POWERFUEL

Portland energy recovery facility

Lighting statement

September 2020

PowerFuel

Portland Energy Recovery Facility

Lighting Statement

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ARUP

Contents

Executive Summary

Arup has been appointed by PowerFuel Portland to develop the design proposals for the external lighting to support the planning application for the proposed plant. This document presents the design intent, and the lighting performance criteria that the final installation will comply with.

The lighting requirements have been developed using recommendations described within British Standards and industry best practice codes and guidance documents; these documents have been used to select lighting levels for the pedestrian footpaths, vehicular access routes, car parks and external loading and unloading areas within the site. The lighting design proposes a strategy to achieving the operational requirements of a safe working environment.

Safety lighting will also include the provision of aviation obstruction lighting, in accordance with Civil Aviation Authority's (CAA) requirement, to the top of the chimney; ensuring the stack is visible at all times of day to commercial and military aircraft.

The lighting design balances the operational requirements with the local ecological sensitivity to light spill; the site sits between a Site of Special Scientific Interest (SSSI) / Special Area of Conservation (SAC) and the sea of Balaclava Bay. Additional consideration has been given to observers located across the bay to the north of the site in Weymouth and the boundary of the Dorset Area of Outstanding Natural Beauty (AONB). The lighting design proposes maximum illuminance criteria at and beyond the site boundary that the final design must comply with.

To minimise the amount of light cast beyond the site boundary the design has followed these general principles:

- The use of luminaires with tightly controlled optics to, as far as practical, deliver light to the intended surfaces only.
- Selection and positioning of equipment so that it is orientated towards the centre of the site
- Minimise upward tilt of luminaires to further prevent spill beyond the site boundary.
- Selection of minimum design criteria illumination levels to allow the safe operation of the facility at night.
- The use of lighting equipment at an appropriate mounting/column height to both reduce visibility from a distance at night and of lighting equipment during the day.
- Application of a zoned lighting control strategy will limit unnecessary lighting of work areas outside of operational hours.
- Introduction of solid fences along the Balaclava Road and the Service Yard to contain light within the site and minimise direct light spill beyond the boundary.

Lighting calculations have been produced to demonstrate that operational requirements can be met while maintaining the magnitude of light spill beyond the boundaries and into the sky within the proposed target criteria. Whilst it is acknowledged that light spill cannot be fully eliminated due to the minimum requirements to allow safe operations of the site, mitigation principles have been proposed to further reduce spill of light beyond the site into the surrounding environment.

This report is not intended to mandate the number, location and position of lighting within the site boundary as it is expected that the as the lighting provision will develop as the detailed design of the plant evolves. However, this report details the design intent, including maximum parameters, with which any further design development must comply with.

1 Introduction

Arup has been appointed by PowerFuel Portland to develop the design proposals for the external lighting to support the planning application for the above project.

This document considers the minimum lighting requirements to facilitate safe operation of the site and proposes criteria to limit the impact on surrounding receptors; such as neighbouring ecology areas on land and sea, and visibility from across the bay.

A reference design has been presented to demonstrate how compliance with the proposed criteria may be achieved and the impact of the development be mitigated. The lighting must be sensitive to the surroundings to minimise the impact of the development at night.

This document considers the following:

- Site Context – an understanding of the surroundings. The inclusion of which sensitive receptors to light will be included in the analysis.
- Design Criteria – the development of proposed lighting criteria that the final installation must comply with. The design criteria look to:
    - Satisfy the operational requirements for specific areas of the site,
    - Control obtrusive and unwanted light pollution.
- Proposed Lighting Strategy – a high-level approach developed to meet the criteria for each area.
- Proposed Lighting Control Strategy – a high-level approach developed to meet operational requirements and further reduce the need for light after dark.
- Reference Lighting Design – a proposed lighting design that achieves the lighting criteria and strategy. Details of the calculations have been provided to demonstrate compliance against the target criteria.
- Mitigation Strategies –future mitigations that could further improve the proposal's impact on the surrounding area.

1.1 Design Criteria Objectives

The purpose of this document is to:

- Ensure the lighting design is appropriate for the intended site location and minimise impact of any lighting on the surrounding environment,
- Ensure that the safety issues are addressed in the design of the site layout,
- Set and agree technical design criteria with PowerFuel Portland,
- Set out and agree the Basis of Design to governing standards, codes and good practice to which the design will be delivered to and which the final installation will comply with.

The outcome of this report is not intended to mandate the number, location and distribution of lighting within the site boundary as it is expected that the detailed operational requirements will develop as the detailed design of the plant evolves. This document is intended to present a reference design; detailing the design intent, and performance criteria that the final lighting installation will comply with.

2 Site Context

The PowerFuel Facility is situated on an existing, cleared brownfield site owned by Portland Port where former buildings have been previously demolished. The surrounding businesses are active docks for shipping, the Ministry of Defence and other 24hr businesses, therefore there are high levels of light locally. The site lies between the Site of Special Scientific Interest (SSSI) and the Isle of Portland to the Studland Cliffs Special Area of Conservation (SAC) and Balaclava Bay. To the north beyond Balaclava bay lies Weymouth and Dorset Area of Outstanding Natural Beauty (AONB).

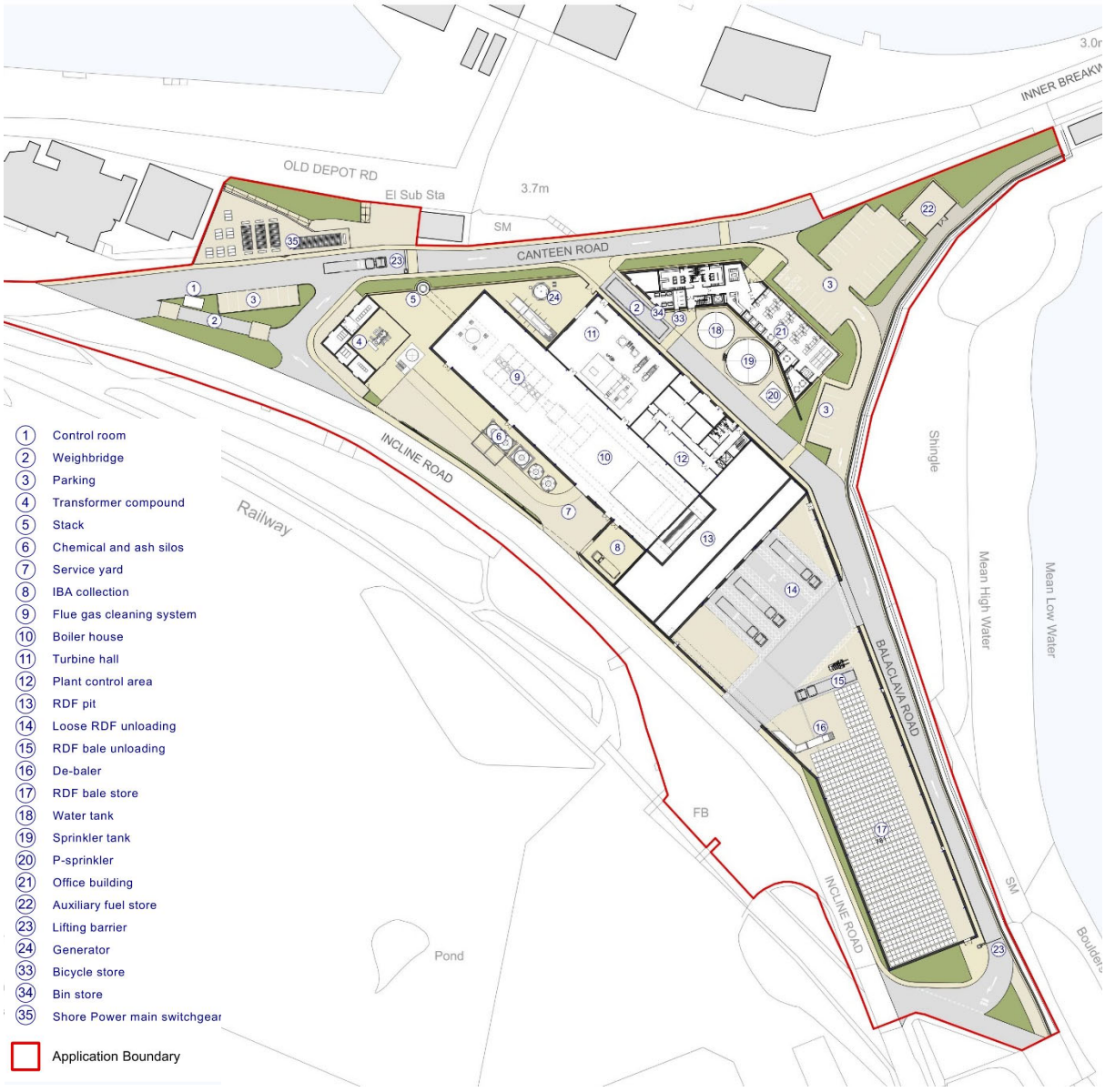


Figure 01 – Plan of site with Main Development Red Line Application Boundary

The proposed development comprises of:

- Processing facility
- Office and administration building
- Access road and general pedestrian circulation
- Parking provision
- Emergency generator, fuel storage
- External bulk storage and waste removal access points that may require access at any time of day or night.

The planning submission includes a substation connection and ship-to-shore cable routes as part of the works. The substation routes will be located underground and in-port routes do not require additional lighting.

The lighting design has been considered to meet the competing requirements in relation to lighting performance, light obtrusion, equipment visibility and environmental impact of the proposed installation over the sensitive boundaries of the site.

The receptors sensitive to light that are considered to be:

- SSSI/SAC to the west of the site beyond Incline Road
- Balaclava Bay beyond the east of the site
- General visibility of the site at night from the north across Balaclava; including Weymouth and the Dorset AONB boundary.

