Measured values: Maximum 6 digits Elapsed time since first measurement: 00:00 to 99:59 (h:m)
Interval timer		Interval time: 10s, 30s, 2m, or 10m Automatic printout after measurement
Analog output	Output range	10, 10^2, 10^3, 10^4, 10^5, or 10^6 (cd/m^2 or fL); manually selected
	Output voltage	1V (full scale)
	Output resolution	0.1mV/digit (1mV/digit when range of 10 is selected when using LS-110)
	Response time	300ms
	Temperature drift	0.02mV/°C
	Accuracy	0.4% of value displayed by Luminance Meter ±0.2mV
Power source		6 AA-size batteries or optional AC Adapter AC-A10 (output: 9V, 1A)
Dimensions		186x53x102mm (7-5/16x2-1/16x4 in.)
Weight		440g (15.5 oz.) without batteries or thermal paper

Specifications are subject to change without notice.

Close-Up Lenses

Minimum measuring area		
Close-Up Lenses	With **LS-100**	With **LS-110**
No.153	ø8.0mm	ø2.7mm
No.135	ø5.2mm	ø1.8mm
No.122	ø3.2mm	ø1.1mm
No.110	ø1.3mm	ø0.4mm

Long Eye-Relief Eyepiece

When the Long Eye-Relief Eyepiece is used, the measuring area and measurement display inside the viewfinder can be seen with the eye 5cm (2 in.) away from the eyepiece.

Angle Finder V_N

Angle Finder V_N allows the measuring area and measurement display inside the viewfinder to be seen at an angle of 90° to the normal viewfinder optical axis. Angle Finder V_N can also be focused and the magnification can be set to 1x or 2x.

SYSTEM DIAGRAM (Optional Accessories)