LIGHTING TECHNICAL STUDY

Project Eider Rock – Proposed Petroleum Refinery and Marine Terminal in Saint John, New Brunswick

IRVING OIL COMPANY, LIMITED
SAINT JOHN, NEW BRUNSWICK

REPORT NO. 1013263.03-013

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ON **Lighting Technical Study**

FOR **Project Eider Rock – Proposed Petroleum Refinery and Marine Terminal in Saint John, New Brunswick**

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EXECUTIVE SUMMARY

This document is a Lighting Technical Study prepared as background information for the Environmental Impact Assessment/Environmental Assessment (EIA/EA) for Project Eider Rock ("the Project").

The Project, proposed by Irving Oil Company, Limited ("the Proponent") involves the development of a new petroleum refinery, marine terminal, and associated land-based and marine-based infrastructure in the Red Head area, near east Saint John, New Brunswick. The new refinery and associated land-based and marine-based infrastructure will process 40,000 m^3/d (250,000 barrels per day, nominal) of crude oil into finished products for supplying export markets in North America and elsewhere.

Lighting and the resulting light emissions from the Project components have been identified in the Final Guidelines for the EIA/EA of the Project, in terms of the potential for causing adverse environmental effects to nearby receptors. This Lighting Technical Study, carried out to characterize the existing lighting conditions in the area and to provide information on the expected lighting conditions once the Project is operational, involved:

- Measuring existing sky glow conditions in the area surrounding the existing Saint John refinery and within and surrounding the Project;
- Conducting a quantitative assessment of light trespass and glare within and surrounding the Project during Operation; and
- Conducting a qualitative assessment of sky glow within and surrounding the Project during Operation.

Characterization of existing baseline conditions is necessary background information for the EIA/EA and the environmental effects assessment for this Project. Thus, the purpose of this Technical Study is to describe the existing and anticipated future light quality conditions in the vicinity of the Project.

In general, the baseline sky glow results in the area surrounding the existing Saint John refinery in east Saint John are representative of a typical urban environment, while the baseline sky glow conditions in the area near the proposed Project location are representative of a rural environment. These light conditions would be anticipated to be analogous to those that might result from Project Eider Rock, although mitigation measures and lighting design will reduce ambient light levels to the extent practicable through sustainable and responsible design.

The quantitative assessment shows that the light trespass and the glare will meet the modern, internationally accepted guidelines of the Commission Internationale de L'Éclairage (CIE). In meeting these guidelines, the designs will markedly reduce the potential contribution of lighting to sky glow.

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GLOSSARY

Term	Definition
candela	The SI unit of measure for luminous intensity of a light source in a specific direction.
glare	A potential environmental effect where intense, harsh, or contrasting lighting conditions reduce human, birds, and other organisms' ability to see. The unit of measure for glare is lumens per steradian, which is equal to a candela.
light trespass	Sometimes referred to as illumination on surrounding properties or light spill, refers to the spilling of light from fixtures within a facility to the environment and receptors outside the facility. The unit of measure for light trespass is a lux. A lux is equal to 1 lumen per square metre (lumen/m^2).
illuminance	The density of incident luminous flux on a surface and is measured in lux.
illumination	The luminous flux falling on an area from a source of light intensity, *i.e.,* the degree of visibility in your environment.
lumen	An SI unit of measure for luminous flux, which is a measure of the quantity if light, being emitted from a source.
luminaire	A complete lighting installation including the lamp/lamps and parts involved in distributing the light.
luminance	A measure of the luminous intensity or brightness of light. The unit of measure is candelas per square metre.
lux	A unit of measure for illuminance and is equal to lumens per square metre.
obtrusive light	Spilled light which gives rise to annoyance, discomfort, distraction, and a reduction in the ability to see essential information.
outdoor lighting	Any form of exterior or interior lighting systems that have an environmental effect on the outdoor environment.
pre-curfew	The time after sunset, between 19:00 and 23:00, when lighting may be in use but activity levels are still high.
post-curfew	The time between 23:00 and 06:00 during which stricter requirements for the control of light may be employed because of overnight sensitivity to higher light levels. No curfew applies in New Brunswick.
sky glow	The illumination of the clouds, and haze in the atmosphere that replaces the natural nighttime sky with a translucent to opaque lighted dome. The unit of measure for sky glow is in magnitudes per square arcsecond (mag/$arcsec^2$).
zenith	The point in the sky directly above the observer.