The potential impact of lighting on the night-time activity of wildlife have also considered as part of the proposal, particulalry foraging/community behaviour of bats along the coastline. As described within the ecological assessment (CGO Ecology Ltd., 01/05/2020) the existing lighting is likely to discourage the use of the site by most species of bat; recommending to avoid lighting of currently-dark areas as not to disturb foraging/commuting bats.

2.1 Existing site lighting and immediate surroundings

The current site lighting comprises of area floodlighting and column mounted lanterns along Main Road, Incline Road and Canteen Road.

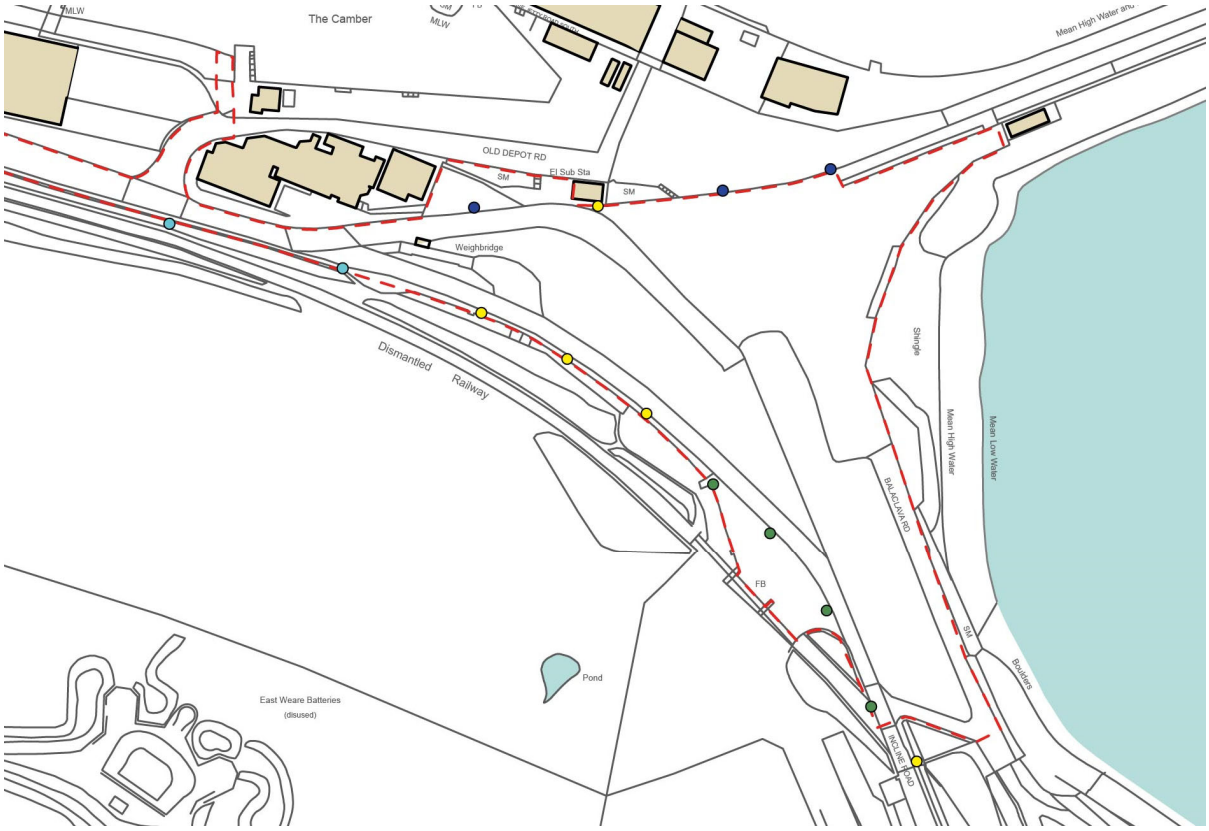


Figure 02 – Plan of existing lighting provision including Red Line application boundary

Key:

- Existing road lanterns with SON lamps mounted on 5m columns, to be replaced.
- Existing LED Floodlights mounted on 5m columns to be replaced.
- Existing road lanterns with LED Lanterns mounted on 5m columns, recommended replacement of lanterns.
- Main Road – Existing road lanterns, lighting to remain.

The existing Port infrastructure lighting surrounding the site, beyond the site boundary with Incline Road and Canteen Road, may require replacement to better meet the future needs of the Port operation, but this is outside the remit of this planning application. As a result, lighting to Canteen Road and Incline Road has been omitted from the presented lighting calculations.

Refer to Appendix A of this report for images and narrative of the existing lighting provision.

2.2 Operational Case Statements

During the operation of the site the following elements are expected to be in use during the hours of darkness and therefore are required to be lit in order to provide a safe working environment:

- Access road around the site
- Service Yard
- Emergency access routes around the perimeter of the facility buildings from final exits to the fire assembly point
- Parking for approximately 36 cars
- Existing and new Weighbridge

The following statements have been made in the development of the lighting strategy:

2.2.1 General

The requirement and provision for lighting has been considered in the context of the anticipated tasks to be undertaken at the site during hours of darkness. Where an area has limited requirement for use after dark or if the risk of hazard has been considered low, then lower lighting levels have been proposed with localised enhancement provided where necessary.

2.2.2 Hours of operation/Areas of activity

The understanding is that during operation of the facility there will be three shift patterns, with 8hour shifts. External visitors to site are expected during the workday 9am – 5pm. Deliveries will be expected during the evening. Therefore, there will be a requirement for a continuous level of lighting throughout the hours of darkness to maintain a safe working environment.

With shift changes at 7am and 7pm, for half the year shift changes will occur in the hours of darkness.

Visitors will be escorted from a car park off site and will generally be on site during normal business hours of 9am to 5pm.

There are typically 10-15 people working within the office buildings as maintenance staff and 16 people on shift work, with a total of around 30-35 people during the daytime.

Deliveries and loading activities are not expected to be as frequent during the night.

2.2.3 Transportation of material within the site area

Material on site can be defined in two categories:

- Materials that are delivered and removed from the service yard, such as the Incinerator Bottom Ash (IBA)
- Deliveries of Refuse Derived Fuel (RDF) to the Energy Recovery Facility (ERF)

Transportation of materials will generally be via HGV along the main access route from Main Road via the weighbridge, through the site between the Office and main building, onto the eastern boundary and into the RDF drop off area located within the building. After delivering the material the trucks exit the building onto Incline Road and leave site via the weighbridge.

Deliveries are expected during the day and night therefore it is important to have a good uniform level of light at intersections so that vehicles can safely navigate the roads.

2.2.4 Pedestrian Movement

Pedestrian movement is anticipated between the car park, office building and main buildings. Lit routes will be provided from the car park to the entrances of the buildings around site.

During hours of darkness there will be pedestrian movement between the buildings, therefore enhanced levels of light will be provided to crossings to ensure the safety of pedestrians.

2.2.5 Security lighting

Lighting for security is required around the perimeter of the buildings and at the service yard.

There is a security barrier at the southern tip of the site. Lighting for CCTV coverage will be non-visible, far-infrared black light illumination and therefore not covered as part of this document.

2.2.6 Inclusive lighting requirements

Lighting levels will be enhanced in specific locations to improve the opportunity for navigation for the visually impaired. Enhanced lighting levels will be provided around accessible car parking spaces, with further enhanced lighting levels between these spaces and the main entrance. Additional areas of enhanced lighting will be provided at entrances between the office building and main facility.

2.2.7 Lighting in event of emergency

General lighting to roads and pathways around the site will already be provided therefore in the event of an emergency, occupants will be able to safely navigate to the fire assembly point.

Lighting for safety will be required at the following areas for specific tasks during an emergency:

- LPG fuel storage
- Emergency Generator

3 Design Criteria

3.1 General

The site lies between a Site of Special Scientific Interest, a Special Area of Conservation and Balaclava Bay to the west, south and east; therefore these boundaries are considered sensitive to obtrusive light beyond the boundary of the site.

The site is bounded to the north by Portland Port, so while light spill in this direction is less likely to be as significant, consideration will be given to the visibility of lighting equipment from the mainland across Balaclava Bay and Portland Harbour.

The surrounding businesses are active docks for shipping, the Ministry of Defence and other 24-hour businesses, the operation requirement of which require significantly higher intensities of light locally. As a result light spill as a result of the proposed development will have a significantly lower intensity and therefore less obtrusive in comparison to the retained Port infrastructure.

The following criteria will be incorporated into the lighting design:

- The use of luminaires with very low or no upward distribution will minimise contribution to ‘sky glow’. Light will be tightly controlled and considered to avoid light spill.
- Selection of minimum design criteria illumination levels to allow the safe operation of the facility at night.
- The use of lighting equipment at an appropriate scale (4-6m where possible) will limit mounting heights of equipment to both reduce visibility from a distance at night and of lighting equipment during the day.
- Selection and positioning of equipment so that it is orientated towards the centre of the site where possible, will limit the visibility of sources from outside the site and maintain function of the lighting design approach.
- Zero tilt and provision of accessories that will limit upward light spill with the use of flat glass lanterns and back shields to further mitigate light spill beyond the intended areas.
- Application of a zoned lighting control strategy will limit unnecessary lighting of areas outside of operational hours.

3.2 Environmental Requirements

The site is considered as being classified as an E2 zone, as defined within CIE 150:2017 and IPL GN01:2020. While it could be considered that the operational Port immediately adjacent to the proposed development has higher ambient brightness (and could be classed as E3 or even E4), the proximity to the SSSI and Balaclava Bay outside of the inner break water warrants a lower ambient lighting level.

An E2 zone is defined in the CIE 150:2017 Guide on the limitation of the effects of obtrusive light from outdoor lighting installations as the following:

"an area of low district brightness that is sparsely inhabited, within a rural area".