LIST OF ACRONYMS AND UNITS

Acronym/Unit	Definition
CCME	Canadian Council of Ministers of the Environment
cd	candela
cd/m^2	candela per square metre
CEAA	*Canadian Environmental Assessment Act*
CIE	Commission Internationale de l'Éclairage (International Commission on Illumination)
e.g.,	for example
EIA/EA	Environmental Impact Assessment/Environmental Assessment
i.e.,	that is
HPS	high pressure sodium
LEED	Leadership in Energy and Environmental Design
lumen/m^2	lumen per square metre
lux	1 lumen per square metre
mag/$arcsec^2$	magnitudes per square arcsecond
steradian	SI unit for a solid angle
VEC	valued environmental component
W	Watt

LIGHTING TECHNICAL STUDY

1.0 INTRODUCTION

This document is the Lighting Technical Report prepared as background information for the Environmental Impact Assessment/Environmental Assessment (EIA/EA) for Project Eider Rock ("the Project"), the proposed petroleum refinery and marine terminal in Saint John, New Brunswick. The location of the Project is shown in Figure 1.1.

The Project, proposed by Irving Oil Company, Limited ("the Proponent") involves the development of a new petroleum refinery, marine terminal, and associated land-based and marine-based infrastructure in the Red Head area, near east Saint John, New Brunswick. The new refinery and associated land-based and marine-based infrastructure will nominally process 40,000 m^3/d (250,000 barrels per day, nominal) of crude oil into finished products for supplying export markets in North America and elsewhere.

1.1 Purpose of this Technical Study

The Atmospheric Environment has been identified as a Valued Environmental Component (VEC) to be assessed as part of the EIA/EA for the Project. An essential component for the assessment of environmental effects on the Atmospheric Environment and on Land Use is the assessment of lighting conditions in the vicinity of the Project.

Characterization of existing baseline conditions is necessary background information for the EIA/EA and the environmental effects assessment for this Project. Thus, the purpose of this Technical Study is to describe the existing and anticipated future light quality conditions in the vicinity of the Project.

1.2 Overview of this Technical Study

In this Lighting Technical Study, the existing light quality in the vicinity of the Project is described, and the predictive light measurements are identified.

This Lighting Technical Study involved the following:

- Measuring existing sky glow conditions in the area surrounding the existing Saint John refinery and within and surrounding the Project;
- Conducting a quantitative assessment of light trespass and glare within and surrounding the Project during Operation; and
- Conducting a qualitative assessment of sky glow within and surrounding the Project during Operation.

The potential for lighting from construction and operation activities associated with Project Eider Rock to cause adverse environmental effects on the Atmospheric Environment and Land Use will be assessed in the EIA/EA Report on the basis of measured and expected light conditions surrounding the Project. The environmental effects of lighting on avian species will also be addressed in the EIA Report under the assessment of the Terrestrial Environment.

The Assessment Area for this work encompasses the Project lands and the residences that may be affected by the light emitted from the Project, and is generally comprised of the Mispec/Red Head area. This Technical Study also included work at the existing Saint John refinery site in east Saint John, where baseline measurements were made, but where no assessment was conducted. The combination of the Mispec/Red Head area and the areas surrounding the existing Saint John refinery and perimeter areas comprise the Study Area for this work (Figures 1.1, 2.1 and 2.2).

1.3 Some Basic Attributes of Light

Light in itself is not a pollutant. However, badly designed lighting or excessive lighting can cause adverse environmental effects ranging from a minor nuisance to a disruptive environmental effect. The three attributes that are used to describe light, and which can cause lighting to become obtrusive if criteria for each of these attributes are not met, are generally referred to as light trespass, glare, and sky glow, as defined below.

- **Light Trespass:** Sometimes referred to as spill or illumination on surrounding properties, light trespass refers to the spilling of light from fixtures within a facility to the environment and receptors outside the facility. The unit of measure for light trespass is a lux, which is equal to 1 lumen per square metre (lumen/m^2). For example, problematic light trespass would occur when lights located on the outside of an industrial facility shine in through the windows of nearby residential homes. In the middle of the night, light trespass at residential properties should not exceed 1 lux (CIE 2003).
- **Glare;** Glare is a potential environmental effect where intense, harsh, or contrasting lighting conditions reduce humans, birds, and other organisms' ability to see. The most common example is oncoming high-beam headlights of a car that provide lots of light but paradoxically make it difficult to see. The unit of measure for glare, sometimes referred to as luminance, is lumens per steradian, which is equal to a candela (cd). Lights emitting greater than 500 cd during the night exceed a common international guideline for glare (CIE 2003).
- **Sky Glow:** Sky glow refers to the illumination of the clouds by light sources on the surface of the earth (such as street lighting), and haze in the atmosphere that replaces the natural night time sky with a translucent to opaque lighted dome. The unit of measure for sky glow is in magnitudes per square arcsecond (mag/arcsec^2). Values for sky glow range from approximately 22 mag/arcsec^2 in a rural environment where stars are abundant, to approximately 18 mag/arcsec^2 in an urban environment where stars are barely visible.

1.4 Light Assessment Criteria

There are currently no regulations, guidelines, or policies in place within the Province of New Brunswick that regulate lighting conditions or limit the amount of obtrusive light being emitted from facilities. However, the Commission Internationale de L'Éclairage (CIE), also known as the International Commission on Illumination, has developed sets of maximum values for both light trespass and glare that should not be exceeded. These guidelines have been adopted in Great Britain and form the basis of a number of recommendations in the LEED Green Building Council Certification Program of Canada (LEED 2004). These values are based on environmental zones and time of day.

The CIE has established four environmental zones as a basis for outdoor lighting regulations (CIE 2003). These four zones are summarized in Table 1.1.

Figure 1.1 Project Location

Table 1.1 CIE Environment Zones

Zone	Surrounding	Lighting Environment
E1	Natural	Intrinsically Dark
E2	Rural	Low District Brightness
E3	Suburban	Medium District Brightness
E4	Urban	High District Brightness

Source: CIE (2003)

The maximum values recommended by CIE for light trespass (illuminance) on properties by environmental zone and time of day are presented in Table 1.2.

Table 1.2 CIE Maximum Values of Light Trespass (Illumination) on Properties

Time of Day	Environmental Zones			
	E1	E2	E3	E4
Pre-curfew (19:00 – 23:00)	2 lux	5 lux	10 lux	25 lux
Post-curfew (23:00 – 6:00)	0 lux	1 lux	2 lux	5 lux

Source: CIE (2003)

The maximum values recommended by CIE for glare (intensity of luminaires) in designated directions by environmental zone and time of day are presented in Table 1.3.

Table 1.3 CIE Maximum Values for Glare (Intensity of Luminaires) in Designated Directions

Curfew	Environmental Zones			
	E1	E2	E3	E4
Pre-curfew (19:00 – 23:00)	2,500 cd	7,500 cd	10,000 cd	25,000 cd
Post-curfew (23:00 – 6:00)	0* cd	500 cd	1,000 cd	2,500 cd

* If for public lighting value may be up to 500 cd

Source: CIE (2003)

Based on the Study Team's knowledge of the area, the location of the Project and surrounding areas (Mispec/Red Head) would likely be considered to fall in an E2 (Rural) category, and the area near the existing Saint John refinery would be considered E4 (Urban).

Reference levels of sky glow are presented in Table 1.4. The higher the number, the more the sky is dominated by the natural background; the lower the number, the greater the degree of sky glow that is caused by reflection from the atmosphere of man-made lighting.

Table 1.4 Reference Levels of Sky Glow

Sky Glow (mag/arcsec^2)	Corresponding Appearance of the Sky
21.7 (Rural)	The sky is crowded with stars that appear large and close. In the absence of haze the Milky Way can be seen to the horizon. The clouds appear as black silhouettes against the sky.
21.6	The above with a glow in the direction of one or more cities is seen on the horizon. Clouds are bright near the city glow.
21.1	The Milky Way is brilliant overhead but cannot be seen near the horizon. Clouds have a greyish glow at the zenith and appear bright in the direction of one or more prominent city glows.
20.4	The contrast of the Milky Way is reduced and the detail is lost. Clouds are bright against the zenith sky. Stars no longer appear large and near.
19.5	Milky Way is marginally visible, only near the zenith. Sky is bright and discoloured near the horizon in the direction of cities. The sky looks dull grey.

Table 1.4 Reference Levels of Sky Glow

Sky Glow (mag/arcsec^2)	Corresponding Appearance of the Sky
18.5 (Urban)	Stars are weak and washed out and reduced to a few hundred. The sky is bright and discoloured everywhere.

Source: Berry (1976).