The lighting concept places great emphasis on limiting the environmental impact of any new external lighting associated with the proposed development. The design will be developed to minimise the impact upon the surrounding environment whilst maintaining functional, safety and operational requirements.

3.3 Lighting Criteria

The design of the exterior lighting will comply with British Standards and best practices; in particular to the following standards and guidance documents:

- SLL Code for Lighting, 2012
- BS EN 12464 Part 2: 2014 – Lighting of outdoor workplaces
- BS EN 5489 Part 1 – Lighting of roads and public amenity, 2013
- EN 13201 Part 2 – Performance requirements, 2015
- CIE 150: 2017 – Guide on the limitation of the effects of obtrusive light from outdoor lighting installations
- ILP GN01:2020 – Guidance notes on the reduction of obtrusive light
- ILP GN08:2018 – Bats and artificial lighting in the UK
- BS EN 8300-1:2018 – Design of an accessible and inclusive built environment. Part 1 – External environment, code of practice

Lighting will be provided along routes and within areas as indicated on the lighting treatment plan with the corresponding criteria. The principles of lighting classifications selected are based upon best practices for outdoor working environments, with special consideration to the reduction of obtrusive light to sensitive surroundings.

The average maintained illuminance that falls onto a horizontal plane (Eav) and the uniformity (Uo); the ratio of minimum:average illuminance over an area, is defined for each space type within Figure 03.

Aviation obstruction lighting will be provided in accordance with CAA and international regulations.

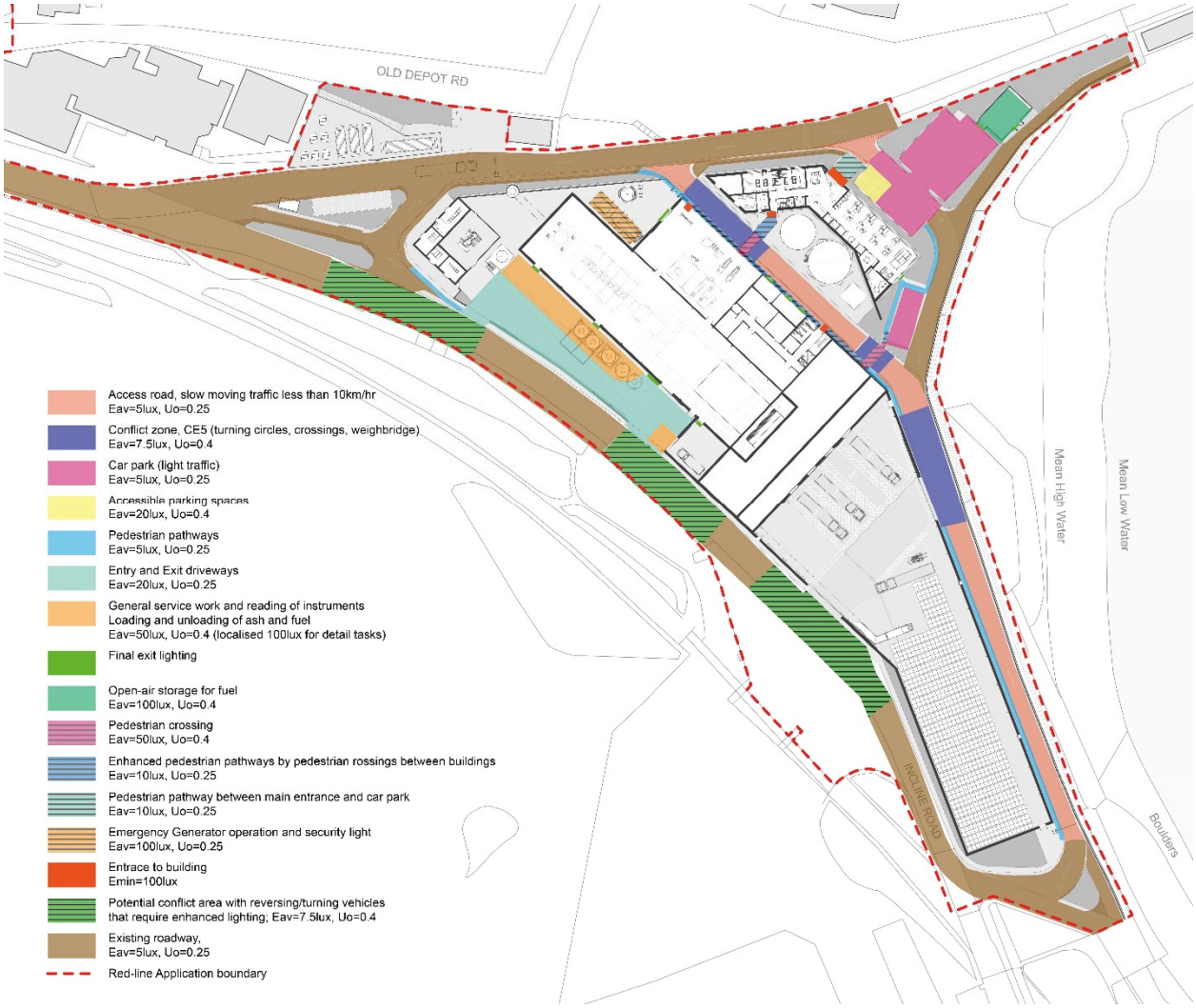


Figure 03 – Site Plan with Lighting Criteria

In accordance with BS EN 8300, car parking with disabled spaces will have an enhanced level of light and will be lit to an average illuminance of 20lux. There will be enhanced levels of light at changes in level at ramps and stairs.

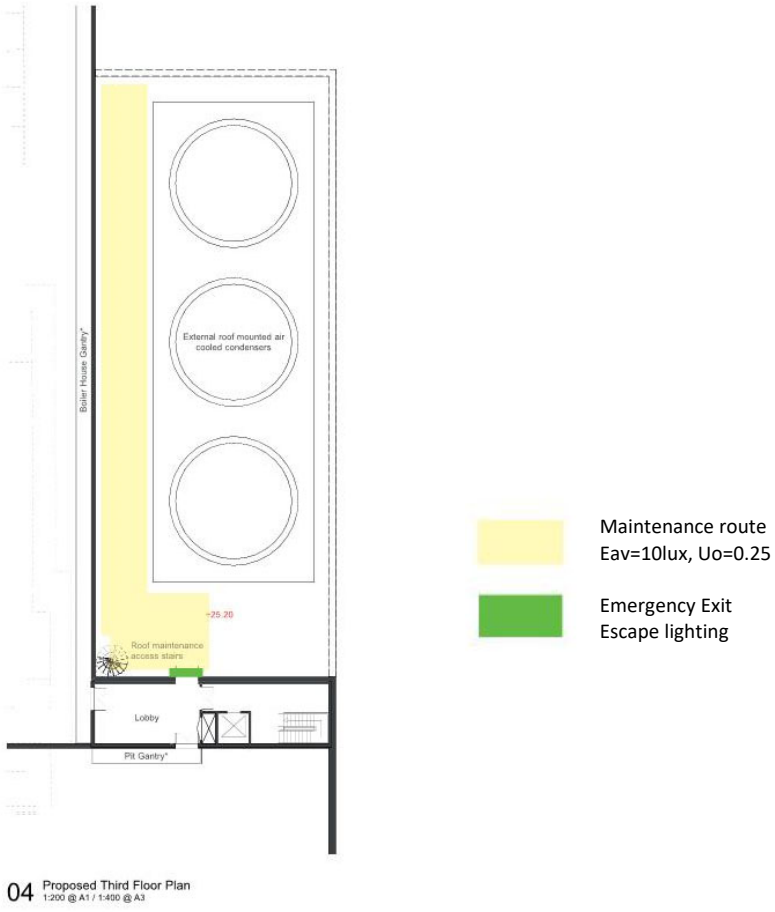


Figure 04 – Level 3 roof, Lighting Criteria to Plant

Lighting at the roof will only be required when maintenance is taking place and is assumed to be controlled locally via a switch next to the exit. Absence detection through PIR sensors will switch lighting off in the case of it being left on.

3.4 Vertical illuminance criteria

The following table proposes the maximum values of vertical illuminance, façade luminance, and the upward light ratios for the installation for an E2 Zone, based on guidance from the ILP GN01 and engineering judgement.

Light Technical Parameter	Application Conditions	Criteria
Illuminance in vertical plane (Ev) set back behind Red-Line Boundary (refer to Section 6.1.2)	For normal conditions where lighting is not required to be enhanced, i.e. when there are no night-time deliveries, and non-emergency.	1lux (max)
Upward Flux Ratio (%)	Applicable to whole site	5%
Average maintained building Façade Luminance (Lb)	For normal conditions where lighting is not required to be enhanced	5 cd/m^2

Table 01 – criteria taken from ILP GN01

As there are no residential receptors within the vicinity of the site or lying below the luminaire mounting height, the calculation of source intensities from residential windows have therefore not been included in this context.

The average maintained building façade luminance has been defined as a maximum threshold here, but it is not proposed to provide dedicated façade lighting to the development.

As an alternative metric to demonstrate the control of spill light beyond boundaries, a maximum threshold of illuminance in the vertical plane has been propsoed for the purpose of this assessment. The vertical planes will be located at the sensitive boundaries [SSSI to the west and Balaclava Bay to the east] to capture spill of light in these directions.

The existing port requires a significantly higher level of illumination for safe operation of the docks compared to that of the proposed development, and in order to maintain clear working areas equipment tends to have a greater column height and upward tilt to provide adequate distribution. As a result, any night-time views from sensitive receptors to the north of the proposed development, such as Weymouth and the Dorset AONB boundary, will generally be dominated by the activities of Portland Port.

Due to the comparatively low illuminance levels proposed and mitigation measures described within this application to be adopted, it is expected that any obtrusive light in the direction of sensitive receptors to the north would be barely noticeable and negligible in comparison to that of the existing port infrastructure.

For these reasons, the northern boundary has not been included within this analysis due to the anticipated light spill as a result of the proposed development being considered to being in the

same order as that expected to within the SSSI to the west and Balaclava Bay to the east, any increase in obtrusive light to the north can be considered negligible to that of the existing port.

The following boundaries have been examined:

- Western boundary of SSSI and SAC (shown in blue)
- Eastern boundary of Balaclava Bay (shown in orange)

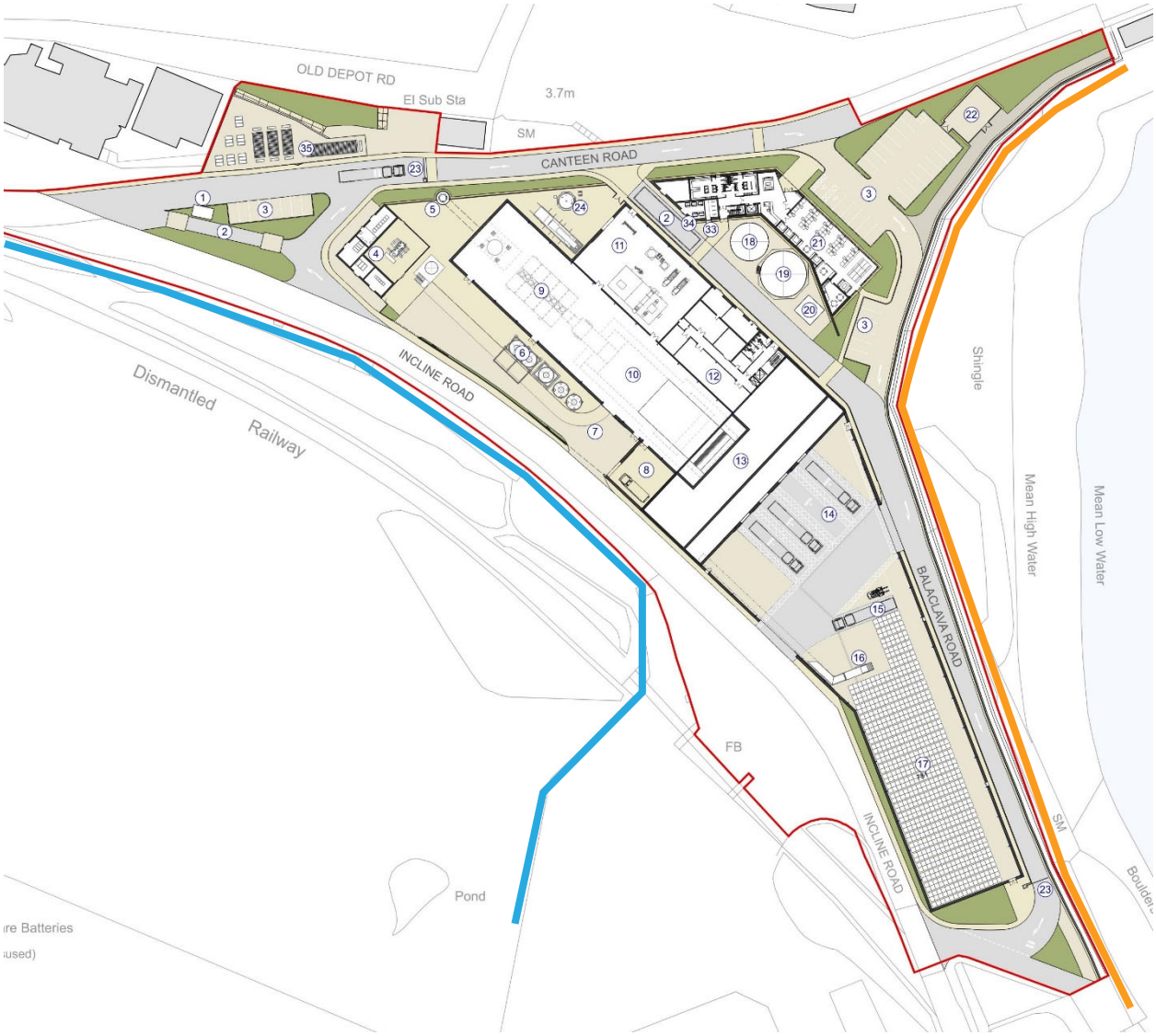


Figure 05 – Boundary Definitions

4 Proposed Lighting Strategy

The lighting strategy has been shown on the drawing included below and is described within this section of the report. This chapter provides a high-level description of equipment types, positioning and other details to be employed and ensure compliance with the lighting criteria set out in Section 3.

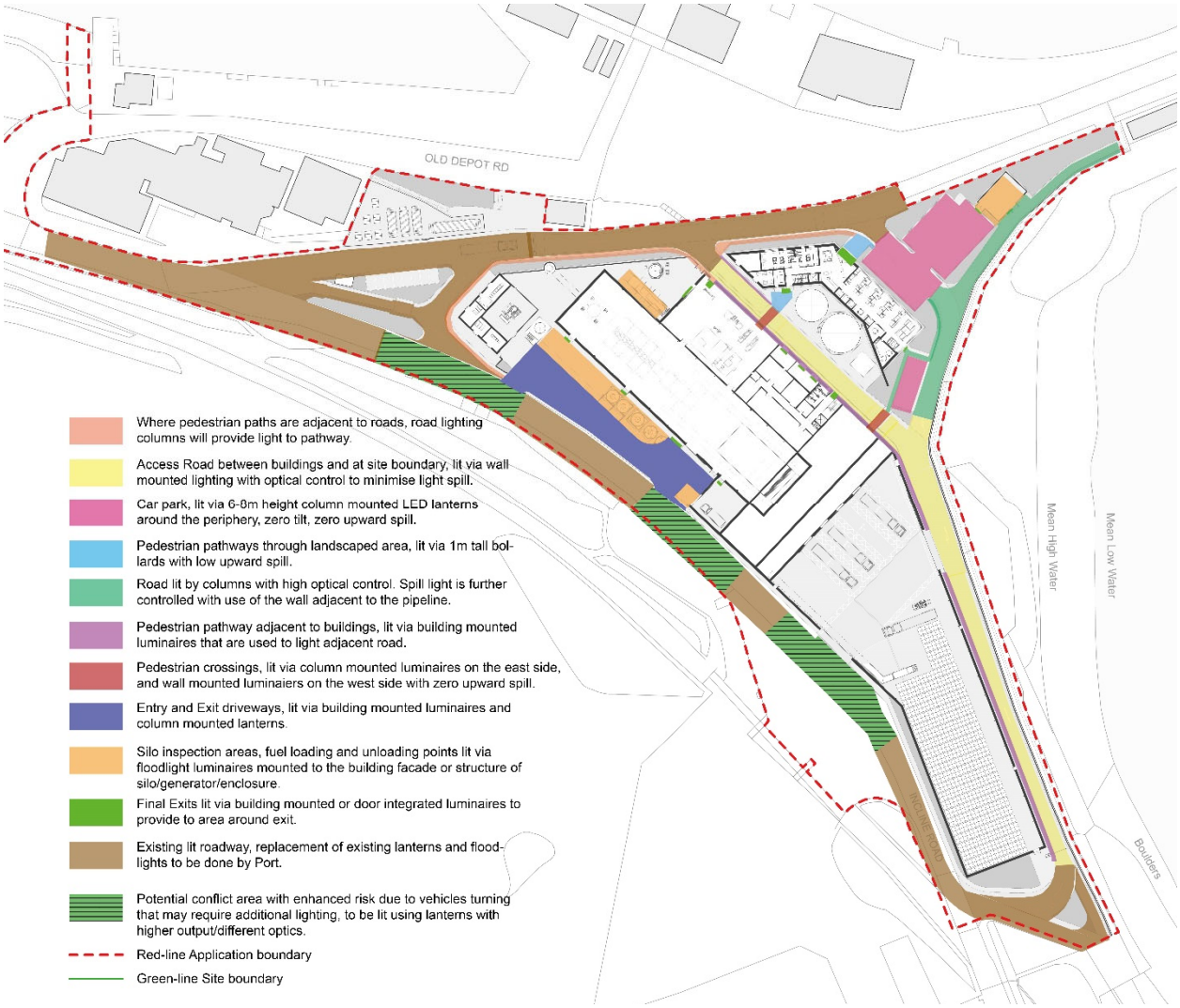


Figure 06 – Lighting Strategy Treatment Plan with Key

4.1 Access Routes

The roads around the facility will be lit via column mounted lanterns positioned at the side of the road.

Lighting columns will be 6-8m tall to allow even distribution of light over the road surface to meet the recommendations set out in the relevant standards.

4.1.1 Crossings

Pedestrian crossings require a higher level of light and uniformity therefore columns will be placed on both sides of the road in these locations to meet criteria.

4.1.2 Intersections between roads and junctions into Facility

Placement of road lighting columns and lantern optics at junctions and intersections will be considered to provide uniform levels of light over the area of conflict.

4.1.3 Existing lighting along Incline Road

As discussed within this report, it has been noted that the existing lighting along Incline Road is not appropriate for the Facility, refer to Appendix A. It is required therefore that the lantern heads on the columns located on Incline Road as it passes the facility are replaced to meet the lighting criteria.

4.2 Pedestrian Routes

Where pedestrian pathways follow the side of the road; lighting to the path will be via spill from the road lighting columns.

Where pedestrian pathways are segregated from the road, along the perimeter of the building, lighting will be provided via building mounted luminaires.

4.3 Car Parks

Car parks will be lit to ensure the safe movement of pedestrians and vehicle users.

Lighting of car parks will include 6-8m columns to ensure a good distribution of lighting. Positioning of columns will be carefully considered in relation to parking bays, by setting columns back from the edge of parking bays to prevent contact with vehicles.