1.5 Organization of this Technical Study

This Technical Study was developed in support of the EIA/EA for Project Eider Rock, and is presented in five sections, as follows.

- Section 1.0 is a general introduction and background information about the Project and the Technical Study.
- Section 2.0 is an overview of the baseline light conditions at the existing Saint John refinery and the Assessment Area.
- Section 3.0 provides the predicted lighting from the Project, including the approach for the prediction of light conditions. A description of the predicted light conditions for the Project, and a discussion on the results.

The closing remarks are provided in Section 4.0. References consulted as part of the work and personal communications are provided in Section 5.0, and additional supporting documentation is provided in the appendices.

2.0 EXISTING CONDITIONS

Baseline studies were conducted by measuring existing sky glow conditions at both the existing Saint John refinery and in the Mispec/Red Head area (also referred to as the Assessment Area). The general Project location and the Project Assessment Area are shown in Figure 2.1.

The same procedure was used to conduct both sampling events and is described in the following sub-sections. Sky glow measurements were taken at both the existing Saint John refinery and in the Mispec/Red Head area. Light trespass was measured at the existing Saint John refinery only, as there is no large light source currently in the Mispec/Red Head area to measure. Glare at the existing Saint John refinery and the Mispec/Red Head area was not addressed in this Technical Study.

2.1 Existing Saint John Refinery Area

The light quality surrounding the existing Saint John refinery is expected to be typical of an urban environment. A baseline light assessment was conducted to quantify light levels near the existing Saint John refinery. The baseline light assessment, conducted in April 2008, consisted of measuring sky glow using a Sky Quality Light Meter at various locations along the fence line of the existing Saint John refinery and at 100 m back from each fence line location. The measured results of the baseline light assessment were also compared to the comparative levels of sky glow listed in Table 1.4. The sampling locations are identified in Figure 2.1.

The location and measured baseline sky glow levels at and surrounding the existing Saint John refinery are presented in Table 2.1.

By comparing these results to the standard sky glow measurements listed in Table 1.4, it is seen that light measurements in the area surrounding the existing Saint John refinery vary between 11.5 and 17.0 mag/arcsec^2, and are representative of an urban environments.

Measurements of existing light trespass (light readings on a vertical surface facing the facility) were also taken around the existing Saint John refinery at various locations along the perimeter, one set at the fence line, and another set 100 m back from the fence line points. All but two locations were less than 1 lux, the maximum acceptable level according to guidelines of the Commission Internationale de L'Éclairage (CIE). Both sites at the entrance to the refinery off Grandview Avenue exceeded the CIE levels, the nearest being 5.4 lux, and the site at 100 m setback was 1.6 lux. This entrance area was identified visually as the "brightest" on the perimeter. The next brightest site was #8 Loch Lomond Road, where the light from the refinery was 1.5 lux, marginally above the criterion of 1 lux.

Table 2.1 Baseline Sky Glow Measurements, Existing Saint John Refinery Area

Sample Location No.	UTM Coordinates at Fence Line		UTM Coordinates 100 Metres Back from Fence Line		Sampling Location	Time of Measurement	Light Measurement (mag/arcsec^2)	
	Easting (m)	Northing (m)	Easting (m)	Northing (m)			Fence Line	100 Metres Back from Fence Line
1	734670	5020434	734731	5025463	Corner of Champlain Drive and Loch Lomond Road	21:18	16.0	15.5
2	734970	5019486	734998	5019507	Champlain Drive	21:32	17.9	17.2
3	735212	5018761	735259	5018709	Grandview Avenue	21:48	16.8	17.1
4	734717	5018451	734749	5018304	Project Office Entrance to Refinery – Grandview Avenue	21:56	11.5	13.1
5	733982	5017731	734039	5017707	Bayside Drive	22:07	15.6	14.2
6	733203	5018881	733213	5018967	Mt. Pleasant Avenue, off Bayside Drive	22:18	17.3	14.9
7	733661	5019601	733527	5019647	Loch Lomond Road, Refinery Gate	22:33	15.5	16.1
8	733726	5019776	733717	5019820	Loch Lomond Road	22:52	16.3	14.5

Figure 2.1 Baseline Light Sampling Locations, Existing Saint John Refinery Area

2.2 Mispec/Red Head Area (Assessment Area)

The light quality in and surrounding the Assessment Area near the proposed location of the Project is expected to be typical of a rural environment. To quantify the light levels in the Assessment Area, a baseline light assessment was conducted in March 2008 in a manner similar to that conducted at the existing Saint John refinery, described in Section 2.1. The measured results of the baseline study were also compared against the comparative levels of sky glow as listed in Table 1.4. The sampling locations are displayed in Figure 2.2.

The location and measured baseline sky glow levels within and surrounding the Assessment Area are presented in Table 2.2.

Table 2.2 Baseline Sky Glow Measurements, Mispec/Red Head Area

Sample Location No.	UTM Coordinates		Sampling Location	Time of Measurement	Light Measurement (mag/arcsec^2)
	Easting (m)	Northing (m)			
1	734008	5017041	Midwood Avenue	21:12	19.3
2	733861	5016349	Red Head Marsh Brook Watch	21:18	18.8
3	734892	5015030	Red Head Road	21:27	19.1
4	265109	5014578	Debly Avenue	21:32	19.2
5	265049	5013183	Red Head Road, east of Anthonys Cover intersection	21:38	18.3
6	265423	5012107	Red Head Road, east of Bayside Drive	20:43	19.7
7	266218	5011582	Red Head Road at the intersection to the Canaport Entrance	21:48	19.3
8	268146	5012792	Red Head Road, west of Mispec River Bridge	21:55	20.1
9	268498	5011805	Red Head Road at Mispec Beach	22:01	20.3
10	269506	5010913	Red Head Road, east of Mispec Beach	22:05	20.8
11	266183	5013599	Proud Road, west of Bayside Drive	22:18	20.1
12	267191	5015107	Proud Road, east of Bayside Drive	22:27	19.5
13	267535	5015602	Intersection of Proud Road and Old Black River Road	22:31	19.7
14	268059	5015510	End of Asphalt at Old Black River Road	22:35	20.3
15	269013	5015355	Past Tributary to Mispec River on Old Black River Road	22:41	20.4
16	266869	5016437	Old Black River Road, north of Proud Road	22:50	19.8
17	265568	5017379	Old Black River Road, south of Cottage Road	22:56	18.4
18	734634	5017684	Old Black River Road, south of Grandview Avenue	23:04	17.5

All measurements were taken during clear sky conditions to minimize the appearance of cloud cover or fog, both of which can increase the sky glow. By comparing these results to the standard sky glow measurements listed in Table 1.4, with light measurements ranging between 17.5 and 20.8 (in the range between urban and rural), it can be concluded that the area within and surrounding the Assessment Area is largely representative of a rural environment.

Light trespass within and surrounding the Assessment Area was not measured in this Technical Study.

Figure 2.2 Baseline Light Sample Locations, Mispec/Red Head Areas (Assessment Area)

3.0 PREDICTION OF PROJECT-RELATED LIGHTING

3.1 Approach

This analysis of the prediction of light quality from the Project focuses on the potential environmental effects of the Project on light trespass, glare, and sky glow.

3.1.1 Light Sources

Light sources during Construction, Operation, and Decommissioning and Abandonment of the Project are described in the following sub-sections.

Construction

Project-related lighting during Construction has not been analyzed in this Technical Study, as the activities to be conducted during Construction will be typically during daylight hours, temporary, and confined to the same general areas where the Project's permanent facilities will ultimately be located and operated. At present, there are no plans to conduct any substantive construction activities at night, although some limited construction activity may occur at night under some circumstances, therefore there will be minimal lighting, consisting primarily of security lighting overnight.

Operation

The light sources during Operation include the building exterior and interior lighting, lighting for plant stairways, ladders, towers, streetlights, and process units. For the most part, these light sources will be emitted from the major refinery process units. The major process units are likely to be distributed within twelve process modules that make up the refinery complex, according to the current conceptual engineering design of the Project. There are also two flares located within the refinery complex. Figure 3.1 shows the preliminary layout of the refinery complex, process modules, and the process units contained in each module, according to current conceptual engineering design of the Project.

Estimated light levels from the refinery were based on information provided by the Design Team. They estimated that each process module associated with the operation of the refinery complex could have up to 200 luminaires, each of 150 watts of electrical power.

Decommissioning and Abandonment

As with Construction, Project-related lighting during Decommissioning and Abandonment was not analyzed in this Technical Study, as the activities to be conducted during Decommissioning and Abandonment construction are temporary and confined to the same general areas where the Project's permanent facilities will ultimately be located and operated.