Illumination will be provided from the periphery of the car park.

4.4 Fuel storage and emergency generator

General security lighting will be provided at the LPG fuel store and emergency backup generator at the facility. Lighting will be provided via ATEX explosion rated fixtures to the secure pen fencing posts.

4.5 Service Yard

The turning area for trucks pulling into the yard will be lit via flat glass lanterns on 6-8m columns to maintain a uniform level of light for pedestrians and vehicles using the same space.

The silo inspection areas and fuel loading / unloading points will be lit via floodlight luminaires mounted to the building façade where appropriate.

Where it is necessary for higher levels of light for detailed tasks, directional luminaires will be mounted above to the structure, and separately controlled to allow for localised enhancement when tasks are being undertaken.

4.6 Entrances and Final Exits

Entrances to buildings will have enhanced levels of light to provide wayfinding during the night for visitors and staff to make their way into the building.

Lighting at entrances will be integrated into the canopy over the entrance lobby area.

Lighting at final exits will be building mounted onto the facade structure, centrally located above the doorway.

4.7 Aircraft Obstruction Lighting

Red aviation warning lights will be provided on or near the top of the chimney stack in accordance with CAA and international guidance.

5 Proposed Lighting Control Strategy

The lighting control strategy will include site wide photocell control to ensure that lighting is not on during the hours of daylight. Multiple photocells will be located around the site to reduce risk in case of individual failure. Manual control switches, located either within a control room or adjacent to the area, will be used to enhance/supplement levels of light when activities take place.

The plan shown in this section highlights areas (in orange) where lighting will be dimmed or switched off when not required, to reduce both energy consumption and light spill.

The wider site lighting will remain on throughout the hours of darkness for safety, and this will be referred to as the 'normal operational' conditions.

Aviation obstruction lighting will remain operation at all times.

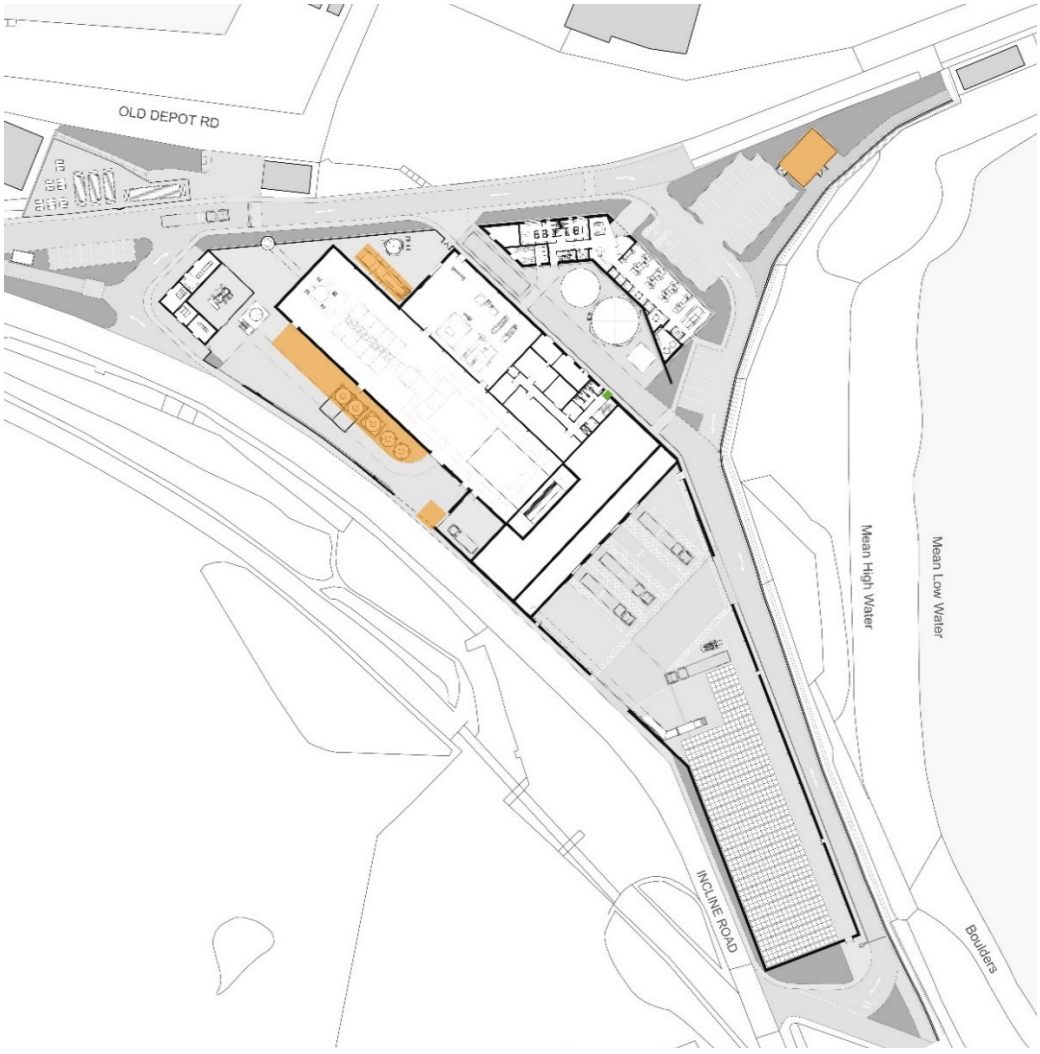


Figure 07 – Localised enhanced lighting

6 Reference Lighting Design

The Reference Design has been developed to present how the site could be delivered to meet the limiting design criteria as proposed within Section 3. It is not the intention that the Reference Design necessarily represents the final installation, though it may, as the lighting design is anticipated to change as the detail design of the facility is refined and developed.

Calculations have been undertaken to demonstrate a possible lighting configuration that meets the requirements set out within this report, including the following:

- Horizontal calculations for each task area as defined within Figure 03.
- Overall horizontal illuminance to show distribution and intensity of light over the site and a '1 lux' contour line showing spill beyond the boundary as a result of the proposed development.
- Vertical illuminance calculation points along the boundaries with Balaclava Bay and the Isle of Portland SSSI to demonstrate that the vertical spill of light is within the proposed target criteria.

Consideration has also been given to light beyond the boundary to the north of the site with respect to receptors in the distance across the bay. Explicit calculations have not been completed for this boundary, as the assessment can be completed through critical analysis of the adjacent port lighting.

Indicative locations of columns and luminaires is shown on Figure 08. A short description of fixture type, mounting height, photometric data (lumen output and optic/beam angles) and tilt is provided for information.

Illuminance calculation points have been placed vertically at 1m intervals from a height 0.05m above grade to 20.05m above grade. This vertical stack of points has been repeated at 1m intervals along the boundary. The calculation points face inwards towards the site, and therefore this calculation captures the potential light spilling out beyond the site boundaries.

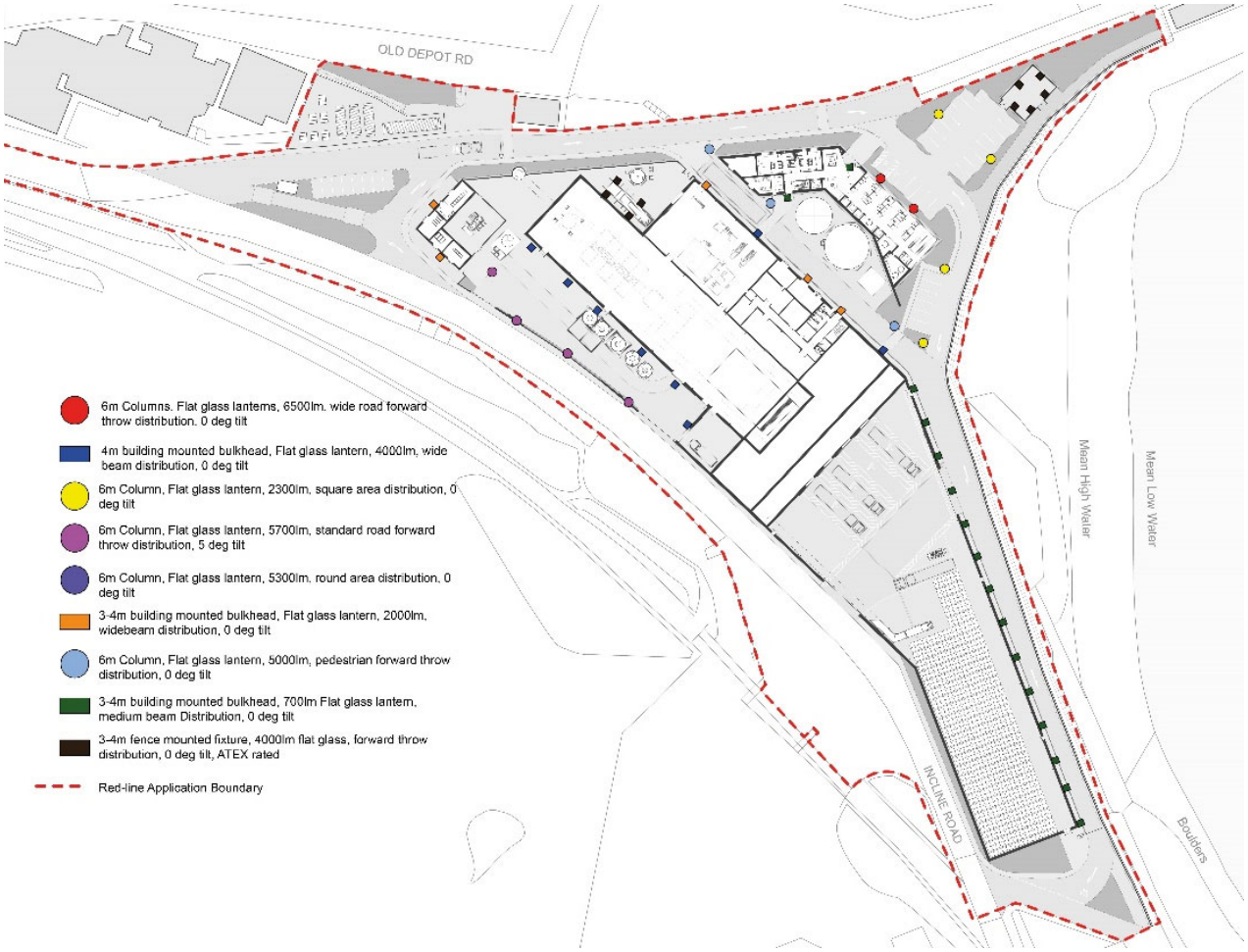


Figure 08 – Indicative Lighting Layout

6.1 Indicative Performance Criteria

A 3D digital model of the proposed development site layout, terrain context and development massing formed the basis of the lighting calculation assessment, allowing accurate assessment of achieved lighting distribution and likely spill beyond the boundary and into the air. Luminaries were placed within lighting analysis software as indicated in Figure 08 to meet the lighting criteria described within Section 3 of this report.

A 3m solid fence along the boundary of the service yard has been included in these calculations, helping limit spill over the western boundary. This is shown in the architectural site plan within this planning submission.

6.1.1 Horizontal Illuminance

Figure 08 – Greyscale aerial rendering of Site

Figures 08 and 09 demonstrate the likely extent and intensity of light distributed in and around the development on the horizontal surface as a result of the proposed lighting installation.

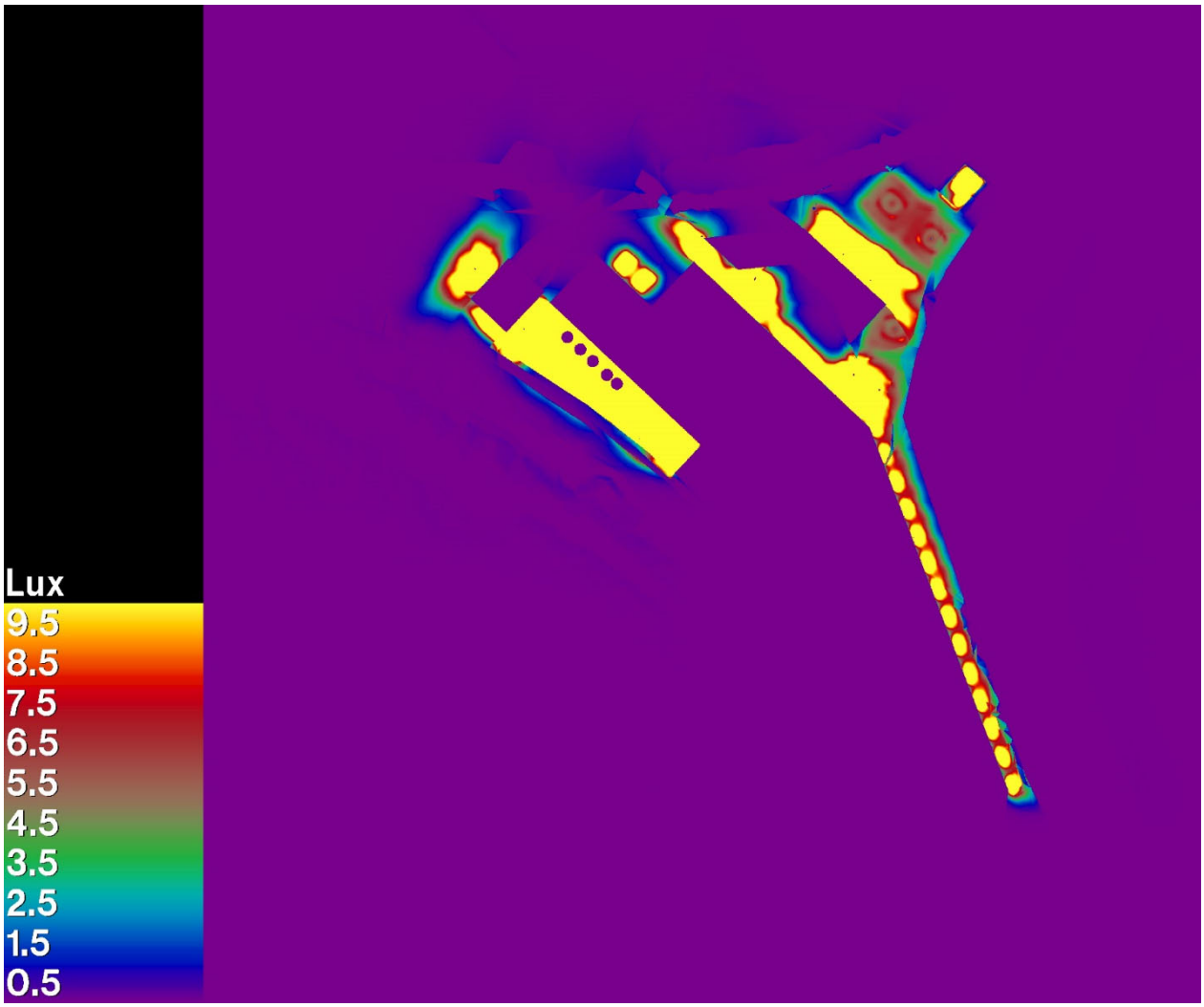


Figure 09 – Plan view false colour rendering of illumination levels within the Site boundary

Figure 10 provides additional detail as to where the proposed light intensity on the horizontal surface would be reduced to 1lux.

Figure 10 – Greyscale rendering of site with 1 lux horizontal illuminance contour line at ground level to show spill of light outside of boundary, considering the 3D topographic model

6.1.2 Vertical Calculations

The vertical lighting calculations were undertaken under normal operational conditions (i.e. the lighting within the LPG fuel storage, emergency generator and service yard was dimmed or off) with a maintenance factor of 1.0 as a worst-case initial value.

Reference lighting calculations have been undertaken accounting for the contribution from reflected light (indirect lighting) off surfaces such as the road and buildings in the site.

The position of vertical analysis grids are shown in Figure 11 and comprise of illuminance analysis points orientated perpendicular to the boundary directed towards the site. Calculation results account for effects of reflections and interreflections off building and ground elements included within the model.