3.1.2 Project-Related Light Sources

The refinery complex is expected to be the area where the largest concentration of Project-related light sources will be located. There may be lighting in other areas such as at the marine terminal, but refinery is likely to have the greatest concentration of lighting associated with the Project. Various

process units at the refinery will be equipped with lights. The refinery complex may consist of the following units:

- Crude Distillation Unit (including an Atmospheric Distillation Unit and a Vacuum Distillation Unit) (CDU);
- Heavy Oil Upgrader (HOU) and Upgrader Gas Plant;
- Gas Oil Hydrocracker Unit (HCU) and Saturated Gas Plant;
- Continuous Catalytic Reforming (CCR) Unit;
- Treater Units (including a Light Hydrotreater, a Medium Hydrotreater, and a LPG Treater Unit (for C4));
- Sulphur Recovery and Treatment Units (including an Amine Regeneration Unit, Sour Water Strippers, Sulphur Recovery Units, and Tail Gas Treatment Units);
- Ancillary processes, equipment, and systems (including flares, a hydrogen plant, steam and electrical supply systems, and other utilities).

The proposed pipeline, rail line, conveyor corridors, tank farms, sea water cooling, and marine terminal are not expected to have substantive light sources that could lead to substantive adverse environmental effects to receptors, and therefore have not been included in this lighting assessment. Additionally, navigation lighting for the Project will comply with applicable requirements, and will have some horizontal component, but the limited number will not result in appreciable light spill. Area lighting on towers or standards can be controlled by design to focus light downward, using full horizontal cut-off to eliminate glare and light trespass.

3.1.3 Receptors

The potential areas of concern in terms of the light trespass, glare, and sky glow during Operation include the following:

- Old Black River Road;
- Subdivisions extending from Old Black River Road;
- Red Head Road;
- Subdivisions extending from Red Head Road;
- Proud Road;
- Bayside Drive; and
- Anthonys Cove.

Visibility

A Project line of sight analysis was conducted to determine which of the above areas could actually be seen from the refinery complex and hence the areas that could see the refinery. The visibility assessment was conducted at two heights above ground level; 19 m and 100 m. The 19 m height

represents the average height of the process units contained within the refinery complex, and the 100 m height represents the height of the flare system.

Figure 3.1 Conceptual Layout of the Refinery Complex

The results of the line of sight analysis at both heights are shown in Figures 3.2 and 3.3. The analysis was based on the topography of the area (*i.e.,* elevation of ground level at each receptor), but the environmental effects of potential visibility obstruction from structures or vegetation were not included. There will clearly be a reduction in the light transmission by the tree cover, where applicable, thereby resulting in lesser light intensities than evaluated in this analysis.

From the line of sight analysis, the receptors of concern (*i.e.,* those with greatest visibility of the facility lighting and flares), were found to include the following:

- Red Head Road, east of Mispec River Bridge; and
- The majority of Old Black River Road south of and including a segment of Cottage Road.

Areas that have limited visibility of the refinery complex include the following:

- Red Head Road, west of Mispec River Bridge including all subdivisions;
- Anthonys Cove;
- Bayside Drive, north of Proud Road; and
- Old Black River Road, northwest of Goldsworthy Road.

The flare system is visible at much greater distances, but is not visible in the following areas:

- Red Head Road, east of Bean Brook and west of Mispec River; and
- Anthonys Cove.

3.2 Potential Project-Related Lighting

The predicted results for light trespass, glare, and sky glow from Operation are described in the following sub-sections.

3.2.1 Light Trespass

The predicted levels of light trespass during Operation were calculated using the following procedure. From block diagrams of the refinery process units, the average height and the total perimeter of the refinery complex was calculated. It was assumed for the conservative case that the maximum area of unit vertical surface visible offsite would be the maximum projected width times the average height. Thus, the number of visible luminaires was calculated as the total number on the facility multiplied by the ratio of the maximum observable area of the facility to the total perimeter area. This resulted in an estimated 356 visible luminaires.