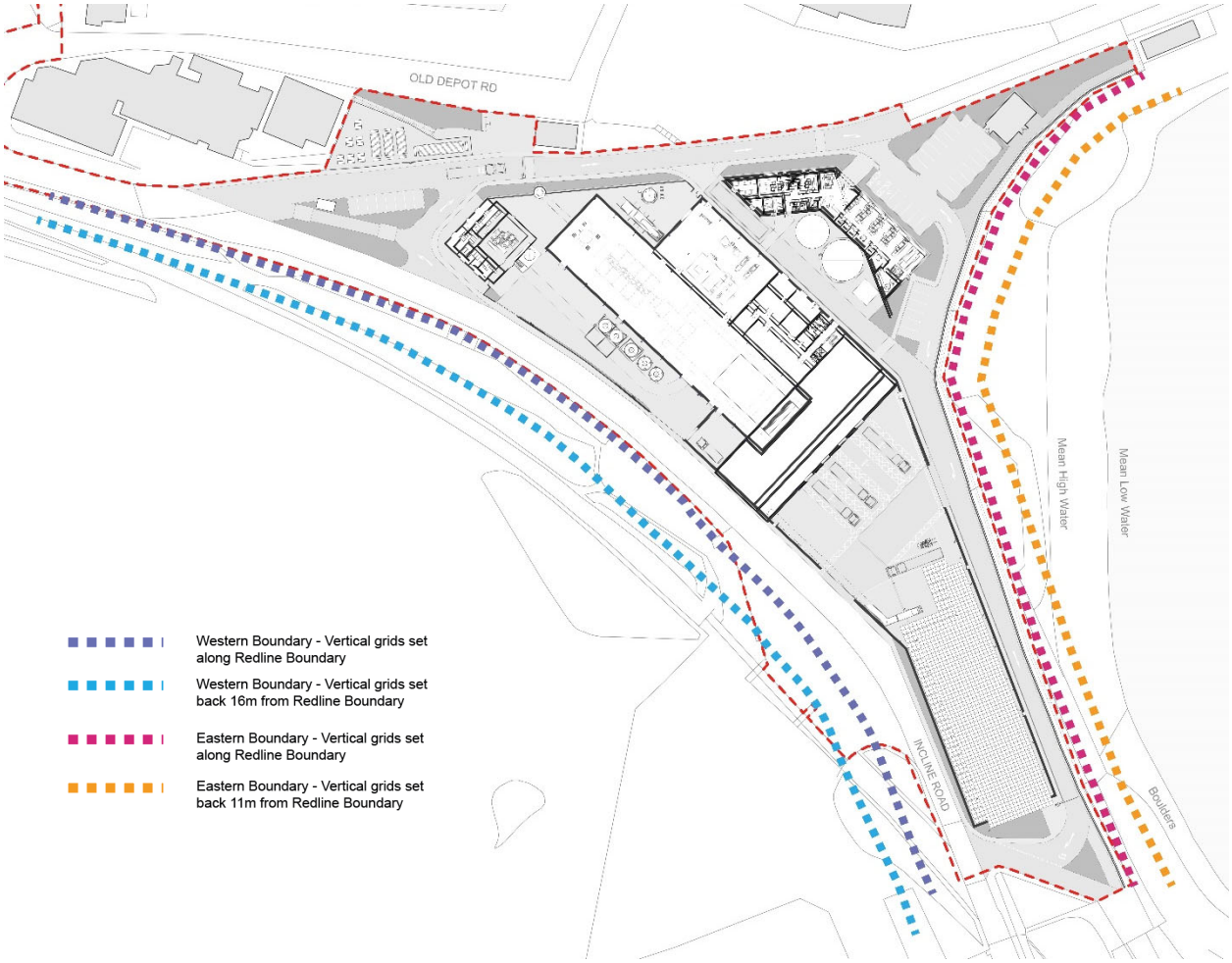


Figure 11 Calculation grid locations

Western Boundary

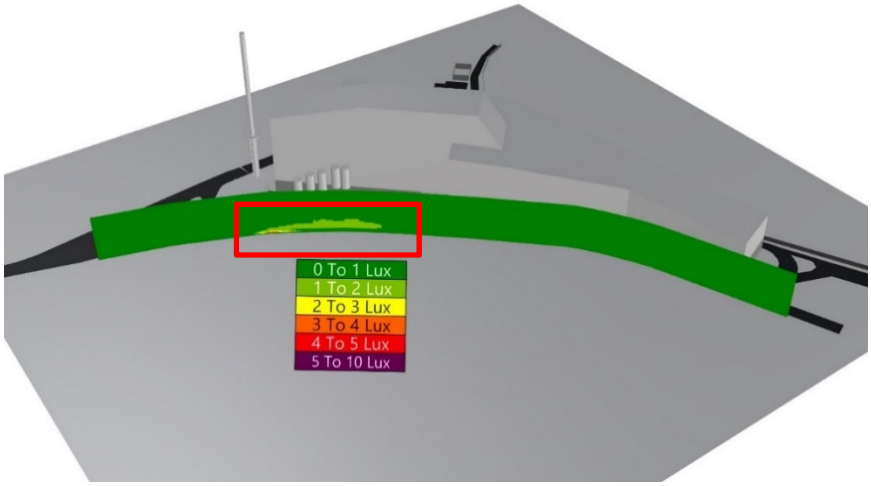


Figure 12 – red box highlights >1lux light spill is measured vertically at the west redline boundary.

Lighting spill vertically at the SSSI boundary along Incline Road is generally less than 1lux.

The magnitude of light spill increases opposite the service yard due to reflection from the building mounted lighting, rather than as a result of direct distribution of light from equipment beyond the boundary line.

Proposed mitigation measures include the provision of a 3m solid fence around the boundary of the yard. It is possible to further reduced indirect spill light by the use of less reflective colour/materials to the building façade in this location and the application of a black tarmac finish to the service yard.

Further detailed analysis has been performed simulating the potential beneficial effects of the proposed mitigation measures. The analysis below indicates that direct light is not measured above a 5m elevation on the boundary and not quantified at all when assessed at an offset of 16m west of the boundary.

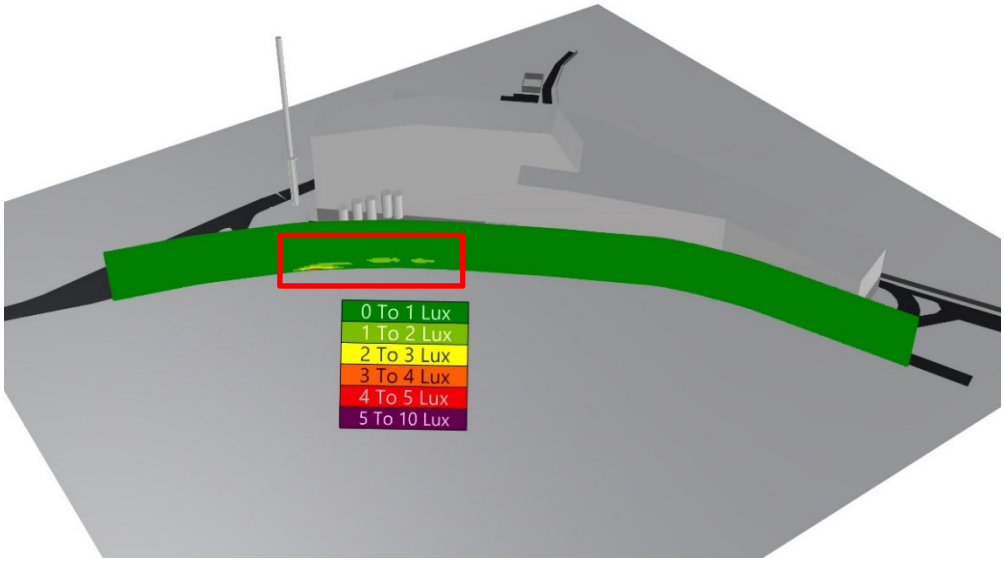


Figure 13 – red box highlights >1lux direct light spill measured vertically at the west redline boundary with 3m solid fence at Service Yard.

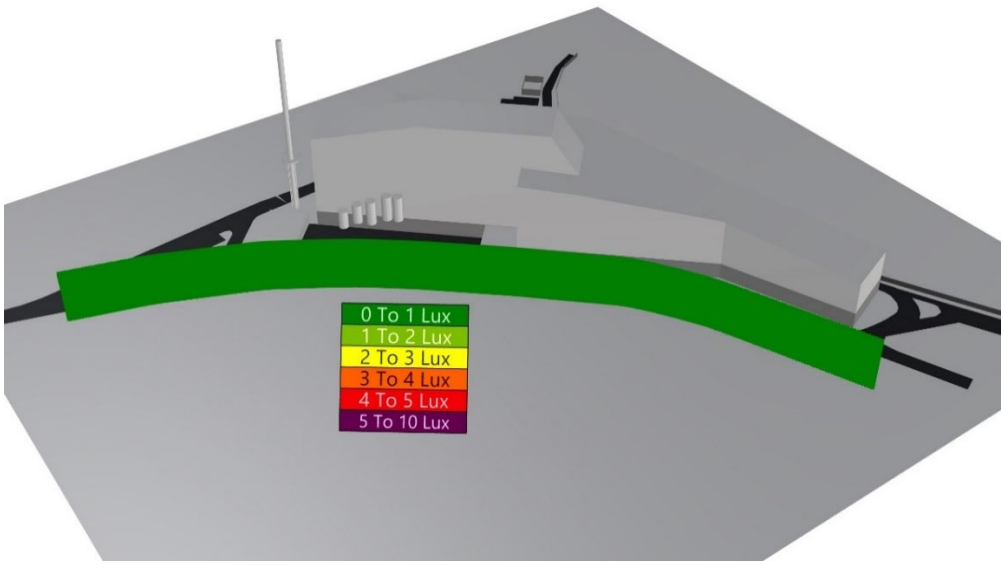


Figure 14 – zero direct light spill measured vertically at a 16m offset from west redline boundary

Incline Road is bounded by a cliff face and steep hill to the west. As shown here, the light spill above the height of the columns (5m) will be zero, therefore direct light spill into the SSSI and SAC will be limited by the cliff face.

Eastern Boundary

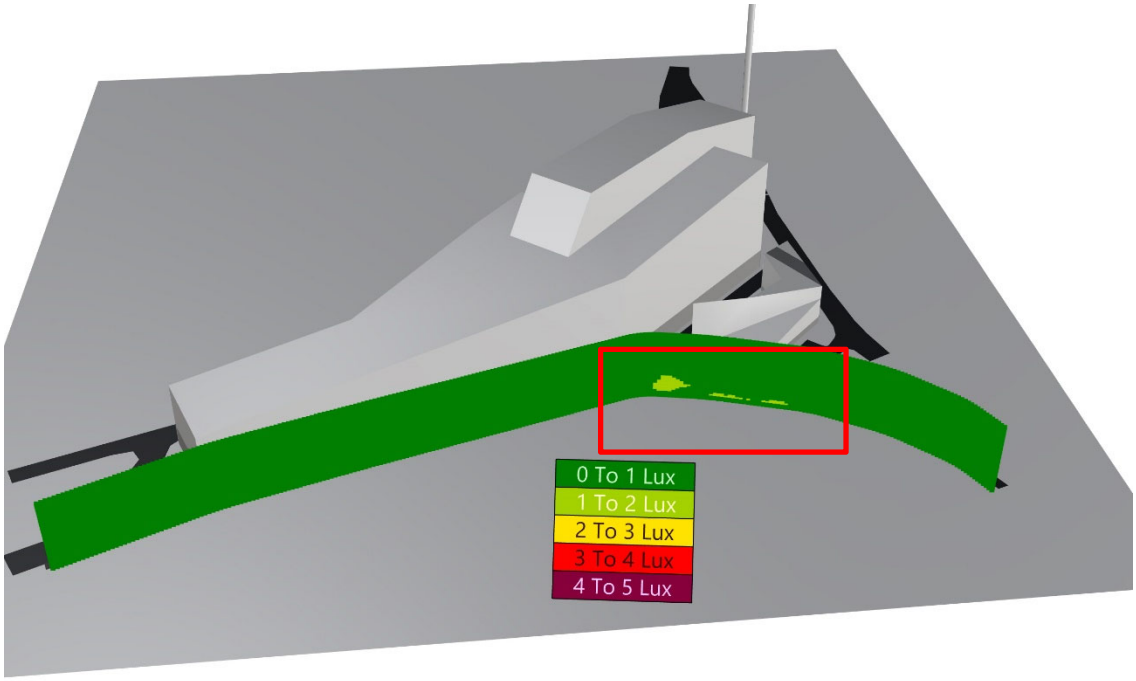


Figure 15 – red box highlights >1lux light spill measured vertically at the east redline boundary with a 2m solid fence along the pipeline as indicated on drawings.

Vertical spill light at the Balaclava Bay boundary is generally less than 1 lux.

In the vicinity of the carpark spill increases as a result of providing sufficient light to the parking bays.

Spill in this area can be mitigated if the 2m solid fence were to continue along the pipeline opposite the car park.

Additional detailed analysis has been performed (Figure 16) considering the implementation of the proposed mitigation measure. While the amount of light detected beyond the boundary is significantly reduced as a result, some light is expected to breach the boundary just above the proposed extension of the tall 2m fence line.

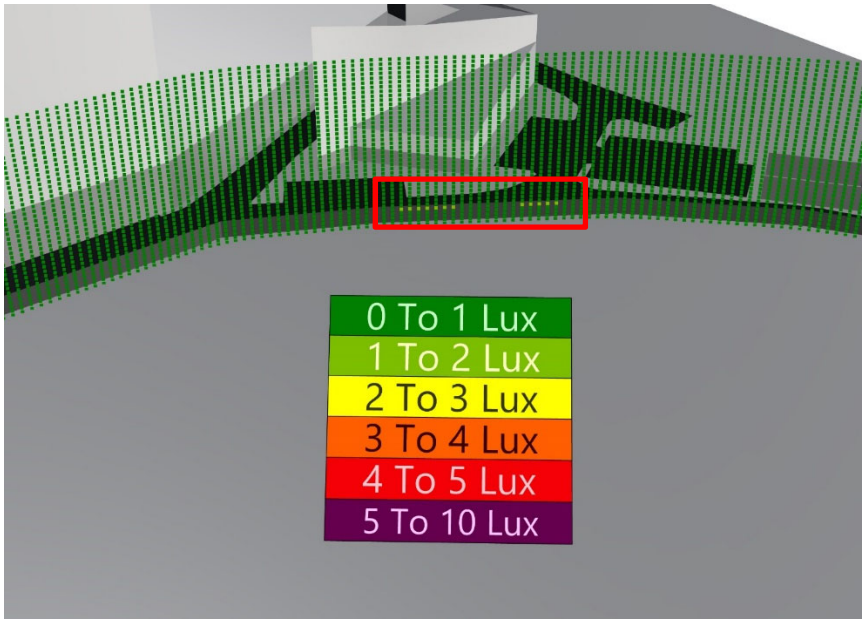


Figure 16 – red box highlights >1lux direct light spill above the fence at the vertical plane along the east redline boundary with a 2m solid fence at the pipeline.

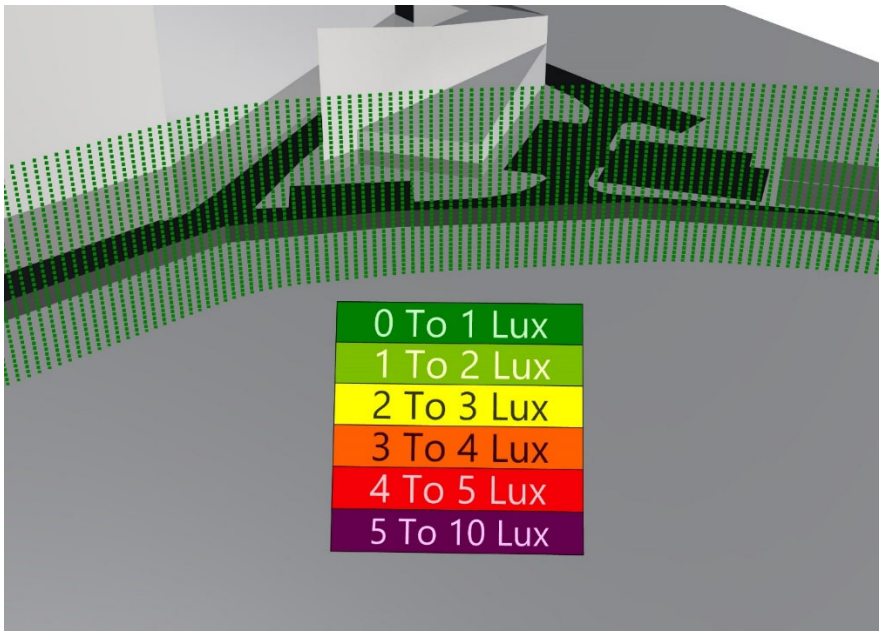


Figure 17 – zero direct light spill measured vertically at 11m from the east boundary with a 2m solid fence at the pipeline.

While the calculated spill illuminance reduced to less than 1 lux at 11m from the pipeline boundary (Figure 17), the amount of spill light could be further mitigated through either increased height of the boundary fence adjacent to the carpark or application of shields of baffles to lanterns on site post installation.

6.1.3 Upward Light Pollution - CIE 150 Compliance

The CIE 150: 2017 defines the upward flux ratio, or the intensity of light emitted or reflected upward from a lighting installation, as:

The ratio between the luminous flux above the horizon resulting

- *Directly from all luminaires into the sky*
- *Light from the installation reflected off the surface intentionally lit, and*
- *Light reflected off the surrounding surface lit unintentionally because of spill light*

to the luminous flux above the horizon in the hypothetical ideal solution where the luminaires have no direct light radiated above the horizon, and all their light is concentrated only to the surface area lit intentionally and that area has exactly the required lighting level.

For the baseline 'ideal' solution, the total luminous flux has been calculated by multiplying each calculation surface area by their target illuminance level. These values have been multiplied by the respective surface light reflectance values. It is assumed that all of the luminous flux that leaves this surface reaches the sky dome. In reality, some of this light would be obstructed by buildings and other solid objects within the site.

Surface	**Reflectance**
Tarmac Roads	0.1
Concrete hardcore surfaces (with black tarmac)	0.1
Grass/planted areas	0.3
Pathways	0.3
Louvre grill façade, black finish	0.1
Buildings	0.3

Table 02 – Assumed surface reflectance properties utilised within software simulation

Software analysis has been undertaken for each of the comparative scenarios. For consistency with CIE 150: 2017, obstructions have been included (such as buildings, silos and topography).

The light intensity from luminaires represents the maximum light output at 'day one' of use (before depreciation as a result of dirt, wear and ageing of the light source) to represent the worst-case 'brightest' initial value. Lighting levels calculate the normal nigh time operational mode, i.e. The LPG fuel store, generator and service yard lighting levels are not in use and all at the dimmed reduced output or switched off.

The ratio of the two values has been compared, i.e. UFR = Flux $_{proposed}$ / Flux $_{ideal}$ and has been calculated at 2.1 which comfortably meets the target maximum ratio of 5.

7 Proposed Mitigation Strategies

7.1 Day to Day Operations

Whilst it is acknowledged that light spill cannot be fully eliminated due to the minimum requirements to allow safe operations of the site, it is possible to reduce spill of light beyond the site into the surroundings by applying the following principles:

- Flat glass luminaires and zero tilt where practical
- Orientating luminaries to face into the site and use of accessories (such as louvers or back shields)
- Using columns that are no higher than 6m tall, whilst maintaining the required uniformity over the horizontal plane
- Using dark/black paint finishes on the lower façade where there are building mounted fixtures
- Using dark/black tarmac surfaces at the loading bay to reduce reflectance of light upwards.

To encourage bats to nest and fly through areas of darkness surrounding the site it is recommended that a warm white, 2700-3000K correlated colour temperature is used. It has been found that warmer colour temperatures with peak wavelengths greater than 550nm have less impact upon bats.

In areas where lighting for maintenance procedures is infrequent, for example the roof, lighting will be controlled by PIR to ensure luminaires switch off after a set time when not required.

7.2 Dynamic Lighting Impact

General night-time operations and movement of vehicles on and around the proposed development have the potential produce short duration dynamic light pollution from headlights and doors opening/closing.

To mitigate unwanted obtrusive effects an optically solid boundary shall be proposed along the length of the Balaclava Bay boundary. The fence is intended to block direct transmission of headlights through the boundary, effectively reducing light spill into the marine environment.

Solid fences will also be in place at the LPG fuel store, and the Service Yard to perform a similar function to vehicle and fixed lighting installations in these locations.

A roller shutter door will be used at the entrances of the RDF bale store where HGV enter and exit to unload, reducing the spill of light at these points.

It is expected that office windows will be provided with blinds that can be brought down to mitigate light spill from internal spaces during hours of darkness.

Appendix A

Existing Lighting Appraisal

A1 Introduction

The existing lighting along Incline Road was photographed on the 21st April 2020 and the following provides a narrative to the suitability of retaining the equipment in place.

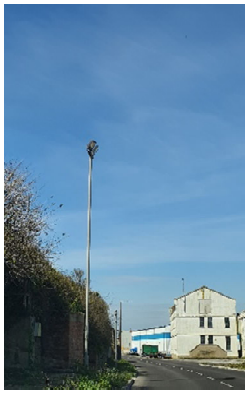
A2 Existing Lighting

The information on luminaires has been gathered by using the photographs provided and professional experience to obtain a likely manufacturer and product as stated.

Column heights have been estimated using photographs.

Lighting levels have been measured and provided by the Port therefore it is possible to understand the suitability of the fixture and whether the retention of the existing lighting will be appropriate for the new use of the site.

Images of existing lighting	Notes
 Fixture Type A	It has been assumed that this fixture is a 100W LED lantern by One Electrical, mounted on a 5m column. The fixture has little optical control and a very high wattage. The lux level readings show 0-1 lux points between two columns therefore the uniformity across the road is very low. Where trucks are turning out of the facility along Incline Road, a higher level of uniformity is key to ensure the safety of vehicle users on the approach.
 Fixture Type B	It is assumed that this fixture is a 100W LED lantern, but the manufacturer is unknown. It is assumed to be mounted on a 5m column. Similar to Type A, the optical control is low and lux level readings demonstrate poor uniformity over the road.

  Fixture Type C	It is assumed that this fixture is a 150W LED Floodlight by One Electrical. It is tilted approximately 80 degrees upward from the horizontal plane. This type of floodlight fixture would typically be used for area lighting and during the demolition of the site. As the function of the site has been developed, the floodlights are no longer appropriate, creating unnecessary spill of light over the site boundary.