At the time of completing this Technical Study, the Design Team had not proceeded with a detailed design, but had identified high pressure sodium (HPS) lights as a likely choice. While this selection is subject to change during detailed engineering design, HPS lights are preferable from an energy efficiency standpoint, as they can provide up to 87 lumens per watt—substantially higher than the efficacy of older, conventional tungsten bulbs that are about 17 lumens per watt. HPS lights are also preferable from the point of view of obtrusive light abatement. Backscatter of light is most prevalent in the shorter ("bluish") wavelengths associated with metal halide lighting. HPS lights reduce backscatter. Additionally, the narrower group of wavelengths associated with HPS lights are more readily removed

using optical filters that are available to professional and amateur astronomers (United Kingdom Parliament 2003). The Design Team will be evaluating other innovative and energy efficient options for lighting during the subsequent design phases, including a preference for lights that will reduce light trespass and sky glow.

In the calculation of light trespass, the total light output from the refinery complex (expressed in lumens) was assumed to be visible at sites where topography did not obstruct the light path. The effect of light obstruction from structures or vegetation was not included, although there will be a reduction in the light transmission by structures or the tree cover, where applicable. It has also been assumed that the light disperses uniformly in all directions, although it has been stipulated by the Design Team that luminaires will be selected to reduce upward or light spill. These estimates therefore are likely to be conservative.

The calculated results for potential light trespass during Operation are presented in Table 3.1.

Table 3.1 Calculated Values for Light Trespass

Distance from Source (m)	Calculated Light Trespass (lux)
100	37.0
200	9.25
300	4.11
400	2.31
500	1.48
600	1.03
800	0.58
1000	0.37
1500	0.16
2000	0.09
2500	0.06
3000	0.04
3500	0.03
4000	0.02
5000	0.01

Comparing these results to the assessment criteria for light trespass (Table 1.2), a receptor located at a distance of 300 m away from the refinery complex would meet the CIE maximum value of 5 lux for pre-curfew hours. In terms of post-curfew hours, a receptor located at a distance of approximately 600 m from the refinery complex would be below the CIE maximum value of 1 lux.

3.2.2 Glare

The predicted amount of glare associated with the Operation phase of the Project was calculated using information provided by the Design Team.

The amount of glare from one luminaire at the refinery complex was calculated by multiplying the power of the luminaire (150 W) by the luminous efficiency of the luminaire (87 lumens/W) and dividing by the area of a sphere, thereby assuming that the light is emitted uniformly in all directions, as was done to estimate light trespass in the foregoing section. This is a conservative assumption; if luminaires are selected to direct light downward, and to prevent horizontal light trespass, there will also be a reduction in glare.

Figure 3.2 Project Visibility Areas – Process Units

Figure 3.3 Project Visibility Areas – Flare Systems

The predicted maximum amount of glare for one luminaire at the refinery complex was estimated 1,038 lumens per steradian, or 1,038 candela (cd). The CIE maximum value for glare at pre-curfew for a rural environment (Table 1.3) is 7,500 cd, and at post-curfew is 500 cd. To ensure that the post-curfew maximum value is not exceeded, the Proponent should ensure proper placement of each luminaire and associated parts, and the selection of luminaires that maximize downward lighting and minimize the potential for adverse environmental effects from Project-related lighting.

3.2.3 Sky Glow

The foregoing sections indicate that luminaires will be selected to reduce the wasted light (*i.e.,* light that is directed upwards, above the horizontal, or directly into the eyes of observers as glare). These design goals are contained within the Canada Green Building Council LEED guidelines (LEED 2004). The use of such guidelines and recommended techniques therein can markedly reduce stray light that directly or indirectly contributes to the increase of sky glow and the adverse effect on the night sky.

3.3 Discussion and Limitations

Modern industrial designs are incorporating more progressive, and energy saving concepts in lighting design. These still provide the security and safety illumination that is required in industrial facilities. The reduction in glare and the more efficient luminaires that focus lighting in necessary areas actually improve the security and safety of the site.

Light, as a component of the environment, has received increased attention, and is now addressed in major environmental assessments. The lighting assessment for the Project has taken place at an early stage of design, and the approach has been to use worst-case assumptions together with the limited design information to calculate the potential lighting environmental effects of the Project on surrounding residential receptor areas with respect to three components of obtrusive light:

- Light trespass (also referred to as spill);
- Glare; and
- Sky glow.

The quantitative assessment based on preliminary design information, shows that the light trespass and the glare resulting from Operation will largely achieve CIE guidelines. In achieving these guidelines, the designs will markedly reduce the potential contribution of lighting to sky glow.

4.0 CLOSURE

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This report has been prepared by a team of Jacques Whitford professionals on behalf of Irving Oil.

5.0 REFERENCES

5.1 Literature Cited

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